Flame Resistant Clothing for the Flash Fire Hazard: Care, Use, and Maintenance

June, 2019
FR Clothing in the Flash Fire Environment

Overview
The National Fire Protection Association (NFPA®) defines a flash fire as “a type of short-duration fire that spreads by means of a flame front rapidly through a diffuse fuel, such as dust, gas, or the vapors of an ignitable liquid, without the production of damaging pressure.” In many industries, flash fire is a known yet unpredictable hazard.

The dangers to workers can be mitigated in several ways, including conducting a hazard assessment, eliminating hazards where possible, instituting engineering and administrative controls, and ensuring the issuance and proper use of personal protective equipment (PPE).

Because hazard removal and engineering and administrative controls are not always maximally effective, PPE should be a key component of a worker safety program. In a flash fire context, flame resistant (FR) clothing provides further protection and offers a foundational defense.

This paper guides safety managers and purchasers in the selection, use, care and maintenance of clothing for flash fire protection that’s compliant with the industry consensus standard NFPA® 2112 (see below).

Flash Fires
Flash fires result when gas or vapor is ignited. Sources of ignition can include an open flame, a spark, static or a hot surface. Typically, the fire flashes and either abates or is extinguished quickly. The intensity of a flash fire depends on the nature of the fuel and the concentration of the gas or vapor cloud.

No matter the source or cause of ignition, flash fires can be unpredictable and can occur in a wide variety of industries and environments. Because the majority of burn injuries are caused by “non-flame resistant clothing igniting and continuing to burn,” employees working in a potential flash fire environment need PPE, including FR clothing, to effectively manage risk.1

Standards
Employers are mandated by the Occupational Safety and Health Administration (OSHA) General Duty Clause to provide employees with a workplace free of recognized hazards. The clause requires employers to protect employees from the recognized hazard such as flash fires, but it does not dictate how such protection should be provided.

In general, employers determine appropriate measures of protection after conducting a hazard risk assessment, identifying hazards2, and understanding and adhering to consensus-based industry safety standards. For example, in workplaces where flash fires pose a hazard, such as in oil and gas drilling, well servicing, material handling and production-related operations, employers typically choose to follow the PPE standards recommended by organizations such as the NFPA®, the American National Standards Institute (ANSI), the American Society for Testing and Materials (ASTM) and others.

NFPA® 2112: Standard on Flame-Resistant Clothing for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire sets the minimum performance criteria for FR fabric, thread, hardware and labels, as well as the design criteria for FR garments. It includes a battery of five primary tests that FR fabrics and components must pass, including tests for flame resistance (vertical flammability), heat resistance, thermal shrinkage, heat transfer performance (HTP) and ASTM F1930: Standard Test Method for Evaluation of Flame-Resistant Clothing for Protection Against Fire Simulations Using an Instrumented Manikin.

NFPA® 2112 component recognized fabrics must:
1. Meet minimum performance standards for vertical flammability, as well as for HTP, thermal stability and heat resistance.
2. Demonstrate that the flame-resistant properties are durable to laundering.
3. Result in no greater than 50% predicted body burn when tested on an instrumented manikin in a simulated flash fire exposure lasting 3 seconds at a heat flux of 2 cal/cm2.

It is not enough for FR fabric and clothing manufacturers to pass NFPA® 2112 protocols, however. For FR clothing to be labeled compliant, fabrics and garments must also be certified by an independent third party such as Underwriters Laboratories (UL).

**Complementary Standards**
NFPA® 2112 is not the only industry standard used in North America. Canadian manufacturers can also reference Canadian General Standards Board (CGSB) 155.20: *Workwear Protection Against Hydrocarbon Flash Fire*. It’s similar to NFPA® 2112, with a few important differences.

For example, the 2017 edition of the Canadian standard uses the Thermal Protective Performance (TPP) test method rather than the HTP method used by NFPA® 2112. It also uses the thermal manikin test but requires no greater than 40% predicted body burn versus the 50% in NFPA® 2112. U.S. purchasers typically specify clothing that is certified to NFPA® 2112; purchasers in Canada typically opt to purchase FR clothing certified to NFPA® 2112 or CGSB 155.20 standards.

