



Bulwark[®]FR

SELECTION, USE, CARE AND MAINTENANCE OF FR CLOTHING

10/27/16

Table of Contents

Overview

Pg 3

Responsibility

Pg 3

Hazard Risk Assessment

Pg 3-4

Standards and PPE

Pg 5-6

Selection

Pg 6-8

Labeling

Pg 8-9

Implementation: Using FR Correctly

Pg 9-10

Care and Maintenance

Pg 10

Customer Policies on Use, Care, Maintenance and Retirement

Pg 10-11

Conclusion

Pg 11



Selection, Use, Care & Maintenance of FR Clothing

Overview

Whether employees are operating in an inherently dangerous environment, or are exposed to potential hazards as part of their regular job duties, it's critical to select the Personal Protective Equipment (PPE) that is appropriate to the task. Once the proper PPE has been selected, the law requires employers to implement an ongoing program and to ensure there is a policy in place that governs the use, care, and maintenance of PPE.

In the United States employers are responsible for the safety of their workers and are subject to a wide range of rules and requirements imposed by government agencies and industry consensus standards. Some are legally binding and compulsory, while others are voluntary, so assessing which laws and standards apply to a specific industry, figuring out what the requirements actually are, understanding how to comply, and determining compliance can be a challenge.

Burn injuries and fatalities are nearly always the result of a victim's clothing catching fire. Because of this, the use of Flame-Resistant (FR) and Arc-Rated (AR) clothing is required in a wide range of industries.

While firefighters and others use primary PPE—such as turnout gear, respirators, and helmets—this paper focuses on secondary PPE flame-resistant clothing. FR clothing is the last line of defense for workers who could be exposed to flash fire, electric arc, or other thermal hazards, and it is meant for continuous wear in a work environment where these potential hazards have been identified. Unlike everyday clothing that can ignite, burn, and melt when exposed to flame, FR/AR clothing self-extinguishes when an ignition source is removed and will not continue to burn.

Selection, proper use, care, and maintenance of FR/AR clothing is essential to ensuring the safety of workers, and while employees may be required to wear appropriate PPE, it is up to employers and safety managers to identify, select, and provide the clothing for their workers.

Responsibility

When Congress passed the Occupational Safety and Health Act in 1970, it also created the Occupational

Safety and Health Administration (OSHA). Beginning with a basic concept called the General Duty Clause, it not only placed the responsibility for worker safety on employers, it also delegated authority to OSHA to make rules to further implement the standard.

The General Duty Clause states:

(a) Each employer --

- (1) shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or likely to cause death or serious physical harm to his employees;
- (2) shall comply with occupational safety and health standards promulgated under this Act.¹

This requirement that employers be aware of all actual and potential hazards in the workplace and to take necessary precautions to protect their employees, places all of the responsibility of protecting workers on employers, but it doesn't tell them how they are supposed to do it.

Employers are required to determine whether they are affected by OSHA requirements, find applicable industry consensus standards, determine which ones are relevant, read and understand them, find PPE that complies with those standards, ensure that it is compliant, and then make sure everyone on a jobsite is following the rules and using their PPE correctly and effectively.

Beginning in the 1800s, long before OSHA, a number of private professional organizations were already publishing safety standards and best practices based on industry or hazard. For example, the National Fire Protection Association (NFPA) began addressing the challenges faced by professional firefighters shortly after the U.S. Civil War.

Hazard Risk Assessment

While the General Duty Clause places the responsibility for worker safety on the employer, the first thing employers must do to protect workers is determine whether workplace conditions could present a threat by conducting a Hazard Risk Assessment.

¹ Occupational Safety & Health Act [OSHA]. 29 USC §654 (1970).



Selection, Use, Care & Maintenance of FR Clothing

According to OSHA, employers must “assess the workplace to determine if hazards are present, or are likely to be present, which necessitate the use of personal protective equipment.”²

In addition to identifying hazards, employers are required to document all risk assessments and keep their records current. OSHA 1910.132(d)(2) states:

The employer shall verify that the required workplace hazard assessment has been performed through a written certification that identifies the workplace evaluated; the person certifying that the evaluation has been performed; the date(s) of the hazard assessment; and which identifies the document as a certification of hazard assessment.

