Session No. 786

FRC 101: An Overview of Standards, Testing, and Options

Rob Whittenberger, MBA
President
Abigail Lutte
Tyndale Company, Inc.
Pipersville, PA

Introduction

With numerous arc flash, flash fire, and combustible dust incidents placing an increasing number of workers at risk, many companies are seeking safety solutions that will ensure both compliance and protection for their workers. Among these, the use of flame resistant clothing (FRC) is often a last layer of protection that helps ensure survival in the event of an explosion or arc flash event. In hazardous industries such as electrical maintenance and oil and gas, a full understanding of the applicable standards is of the utmost importance. An enhanced awareness of recent changes to the standards guides key safety decisions. Additionally, familiarity with the garment supply chain and the services available from FRC suppliers aids employers in making the safest and most cost-effective purchasing decision. This paper highlights key industry standards, provides a supply chain, fabric, and testing overview, and outlines key service components to consider when selecting FRC. Such awareness can drive not only the safety component of an FRC program, but enhance worker satisfaction and thus, compliance, over the long term. In addition, full awareness of all the various components of FR products can also offer companies significant cost savings over the long term by enabling them to choose a quality FRC supplier.

Industry Overview: Key Steps in the Development of FRC

The FRC product's quality, protective capabilities and fit are apparent in the look and feel of the final garment. Deeper awareness of the development of the product and its supply chain, however, helps the employer to truly understand and appreciate the quality and protective capabilities of the final garment selected.

Fiber: Inherent FRC

Typically created by FR fiber leaders such as Kaneceron (Protex® fiber), Dupont (Nomex® fiber) and others, the flame resistant fiber used in inherently flame resistant fabrics is an extremely important component of the protective capabilities, hand, and appearance of the final FR fabric. These performance fibers with characteristics of flame resistance (FR) result in no deterioration in flame resistance after repeated washing or normal use over time. The fibers can be blended with other fibers, most typically cotton, rayon or nylon, while retaining their protective capabilities. These FR fibers allow a light, warm, soft, and flexible hand. Garments made with this fiber are called "inherently" flame resistant because the polymer base of the fiber

is, itself, flame resistant, and there is no need for FR treatments. The treatment process ensures the sustainability of flame resistance over time. FRMC® is one example of an inherent fabric that utilizes Protex® fiber, while Nomex IIIa® is an example of an inherent fabric that uses Nomex® fibers.

Exhibit 1. A closeup of Protex® fiber.

Exhibit 2. Bales of cotton await spinning.

Fabric

The fabric manufacturing process is crucial to the safety and performance of a final garment. First, it's important to realize that any fabric used in the manufacturing of FR apparel must go through testing to ensure it meets specific safety standards that have been established (outlined below). The fabric or combination of fabrics used in the manufacturing of any apparel must be arc tested to determine the rating, (or flash fire tested for flash fire scenarios) and labeled according to strict standards. For example, for a lined jacket, the outer shell fabric and the inner lining fabric must be arc tested together to accurately measure the arc rating provided by the finished garment.

There are two categories of fabrics available: inherently flame resistant fabric and flame retardant treated fabric. Flame resistant treated fabrics go through the entire textile manufacturing process, and then the finished fabric is treated with chemicals that impart flame resistant properties into the material. Amtex® by Mount Vernon Mills is an example of a well-known treated fabric, as well as Indura® and UltraSoft® by Westex. Inherently flame resistant fabrics are manufactured by incorporating inherently flame resistant fibers during the spinning of the yard during the textile manufacturing process. FRMC® and Nomex® are examples of reputable inherently flame resistant fabrics.

Fabric manufacturing consists of several key steps—from scrutinizing cotton and fibers to spinning the yarn to weaving the fabric to treating it (for treated FR fabrics). Leading FR fabric manufacturers include Mount Vernon Mills, Westex, Polartec Milliken, Tencate, and FLF. Fabrics made by these manufacturers generally deliver high quality and superior protection.

Initially, the fiber is examined prior to spinning to verify that it meets stringent quality guidelines. The fiber is then spun into yarn and tested for quality control standards: strength, evenness, hairiness, elongation, yarn count, and variation. Documentation is maintained for all tests performed. In general terms, for inherently FR fabrics, spinning is the primary driver of the FR characteristics, because this step is where an inherently FR fiber is blended with cotton in the proper ratio. The weaver then turns the yarn or thread into fabric. At this stage in the process, the weaver has a key role in ensuring that the fabric is the proper density and weight to protect the wearer in the event of an arc flash or flash fire event. Many U.S. weavers and spinners are ISO certified.

