



**PROTECTING ELECTRICAL  
WORKERS AND PEACE OF MIND  
WITH FLAME RESISTANT, ARC  
RATED (FR/AR) APPAREL**

# ARC FLASHES DUE TO POOR EQUIPMENT MAINTENANCE CAN DAMAGE EQUIPMENT AND PROPERTY, AS WELL AS INJURE WORKERS INTERACTING ON OR AROUND THE EQUIPMENT.

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Electrical workers face the risk of unexpected arc flash incidents throughout their daily operations by the very nature of their job. The right apparel can offer protection and peace of mind.

When arc flashes occur, the most severe injuries often are the result of non-flame-resistant clothing igniting and continuing to burn, causing far more severe burn injuries than the arc flash itself. The use of appropriate flame-resistant (FR), arc-rated (AR) clothing has a proven track record of protecting workers and saving lives.

Let's examine the three situations that are common causes of hazardous arc flash:

- Energized work that should be in electrically safe work conditions
- Operator error
- Poorly maintained equipment

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## Energized Work

NFPA 70E strongly encourages electrical workers to de-energize equipment (put in an electrically safe work condition) – and potentially utilize an energized electrical work permit – to help determine if the work can safely be done while energized. Energized work should only be done when de-energized work is deemed infeasible (infeasible, not inconvenient) based on equipment design, operational limitations, need for diagnostic work, or when de-energized work creates additional hazards or increases risk.

For example, at hospitals, removing power to conduct electrical work would create an adverse situation for patients. Causes of unnecessary energized work include situations where the electrical worker believes that they have the expertise to work on “hot” equipment or they are pressed for time. They may choose to not de-energize equipment since de-energizing will halt plant operations, inconvenience clients, extend work time, and cost money. While working hot may keep the system operational or allow for troubleshooting, it presents an environment for arc flash. Usually, to diagnose/troubleshoot equipment, the energized condition is necessary to determine the problem. Once the issue is diagnosed, however, the equipment should be put into an electrically safe work condition to make the repair.

## Operator Error

Electrical worker error is another cause of catastrophic arc flash incidents. Failure to verify absence of voltage, utilizing incorrect testing equipment (i.e. voltage testers), overconfidence, complacency, poor co-worker communication, and lack of lockout/tagout procedures have all been underlying root causes of arc flash incidents. Improper communication with the utility may allow for the system to be re-energized upstream. Or, some feeds may be disconnected, but additional feeds may be hidden or non-obvious due to equipment/system design.

Some workers and employers claim they don't need personal protective equipment (PPE), since they de-energize all their equipment, thus eliminating the hazard. This line of thinking is erroneous; putting equipment in an electrically safe work condition is considered energized work and requires FR/AR PPE. You must verify with a voltage meter that there is indeed an absence of voltage before it is safe to remove FR/AR PPE.

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While no one plans for an arc flash incident to occur, there are ways to prepare for the dangers it presents.

## Poor Equipment Maintenance

All equipment has an expectation for routine ongoing maintenance. However, in cost-cutting circumstances, sometimes maintenance is skipped or done incorrectly, jeopardizing the long-term safety of the system. The lack of housekeeping and maintenance causes corrosion, which leads to increasing resistance and unwanted heat. This is the primary culprit in electrical system breakdown and potential causes of arc flash events.

Other equipment, such as overcurrent devices, when not properly maintained, can cause longer clearing times that lead to higher incident energy exposures than indicated on the equipment PPE label. Arc flashes due to poor equipment maintenance can damage equipment and property, as well as injure workers interacting on or around the equipment.

The 2024 edition of NFPA 70E emphasizes “assessing the condition of maintenance” (new Informative Annex S) since improperly maintained equipment increases the likelihood of an arc flash incident (law of entropy) and as mentioned earlier, for unmaintained overcurrent devices, cause increased arc flash incident energy exposures to unsuspecting workers wearing PPE with an inadequate arc rating.

## Industry Regulations and Consensus Standards

OSHA, NESC and NFPA mandate the use of FR/AR clothing for safe electrical workplace practices. OSHA regulations state that companies must prioritize safety and provide a workplace that is free of recognized hazards that could cause harm. OSHA regulations and consensus standards provide actionable steps for organizations:

1. Conduct a risk assessment of the workplace.
2. Provide adequate protection, such as FR/AR PPE for identified electrical hazards.
3. Educate employees on dangers present and the use of PPE to create a safer workplace.

NESC and the NFPA 70E standard also mandate the use of appropriate FR/AR apparel wherever arc flash hazards exist. These confounding factors as well as industry regulations and standards surrounding electrical safety demonstrate the ongoing need for electrical workers to protect themselves daily against arc flash.

