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WHY WEAR CARHARTT FR?

Carhartt has been manufacturing heavy-duty, high-quality, workwear since 1889. Carhartt introduced its line of flame-resistant workwear in the late 1990's because many tough jobs require flame-resistant safety clothing—and for every one of these tough jobs, there's Carhartt FR. Because workers' peace of mind and safety are paramount, Carhartt men and women's flame-resistant clothing meets the performance requirements of NFPA 70E, ASTM F1506 and most are UL Classified to NFPA 2112. In a world where rugged and hazardous workplaces are a reality, Carhartt FR clothing is an everyday staple for men and women who work in these jobs. Carhartt's FR clothing for men and women can help keep workers safer from exposure to dangerous arcs and flame they might encounter while working in these hazardous environments.

WHY IS WEARING FR CLOTHING IMPORTANT?

SIMPLY BECAUSE FR CLOTHING HAS BEEN SHOWN TO SAVES LIVES.
FR clothing is a critical component in protection for those industries that put workers at risk of their clothes igniting. When FR clothing is exposed to a heat source, like a fire or explosion, it either does not ignite or self-extinguishes.

The most serious burns aren't usually caused by the fire or explosion itself, but by common work clothes (e.g., non-FR cotton, nylon or polyester) igniting and continuing to burn even after the heat source has been removed. Because FR clothing either does not ignite or self-extinguishes, it can dramatically reduce the amount and severity of burn injuries, increasing the chances of survival.

PURPOSE AND LIMITATIONS OF FR GARMENTS

Purposes

- Clothing is designed to not ignite and continue to burn or self-extinguish.
- Provides a degree of protection against short-duration thermal exposures, such as a flash fire or electric arc flash.
- Helps minimize the amount and degree of burn injury from the exposure.
- Increases the chances of survival.

Limitations

- Not for use for protection against continuous thermal exposures, radiant heat, molten metal splash, hot liquids, steam or chemical exposures, unless the FR fabric is specifically designed for that application.
- Not to be worn alone for structural or other firefighting activities.

Note: The user is responsible for determining the proper personal protective equipment (PPE) needed. Wearers should be properly trained and understand the requirements for use and care of the garment to be qualified to wear it. Know the protection level required at your worksite, or consult your employer.

What is required for a fire to start and continue to burn?

The fire triangle shows the three elements needed for a fire to start and continue to burn. Fuel, oxygen and heat are essential to sustain combustion. The ignition source is the heat that initiates the combustion and as long as there is fuel (clothing) and oxygen, the combustion process will continue. When a fabric is exposed to a heat source, it can quickly decompose, releasing flammable gasses which ignite and burn. This generates more heat, so as long as there is fuel and oxygen, the combustion process will continue. In order to stop the combustion process, one leg of the triangle must be eliminated – remove the fuel, block the oxygen, or eliminate the heat.

Different flame-resistant fabrics stop the combustion process in different ways.

Fabrics with a very high temperature to decompose and the creation of char stop the combustion process from getting started. Aramids are an example of this method.

Fabrics with a decrease in the formation of flammable volatiles and an increased production of char and other non-flammable species like water vapor remove the fuel and dilute the oxygen leg of the triangle. Aramids and most cotton and cotton blends with phosphorus- and nitrogen-containing flame retardants are examples of this method.

Fabrics that reduce access to oxygen via displacement or dilution use char-promoting retardants to create char and release water vapor. This results in blocking the oxygen and fuel legs of the triangle. FR-treated cotton and some modacrylic blends are examples of this method.

Fabrics that interfere with the flame chemistry and/or increase the fuel ignition temperature block the oxygen and change the fuel so it doesn't decompose. Modacrylic blends and chlorinated phosphorus FR treatments are examples of this method.

HAZARDS REQUIRING FR CLOTHING

The most common hazards with the potential to cause clothing ignition and therefore severe burn injuries are hydrocarbon flash fires, electric arc flash and welding/cutting/grinding.

What is a hyrdocarbon flash fire?

A short-duration burst of flames that occurs when flammable gases, vapors or dusts are released into the air and ignited.

FLASH-FIRE HAZARD FACTS:

- A hazard when working around flammable gasses or ignitable dust
- Occurs when flammable gasses or dusts ignite
- Requires fuel, oxygen and ignition source
- Typically last 1-5 seconds
- Total energy of typically 1-15 cal/cm^2

PROTECTIVE CLOTHING REQUIREMENTS:

- UL-classified to the NFPA 2112 standard
- < 50% predicted body burn injury when fabric is tested to ASTM F1930
- Minimum Heat Transfer Performance (HTP) not less than 6 cal/cm^2 (spaced) and 3 cal/ cm^2 (contact)
- Minimum Heat & Thermal Shrinkage Resistance – No melt, drip, separation or ignition, and maximum 10% thermal shrinkage

What is an electric arc-flash hazard?

