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Arc Flash Prevention

What you Need to Know

White Paper

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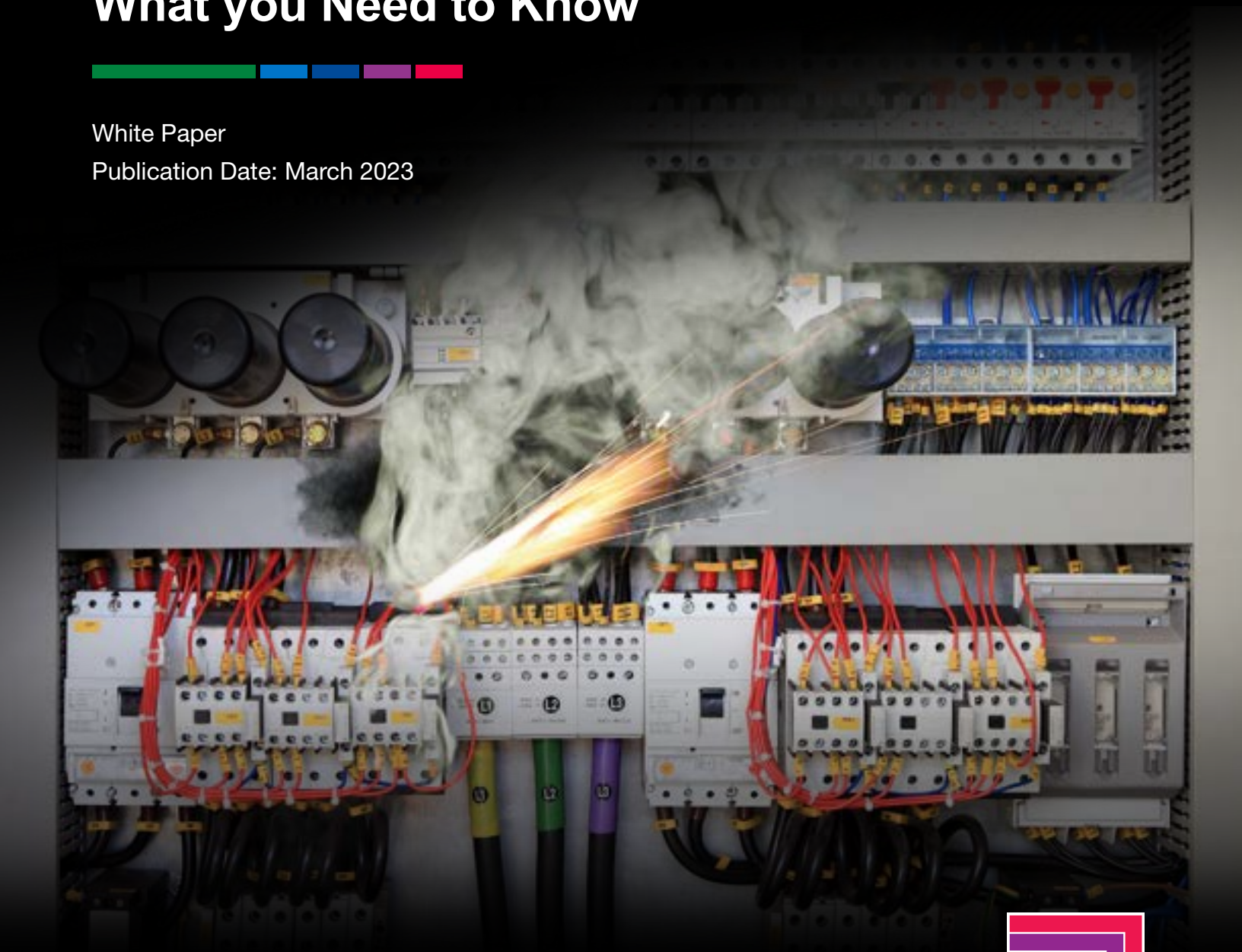