While OSHA does not offer direct instruction for how to conduct a hazard risk assessment within the regulations, it has provided some guidance by publishing booklets that outline the purpose of an assessment and offers suggestions for carrying it out. Typically, a hazard assessment begins with a review of past accidents, listing and ranking hazardous tasks, and outlining the steps involved. Then the employer should ask questions, such as,

- What can go wrong?
- What are the consequences?
- How could it arise?
- What are other contributing factors?
- How likely is it that the hazard will occur?

Then, OSHA states, the employer should “document the answers to these questions in a consistent manner. Describing a hazard in this way helps to ensure that your efforts to eliminate the hazard and implement hazard controls help target the most important contributors to the hazard.”³

In most industries, a simple walk-through can help determine if there are potential sources of ignition and

whether flame resistant clothing is necessary. The primary hazards that require flame-resistant PPE are:

- Flash Fires
- Combustible Dust Fires/Explosions
- Electric Arcs
- Welding Slag
- Molten Metal Splash

NFPA defines flash fire as “a 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.” This is the main hazard for exploration, drilling, field services, refinement, and chemical production within the Oil & Gas industry.

Combustible dust is also a flash fire hazard, but when it is ignited within a confined space, it can explode. Any finely divided flammable particulate that could become suspended in the air is considered a combustible dust hazard, so a wide range of industries could be affected. Anywhere that dust is created and collected—whether by grinding, polishing, or sanding, or within industries such as food processing, pharmaceuticals, agriculture, and coal—combustible dust is a potential threat.

In 2015, NFPA 652, *Standard on the Fundamentals of Combustible Dust* was published. This new standard requires all owners/operators of facilities that produce dust determine if the particulate is combustible, prior to conducting a hazard risk assessment.⁴

An electrical arc, also called an “arc flash” or “arc blast,” occurs when an electric current moves through the air between two electrified conductors or an electrified conductor to ground. This dangerous and instantaneous discharge of energy is usually caused by an electric fault, producing intense heat, blinding light, blast pressure, loud sound, and shrapnel in the form of molten metal debris.

² Occupational Safety & Health Administration [OSHA]. (2012). Regulations (Standards-29 CFR 1910.132(d)(1)).

³ U.S. Department of Labor, Occupational Safety and Health Administration. (2002, Revised). *Job Hazard Analysis*. Retrieved September 3, 2016, from <https://www.osha.gov/Publications/OSHA3071.html>

⁴ Peacock, M. L., Sang, D., & Statham, D. (2016, April 26). Combustible Dust: NFPA(R) 652 is Finally Here...How Will It Affect Flame Resistant Clothing? [White Paper] Retrieved September 3, 2016, from http://www.bulwark.com/Content/Media/Resources/whitepapers_combustible-dust.pdf



Selection, Use, Care & Maintenance of FR Clothing

In one of the earliest scientific articles addressing the dangers of electric arcs, R.H. Lee wrote:

Next to the laser, the electric arc between metals is the hottest thing on earth, or about four times as hot as the sun's surface. Where high arc currents are involved, burns from such arcs can be fatal when the victim is even several feet from the arc, and debilitating burns at distances of 10ft are common. Clothing is ignited at distances of several feet; this itself can cause fatal burns because the clothing cannot be removed or extinguished quickly enough to prevent serious burns over much of the body's skin.⁵

These dangerous events can be the result of failed equipment or a simple mistake. In general industry, as well as in electric utilities, electricians are most vulnerable to potential shock, arc flash, and molten metal when they are working with energized equipment.

While arc flashes produce molten metal—depending on the intensity and duration of the electric arc—the molten metal hazard itself can be as, or more severe, for foundry workers and welders.

Wherever molten metal is poured to cast products, splashes can occur. The high melting temperatures required for aluminum, steel, and other white metals can exceed 1900 deg F. In these cases, workers should be protecting themselves with primary PPE, as well as secondary FR clothing, because they are exposed to a clothing ignition source throughout the process. While a large splash event is usually the result of some kind of process malfunction, welders deal with the molten metal hazard in a different, more routine way.

The small droplets of molten metal, called “slag,” produced during welding are unlike the large splash hazards foundry workers face. For welders, these by-product particles are a feature of everyday welding work. Typically, as these metal droplets fly through the air, they cool rapidly and are small enough that they won't ignite clothing. The worst-case scenario would be a flying piece of slag getting lodged in the folds of the clothing at the elbow or at the back of the knee when still large enough and hot enough to ignite the fabric.