A dangerous release of energy caused by an electric arc, when working on or around energized electrical conductors or equipment.

ELECTRIC ARC-FLASH HAZARD FACTS:

- A hazard when working on and around energized conductors or equipment
- Occurs when electricity is released and finds a path to ground
- Lasts a fraction of a second
- Creates heat, flames, a pressure wave, and a load noise
- The amount of thermal energy experienced depends on the current, duration, and distance from the arc source

PROTECTIVE CLOTHING REQUIREMENTS:

- Meets the requirements of the ASTM F1506 standard
- Must be flame resistant (FR)
- Must be arc rated (AR) – with either an Arc Thermal Performance Value (ATPV) or Energy Breakopen Threshold (EBT)
- NFPA 70E PPE category ratings of 1, 2, 3 or 4 when applicable

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What is a welding/cutting/grinding hazard?

Release of hot metal sparks or spatter sprayed into the surrounding area.

WELDING/CUTTING/GRINDING HAZARD FACTS:

- A hazard when performing various welding, cutting or grinding operations
- Hot metal sparks and/or spatter can be ejected causing skin burns to unprotected areas
- Inappropriate clothing can result in ignition, burning, sticking, or trapping hot sparks and spatter
- The potential for sparks and/or spatter depends on the type of welding being performed (eg. Arc, TIG, MIG, Flux core, Plasma, etc.)

PROTECTIVE CLOTHING REQUIREMENTS:

- The ANSI Z49 only requires heavy materials; if cotton, it should be treated to reduce combustibility
- Clothing should minimize the potential for ignition, burning, trapping hot sparks, or electric shock
- Clothing materials that can melt should not be used

HAZARDS REQUIRING HIGH-VISIBILITY CLOTHING

The need to be seen is recognized as a critical issue for workers' safety. Low visibility is a serious issue for workers who must perform tasks near moving vehicles and/or equipment. There are many work environments that require High-Visibility Safety Apparel (HVSA), including anyone working on or around roadways, oil and gas, mining, warehouses, shipyards, and other manufacturing facilities and environments where vehicles, equipment, or machinery could strike workers. The Federal Highway Administration published a regulation to establish a policy for the use of HVSA for workers within the Federal-aid highway rights-of-ways.

What is a visibility hazard?

A visibility hazard is a condition where a worker's ability to be seen by those operating vehicles or other moving equipment is necessary to avoid them being struck.

VISIBILITY HAZARD FACTS:

- A hazard when working in low-light condition either daytime or nighttime
- The ability to be seen is enhanced by high contrast between the garment and the background against which it is seen
- The degree of visibility enhancement required can be based on things like the degree of risk, the light level, complexity of the work background, and the speed of the vehicle or equipment
- HVSA is categorized by Type and Class depending on the environment
- The different types and classes of HVSA requires different amounts and configurations of background material and reflective striping

HVSA REQUIREMENTS:

- Specify a garment type – 0 (Off-road), R (Roadway), P (Emergency Personnel)*
- Specify a performance class – 1 (minimum materials, slower vehicle speeds), 2 (additional materials, minimum for roadway applications), 3 (greatest visibility in complex backgrounds and maximum materials and required placement on moving parts). *
- Minimum amounts of background material for different types and classes*
- Minimum reflective tape for different types and classes*
- Various garment and tape configurations and rules*
- HVSA garments are required to be labeled as either FR or Non-FR; if designated as FR, the label must indicate which of the approved FR standards it complies with*

**Note: See ANSI/ISEA 107 for details*

Emblems, nametags, and embroidery

Emblems, nametags and embroidery are not required to be flame resistant, by either NFPA 2112 or ASTM F1506. Non-FR versions of these items are not thought to be of significant danger to the wearer, should they be kept to a minimum in size and overall area.

In the Annex/Appendix of each standard, it is recommended that any individual non-FR emblem, nametag or embroidery used on the outside of an FR garment be a maximum of 16 square inches, and if more than one is used the total area be no more than 40 square inches.

FR FABRIC TYPES

FR fabrics are typically categorized into two different types: inherently FR and FR-treated.

Inherently FR

The fibers used in the construction of the fabric have a molecular structure that does not support combustion or have the ability to self-extinguish. The fabric does not have any flame-retardant chemicals added. Being inherently FR also means the FR properties cannot be washed or worn out of the fabric. A common inherently FR fabric is Nomex® IIIA.

FR-Treated

A non-FR fabric, typically either 100 percent cotton or a blend of 88 percent cotton and 12 percent nylon that has been treated by adding flame-retardant chemicals so it self-extinguishes. Because the FR properties are added to the fabric, it is important to make sure the FR fabric is guaranteed to be FR for the life of the garment, so you are assured the treatment does not get washed or worn away over time.