After the fabric is spun and woven, the fabric is dyed and finished. The dye process is where color is imparted into the fabric. For inherently FR fabric, dying and finishing is the final process. For flame retardant treated fabric, once it is finished and dyed, undergoes a chemical treatment process. The treatment process chemically alters the fiber, imparting the flame resistant characteristic. Many FR treated fabric manufacturers impart permanent flame resistance, while others provide treatments that are not durable over time.

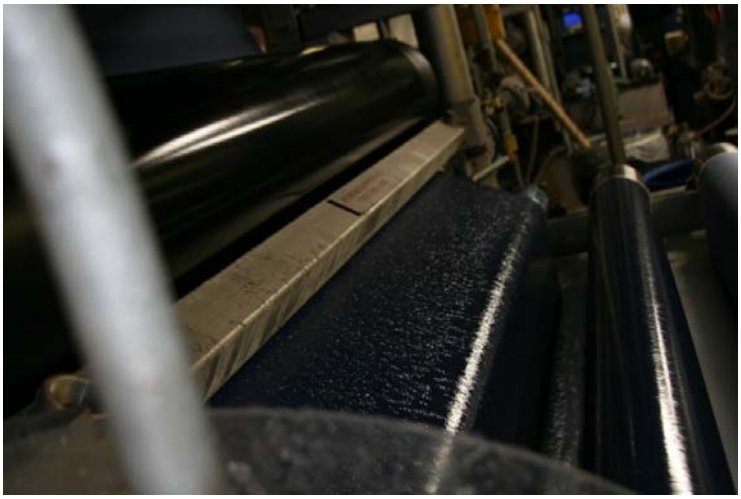

Exhibit 3. Fabric goes through the finishing process.

After the fabric has gone through the treatment process, each lot is tested and inspected. A lot is defined as 5000 yards or the manufactured yardage, whichever is less. This testing, which applies to both inherent and treated fabrics, includes the following:

- Breaking load
- Tear resistance
- Seam slippage
- Dimensional changes, maximum after 5 launderings
- Afterflame and char length new
- Afterflame and char length after 25 washes

Garment

A supplier dedicated to the quality of FR stands behind its product and works to ensure that every step of the process above is followed correctly on a consistent basis, maintaining a 100% satisfaction guarantee for the entire product line.

The quality of the finished garment is directly tied to the quality processes used in the manufacturing process. Each garment sewing facility should utilize garment specifications which detail construction, sizing specifications, product quality checks and label placement. Cutting facilities typically utilize digitized patterns, in addition to cutting report details of all label requirements. Leading FRC suppliers with a strong quality reputation include Bulwark, Workrite, Carhartt, and Tyndale, among others.

Garments that offer proper protection are key, but offering a range of choices from different manufacturers, at different price and quality points along a continuum enables employees to make a product choice that best meets their needs. Choosing well-fitting, comfortable garments should also be a priority for employers. No longer limited to coveralls, progressive flame resistant clothing programs encompass a full variety of products, from the basics—shirts, pants, underwear, outerwear—to performance wear comparable to North Face® and Patagonia®.

Current technology has rendered many FRC fabrics virtually indistinguishable from regular clothing. Garment manufacturers who have a strong commitment to quality, appearance, and garment fit, as well as a commitment to customer feedback, should be selected over suppliers who do not have the above quality controls in place. In addition, quality construction features, such as triple-needle stitching and bar-tacking at stress points, can substantially improve the life of a garment over time and add value overall. In sum, manufacturing and supplying quality FRC is a combination of a long stream of activities, quality control processes, and a commitment to customer satisfaction at every step.

Service

FRC-related services are generally categorized into three distinct options: individually delivered, direct-buy clothing programs; storeroom programs; and industrial laundry programs.

An individualized delivery, direct-buy program would likely include: customer service; custom reporting and invoicing; web-based order management, returns and exchanges; embroidery capabilities; and an extensive inventory and distribution system. These services may be built into the cost of the garment or billed separately to the company, depending on the supplier. By eliminating the need for management oversight of the distribution, billing, and overall ordering process of the FRC program, these services can result in substantial cost savings. Below are some of the services currently available in the marketplace.

A storeroom program is generally an add-on to an existing PPE safey program that may also include items such as hardhats, gloves, safety glasses, and so forth. The FRC items are stocked by the employer, often in a company-owned storeroom, and the employer takes on all costs associated with their distribution to the ultimate wearer.