In any case, when a hazard in the workplace is identified, personal protective equipment should not be considered the immediate solution. Adopting PPE does not eliminate hazards, so PPE must be the safety measure of last resort. To address the hazard itself, safety organizations have utilized what is called the “Hierarchy of Hazard Control.” This approach to hazard mitigation is widely accepted and is designed to systematically remove or minimize hazards from a work environment. This plan of action begins with the most effective way to address hazards and offers subsequently less effective recommendations in descending order.

Hierarchically, these hazard controls appear in the following order:

- Elimination – Physically removing a hazard
- Substitution – Replacing a known hazard with a lesser or non-hazardous alternative
- Engineering Controls – In this approach, hazards that cannot be eliminated or substituted are bypassed by implementing or installing technology that isolates a hazard
- Administrative Controls – This involves changes to rules and procedures for workers in hazardous environments, and its effectiveness depends on workers changing the way they think and operate when exposed to hazards.
- Personal Protective Equipment – PPE is the last line of defense. When an employee is required to wear PPE, efforts at elimination, substitution, and controls through engineering should have been implemented or attempted, and administrative controls should already be in place.

In the same way that vehicles with numerous safety measures in place—including automatic braking systems, adaptive headlights, computer-assisted lane correction and safe-distance controls, crumple zones, and airbags—still require drivers to fasten their own seatbelts, PPE must be implemented and worn correctly to be considered an effective last line of defense.

Standards and PPE

Across the various industries and occupations that face potential thermal hazards, a wide range of standards,

⁵ Lee, R. H. (1982). The Other Electrical Hazard: Electric Arc Blast Burns. *IEEE Transactions on Industry Applications IEEE Trans. on Ind. Applicat.*, IA-18(3), 246-251. doi:10.1109/tia.1982.4504068



Selection, Use, Care & Maintenance of FR Clothing

requirements, and laws apply. An industry-specific regulation may simply require an employer to comply with another more general standard, and navigating this maze can be difficult.

For industries, such as oil and gas, facing the flash fire hazard, the “go-to” industry consensus standards are NFPA 2112⁶ and NFPA 2113⁷. NFPA 2112, “Standard on Flame-Resistant Garment for Protection of Industrial Personnel Against Flash Fire,” covers the performance and material standards to which FR garments must comply. This includes everything from fabric capabilities and characteristics to garment construction. NFPA 2113, “Standard on Selection, Care, Use, and Maintenance of Flame-Resistant Garments for the Protection of Industrial Personnel Against Flash Fire,” is the companion standard to NFPA 2112. It covers the criteria that employers, safety managers, and individual wearers should consider when choosing the correct garment.

NFPA 652 and the combustible dust hazard are most likely to introduce new industries and companies, for the first time, to the need for FR uniforms. Standards that some industries may already be familiar with, may have been revised to require FR clothing. For example:

- NFPA 61-2017 (Agriculture/Food Processing), for example, has been revised to align with the new NFPA 652, and its PPE section consists only of two sentences, both lifted directly from NFPA 652 which reference NFPA 2112 and NFPA 2113.
- NFPA 484 (Combustible Metals), in section 5.3.3 Primary PPE for Dust Flash Fires, points to NFPA 2112 and NFPA 2113 as well.
- NFPA 654 (the general one) states, “This standard shall be used to supplement the requirements established by NFPA 652,” and lists NFPA 2113 in the reference section.

- NFPA 655 (Sulfur) references NFPA 2113 under operating procedures, and it references NFPA 654, which references NFPA 652.
- NFPA 664-2017 (Woodworking and Wood Processing) has been revised to align with the new NFPA 652. It has also been clarified to indicate that it includes carpentry shops and woodworking facilities of a certain size.

Arc flash for general industry electricians is essentially the same hazard for electricians in utilities, but NFPA 70E, “Standard for Electrical Safety in the Workplace,” only applies to general industry, while there is no NFPA standard specifically for electrical utilities.

OSHA regulations 1910.269⁸ and 1926.960⁹ address the specific circumstances faced by electricians in power utility, including generation, transmission, distribution, and metering, and requires arc rated clothing matching the incident energy of the electric arc hazard.

NFPA 70E, as well as both OSHA regulations refer to ASTM F 1506¹⁰, which provides performance requirements for FR and AR fabrics and garments for use by electrical workers that could be exposed to electric arc and any related thermal hazards.