Common FR Fabrics*

Aramid Blends (Inherent)

Fabric Brands	Fiber Content	Strengths	Weaknesses	Fabric Mill(s)
Nomex IIIA	93% Nomex 5% Kevlar 2% Antistat	Thermal stability Longer wear life Good flash fire performance High air permeability Low shrinkage	Difficult to dye Poor wicking Lower initial comfort Lower ATPV Higher cost	Tencate, Westex by Milliken

Modacrylic Blends (Inherent)

Fabric Brands	Fiber Content	Strengths	Weaknesses	Fabric Mill(s)
Tecasafe Plus	48% Modacrylic 37% Lyocell 15% Para-aramid	Good comfort Good moisture absorption Good for flash fire and arc flash Lower cost than aramid blends	Less durable than aramids Higher shrinkage than aramids Higher cost than 100% cotton	Tencate
DH	48% Lyocell 40% Modacrylic 12% Aramid	Good comfort Good moisture absorption Good for flash fire and arc flash Lower cost than aramid blends Easier to dye than aramids	Less durable than aramids Higher shrinkage than aramids Higher cost than 100% cotton	Westex by Milliken
GlenGuard	79% Kermel 20% Modacrylic 1% Antistat	Good comfort Good moisture absorption Good for flash fire and arc flash Lower cost than aramid blends Best colorfastness	Less durable than aramids Higher shrinkage than aramids Higher cost than 100% cotton	Geln Raven

FR Treated Cotton & Cotton Blends

Fabric Brands	Fiber Content	Strengths	Weaknesses	Fabric Mill(s)
Indura	100% Cotton	Good comfort Lowest cost Good ATPV compared to aramids	Least durable Higher shrinkage Least colorfastness Highest body burn %	Westex by Milliken
Amtex	100% Cotton	Good comfort Lowest cost Good ATPV compared to aramids	Least durable Higher shrinkage Least colorfastness Highest body burn %	Mount Vernon Mills
UltraSoft	88% Cotton 12% Nylon	Good comfort More durable than 100% cotton Lower cost than inherents Good ATPV & body burn %	Moderate colorfastness Higher shrinkage Higher cost than 100% cotton	Westex by Milliken

Carbon Fiber Blends (Inherent)

Tecgen, Spentex & CarbonX	100% oxidized polyacrylonitrile	High thermal stability Good longitudinal strength	Brittle Poor abrasion resistance Difficult to dye Poor aesthetics (black)	NSA, TexTech Industries

* These are a number of the most common FR fabrics. There are other fabrics not shown on this list.

REGULATIONS

The Occupational Safety and Health Administration (OSHA) is a large regulatory agency of the United States Department of Labor. OSHA commonly issues regulations for safety equipment and practices in the United States. The following OSHA regulations are used as the basis of requiring FR clothing.

OSHA 5(A)(1) "GENERAL DUTY CLAUSE"

This standard requires each employer to furnish each of his or her employees with a place of employment that is free from recognized hazards that are causing or are likely to cause death or serious physical harm to his or her employees.

OSHA 1910.132 "GENERAL PERSONAL PROTECTIVE EQUIPMENT"

This standard requires employers to identify risks and protect employees from hazards in the workplace. The rule applies to many types of PPE, such as safety glasses, protective clothing, hard hats and safety shoes. In some instances when employees suffered burns in the workplace, OSHA has used this standard to cite employers that did not require the use of FR protective apparel.

OSHA 1910.119 "PROCESS SAFETY MANAGEMENT REGULATION"

This standard requires employers to assess risk throughout the entire manufacturing process to ensure that the process is safe. The standard applies to chemical plants and petroleum plants. It has specific requirements on handling flammable substances. The standard does not specifically require FR clothing. However, OSHA has used this standard as the basis for citing employers for not requiring FR clothing.

OSHA 1910.269 "ELECTRIC POWER GENERATION, TRANSMISSION AND DISTRIBUTION STANDARD"

This maintenance standard applies to electric utilities and industrial co-generation plants when work is performed on existing facilities (i.e., maintenance work). This standard does not apply to the construction of new facilities. This standard requires the employer to assess the workplace to identify employees exposed to hazards from flames or from electric arcs. The employer must make a reasonable estimate of the incident energy to which the employee would be exposed.
The employer shall ensure that the outer layer of clothing be flame-resistant under any of the following conditions:

- Employee is exposed to contact with energized circuits operating at more than 600 volts
- The electric arc could ignite flammable materials or clothing
- The incident heat energy estimate exceeds 2 cal/cm^2

Note: This standard does not require clothing to meet any specific standards. However, FR clothing that meets the performance requirements of the National Electrical Safety Code (NESC) and ASTM F1506 "Flame Resistant and Arc Rated Textile Materials for Wearing Apparel for Use by Electrical Workers Exposed to Momentary Electrical Arc and Related Thermal Hazards" complies with OSHA 1910.269.