NFPA® 652: *Standard on the Fundamentals of Combustible Dust* functions as the umbrella standard for garments used to protect workers from combustible dust fires.

In combustible dust fires, the pressure and concussion caused by an initial explosion can dislodge other nearby dust accumulations, which can then become suspended in the air and fuel secondary and tertiary explosions and/or fires. The resulting chain reaction can repeat throughout a facility to devastating effect.

NFPA® 652 functions as the umbrella standard for all industry- and commodity-specific combustible dust standards. The 2019 edition of NFPA® 652 has extended the deadline for employers to complete their initial Dust Hazard Analyses (DHA) to September 7, 2020.

**ASTM 1930 Alone Does Not Certify FR Clothing**
ASTM 1930: *Standard Test Method for Evaluation of Flame-Resistant Clothing for Protection Against Fire Simulations Using an Instrumented Manikin* was a test method based on early research conducted by the U.S. military and DuPont to test for total predicted burn injury (TPBI). ASTM F1930 describes the method of evaluating a fabric for TPBI no greater than 50% at total heat flux of 6 cal/cm², but is only one of the battery of tests mandated by NFPA® 2112.

**Costs of Flash Fires**
Beyond protecting workers from accidental burn injuries, FR clothing can also help reduce employer costs. Costs matter and not just because they are reflected in an employer’s bottom line. They also stand as evidence of the dangers to which workers were exposed if left unprotected. FR garments may be more expensive than non-FR clothing, but the clothing costs are minimal relative to the cost of burn injuries.

There is no comprehensive national data collection system of occupational illness and injury, but according to the American Burn Association, 486,000 burn injuries required medical treatment in 2016, and occupational burns accounted for approximately 38,000 of those injuries.³

Burn treatments are incredibly expensive. The National Business Group on Health estimates that although fires and burns represent only 1% of all injuries in the United States, the cost of treatment exceeds $10.4 billion a year.⁴ Patients with severe burns and no complications can expect to pay $1.6 million for treatment over their lifetime. For patients who develop complications, lifetime treatment bills can run more than $10 million.⁵ Other sources report that the median cost of burn care in high-income countries is $88,218.⁶

Employers bear significant costs for employee burn injuries, including treatment costs and productivity losses. By helping ensure workers have at least the minimum level of protection in a flash fire environment, FR clothing can help keep total costs to employers lower.

FR Clothing in the Flash Fire Environment

FR Clothing Basics
FR clothing sold for use in flash fire environments should be engineered to have flame-resistant properties as specified by NFPA® 2112. This clothing is made from fabrics that are designed to self-extinguish once the source of ignition is removed. Therefore, while FR clothing will not eliminate burn injury, it can limit their number and extent.

Effectiveness Against Burn
Data from an American Burn Association study shows that the age of a victim and the percentage of the body affected by burn injury are strong predictors of the chances of survival. 

![Graph showing age range and survival rate]

Of course, other variables can affect the outcome, but this is clear evidence that FR clothing, when properly maintained and worn, can minimize burn injury, which in turn can increase the chances of surviving a thermal event.

FR Fabrics
Many different fabrics are used in FR clothing, including those that are treated to be flame resistant and those that are designed to be inherently flame resistant. For instance, cotton can be treated to be FR. In fabrics such as Nomex®, fibers are polymerized to be inherently FR. Both types of fabrics can be NFPA® 2112 certified. FR fabrics often incorporate several different fibers and contemporary FR clothing may employ more than one fabric in a single garment.

Fabric selection should ultimately be based on a number of factors. First and foremost, to offer workers flash fire protection the fabric must perform to the NFPA® 2112 standard. Purchasers should also consider comfort, breathability, durability, price and other factors specific to their workplace conditions.