Selection

Once the hazard risk assessment has been completed, if hazards have been identified, OSHA requires employers to “Select, and have each affected employee use, the types of PPE that will protect the affected employee from the hazards identified in the hazard assessment.”¹¹

When selecting FR clothing, employers should refer to industry consensus standards for guidance.

⁶ NFPA® 2112, *Standard on Flame-Resistant Garment for Protection of Industrial Personnel Against Flash Fire*, (2015) National Fire Protection Association. Quincy, MA.

⁷ NFPA® 2113, *Standard on Selection, Care, Use, and Maintenance of Flame-Resistant Garments for the Protection of Industrial Personnel Against Flash Fire*, (2015) National Fire Protection Association, Quincy, MA.

⁸ *Occupational Safety & Health Administration [OSHA]. (2014). Regulations (Standards-29 CFR 1910.269).*

⁹ *Occupational Safety & Health Administration [OSHA]. (2014). Regulations (Standards-29 CFR 1926.950).*

¹⁰ ASTM F 1506, *Standard Performance Specification for Flame Resistant and Arc Rated Textile Materials for Wearing Apparel for Use by Electrical Workers Exposed to Momentary Electric Arc and Related Thermal Hazards*, (2010)

¹¹ *Occupational Safety & Health Administration [OSHA]. (2012). Regulations (Standards-29 CFR 1910.132(d)(1)(I)).*



Selection, Use, Care & Maintenance of FR Clothing

For the Oil & Gas industry, NFPA 2112¹² and NFPA 2113¹³ are the industry consensus standards that address flash fire in the context of FR clothing. NFPA 2112, “Standard on Flame-Resistant Garment for Protection of Industrial Personnel Against Flash Fire,” covers the requirements that FR garments should meet before entering the market. This includes everything from the types of fasteners that must be used, the qualities and capabilities of fabrics, to garment construction. NFPA 2113, “Standard on Selection, Care, Use, and Maintenance of Flame-Resistant Garments for the Protection of Industrial Personnel Against Flash Fire,” provides certain criteria upon which organizations and employers—as well as wearers—should base their garment selection decisions.

When addressing flash fires (whatever the cause) or molten metal (whether in foundries or in welding), basic FR garments that self-extinguish when an ignition source is removed are sufficient, but when it comes to electrical hazards, FR clothing is different.

The significant difference between flame-resistant and arc-rated clothing is that all AR garments are flame-resistant, but not all FR clothing has an arc rating. It is critical to select the right apparel for the task.

Electricians in general industry and electric utility are potentially exposed to electrical arcs that produce enough heat energy and blast pressure to either tear clothing apart or burn the wearer through the garment. The energy levels workers could be exposed to vary, so the protection level of the clothing must match the potential severity a hazard presents.

When an electrical arc event occurs, the level of energy to which a worker could be exposed is called Incident Energy or IE, and that energy is described in calories per square centimeter or cal/cm². NFPA 70E®, “Standard for Electrical Safety in the Workplace”¹⁴ focuses on general industry electricians and requires that AR clothing for any

potential exposure exceed 1.2 cal/cm², which equals the onset of a second-degree burn.

Electrical utility workers face the same hazard in a different environment, so when OSHA published 1910.269 and 1926.950, both stated that all electric power utility workers are required to wear arc-rated clothing that matches the risk identified through hazard analysis.

Arc rated (AR) garments are secondary PPE meant for continuous wear. Like FR clothing, arc-rated (AR) clothing protects wearers in two different ways. First, the thermal barrier provided by the fabric insulates the wearer against burns. Second, the fabric self-extinguishes once the source of ignition, electric arc in this case, is removed. Additionally, compliant AR clothing is required to carry an arc rating on the garment label. An arc rating is a numerical rating reported in cal/cm² and is an indicator of how much protection the garment offers in an electric arc exposure.

To establish an arc rating, a fabric intended for use in AR clothing is tested according to ASTM F1959 against a controlled electric arc over a range of incident energies. An arc rating can be reported in one of 2 ways: as an Arc Thermal Protective Value (ATPV) which is the incident energy at which there is a 50% probability that the wearer will sustain a second-degree burn through the fabric,¹⁵ or as a Breakopen Threshold Energy (E_{BT}) which is the incident energy at which there is a 50% probability that the fabric will breakopen. It is possible to calculate an ATPV and EBT for each fabric that is tested, but ASTM F1959 requires that only the lower, more conservative value be reported as that fabric's arc rating.