STANDARD-SETTING ORGANIZATIONS FOR FR WORKWEAR

Performance standards are developed by numerous government and nonprofit organizations to establish guidelines for PPE and procedures for working in hazardous areas. Standards are not law, and in most cases each company or organization can decide if it wishes to comply with available standards. Over time, however, standards sometimes gain the force of law. Frequently, law-making bodies incorporate voluntary compliance standards into new laws and rules. The four most influential standards-setting organizations in the USA that commonly address protective clothing, including FR workwear, are:

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA):

NFPA writes voluntary compliance standards related to fire service and other relevant industries. Participants that serve on the committees that write the standards are volunteers representing manufacturers, users, testing organizations and special experts. NFPA requires balanced participation from each of the four interest groups. NFPA standards have a predetermined development schedule that sets goals and establishes a timeline. These schedules can be changed, but they tend to keep the process on track. NFPA standards are subject to public comment before publishing and are renewed every five years.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM):

ASTM publishes both performance specifications and test methods for evaluating protective clothing and equipment. Participants in ASTM are volunteers, including industry personnel, testing organizations and users who have an interest in the field. Each committee is supposed to have a balanced representation; however, this rule is not as clearly defined as in NFPA or Canadian General Standards Board (CGSB). ASTM functions by consensus, which can cause the process to be more cumbersome than a simple majority. Standards and test methods are published by ASTM and typically renewed at least every five years.

AMERICAN NATIONAL STANDARD INSTITUTE (ANSI):

ANSI is a private non-profit organization that oversees the development of voluntary consensus standards for products, services, processes, systems, and personnel in the United States.

INTERNATIONAL SAFETY EQUIPMENT ASSOCIATION (ISEA):

ISEA is the leading association for personal protective equipment and technologies that enable people to work in hazardous environments, and an ANSI-accredited standards developing organization. The association works closely with manufacturers, test labs, subject matter experts, end-users and government agencies in the standards development process. ISEA members—leaders in safety equipment manufacturing, testing and application—are united in the goal of protecting workers worldwide.

FR GARMENT STANDARDS

There are a number of standards related to the selection, use, care and performance requirements of FR garments. Those standards include:

NFPA 2112 – FLAME-RESISTANT GARMENTS FOR PROTECTION OF INDUSTRIAL PERSONNEL AGAINST SHORT-DURATION THERMAL EXPOSURES FROM FIRE:

This is a standard for industries such as: oil and gas drilling, petrochemical, gas utilities, university research labs, and combustible dust industries. The standard specifies the minimum performance requirements and test methods for FR fabrics and components, and the design and certification requirements for garments for use in areas at risk of flash fires. It requires FR fabrics to pass a comprehensive battery of thermal tests, including:

- ASTM D6413 Vertical Flame test (maximum two-second afterflame and 4-inch (100-millimeter) char length)
- ASTM F2700 Heat Transfer Performance (HTP) test (minimum HTP of 6 cal/cm^2 with spacer and 3 cal/cm^2 in contact)
- Thermal Stability test (fabric must not melt or drip, separate, or ignite after five minutes in a 500°F oven)
- ASTM F1930 Thermal Manikin test (maximum 50% body burn after three-second exposure)

NFPA 2113 – SELECTION, CARE, USE AND MAINTENANCE OF FLAME-RESISTANT GARMENTS FOR PROTECTION OF INDUSTRIAL PERSONNEL AGAINST SHORT-DURATION THERMAL EXPOSURE FROM FIRE:

This standard serves as a user's guide for industrial FR clothing. It addresses topics such as hazard assessment, purchasing, cleaning, repairs, storage, decontamination, retiring garments and proper use procedures.
This standard requires that garments be classified to NFPA 2112.

NFPA 70E – ELECTRICAL SAFETY IN THE WORKPLACE:

This standard specifies requirements for workplace electrical safety when working on energized electrical equipment and conductors. It requires the employer to perform a hazard assessment to determine the potential arc-flash incident energy exposure from the equipment, which establishes the arc-rating requirement for the workers' protective clothing. The standard also provides performance requirements for clothing worn by electrical workers and other personnel working around energized parts. It refers to ASTM F1506 "Flame-Resistant and Arc-Rated Textile Materials for Wearing Apparel for Use by Electrical Workers Exposed to Momentary Electric Arc and Related Thermal Hazards."

To simplify the process, the standard has established four PPE Categories (1, 2, 3, 4) associated with common tasks an electrical worker would perform. Each category has a minimum arc rating for protective clothing measured in cal/cm^2, plus other PPE requirements.