ENCLOSURES | POWER DISTRIBUTION | CLIMATE CONTROL | IT INFRASTRUCTURE | SOFTWARE & SERVICES

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Abstract

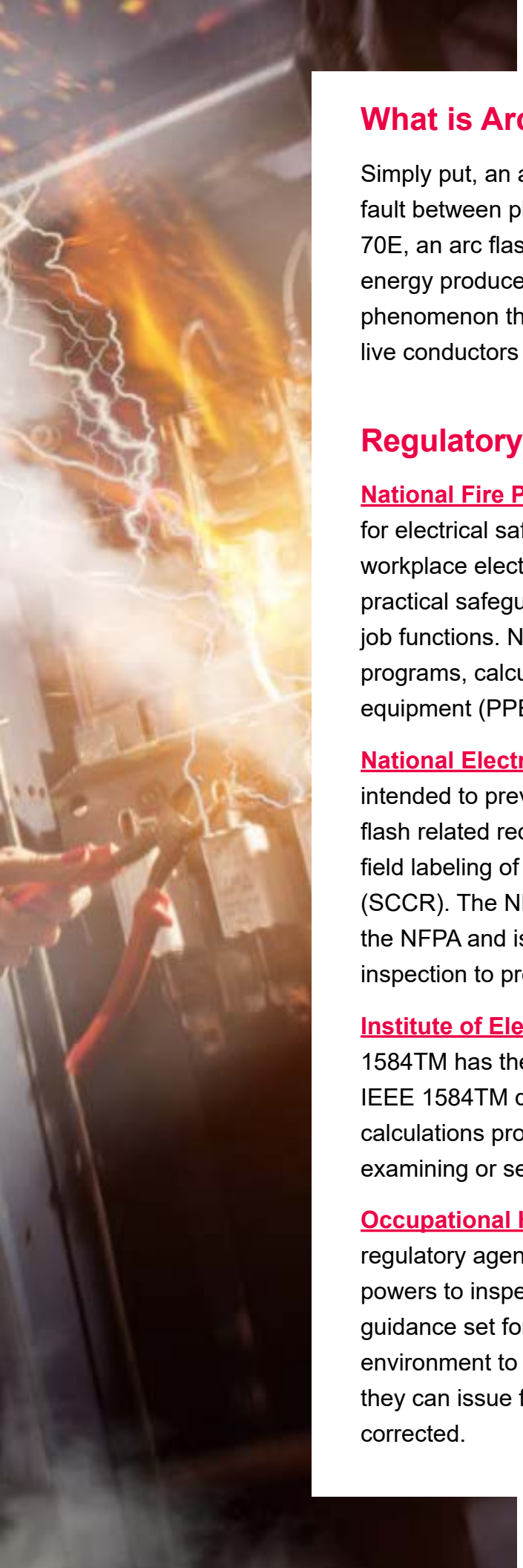
In this whitepaper, you'll read about arc flash regulations and standards developed by the leading regulatory agencies. Throughout this paper, you'll uncover common misconceptions related to arc flash, take an in depth look at how an arc flash forms, and dive into causes of arc flash hazards. This whitepaper will also discuss best practices for posting arc flash hazards and safety protocols and why it's important to always follow the posted guidance as determined by NFPA 70E. Additionally, you'll learn about safety recommendations from the regulatory agencies and solutions to help prevent arc flash exposure including information on proper personal protective equipment (PPE), lockout tagout, and energy isolating devices. Lastly, we'll explore how engineers can build a custom solution to help prevent arc flash exposure and how this helps to keep employees safe.

Summary

Arc flash risk is a concern where energized equipment over 50V is involved. Not following proper safety protocols or having the right equipment for the job can lead to potentially fatal injuries.

It is important that engineers and panel builders design the enclosure system with arc flash prevention and risk mitigation in mind. However, it is equally important that employees working on or near the energized equipment understand the required safety regulations and follow them at all times. It is vital for employee safety to stay up to date on the latest information from the leading regulatory agencies including OSHA, IEEE, and NFPA 70E to help ensure energized equipment is properly marked and secured to help prevent arc flash exposure.