FR Clothing Selection
As discussed above, NFPA® 2112 is the gold standard for clothing that provides protection against flash fires. Therefore, when evaluating and selecting FR clothing, safety managers and purchasers should first focus their efforts on ensuring all FR clothing is certified compliant. To help ensure compliance:

1. **Ask to see the certification for each garment.** Certification means that the garment is certified NFPA® 2112 compliant by an independent third party like UL. A compliant label, which bears the mark of the third-party certifier, is the most efficient way to ascertain this information. (See below.)

2. **Ask to see test results, which manufacturers should retain.** Test results should refer to NFPA® 2112.

3. **Work with a proven supply chain.** Look for garment and fabric manufacturers that have been in the industry for multiple years, providing quality certified garments to the specific industry. Manufacturers can illustrate the integrity of their supply chain through a documented quality-control process, such as ISO 9001 or another similar process, along with third-party facility audits as required by NFPA® 2112.

4. **Specify that only certified compliant garments are allowed on site.** Safety managers and purchasers can help ensure workers’ choices are limited to certified compliant garments.

5. **Periodically monitor safety programs for standards and workforce compliance.**

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FR Clothing in the Flash Fire Environment

Garment Labeling
Because certified compliant garments have specific labeling requirements, understanding labeling is important to verifying compliance. All employees must thoroughly understand label requirements.

NFPA® 2112 dictates that FR garment labels must be printed legibly in letters at least 1.6mm (0.063 in.) high and include the following language:

*This clothing item meets the requirements of NFPA® 2112-2018. NFPA® 2113 requires upper and lower body coverage.*

**NFPA® 2112 also requires the following information:**
1. Model name, number or design
2. Manufacturer’s name, identification or designation
3. Manufacturer’s address
4. Country of manufacture
5. Manufacturer’s garment identification number, lot number or serial number
6. Size
7. Fiber content for each primary fabric layer, including insulation but excluding interlinings and labels
8. A “DO NOT REMOVE” warning
9. If an online user guide is available, the URL must appear on the label

The information on FR clothing labels is vital to the end user, which is why NFPA® 2112 requires garments use labels that remain legible after 100 launderings. This ensures that label information is available for the life of the garment.

Other Selection Criteria
Once compliance is confirmed via appropriate labeling or certification documentation, purchasers must make a number of other selection decisions. Because NFPA® 2112 sets the minimum requirements for protection, it should not be the only factor in selection. Going beyond the minimum standard is always wise, and other variables also matter, including comfort, which may differ from one fabric to the next; durability, which may affect garment life; and finish, which may include water-repellent or wicking features. A reputable supply chain partner will work with safety managers and purchasers to determine the most appropriate FR clothing for the specifications dictated by the workplace hazard assessment.

Workforce Compliance
When evaluating the use and protective value of FR clothing for flash fires, safety managers and purchasers should not just consider standards compliance; they should also consider workforce compliance. The effectiveness of FR clothing depends on employees’ understanding of how to properly wear their FR garments and their willingness to do so. Therefore, meeting employees’ needs in terms of fit, breathability, comfort, appearance, etc. is important.

Safety Programs
Safety managers and purchasers should consult 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, 2018 Edition when building a safety program.

NFPA® 2113 provides commonsense protocols for:
1. Conducting a hazard risk assessment
2. Selecting FR clothing
3. Properly using FR clothing
4. Caring for and maintaining FR clothing

Training
A worker’s survival, extent of injury, recovery time and, ultimately, quality of life can depend on FR clothing performance, and proper use is imperative for FR clothing to perform as designed. Consequently, to ensure workers receive the full benefit of FR clothing in a flash fire environment, employers must train employees in PPE and FR clothing best practices.

A proper training program is founded on the employer’s hazard risk assessment. This typically includes information about when PPE is necessary, what PPE is necessary, and the proper procedures for donning, doffing and adjusting PPE. A comprehensive training program should also discuss the limitations of PPE. Workers should be able to demonstrate sufficient
knowledge before performing work that requires PPE. For workers who face a flash fire hazard, training should also include information on the care, maintenance and ultimate disposal of FR clothing.