For welders and foundry workers, dealing with molten metal requires attention to a separate set of workplace conditions. In the chapter “Flame resistant textiles for molten metal hazards,” from Handbook of fire resistant textiles, H. Mäkinen writes, “The determining factors are temperature, metal density, the size of splash droplets

¹² NFPA® 2112, *Standard on Flame-Resistant Garment for Protection of Industrial Personnel Against Flash Fire*, (2015) National Fire Protection Association. Quincy, MA.

¹³ NFPA® 2113, *Standard on Selection, Care, Use, and Maintenance of Flame-Resistant Garments for the Protection of Industrial Personnel Against Flash Fire*, (2015) National Fire Protection Association, Quincy, MA.

¹⁴ NFPA 70E®, *Standard for Electrical Safety in the Workplace*, (2015) National Fire Protection Association, Quincy, MA. NFPA 70E and the title *Electrical Safety in the Workplace* are registered trademarks of the National Fire Protection Association, Quincy, MA.

¹⁵ Peacock, M. L., Sang, D., & Statham, D. (2016, July 7). *Understanding Arc Ratings*. [White Paper] Retrieved September 3, 2016, from http://www.bulwark.com/Content/Media/Resources/whitepapers_arc-rating.pdf



Selection, Use, Care & Maintenance of FR Clothing

and droplet surface reactivity.” This is true for welding as well as splash hazards in foundries. In discussing recent developments in FR to address molten metal, he goes on, “the trend is to develop fabrics with fibre blends containing flame retardant natural fibres and inherently flame-resistant synthetic fibres, taking advantage of the best properties of the various fibres.”¹⁷

Labeling

Attention to labeling is important because, even after correctly selecting appropriate FR or AR clothing based on a thorough hazard risk assessment, the employer is responsible for verifying that the garments match the identified hazard.

NFPA and ASTM labeling requirements are strict, but it's not always clear who's following the rules. Proper labeling is a good indicator that a manufacturer has produced a compliant garment and maintained due diligence, while improper labeling should evoke caution and prompt further investigation.

ASTM F1506 Paragraph 6.3 requires that:
Garments shall be labeled with the following information:

- 6.3.1 Tracking identification code system,
- 6.3.2 Meets requirements of Performance Specification F1506,
- 6.3.3 Manufacturer's name,
- 6.3.4 Size and other associated standard labeling,
- 6.3.5 Care instructions and fiber content, and
- 6.3.6 Arc rating (ATPV) or arc rating (EBT).

6.3.6.1 When garments are made with a different number of fabric layers in different areas of the garment, the arc rating for each area shall be designated. Pockets, trim, closures, seams, labels, and heraldry shall not be considered as extra layers

A label that meets each of these requirements is expressly compliant, while others can be misleading or omit critical information.

NFPA 2112 takes a slightly different approach when it comes to labeling. Section 5.1, Product Label Requirements,

specifically states that the mark of the third party certifier be permanently applied on the garment label in order for the certification to be complete. In addition to the label information similarly required by ASTM F1506, these words must appear on the label of an NFPA 2112-certified garment:

THIS GARMENT MEETS THE REQUIREMENTS OF NFPA 2112, STANDARD ON FLAME-RESISTANT GARMENTS FOR PROTECTION OF INDUSTRIAL PERSONNEL AGAINST FLASH FIRE, 2012 EDITION. NFPA 2113 REQUIRES UPPER AND LOWER BODY COVERAGE.¹⁷

The most recent update to ANSI 107 included a new requirement meant to make understanding labels less confusing. It now requires that all high-visibility clothing and accessories be labeled as FR or not FR. Garments that meet the requirements of one or more of the following six performance standards:

- ASTM F1506-10a, Standard Performance Specification for Flame Resistant and Arc Rated Textile Materials for Wearing Apparel for use by Electrical Workers exposed to Momentary Electric Arc and Related Thermal Hazards
- ASTM F1891-12, Standard Specification for Arc and Flame Resistant Rainwear
- ASTM F2302-08, Standard Performance Specification for Labeling Protective Clothing as Heat and Flame Resistant
- ASTM F2733-09, Standard Specification for Flame Resistant Rainwear for Protection Against Flame Hazards
- NFPA 1977, Standard on Protective Clothing and Equipment for Wildland Firefighting, 2011
- NFPA 2112, Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire, 2012

If a garment doesn't comply with at least one of these standards, in order to be compliant with ANSI/ISEA 107-2015 it must be labeled:

This garment is not flame resistant as defined by ANSI/ISEA 107-2015 Section 10.5.