In this paper, details from each of the three regulatory agencies will be discussed to help build a solid foundational understanding of arc flash, potential risks and hazards, and best practices for minimizing arc flash related risks and exposure. Understanding these concepts will make it easier to identify the best solution for unique applications, which will be discussed at the end of the paper.



What is Arc Flash

Simply put, an arc flash is the rapid release of energy due to an arcing fault between phase-to-phase, neutral, or ground. As defined by the NFPA 70E, an arc flash is the sudden release of unexpected heat and light energy produced by electricity passing through the air like lightning. It is a phenomenon that is usually caused by the accidental connection between live conductors or between live conductors and the ground.

Regulatory Codes and Standards

National Fire Protection Association (NFPA) 70E is the standard for electrical safety in the workplace. NFPA 70E addresses employee workplace electrical safety requirements. This standard focuses on practical safeguards that also allow workers to be productive within their job functions. NFPA 70E outlines safety related work practices, safety programs, calculations for the degree of hazard, personal protective equipment (PPE), worker training, and warning labels for equipment.

National Electrical Code (NEC) addresses proper installation techniques intended to prevent fire, electrocution, and shock hazard in addition to arc flash related requirements. The NEC provides requirements for proper field labeling of equipment with the maximum short circuit current rating (SCCR). The NEC is part of the National Fire Codes series published by the NFPA and is the benchmark for safe electrical design, installation, and inspection to protect people and property from electrical hazards.

Institute of Electrical and Electronics Engineers (IEEE) Standard 1584TM has the IEEE guide for performing arc flash hazard calculations. IEEE 1584TM deals with calculating the size of a potential fault. These calculations provide a basis for the level of PPE that is required when examining or servicing equipment.

Occupational Health and Safety Administration (OSHA) is the regulatory agency of the U.S. Department of Labor that has visitorial powers to inspect and examine workplaces. OSHA enforces proper guidance set forth from NFPA 70E and IEEE. If OSHA finds a work environment to be not in compliance with the standard or dangerous, they can issue fines, penalties, or shut down the facility until issues are corrected.

Common Misconceptions

There is a reduced chance of an arc flash incident occurring if the facility has not had an accident in a prolonged period of time.

No, if workers are not sufficiently protected, injuries can occur at any time regardless of past safety records. Therefore, it is important to always follow posted arc flash protection guidance.

Arc Flash will not occur at voltages below 240 volts.

Although it is more difficult to sustain an arc flash at lower voltages, arc flash incidents can occur at any voltage. Precautions must be taken regardless of the voltage level of individual components.

Working on an energized control center is okay if all loads are not currently in use and work is being done by a trained electrician.

OSHA standard 1910.333(a)(1) states that live parts to which an employee will be exposed must be deenergized before the work begins unless the employer can demonstrate that deenergizing can 1) Introduce additional or increased hazards or 2) Is infeasible due to equipment design or operational limitations.

OSHA does not enforce the guidelines set by NFPA 70E

Arc flash incidents have increased causing OSHA to have heightened awareness of facilities that are not sufficiently protecting their employees. OSHA will provide notice to these facilities and potential fines and penalties may be assessed where operators are at risk of exposure to arc flash hazards.

Breakdown of an Arc Flash Formation

1. The fault or short circuit occurs
2. Temperature increases, causing air to ionize and become conductive
3. The arc begins to form
4. Air temperature continues to rise, becoming even more conductive
5. The single-phase arc becomes a three-phase arc
6. Arc temperature reaches up to 35,000°F
7. Copper expands 67,000X and vaporizes

Quick Facts:

Skin exposed up to 176°F for 0.1 second can result in a curable burn. However, if the temperature reaches 205°F for 0.1 second, the burn is incurable. The melting point of copper is 1,984°F and the boiling point is 4,644°F. Limited and / or short exposure to an arc flash can cause serious injuries, making it necessary to always follow OSHA and NFPA 70E arc flash safety guidelines.