An industrial laundry program is generally a program where a local industrial laundry provides a weekly pick-up and drop-off service, where the garments are laundered between deliveries. Typically, the laundry provider owns the clothing, and "rents" it to the employer for a fixed timeframe—typically three or five years—and charges are a fixed, flat weekly fee. As the clothing wears out due to normal usage, it is replaced as part of the weekly fee. Similar to leasing a car, if the clothing is damaged due to other than normal wear-and-tear, the employer must pay to replace it outside of the weekly fee. Typically, all uniforms must be returned at the end of a rental contract. Laundry programs are excellent if workers are exposed to hazardous or biochemical conditions, where taking contaminated clothing home to wash in their home laundry equipment would not be safe.

While not all suppliers have the capability to offer all the services listed above, Tyndale, Cintas, Aramark, and G&K are reputable suppliers that provide many of the above services.

Garment Laundering

In industries subject to both the arc flash and flash fire hazard, laundering can be performed at home or by an industrial laundry. There are two standards that govern appropriate laundering: ASTM F1449, "Standard Guide for Industrial Laundering of Flame, Thermal, and Arc Resistant Clothing," and ASTM F2757, "Standard Guide for Home Laundering Care and Maintenance of Flame, Thermal, and Arc Resistant Clothing." Depending on a firm's financial or industrial needs, one option may be preferred strongly over another. There are no specific safety reasons to choose one form of laundering over another (unless a worker is expected to be exposed to particularly dirty work conditions with exposure to flammable materials on a regular basis, with stains that cannot be removed through home laundering). The benefits of industrial laundering are primarily in employee convenience. If an industrial laundry program is run well, a launderer performs timely and accurate pick-up of garments in lockers, washes and launders the garment while providing full tracking, and invoices the cost of the laundry services correctly to the company. Well-known laundries on a national scale include Cintas, Aramark, and Unifirst.

Home laundering provides a convenient, cost-effective, and safe laundering solution for nearly all industries, however. Correctly executed, home laundering effectively cleans FR garments and may even help extend the life of an FR garment by many months, and in some cases, years. OSHA has repeatedly ruled that home laundering of FR clothing is a safe and effective method to clean it.

Safety Standards

OSHA 1910.269 (The operation and maintenance of electric power generation, control, transformation, transmission and distribution lines and equipment)

OSHA 1910.269 is a federally enforceable law that requires PPE for electrical utility workers. It pertains to workers involved in generation, transmission and distribution. The portion referring to FR clothing states: "The employer shall ensure that each employee who is exposed to the hazards of flames or electric arcs does not wear clothing that, when exposed to flames or electric arcs,

could increase the extent of injury that would be sustained by the employee."[1] In addition, OSHA 1910.269 was revised to include the following: "Employees in restricted areas shall wear protective equipment meeting the requirements of Subpart I of this Part and including, but not limited to, protective clothing, boots, goggles, and gloves."[2] The protective apparel portions of 1910.269 are currently under review by OSHA. OSHA will likely clarify CFR 1910.269 as follows in 2012:

- The use of FR clothing as PPE will be clarified.
- OSHA will require hazard assessment and protection of workers from each hazard.
- FR clothing will be required for some tasks.

NESC (National Electric Safety Code) 2012

Adopted on the state level by OSHA organizations, the National Electric Safety Code (NESC) sets the ground rules for practical safeguarding of workers during the installation, operation, or maintenance of electric supply and communication lines and associated equipment. This standard covers systems and equipment operated mainly by utilities, but may also be found in an industrial establishment or complex under the control of qualified persons. Although NESC-adoption varies by state, in areas where the code has been adopted, it is enforceable as law. In 2012, an updated version of the NESC was issued containing new additions/changes:

- The 2012 NESC offers an interpretation of appropriate FRC in a low-voltage, long-duration arc exposure of less than 1000 volts.
- The 2012 NESC requires a hazard analysis of low voltages (50V-1000V).

NFPA 70E (Standard for Electrical Safety in the Workplace) 2012

NFPA 70E addresses electrical safety requirements that protect workers from performing activities related to electrical maintenance. OSHA generally draws from NFPA 70E in order to enforce compliance regarding electrical safety. Recommendations within NFPA 70E address some commonly asked questions:

- Underlayer requirements (NFPA 70E 2012) specify that non-FR garments are not counted in a layered ATPV rating.
- Clothing should be loose-fitting to provide additional thermal insulation because of air spaces.
- Employers are responsible for informing employees of known hazards.

In the latest edition of NFPA 70E (2012), changes of note related to flame resistant apparel include:

- Host employers are responsible to inform contract employers of known hazards.
- Contractors must to follow safety-related work practices required by the host employer and specified in NFPA 70E.