70E PPE CATEGORY	MINIMUM ARC RATING	OTHER PPE REQUIREMENTS
1	4 cal/cm^2	Arc-rated face shield or flash suit hood, hard hat, glasses or goggles, hearing protection, leather gloves, leather footwear
2	8 cal/cm^2	Arc-rated balaclava, face shield or flash suit hood, hard hat, glasses or goggles, hearing protection, leather gloves, leather footwear
3	25 cal/cm^2	Arc-rated arc flashsuit jacket, pants, hood and gloves, hard hat, safety glasses or goggles, hearing protection, leather footwear
4	40 cal/cm^2	Arc-rated arc flashsuit jacket, pants, hood and gloves, hard hat, safety glasses or goggles, hearing protection, leather footwear

ASTM F1506 "FLAME-RESISTANT AND ARC-RATED TEXTILE MATERIALS FOR WEARING APPAREL FOR USE BY ELECTRICAL WORKERS EXPOSED TO MOMENTARY ELECTRIC ARC AND RELATED THERMAL HAZARDS":

This is a standard for anyone working on energized electrical equipment including electric utilities. The standard specifies the minimum performance requirements and test methods for FR fabrics and components, and some design requirements. It requires FR fabrics to pass the basic vertical flame test (ASTM D6413) with a maximum 6" char length and 2 second after-flame and establish an arc rating (ATPV or EBT) using ASTM F1959 Arc Thermal Performance test method. In addition to thermal requirements, F1506 requires:

- The fabric have a minimum breaking or burst strength
- Use inherently FR sewing thread
- No metal to touch the skin
- Meet specific labeling requirements

ANSI/ISEA 107, AMERICAN NATIONAL STANDARD FOR HIGH-VISIBILITY SAFETY APPAREL AND ACCESSORIES:

This standard establishes design, material, photometric and physical performance requirements, care labeling and marking rules for high-visibility garments. Garments compliant to ANSI/ISEA 107 are intended to provide visibility to the user in hazardous situations under any light conditions by day and under illumination by vehicle headlights in the dark. Performance requirements include requirements for color, retroreflection, and minimum areas of retroreflective and combined-performance materials, as well as the recommended configuration of the materials.

The standard has established three garment "types" which are based on the work environment of the wearer:

- Type-O garments are intended for "off-road" workers
- Type-R garments are meant for employees working along a "roadway"
- Type-P garments meet the unique needs of "public safety" workers

It also specifies performance classes within each garment Type specified in terms of the minimum area of high-visibility materials to be incorporated. Class 1 is the least amount of area and Class 3 is the greatest amount of area. Also, high-visibility garments marked as flame-resistant must comply with the requirements of at least one of the following standards in its entirety and be labeled as such: ASTM F1506, ASTM F1891, ASTM F2302, ASTM F2733, NFPA 1977 or NFPA 2112.

FR WORKWEAR TEST METHODS

Depending on the use, FR workwear can be put through any number of tests to ensure that it offers the necessary protection for the wearer. Some of the most common tests include:

ASTM D6413

Vertical Flame Test: This test and various modifications thereof determine whether a fabric will ignite and continue to burn after exposure to a flame source. This test is used to define a fabric as FR. The Vertical Flame test is the most commonly used test in the FR industry. The test method sets criteria on how the test should be conducted (sample size, number of trials, type of flame, etc.) but does not establish performance requirements. Reported values are:

- The length of fabric that was damaged (char length recorded in inches/millimeters)
- The time the fabric continues to burn after the flame source is removed (after-flame recorded in seconds)
- The length of time the fabric continues to glow after the flames extinguish (after-glow recorded in seconds); this value is often reported but rarely used in performance standards

ASTM F1930

Manikin Test: This is a full-scale manikin test designed to test fabrics in completed garment form in a flame exposure.

- A manikin, with up to 122 heat sensors spaced around its body, is dressed in the test garment, then exposed to flames for a predetermined length of time, typically 3 seconds
- Tests are usually conducted at heat energies of 1.8-2 cal/cm2
- Results are reported in percent body burn
- For consistency in data and accuracy of comparison, the test method defines a standard garment size and configuration that must be used on each test. This is very important because manikin test results are heavily dependent on garment fit and design

The standard manikin test is not designed to evaluate the protective performance of specific garment designs, although the test can be used in this manner. **Caution:** Results of manikin tests should be used to compare the relative performance of different FR fabrics. Results should not be used to predict the extent of body burn a wearer would receive in a real flash fire exposure.

ASTM F1959

Standard Test Method for Determining the Arc Thermal Performance Value of Materials for Clothing: This test measures the amount of thermal protection a fabric would give a wearer if the person were caught in the vicinity of an electric arc.