According to NFPA® 2113, appropriate use of FR clothing means:
- Wearing all-natural, non-melting or FR undergarments
- Wearing FR clothing appropriate to the hazard
- Wearing FR clothing as the outermost layer
- Ensuring that the outermost layer of an ensemble is FR
- Wearing FR clothing correctly: zipped, buttoned, tucked, sleeves rolled down, etc.
- Wearing clean FR clothing with no flammable contaminant stains
- Wearing FR clothing that has been correctly repaired
- Removing FR clothing from service when necessary

Care and Maintenance of FR Clothing
Proactive care and maintenance policies can extend the life of FR garments. As end-users, workers are ultimately responsible for the use, care and maintenance of FR clothing and should therefore be instructed and encouraged to err on the side of safety in making judgment calls regarding their FR garments. FR clothing should be routinely checked for contamination by accelerants beyond those considered a hazard, such as fabric softeners and insect repellants. FR clothing should also be checked for proper fit, tears, worn or thin spots and holes.

Garment Contamination
Workers should actively monitor their garments throughout the day for the accumulation of petroleum-based contaminants such as oil and grease. When garments are heavily soiled with combustible substances, the FR protection can be compromised. Employees should be advised to always read product labels before allowing their FR garments to come in contact with potentially flammable substances.

If an FR garment has become contaminated with a petroleum-based accelerator, it should be properly laundered until that accelerator is removed. Once the petroleum odor is gone, the contaminant is likely gone as well, although it may leave a stain. Smelling a garment is not always a reliable way to judge safety, however. Paint, for example, can burn but may not have an odor. Whenever the garment’s protective performance is in doubt, the garment should be retired.

Proper Fit
To ensure optimal use and therefore optimal protection, workers must regularly inspect FR clothing for fit. In general, a garment must have enough ease to trap air between the garment and the body—adding an extra layer of insulation from a flame. Shrinkage, which can occur when garments are not properly cared for, can cause a garment to fit too tightly, eliminating this insulating air, causing discomfort and encouraging improper use.

Tears and Holes
When tears, rips and holes are detected, the FR garment must be repaired. Any repairs must be made using fabric and findings matching the protection level of the original garment. Patches, for example, can be made using the viable fabric from retired FR garments.

Laundry
Proper care of FR clothing includes reading, understanding and following the manufacturer’s laundry instructions. As part of NFPA® 2112 compliance, written care instructions must be available to all employees via a user guide. An online user guide is acceptable as long as a URL for the guide appears on the label. The guide should communicate all acceptable means of laundering FR clothing.

Retirement
If a garment cannot be safely and properly repaired, it must be retired. Garment retirement can pose a challenge for many safety programs. In general, workers tend to use FR garments for too long, and this may
compromise their ultimate safety. Proper disposal of FR clothing is so important that NFPA® 2113 specifies that “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.”

Employers and workers alike should be aware that there is a secondary market for used FR garments. However, thrift stores are not the place to sell and certainly not the place to buy FR clothing because it is impossible to determine garment integrity or flame resistance.

**Conclusion**

While the most comprehensive safety program can only mitigate—not eliminate—risk, a reliable and controllable means of effectively protecting employees from harm is the consistent and proper use of PPE. In workplaces where flash fires are an unpredictable hazard, FR clothing is a foundational line of defense.

FR clothing compliant with NFPA® 2112 is designed to self-extinguish once the ignition source is removed. Although it cannot guarantee that the wearer will be unharmed, it can help protect wearers from burn injury and may lessen the severity of a burn.

While looking to industry consensus standards will inform minimum performance guidelines, partnering with market-proven suppliers will help ensure employers choose the best FR garments for their specific workplace.
To learn more about OSHA regulations, occupational hazard assessment, and FR outfitting standards, contact:

Customer Care
800-223-3372