---

[1] Occupational Safety and Health Administration (OSHA). 29 CFR 1910.269, *Electric Power Generation, Transmission, and Distribution* (retrieved February 20, 2012) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=9868).

[2] IBID.

OSHA 1910.132 (General Requirements – Personal Protective Equipment)

OSHA 1910.132 offers employers guidelines on protective equipment for workers. "Personal equipment, including personal protective equipment for eyes, face, head, and extremities, protective clothing, respiratory devices, and protective shields and barriers, shall be provided, used and maintained in a sanitary and reliable condition wherever it is necessary….."[3] The standard delivers guidelines for employers on what is required, including hazard assessment, employee training in proper care and use of PPE, and identifies the party responsible for paying for the required PPE.

In March 2010, OSHA issued an addendum regarding specific industries susceptible to the flash fire hazard—namely drilling, servicing, and production-related occupations—and mandating the use of FR clothing in these occupations under certain working conditions. OSHA explains, "The use of FRC greatly improves the chance of a worker surviving and regaining quality of life after a flash fire. FRC can significantly reduce both the extent and severity of burn injuries to the body."[4] Citing accident and injury data for flash fire incidents, which have resulted in a 16% fatality rate in oilfields in recent years, OSHA reinforces the value of FR clothing in the event of engineering and administrative control failure.

Although OSHA 1910.132 was issued in memo form, it is enforceable by law. Offering employer guidelines on protective equipment for workers, OSHA 1910.132 gives guidance on industries susceptible to the flash fire hazard—namely drilling, servicing, and production-related occupations—and mandating the use of FR clothing in these occupations under certain working conditions.

Garment Standards

ASTM F1506 (Standard Performance Specification for Textile Material for Wearing Apparel for Use by Electrical Workers Exposed to Momentary Electric Arc and Related Thermal Hazards)

ASTM F1506 is one of the key governing standards for flame resistant clothing. While the standard itself is generally complex, its basic requirements are that: (1) a sample of fabric self-extinguish with less than two-second afterflame and less than 6" char length (when tested with ASTM Test Method D6413) after 25 washes or dry cleanings; and (2) the fabric must be tested for Arc Thermal Performance according to ASTM F1959. These results are to be reported to the end user as an Arc Rating on a garment label. *Note: Different colors of the same fabric do not need to be tested separately. A garment that complies with ASTM F1506 also complies with OSHA 1910.269, NESC, and NFPA 70E.*

NFPA 2112 (Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire)

NFPA 2112 specifies the minimum design, performance, certification requirements, and test methods for flame-resistant garments for use in areas at risk from flash fires. Specific criteria for testing garments are included, among over a dozen test methods. The most critical NFPA 2112

---

[3] Occupational Safety and Health Administration (OSHA). 29 CFR 1910.132, *Personal Protective Equipment* (retrieved February 20, 2012) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9777).

[4] Occupational Safety and Health Administration (OSHA). 2010. *Oil and Gas Safety Conference* (retrieved February 21, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=SPEECHES&p_id=2329).

tests include ASTM F1930 and ASTM D6413. Under ASTM F1930, a pass/fail criterion of 50% body burn is described. Garments are exposed to a three-second burn exposure at 2.02 cal cm^2, and the total predicted body burn is measured. Under ASTM D6413, garments must exhibit a maximum char length of 4. Fabric must not melt, drip, or have more than two seconds' afterflame after 25 launderings.

ASTM F1449 (Standard Guide for Industrial Laundering of Flame, Thermal, and Arc Resistant Clothing)

A standard guide outlining the industrial laundering process, ASTM F1449 is helpful in determining the responsibilities of both the manufacturer and the end user. FRC must be specified by fiber, fabric, and finish and divided into one of five categories (such as inherent FR fabrics, treated fabrics, and so on). End-user responsibilities include ensuring that the care instructions are followed on a label and that a determination is made when a garment has exceeded its useful life. The standard also provides a brief overview on "laundering wash formulas." *Note: There are no laws or standards mandating industrial laundering.*

ASTM F2757 (Standard Guide for Home Laundering Care and Maintenance of Flame, Thermal and Arc Resistant Clothing)

A standard guide offering key points on home laundering of FRC, ASTM F2757 is intended to be used by FRC program administrators, such as safety personnel or program administrators who have chosen to implement a home laundered flame, thermal or arc resistant program. Considered to be a safe, cost-effective means to protect garments and ensure their cleanliness, ASTM F2757 outlines the responsibilities of both manufacturers and end users. Recommendations for increasing the wear life, appearance, and comfort are also outlined. Repairs of FRC should be made from components equivalent to those used in the original manufacturing to avoid reducing the performance properties of the flame resistant garment.