- The Arc Thermal Performance Value (ATPV) is defined as the arc energy that results in the 50 percent probability of the onset of second-degree burns when a person is wearing the fabric
- The higher the ATPV, the more protective the fabric; alternately, the energy required to break open the test fabric (EBT) is also determined if an ATPV cannot be reached
- Employers can use the ATPV and EBT values to select FR clothing that will protect workers from the expected arc exposure; both are considered arc ratings for the fabric
- This test is only done on FR fabrics
- This test measures protection from the heat and flame byproducts of an electric arc; it does not indicate any protection from contact with energized components
- In this test, panels that contain heat sensors are covered with the test fabric; the panels are exposed to an electric arc of known energy; the temperature rise in the heat sensors behind the fabric is measured to determine whether or not sufficient heat was felt by the sensor to cause a second-degree burn
- The test is repeated multiple times until a statistically valid ATPV or EBT can be calculated

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ASTM F2700

Heat Transfer Performance (HTP) Test: This test measures the amount of thermal protection a fabric would give the wearer in the event of a flash fire. The HTP is related to the energy required to cause the onset of a second-degree burn when a person is wearing the fabric. The higher the HTP, the more protective the fabric. Fabrics are tested with a space gap between the test sample and the heat source to measure the fabrics' ability to provide a barrier between the heat source and the skin ("spaced HTP"). Fabrics are also tested in contact with the heat source to measure the fabrics' ability to provide thermal insulation ("contact HTP").

ASTM F2894

Heat Resistance Test: This test is used in numerous NFPA standards to measure the thermal stability of fabric and components. Garment swatches are heated in a 500ºF oven for five minutes, and then observed for melting, dripping, separation and ignition. Most standards require that the fabric show no sign of melting or dripping.

ASTM F2894

Thermal Shrinkage Test: This test is used in numerous NFPA standards to measure the thermal shrinkage of fabric and components. Garment swatches or components, such as thread and zipper tapes, are heated in a 500ºF oven for five minutes, and then the thermal shrinkage is measured. The performance requirement varies with each standard, but often defines the maximum shrinkage at 10 percent.

Performance Regulations / Standards / Test Methods

Number	Title	Basics Description
OSHA 5 (a)(1)	General Duty Clause	US general requirement for employers to furnish its employees: employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to employees
OSHA 29 CFR 1910.132	General Personal Protective Equipment	US general requirement for employers to assess hazards in the workplace and provide appropriate PPE
OSHA 29 CFR 1910.269	Electric Power Generation, Transmission and Distribution Standard	Includes requirements of clothing for workers, in electric power generation, transmission and distribution, exposed to the hazards of flame and electric arc
ASTM F1506	Flame-Resistant and Arc-Rated Textile Materials for Wearing Apparel for Use by Electrical Workers Exposed to Momentary Electric Arc and Related Thermal Hazards	Performance requirements for materials for arc rated clothing used by electrical workers
ASTM F1891	Standard Specification for Arc and Flame-Resistant Rainwear	Performance requirements for rainwear used by workers exposed to the hazard of flames or electric arcs
ASTM F2302	Standard Performance Specification for Labeling Protective Clothing Which Provides Resistance to Incidental Exposures to Heat or Open Flame	Minimum requirements for labeling protective garments as flame and thermal resistant
ASTM F2733	Standard Specification for Flame-Resistant Rainwear for Protection Against Flame Hazards	Performance requirements for Rainwear used by workers exposed to the hazard of flash fire
ANSI/ISEA 107	American National Standard for High-Visibility Safety Apparel and Accessories	Performance requirements for high-visibility safety apparel and headwear
NFPA 70E	Electrical Safety in the Workplace	Work practices, including PPE, for workers performing work on or near energized electrical circuit parts
NFPA 654	Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids	General industry safe work practices for combustible dust environments; addresses need for FR clothing
NFPA 1975	Standard on Emergency Services Work Apparel	Performance requirements for fabrics and garments used in firefighter's station uniforms
NFPA 1977	Standard on Protective Clothing and Equipment for Wildland Fire Fighting	Performance requirements for fabrics and garments used for protection in wildlands firefighting
NFPA 2112	Flame-Resistant Garments for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire	Performance requirements for garments and fabrics for industrial flash fire protection
NFPA 2113	Selection, Care, Use and Maintenance of FlameResistant Garments for Protection of Industrial Personnel Against Short-Duration Thermal Exposure from Fire	Selection, care and use of flame-resistant garments for industrial flash fire protection, including a requirement for clothing to meet NFPA 2112
ASTM D6413	Standard Test Method for Flame Resistance of Textiles (Vertical Test)	Test method measuring vertical flame resistance of textiles; used to establish a fabrics char length and afterflame performance
ASTM F1930	Standard Test Method for Evaluation of Flame-Resistant Clothing for Protection Against Fire Simulations Using an Instrumented Manikin	Test method simulating a flash fire exposure using an instrumented manikin; used to establish a fabrics estimated body burn injury
ASTM F1959	Standard Test Method for Determining the Arc Rating of Materials for Clothing	Test method to determine the Arc Thermal Performance Value (ATPV) or Breakopen Threshold Energy (EBT) of flame-resistant textile materials, for clothing by electric arc exposure using instrumented sensor panels
ASTM F2700	Standard Test Method for Unsteady-State Heat Transfer Evaluation of Flame-Resistant Materials for Clothing with Continuous Heating	Test method used to determine TPP and HTP
ASTM F2894	Standard Test Method for Evaluation of Materials, Protective Clothing, and Equipment for Heat Resistance Using a Hot Air Circulating Oven	Test method used to determine heat resistance and thermal shrinkage

FR GARMENT LABELING

The Federal Trade Commission (FTC) requires all garments sold in the U.S. to have some basic information including the manufacturer's name and location, fiber content, country of origin, and care instructions. In addition, FR garments have other specific labeling requirements that somewhat vary depending on which standard it meets.