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## A Solution: FR/AR Daily Wear

While no one plans for an arc flash incident to occur, there are ways to prepare for the dangers it presents. Creating a safe workplace means allowing the downtime required to put equipment in an electrically safe work condition, despite the inconvenience to operations. It also means supplying workers with appropriate FR/AR apparel. When electrical workers experience an arc flash, the arc flash itself often is not what causes significant burn injury. Injuries occur when non-FR clothing ignites and fuels the flame, thereby increasing the extent of the injury. FR/AR clothing plays two key roles in protecting electrical workers against burns:

1. Self-extinguishes to mitigate burn injury when the source of ignition is removed.
2. Provides insulation to reduce the probability of enough heat transfer through an FR/AR fabric to cause the onset of a second-degree burn.

For common lower energy, PPE Category 1 and 2 tasks, wearing FR/AR daily wear is the simplest, most effective solution. It removes the guess work of determining if a task requires arc-rated clothing. By doing this, workers avoid the extra step of donning task-based PPE and it can be as simple as choosing to wear one work shirt over another. FR/AR daily wear also eliminates employer safety concerns that employees aren't properly wearing FR/AR for every task, including verifying that natural fiber-based clothing is worn underneath task-based gear to be in compliance. For higher energy tasks (PPE Categories 3 and 4), the extra step of donning appropriate task-based PPE is common due to the high PPE arc-rating requirements.

## Match PPE Arc Rating to Incident Energy or PPE Category

NESC requires utilities to assess hazards for employees that work near or on energized equipment. If energies present exceed  $2 \text{ cal/cm}^2$ , workers must wear FR/AR clothing with an arc-rating equal to or greater than the energies of the electrified equipment with which they work. To comply with NFPA 70E, employers are also required to perform an arc flash risk assessment to estimate the likelihood of incidence occurrence and severity of injury and determine if additional protective measures, including PPE, are needed. If PPE is required as a protective measure, the arc flash boundary (in which arc flash PPE is required) is determined.

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## Match PPE Arc Rating to Incident Energy or PPE Category (cont.)

To select the appropriate FR/AR, arc rated PPE, NFPA 70E denotes two methods: the Incident Energy Analysis Method and the Arc Flash PPE Category method. It's critical to note these procedures cannot be combined on the same piece of equipment.

For the Incident Energy Analysis method, the incident energies of various equipment are calculated using formulas and/or commercially available software. The difficulty of the calculation method is relative to the complexity of the electrical system. Once the incident energy is determined and listed on a specific piece of equipment label, simply select FR/AR PPE with an arc rating higher than the listed incident energy.

The PPE Category method (aka table method) involves utilizing a series of three tables in 70E. Table 130.5(C) helps determine the likelihood of an arc flash occurrence for certain electrical tasks in a “yes/no” format. A “yes” indicates that an arc flash incident is likely for this type of task/condition of equipment and determines that PPE is needed as an additional protective measure, leading to the second table, 130.7 C (15), which determines the PPE category (Cat 1-4) and the arc flash boundary distance for various equipment types and electrical parameters. Finally, the third table, the PPE Table, relates the arc flash PPE categories (4 categories) to the appropriately arc rated PPE. The equipment label will indicate the arc flash PPE Category (Cat 1,2,3, or 4) required for work on that piece of equipment. Where required, employees must wear appropriately arc rated, FR/AR protective clothing/PPE that meets ASTM F1506, the minimum performance specifications for protective clothing for workers exposed to the risk of electrical arc flash.

## Specify the Fabric

Once the PPE Category and/or arc-rating requirements are determined, you'll be able to move forward in selecting the best FR/AR clothing. Start with selecting the fabric first: it's important to understand the FR/AR, fabric manufacturer – history, experience, product line and capabilities – and look for brands that provide the performance that meet the needs of your workplace and job tasks. FR/AR daily wear also must be comfortable while working since an FR/AR garment cannot protect if it's not worn because it's deemed

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For common lower energy, PPE Category 1 and 2 tasks, wearing FR/AR daily wear is the simplest, most effective solution.

## Specify the Fabric (cont.)

uncomfortable! Conduct a wear trial of various garments to assess movement and breathability to ensure workers will be able to work effectively and comfortably.

External work conditions should be considered. The fabric and fabric system needs in diverse climates can be different, such as insulated products for northern climates and lightweight, single-layer constructions for hot and humid conditions. Arc flashes are unexpected and dangerous and can occur during various points of electrical workers' daily operations. By wearing FR/AR clothing, workers can equip themselves to perform their jobs safely, efficiently, and comfortably, all of which help them concentrate on the task at hand: getting the job done right and going home to their families.



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