What Casues an Arc Flash

Arc flash can be caused by a variety of factors that create a connection to live conductors including, but not limited to:

- Accidental touching
- Animal interference
- Condensation
- Corrosion with insulators or with zinc, tin, and silver whiskers
- Dust or impurities
- Dropping of tools / tool connection
- Equipment malfunction
- Faulty installation
- Gaps in insulation
- Human error
- Material failure
- Poor or loose connection of wires or equipment

The severity of arc flash injuries is determined by the proximity of the worker to the hazard, temperature, and time for the circuit or connection to break. **According to OSHA**, temperatures during an arc flash can reach 35,000°F with pressure from the blast reaching around 2,000 lbs. per square foot in addition to the deafening 140+ dB sound from the explosion and intense IR and UV light. Damage to the surrounding areas is also possible, caused by the spread of fire and shrapnel being projected across the open area. Arc flash exposure and the added hazards including the risk of molten metal and toxic vapors can cause serious lifelong injuries or result in death.

Quick Facts:

According to the Bureau of Labor Statistics, there are six injury-causing electrical incidents reported every day in the U.S.; 40-50% are reported as being electrical flash burns.

What is an Electrically Safe Work Condition?

An **electrically safe work environment (ESWC)** goes beyond just deenergizing the work environment. It factors in the first step of removing the power or energy and includes steps to ensure the power will not come back on without the worker's knowledge which has been verified through an adequately rated testing instrument that the voltage is at 0V. Furthermore, NFPA 70E section 110.3 states which equipment must be in an ESWC state.

OSHA says this state must be achieved before work begins, but the NFPA defines two reasons why an ESWC must be established which further helps prevent arc flash exposure.

1. An employee will be within the limited approach boundary – equipment will be deenergized before making contact, preventing connection with an exposed or damaged part that could lead to an arc flash.
2. An employee interacts with the equipment in a manner that increases the likelihood of injury from arc flash, even with the covers on and doors shut.

If there is likelihood of injury, ESWC must be followed. This guidance helps to ensure a safe work environment is established before the worker makes physical contact with the equipment.

If work must be performed on energized equipment, the NFPA outlines two conditions that must be met before work is conducted. 1) Work can be performed at less than 50V if there is no increased exposure to burn or explosions due to electrical arcs. 2) The task is representative of normal equipment operation in normal operating conditions – operating equipment in a manner as intended by the manufacturer.