The basic information on all FR garment labels, in addition to the FTC requirements, includes:

- Garment size
- Garment name or number or identifier
- Standard number and name that it is claiming to meet such as:
    - NFPA 2112
    - ASTM F1506
    - ANSI/ISEA 107

Because each of these standards are for a different hazard, there are a few pieces of unique labeling information.

NFPA 2112:

This standard requires the garment to be certified by a third party such as UL. Therefore it requires a label to include the following statement along with the third party label/symbol, or identifying mark.

"This clothing item meets the requirements of NFPA 2112-2018, NFPA 2113 Requires Upper and Lower Body Coverage."

ASTM F1506:

This standard also requires a unique identifier for the fabric, a garment tracking code and the garment arc rating (ATPV or EBT) to be on a label. In addition it requires the following statement.

"Meets Requirements of Performance Specification F1506."

ANSI/ISEA 107:

This standard also requires a label to have a pictogram showing the garment Type and Class, maximum number of launderings and the letters FR followed by the particular FR standard it meets. For example:

FR: ASTM F2302
FR: ASTM F1506
FR: NFPA 2112

TYPE R
CLASS 2
FR: ASTM F2302

If a garment does not have all the labeling information required by the standard it claims to comply with, it should be considered not in full compliance.

FR GARMENT WEAR AND CARE

How to Wear FR Workwear Properly

Follow all garment manufacturers' recommendations for proper use:

- Wear garments properly: collars closed, sleeves and cuffs down and secured, shirt tails tucked, closures secured, and other manufacturer recommendations
- Wear loose-fitting garments that provide adequate mobility
- Do not wear non-FR clothing over FR garments
- Wear only FR or non-melting undergarments (e.g., cotton, silk or wool); wash garments thoroughly after each wearing
- Do not put on or take off the garment in a potentially explosive environment
- In potentially explosive atmospheres, use proper grounding procedures
- Wear garments with an arc rating as dictated by an electric arc hazard analysis

Proper FR Garment Care

The first rule of FR fabric maintenance is to carefully follow the manufacturers' care label when laundering FR garments. Generally, all FR fabrics and garments require the same basic care:

- Wash new FR garments prior to wearing
- Wash FR garments separately from standard clothing
- Use hot water (maximum 140°F/60°C) with a heavy-duty detergent
- Do not use soap
- Do not use chlorine bleach
- Do not use fabric softeners or dryer sheets
- Do not line dry or store in sunlight; colorfastness can be affected by significant amounts of UV exposure (sunlight or artificial)
- Make sure FR garments are clean and in proper repair before each wearing
- Remove oils and flammable contaminants from FR garments; flammable contaminants may act as a fuel source, increasing the potential severity of a burn injury
- Repair garments using "like materials"; use FR fabric, thread and garment components; return garments to the manufacturer for repair or use an authorized FR repair facility

FREQUENTLY ASKED QUESTIONS

Does FR clothing prevent burn injuries?
No. FR clothing does not totally prevent burn injuries. The FR fabrics are made to either provide protection against clothing ignition or self-extinguish, which should minimize the severity of the burn injury.

Is it OK to wear a jacket or sweatshirt over FR clothing?
The outermost layer of clothing must be FR. Wearing flammable garments over FR clothing will compromise the protection of the FR clothing system. Even though the FR garment resists ignition, the flammable jacket can become a burning fuel source that can burn the wearer by heat transfer through the FR fabric.

What should be worn underneath?
FR garments should be worn over non-melting fabrics or other FR materials. For example, one recommended combination is wearing a Nomex® IIIA coverall over a 100 percent cotton T-shirt and underwear. Layering garments in this manner dramatically increases the thermal protection of the clothing system by adding "air gaps" that provide excellent thermal insulation.

Does the FR performance wear out?
For some products, the FR performance is inherent in the chemical composition of the fiber, and therefore the FR performance cannot be removed. For other products, flame-retardant chemicals are applied to the fabric in the FR treatment process, and are typically guaranteed for the life of the garment, provided that proper laundering procedures are followed.

Can insect repellants be used on FR clothing?
Insect repellants using DEET should not be used on FR clothing as it is flammable. Insect repellants that are Permethrin-based products have been tested to be acceptable. You can use DEET-based products on the skin and Permethrin-based products on the garment.

Will layering garments add to the arc-flash protection?
Yes it will, however the arc rating of that layered system is unknown unless the layered system has been arc tested.