Even with such specific requirements in place, labels can be confusing. In some cases, the manufacturer is

¹⁷ Mäkinen, H. (2013). Flame resistant textiles for molten metal hazards. In F. S. Kilinc (Ed.), *Handbook of Fire Resistant Textiles* (1st ed., Vol. 140, Series in Textiles, p.581). Philadelphia, PA: Woodhead Publishing.



Selection, Use, Care & Maintenance of FR Clothing

unscrupulous and intentionally misleads customers, while in other cases manufacturers mistakenly claim compliance with an irrelevant standard, which is also misleading. Either way, the responsibility for ensuring that the selected garments comply with applicable standards rests on the employer.

For employers and safety managers, the most important thing to do when attempting to select compliant FR clothing is to identify the standard that best matches the specific hazard and then check the label to make sure it correctly indicates that the garment meets the necessary requirements.

Clothing that is worn over FR/AR garments, such as outerwear, rainwear and high-visibility vests, must be tested to the specific hazard, or the entire system could be compromised.

Implementation: Using FR Correctly

For PPE to effectively protect a worker, it must be used correctly, so employers should be certain that any program that is implemented begin with proper training and be accompanied by an ongoing enforceable policy that makes sure workers are caring for their PPE properly and not putting themselves at risk by using it improperly.

OSHA 1910.132(f)(1)¹⁹ along with every other industry consensus standard that requires PPE also requires employers to provide training.

OSHA states that employees who are required to wear PPE must know, at the very least, when it is necessary, what equipment is necessary, how to don and doff, how to adjust it, what its limitations are, and how to properly care for it.

NFPA 2113, in requiring organizations to train workers in the proper use and care of FR garment, states, “The basis of this training should, as a minimum, be the user information provided by the manufacturer of the flame-resistant garment.” However, it does not stop there; it

goes on to require that manufacturers provide extensive user information that includes safety considerations, use limitations, garment marking recommendations and restrictions, warranty information, preparation for use, sizing and adjustment, storage practices, inspection practices, maintenance and cleaning procedures, and more.²⁰

For the Oil and Gas industry, there are some universal rules that should be followed when wearing FR garments.

These rules include some “common sense” practices such as tucking in shirts, not rolling sleeves up, and keeping garments zipped or buttoned up. But there are others that are not so clear. For example, non-FR/AR undergarments are permitted if they are made from non-melting fabrics like cotton, silk, or wool. The small amounts of elastic used in socks and underwear are the only meltable fibers allowed. Also, garments such as coveralls, which are designed to be removed quickly and easily in the event of a flash fire, should never be worn with the sleeves rolled up, half-unzipped or unbuttoned, or with the sleeves tied around the waist.

For the arc flash hazard, changes were made to NFPA 70E 130.7 (9) in 2012 that redefined proper coverage and the correct use of arc-rated PPE in general industry. This update included details requiring full coverage (fastening sleeves at the wrist, tucking shirts into pants, closing shirts and jackets at the neck), and loose fit (for insulation and maneuverability).

Prior to the recent updates to OSHA Regulations 1910.269 and 1926.960, it was common practice to simply adhere to the mandate that non-FR clothing not contribute to a wearer’s injury. Utility workers often wore arc-rated shirts and jackets but wore non-FR cotton jeans or pants. The revisions require that electric utility workers wear arc-rated clothing that has an APTV equal to or greater than the incident energy of a potential electric arc, and that workers may not wear non-FR clothing as an outermost layer.

Layering FR garment is an efficient way to safely increase the arc-rating of an apparel ensemble, but it is not as

¹⁹ Occupational Safety & Health Administration [OSHA]. (2014). Regulations (Standards-29 CFR 1910.132).

²⁰ NFPA® 2113, *Standard on Selection, Care, Use, and Maintenance of Flame-Resistant Garments for the Protection of Industrial Personnel Against Flash Fire*, (2015) (p.16) National Fire Protection Association, Quincy, MA.



Selection, Use, Care & Maintenance of FR Clothing

easy as adding the arc rating of an undershirt to that of a coverall and coming up with a total level of protection.