Testing

Key tests are involved in ensuring that each lot of FR fabric meets the flame resistant criteria that are claimed on the label. Although many dozens of tests are mentioned in NFPA 2112 and ASTM F1506, below are the key tests that are most often referenced in the evaluation of an FR garments' flame resistant properties.

ASTM D6413 (Standard Test Method for Flame Resistance of Textiles (Vertical Test))

This is the defining test method for compliance with OSHA 1910.269 and one of the most commonly used tests on flame resistant fabrics (and is also called the Vertical Flame Test).

The purpose of this test is to determine whether a fabric will continue to burn after the source of ignition is removed. A 12" specimen of fabric is suspended in an enclosed chamber (secured on three sides). The cut edge of the fabric on the bottom is exposed to a controlled methane flame for 12 seconds. After exposure to the flame, afterflame, afterglow, and char length are measured. Five tests are performed, and the results are averaged and reported as the test result. ASTM D6413 is used to determine a pass/fail criterion for ASTM F1506, which requires a maximum char length of 6 inches. *Note: ASTM F1506 requires a maximum char length of 6 inches under this test method, whereas NFPA 2112 requires a maximum of 4 inches.*

ASTM F1959 (Standard Test Method for Determining Arc Thermal Performance (Value) of Textile Materials for Clothing by Electric Arc and Related Thermal Hazards)
This is the test method used to calculate quantitative results for fabrics relating to how they perform in an electric arc environment. The purpose of this test is to determine how much heat a certain fabric (or fabric system) will block from an electric arc before the onset of second-degree burns for the wearer. The amount of energy blocked by the fabric is reported as Arc Thermal Performance Value (commonly abbreviated as ATPV). The value is reported as the Breakopen Threshold Energy (Ebt) if the fabric breaks open before the onset of second-degree burns is reached. Heat Attenuation Factor (the percentage of total heat blocked by the fabric from reaching the sensor) is also determined. Test results from ASTM F1959 must be reported for all garments that meet ASTM F1506.

ASTM F1930 (Standard Test Method for Evaluation of Flame Resistant Clothing for Protection Against Flash Fire Simulations Using an Instrumented Mannequin)
This standard specifies a broad process for measuring the average predicted body burn of a fabric based on a laboratory flash fire simulation. The fabric is sewn into a standard coverall pattern and then placed on an instrumented mannequin. Sensors measure the performance of single-layer garments or protective clothing ensembles in a simulated flash fire environment with controlled heat flux, flame distribution, and duration.

Heat transmitted to each sensor location on the surface of an instrumented mannequin is converted to show the corresponding predicted degree of burn injury to human tissue. The sum of these values can then be converted to a percentage to show the total area of predicted burn injury. The measurements can apply to the particular garment or ensemble tested using the specified heat flux, duration, and flame distribution.

Electric Compliance

Compliance with the governing federal, state, and best-practice standards is key in the electrical maintenance and utility industry. Due to multiple standards for different electrical industries, as well as overlapping state versus federal oversight, it may be difficult to understand exactly which standards apply to you.

Standard	Industry Segment(s)	Scope
OSHA CFR 1910.269	Electric utility workers involved in the transmission and distribution of electricity.	Federal
NESC	Systems and equipment operated by utilities, or similar systems and equipment of an industrial establishment or complex under the control of qualified persons.	Adopted on a state by state basis; voluntary consensus standard. Some states automatically adopt.
NFPA 70E	Electrical maintenance workers and generation workers, except electric transmission and distribution, railroad, marine and mining.	National. Voluntary; has been enforced through the OSHA General Duty Clause.

Table 1. Summary of standards which impact worker FR clothing requirements.

Generally, however, compliance with each standard follows a parallel track. Employers are required to conduct a hazard assessment, estimating the potential incident energy in the event of an arc flash. This incident energy is determined by five factors: amperage, voltage, clearing time, arc gap, and the distance from the arc to the worker. Once this hazard assessment is complete, the employer should determine whether FRC is needed. If the hazard has the potential to ignite NFR clothing, the worker should wear clothing that complies with ASTM F1506 with a sufficient arc rating to reduce his exposure to below 1 calorie. For organizations that cannot perform a complete hazard assessment, both NFPA 70E and the NESC provide simplified tables that indicate the appropriate arc rating of clothing to wear for a particular task.