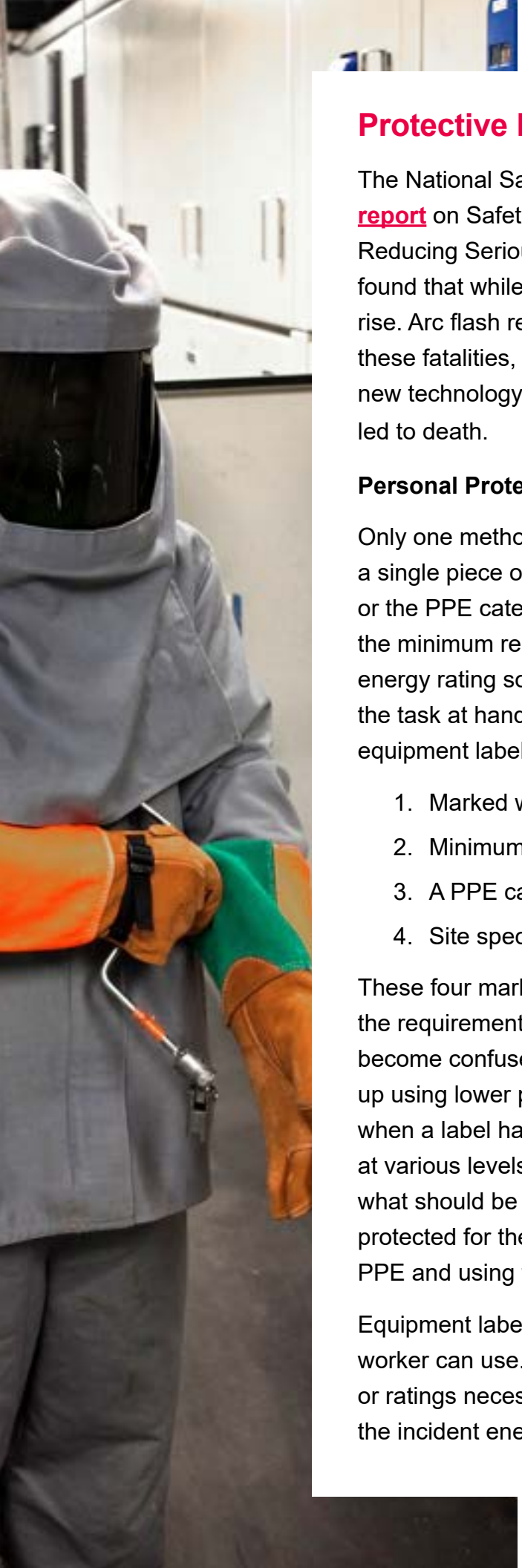
These safety precautions go above basic PPE requirements to help ensure the health and safety of the employee performing the work as well as those working within close proximity that may become exposed to an arc flash. If performing work on energized equipment can be avoided, then it should be avoided to maintain the maximum level of safety precautions.

Understanding Arc Flash Warning Labels

Only qualified workers are allowed to perform work on or near energized parts. They must undergo training and follow posted safety protocols including the use of proper PPE and insulated tools. The safety protocols include protection practices to help ensure the safety of non-qualified employees that may be working near energized equipment.

Equipment operating at 50 volts and up that is not put into a deenergized state must be evaluated for arc flash risk and protection protocols. Part of the evaluation will include the boundaries assessment to help in determining the required PPE. **The boundaries are defined as:**

- **Flash Protection or Outer Boundary** – the farthest established boundary from the energy source. At this distance, an employee would be exposed to a curable second-degree burn.
- **Limited Approach** – A set distance or limit from an exposed live part where a shock hazard exists.
- **Restricted Approach** – A set distance or limit from an exposed live part where there is an increased risk of shock.
- **Prohibited Approach or Inner Boundary** – the distance from an exposed part which is considered the equivalent of making contact with the live part.



Protective Requirements

The National Safety Council (NSC) released their **Work to Zero research report** on Safety Technology 2020: Mapping Technology Solutions for Reducing Serious Injuries and Fatalities in the Workplace. The study found that while workplace injuries are trending down, deaths are on the rise. Arc flash related deaths are among the top causes of fatalities. Of these fatalities, many are preventable deaths; having proper protocols and new technology can help reduce injuries and prevent the exposure that led to death.

Personal Protective Equipment (PPE)

Only one method of conducting an arc flash risk assessment is allowed on a single piece of equipment. Either the incident energy / arc analysis rating or the PPE category is used. This allows the worker to easily identify the minimum requirements – equipment will be labeled with the incident energy rating so the worker can safely identify the proper equipment for the task at hand. NFPA 70E allows one of the **four following marks** on equipment labels:

1. Marked with the incident energy
2. Minimum required rating
3. A PPE category
4. Site specification designation

These four marks are intended to simplify the way the worker interprets the requirements. If a label has too much information, the worker can become confused due to the complexity of the label and ultimately end up using lower protection equipment than is required. This can happen when a label has multiple protection ratings to accommodate equipment at various levels. Hence why NFPA 70E states that the highest rating is what should be used on the label – this helps to ensure the employee is protected for the maximum risk exposure. Clearly stating the appropriate PPE and using the standards correctly is vital to employee safety.

Equipment labeled with the PPE category provides specifics on what the worker can use. Similarly, site specific ratings will list out specific gear or ratings necessary for protection. Common labeling methods including the incident energy label require clear procedures so that employees

understand that the specified gear or specified minimum rating defines the only permitted PPE rating.