Does FR clothing with antistatic fibers prevent static electricity?
No. All fabrics have the ability to generate static electricity and FR clothing is no more likely to generate static than other clothing under the same conditions. The primary hazard is stored energy on the body of an ungrounded person, not the fabric itself. If a wearer is in an environment where a static discharge could be hazardous, use engineering grounding controls like static dissipative wristlets or anklets or other grounding methods that are available for this hazard. And lastly, do not put on or remove clothing in a hazardous atmosphere as this increases the amount of static charge on the body.

Is FR clothing more likely to cause heat stress?
No. Heat stress is created by the inability of the body to dissipate heat faster than it builds up in the body. There are many factors that can affect the ability of a worker to deal with a hot working environment. To minimize the potential for heat-related problems, particularly in hot, humid working conditions, lighter weight, light-colored fabrics can help – but it is more important to take regular rest breaks, drink plenty of water, get out of the sun and know the warning signs so you can take the appropriate actions before the situation gets dangerous.

GLOSSARY OF COMMON FR-RELATED TERMS

After-flame: A parameter measured during vertical flame testing. The length of time (in seconds) a fabric sample continues to burn after the test flame is removed.

After-glow: A parameter measured during vertical flame testing. The length of time (in seconds) a fabric sample continues to glow after all flames are extinguished.

Aramid: The chemical family of Nomex® (a meta-aramid) and Kevlar® (a para-aramid) fibers.

Arc rating: The maximum incident energy resistance of a material expressed in calories per square centimeter (cal/cm^2), stated as either an Arc Thermal Performance Value (ATPV), or Breakopen Threshold Energy (EBT). The lower of either the ATPV or EBT is reported as the arc rating.

ASTM: American Society for Testing of Materials. A voluntary compliance organization that writes test methods and performance standards, for various industries, including FR products.

ATPV: Arc Thermal Performance Value. A measure of thermal protection, reported in units of energy (cal/cm^2), provided by an FR fabric when exposed to an electric arc. Defined as the arc energy that results in the 50 percent probability of the onset of second-degree burns when a person is wearing the fabric.

Cal/cm^2: Calories per square centimeter. The heat rate per unit area, impressed on a surface by an electric arc flash or flash fire.

Char length: A parameter measured during vertical flame testing. The length of fabric (in inches) that was damaged and can be torn by a predefined weight after all flaming and glowing is extinguished and the fabric sample has cooled.

EBT: The Energy Breakopen Threshold. The cal/cm^2 at which the fabric breaks open before it reaches its ATPV. This is the fabric's arc rating.

Flame resistant (FR): A fabric or product that resists ignition and self-extinguishes after removal of an ignition source.

Flame retardant: A chemical treatment applied to a flammable base fabric that provides FR properties.

Flame-retardant treated: A fabric that has been treated with a flame-retardant chemical.

70E PPE Categories: A term used specifically in both NFPA 70E and CSA Z462. When using the task tables, each task has an assigned PPE category for the arc rating of clothing to be worn (Cat 1, 2, 3 or 4). Each category has a minimum arc rating in cal/cm^2.

HTP: Heat Transfer Performance. A rating or value (cal/cm^2) of a material's time-dependent heat transfer response relative to a time-dependent second-degree burn injury curve.

Inherently flame resistant: Property by which the FR performance of a fiber comes from the chemical structure of the fiber itself.

Kevlar®: Brand name for para-aramid fiber used in cut-resistant, bullet-resistant and FR applications produced by DuPont™ Inc.

Lyocell: A cellulose fiber made from dissolving wood pulp (a type of Rayon).

Modacrylic fiber: Generic name for a type of inherently FR fiber.

NFPA: National Fire Protection Association. A voluntary compliance organization that writes test methods and performance standards for the fire service and other industries, including FR products.

Nomex®: Brand name for meta-aramid fiber used in FR and heat-resistant applications produced by DuPont.

Nomex® IIIA: DuPont brand name for a blend of Nomex, Kevlar and a static dissipative fiber used in FR apparel.

Regulation: A law that mandates compliance.

Standard: A document, usually produced by a standards-writing organization, that establishes minimum performance criteria for various safety equipment.

Stoll Curve: A plot of thermal energy and time used to predict a pain sensation, or the occurrence of a second degree burn in human tissue.

Test method: A document, usually produced by a standards-writing organization, that explicitly defines how a particular test should be conducted, including parameters such as sample conditioning, size and number of samples, test conditions, end points to be measured, etc.

Thermal Manikin test: A full-scale flammability test in which a manikin is dressed in an FR garment of standard size and design, and then is subjected to a flame exposure of known energy and duration. The end point is usually expressed in percent body burn.

Vertical Flame test: A thermal test method that determines whether or not a fabric is FR by measuring how long the fabric continues to burn and how much fabric is consumed after being exposed to a flame of known energy. The most common vertical flame test is ASTM D6413 "Vertical Flammability – Cloth."

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