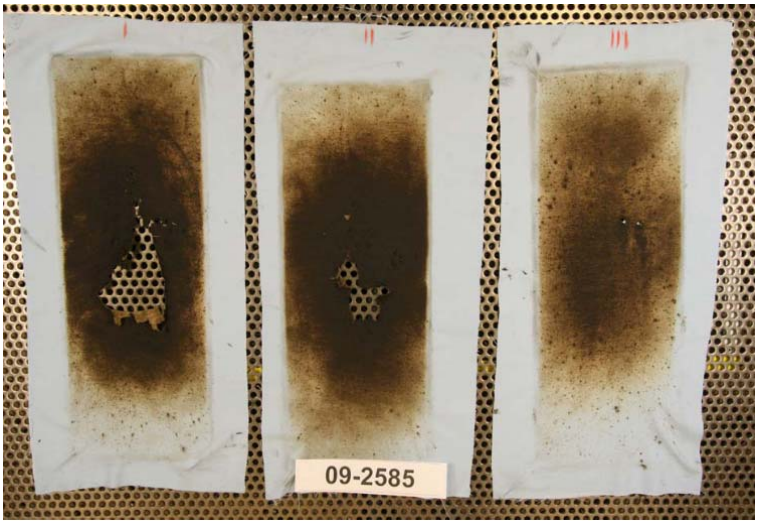

Exhibit 4. A sample arc flash panel test (*Source:* ASTM F1959)**.**

Flash Fire Compliance

Due to its variable nature, the flash fire hazard is as difficult to protect against as it is to predict. Currently, industries vulnerable to flash fire rely most heavily on the recommendations and test methods of NFPA 2112. Even compliance with this standard, however, remains a somewhat subjective matter. In recent years, OSHA has mandated FR clothing for certain occupations—namely drilling—but it remains unclear as to what properties and test methods and certifications must be undergone to declare a garment "compliant." The primary issue an employer should understand is that they are responsible for conducting a hazard assessment, researching the difference in garments, and being able to explain why a particular garment was chosen. Below are three levels of compliance evidenced in various layers of testing and certification:

1. Garments that meet the requirements of NFPA 2112.
2. Garments made from materials that have been flash fire tested, but do not fully meet the requirements of NFPA 2112.
3. Garments that meet the ASTM D6413 requirement, but have not been flash fire tested. This would include garments that meet NFPA 70E, ASTM F1506, or can otherwise be demonstrated to exhibit less than two-second after-flame and less than 6" or 4" char length in ASTM D6413.

NFPA 2112 Compliant

Garments that meet NFPA 2112 must meet a variety of performance standards and a comprehensive third-party certification program. Generally, the key NFPA 2112 fabric performance standards are as follows:

- A flash fire manikin test (ASTM D1930) at a three-second burn time with a predicted body-burn of less than 50%.
- Less than two-second after-flame and 4" char length in ASTM D6413 vertical flame test.
- A Thermal Protective Performance (TPP) rating of more than three seconds unspaced, or six seconds spaced. TPP estimates the amount of time before the onset of second degree burn in fire entry.

A final key component of NFPA 2112 is that it requires third-party certification of all testing and production-related activities. Generally, this means UL Certification, although 2112 does not specifically require UL as the certification agency. NFPA 2112 does require the certifications symbol or mark to be on the garment label. Due to the cost of certification, many manufacturers limit their 2112-compliant offering to a narrow selection of garments, typically only coveralls, shirts and pants.

It is important to note that NFPA 2112 establishes a minimum threshold of performance. garments that meet NFPA 2112 will have differing levels of protection, depending on the hazard, fabric and garment.

Flash Fire Tested

A second option is to choose garments made from fabrics that are tested according to ASTM D1930 at three seconds, and achieve less than a three-second body burn, but do not meet other NFPA 2112 requirements.

Typically these garments do not meet the third-party certification criteria required by NFPA 2112, but they also may not meet other criteria (such as 4" char length, TPP rating, zipper/snap requirements, and so on). These garments are often sold as "Meets the Performance Requirements of NFPA 2112" or as "Flash Fire Rated." Garments that meet NFPA 2112 may or may not be more protective than Flash Fire Rated garments.