In Annex M of NFPA70E the rules surrounding layers for arc protection are clear:

M.3.2 It is important to understand that the total system arc rating cannot be determined by adding the arc ratings of the individual layers. In a few cases, it has been observed that the total system arc rating actually decreased when another arc-rated layer of a specific type was added to the system as the outermost layer. The only way to determine the total system arc rating is to conduct a multilayer arc test on the combination of all of the layers assembled as they would be worn.

Care and Maintenance

Proper care and maintenance of FR/AR clothing is another important element of any effective program. Most industry standards point to manufacturer recommendations, while others provide specific instruction and guidance.

Across all of the relevant standards, there are consistent rules that apply, and no special processes or equipment are needed to clean FR/AR clothing, following a few basic guidelines that will maximize protective capabilities of FR/AR clothing:

- Do not use bleaches or peroxides
- Do not use any additives, such as fabric softeners or starch, that could build up to impede FR performance
- Avoid washing in hard water as mineral buildup can negate the FR properties over the course of many launderings
- Wash FR/AR garments separately from other garments
- Wash FR/AR garments inside out to help with color retention and preserve appearance
- Use liquid detergent for best results
- Avoid extreme washing and drying temperatures to reduce shrinkage
- Soak garments in liquid detergent or non-bleach, non-peroxide pre-wash stain removers to address tough stains
- Dry clean garments with really bad stains
- Tumble dry on low settings and never over dry
- Rewash garments with lingering odor

There are a few basic things to consider. First, a garment, in some cases may look clean but still smell like a flammable substance, while in other cases a garment may have a visible stain but be perfectly safe to wear. Any odor of oil, solvents, flammable chemicals, or other potential accelerants should be taken seriously as it could indicate the presence of a combustible substance. Second, washing with bleach or peroxide will harm flame-resistant fabrics; don't use these laundry products alone or as additives to detergent. Last, any kind of buildup on the surface of the garment fibers is dangerous. There are obvious clothing treatments or additives, such as starch, fabric softener, and DEET-based insect repellent, but hard water is another important thing to consider. Laundering FR clothing in hard water, if done repeatedly, leads to a gradual accumulation of mineral deposits that may ignite.

If FR clothing is damaged, it can be repaired. Holes, tears, or damaged closure systems, such as broken zippers or missing buttons can be repaired as long as the garment's flame resistant integrity is maintained. Only flame resistant fabric and flame resistant thread may be used for repairs, and ASTM F 1449 provides specific guidance for returning FR garments to service.

Customer Policies on Use, Care, Maintenance and Retirement

The law requires that employers establish and maintain an ongoing policy for the use, care, and maintenance, of personal protective equipment. This includes FR clothing, but for many companies, compliance efforts fade once a program has been implemented.

Whether workers are part of a company sponsored uniform or laundry program, or are caring for their garments at home, it is up to the employer to ensure that the status of the PPE used in the field is monitored and managed on a regular basis.

Many companies require new employees to sign an agreement when they are hired. This can include a simple pledge to keep their PPE in working order, based on the manufacturers' instructions. Others issue detailed laundry and inspection guidelines and procedures to make sure that workers understand how to care for their FR garments and are subject to a regular safety and status assessment of their PPE.



Selection, Use, Care & Maintenance of FR Clothing

In any case, employers should set and enforce an inspection timetable that addresses wear and staining and that gives guidance on laundering and repair as well as retirement and replacement once a garment should no longer be in service.

Conclusion

While OSHA requires that employers protect their workers from on-the-job hazards that can cause injury or illness, and that they provide personal protective equipment, it's important to remember that using PPE does not guarantee that a worker will not be hurt.

Following the hierarchy of hazard control—elimination, substitution, engineering controls, and administrative controls—is the key to mitigating a workplace hazard, while PPE, such as FR clothing, should only be considered the last line of defense.

Because secondary PPE is meant for unexpected incidents, it is essential that FR clothing be worn on a consistent basis, as daily wear, wherever a worker is exposed to potential thermal hazards in the workplace.

Industry consensus standards and best practices can help organizations achieve compliance with the regulations surrounding PPE, but ultimately, the responsibility rests on employers. When it comes to selection and use, it is critical that they choose the Personal Protective Equipment appropriate to the task, that they train their employees in proper use, care and maintenance, and that they implement an ongoing policy that ensures workers are using PPE efficiently and effectively to maximize safety.



Bulwark[®]FR

To learn more about OSHA regulations, occupational hazard assessment, and FR outfitting standards, contact:

Customer Care

800-223-3372