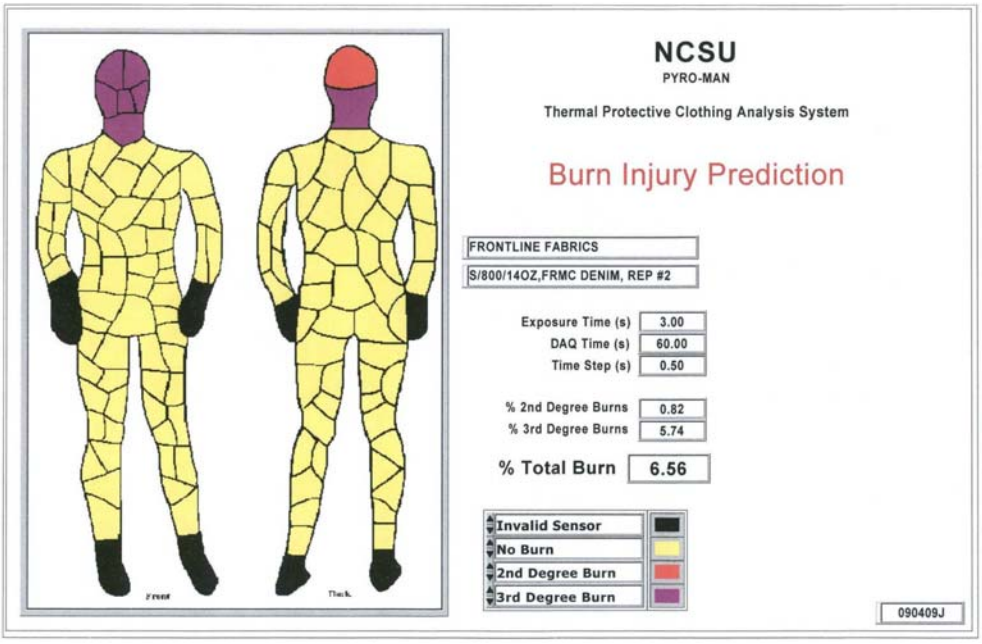

Exhibit 5. ASTM F1930 Results

Flame Resistant Fabrics that are not Flash Fire Tested

The least rigorous approach for meeting the OSHA requirements would be to use garments that meet the arc flash requirements of NFPA 70E, or are otherwise determined to be flame resistant. All NFPA 70E garments are required to meet ASTM F1506. This specification has three core components:

- The fabric must be flame resistant; it exhibits less than two seconds after-flame and less than 6" char length.
- The fabric must be arc tested; it must have an arc rating determined by ASTM F1959.
- It must include a label that states that the garment meets the requirements of ASTM F1506.

Garments that meet NFPA 70E and ASTM F1506 may also meet NFPA 2112 or be Flash Fire Rated. Furthermore, garments that are neither NFPA 2112 compliant, nor Flash Fire Rated may actually provide more protection than those that are. However, without ASTM F9130 Manikin three-second flash fire test results, it would be difficult to determine the level of protection.

Options

Employers have many different options when it comes to appropriate selection of FR clothing fabrics. Below is a list of quality fabrics that provide both safety and a level of comfort for the wearer.

Amplitude™

Amplitude™ is a patent-pending line of flame resistant fabrics for industrial work wear made by Milliken. Amplitude™ is a treated cotton, made-in-the-U.S.A. fabric that is constructed to be UL

certified (NFPA 2112) in addition to offering compliance with NFPA 70E. It offers breathability and is suitable for use in many industries.

Amtex®

Manufactured by Mount Vernon Mills, Amtex® is a trademark for a fabric that undergoes a treatment process guaranteed to ensure the flame resistance of the garment for life. Amtex® fabrics are woven and come in a variety of colors and textures. Amtex® fabric can be expected to last 24-36 months when home laundered once per week. Amtex® fabrics are guaranteed to last for the useful life of the garment, provided laundering instructions are followed.

DRIFIRE®

DRIFIRE® offers both knit and woven fabrics that are inherently flame resistant, and are also a garment manufacturer. DRIFIRE® provides garments for the military market, and its fabrics are known for their moisture-wicking properties. DRIFIRE® typically lasts 12-24 months when home laundered once per week. It retains its flame resistant and moisture-wicking properties over time.

FRMC®

FRMC® (Flame Resistant Modacrylic Cotton) is a high-quality, inherent FR fabric providing a maximum level of comfort and protection. FR Modacrylic Cotton is Tyndale's trademark name for inherently flame resistant fabrics manufactured from a blend of FR modacrylic and cotton. FRMC® is an inherently flame resistant fabric, a characteristic that cannot be degraded through laundering. It is normally perceived as the softest, most comfortable and most breathable FR fabrics. FRMC® is also a durable fabric and offers protection for the useful life of the garment. The fabric can be expected to last from 18-30 months when worn and home laundered once per week and comes in a variety of colors and weights.

Indura®

Indura® is a Westex, Inc. trademark for FR 100% treated cotton fabrics made flame resistant through an ammonia cure process. The process has only a minor affect on the positive characteristics of cotton (soft hand, wear, breathability and shrinkage). Indura® is available in woven fabrics in a variety of colors. You should expect an Indura® garment to last 12-18 months when worn and home laundered once per week.

Nomex®

Nomex IIIa® is a DuPont trademark for 93% Nomex® (an aramid fiber), 5% Kevlar and 2% static dissipative fiber fabric. It is inherently flame resistant, a characteristic that cannot be degraded by laundering. Nomex® has an expected wear life of 36-60 months, making it a top choice for laundry programs.

Protera®

Protera® is a DuPont trademark for an inherently flame resistant fabric. Launched in 2006, it is generally lighter in weight for the level of protection it offers. Available in several weights and colors, it generally offers a more wrinkle-resistant appearance after laundering. Protera® has an expected wear life of 24-36 months when worn and home laundered once per week.

Tecasafe®

Tecasafe® is a registered trademark of Tencate, and is an inherently flame resistant fabric that offers both NFPA 2112 UL certification, as well as NFPA 70E compliance. Tecasafe® is known for its durability, particularly in industrial laundering scenario. Tecasafe® typically lasts 24-36

months when home laundered once per week. It is available in many weights and colors, and high visibility options are also available.

UltraSoft®

UltraSoft®, a treated FR fabric, offers an additional FR fabric option that has traditionally held a high reputation. It is a treated blend of 88% cotton and 12% nylon. UltraSoft® typically lasts 24-36 months when worn and home laundered once per week.

Summary

Selecting FRC for workers is a crucial, complex decision involving multiple steps. Choosing between fabric manufacturers, garment makers, and service options can be especially challenging, considering the wide variety of options in terms of quality, color, cost, and hazard protection. A working knowledge of applicable standards, a coherent supply chain understanding, familiarity with testing, and a working knowledge of service needs will help employers determine the optimal clothing program needed for workers.

Bibliography

American Standards and Testing Materials. ASTM Standard D6413,"Standard Test Method: Flame Resistance of Textiles." West Conshohocken, PA: ASTM International, www.astm.org.

_____. ASTM Standard F1506, "Standard Performance Specification for Textile Material for Wearing Apparel for Use by Electrical Workers Exposed to Momentary Electric Arc and Related Thermal Hazards." West Conshohocken, PA: ASTM International, www.astm.org.

_____. ASTM Standard F1449, "Standard Guide for Industrial Laundering of Flame, Thermal, and Arc Resistant Clothing" West Conshohocken, PA: ASTM International, www.astm.org.

_____. ASTM Standard F 1930, "Standard Test Method for Evaluation of Flame Resistant Clothing for Protection against Flash Fire Simulations Using an Instrumented Manikin." West Conshohocken, PA: ASTM International, www.astm.org.

_____. ASTM Standard F1959, "Standard Test Method for Determining Arc Thermal Performance (Value) of Textile Materials for Clothing by Electric Arc and Related Thermal Hazards." West Conshohocken, PA: ASTM International, www.astm.org.

_____. ASTM Standard F2757, "Standard Guide for Home Laundering Care and Maintenance of Flame, Thermal, and Arc Resistant Clothing" West Conshohocken, PA: ASTM International, www.astm.org.

The Institute of Electrical and Electronics Engineers, Inc. (IEEE). 2012. *National Electric Safety Code (NESC): 2012 Edition*. NY: IEEE.

National Fire Protection Association (NFPA). NFPA 2112, *Standard on Flame Resistant Garments for Protection of Industrial Personnel Against Flash Fire* (retrieved February 20, 2012) (http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=2112).

_____. NFPA 2113, *Standard on Selection, Care, Use, and Maintenance of Flame Resistant Garments for Protection of Industrial Personnel Against Flash Fire* (retrieved February 20, 2012) (http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=2113).

_____. NFPA 70E, *Standard for Electrical Safety in the Workplace* (retrieved February 20, 2012) (http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=70E).

Occupational Safety and Health Administration (OSHA). 29 CFR 1910.132, *Personal Protective Equipment* (retrieved February 20, 2012) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9777).

_____. 2010. *Oil and Gas Safety Conference* (retrieved February 21, 2011) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=SPEECHES&p_id=2329).

_____. 29 CFR 1910.269, *Electric Power Generation, Transmission, and Distribution* (retrieved February 20, 2012) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=9868).

_____. OSH Act Section 5(a)(1), *General Duty Clause* (retrieved February 20, 2012) (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9714).