PPE Category 1 represents the lowest level where a single layer of Arc Rated (AR) PPE is required. PPE Category 2 can likely be met with a single layer, but the minimum arc rating may be higher – most companies opt for category 2 clothing to cover both. PPE Category 3 and 4 require additional layers of PPE in addition to arc flash suit hoods, rubber insulating gloves, and leather protectors or AR gloves – each category has a different minimum AR. The chart below details the differences between the four categories.

PPE Category	PPE Category 1	PPE Category 2	PPE Category 3	PPE Category 4
Minimum Arc Rating	4 cal/cm2	8 cal/cm2	25 cal/cm2	40 cal/cm2
Required Clothing	AR long sleeve shirt or AR jacket and pants or AR coverall with minimum arc rating of 4 cal/cm2	AR long sleeve shirt and pants or AR cov-erall with minimum arc rating of 8 cal/cm2	AR arc flash suit jacket and AR pant or AR coverall with minimum arc rating of 25 cal/cm2	AR arc flash suit jacket and AR pant or AR coverall with minimum arc rating of 40 cal/cm3
Required Face & Head Protection	AR face shield with wrap around guarding or Arc Flash Suit Hood	AR arc flash suit hood or AR face shield and sock hood with minimum arc rating of 8 cal/cm2	AR arc flash suit hood with minimum arc rating of 25 cal/cm2	AR arc flash suit hood with minimum arc rating of 40 cal/cm3
Required Hand Protection	Heavy-duty leather gloves	Heavy-duty leather gloves	Rubber insulating gloves & leather protectors or AR gloves	Rubber insulating gloves & leather protectors or AR gloves
As Needed	AR jacket, rainwear, parka, or hard hat liner	AR jacket, rainwear, parka, or hard hat liner	AR jacket, rainwear, parka, or hard hat liner	AR jacket, rainwear, parka, or hard hat liner
Additional PPE	Hard hat, eye protection - glasses or goggles, and hearing protection	Hard hat, eye protection - glasses or goggles, and hearing protection	Hard hat, eye protection - glasses or goggles, and hearing protection	Hard hat, eye protection - glasses or goggles, and hearing protection
Footwear	Leather footwear - as needed	Leather footwear - as needed	Leather footwear	Leather footwear

Lockout Tagout (LOTO)

OSHA standard 29 CFR **1910.147** is the standard for control of hazardous energy lockout tagout procedures. This standard sets the precedence for when and how lockout tagout protocols need to be used to prevent entrance into an energized device. Additionally, the company must have a written work procedures document that includes the purpose, authorization, rules, and techniques to be used to control hazardous energy.

Lockout is defined as the placement of a lockout device on an energy isolating device in accordance with the established procedure. A lockout device can be a lock, key, or combination type that holds the energy isolation device in a safe position and prevents the energizing of the machine or equipment. This device is intended to prevent entrance to the energy source and equipment being controlled until the lockout device is removed. Standard 1910.147 further states that the tagout devices will be capable of withstanding the environment they are exposed to, will not deteriorate due to environmental conditions, and will be standardized throughout the facility.

Tagout is the placement of an energy isolating device, a prominent warning device such as a tag that is securely fastened to the energy isolating device, in accordance with established procedures. This indicates that the energy isolating device and the equipment being controlled may not be operated until the tagout device is removed.

Energy Isolating Device

Power management systems that control functions and manage capacity and load shedding are key to helping ensure electrical and arc flash safety. The use of proper power management systems is **cited** as being a leading way to prevent arc flash related injuries.

An **energy isolating device** is a mechanical device that physically prevents the transmission or release of energy. This can include a manually operated electrical circuit breaker, a disconnect switch, a manually operated switch by which the conductors of a circuit can be disconnected from all ungrounded supply conductors and no pole can be operated independently, and a device used to block or isolate energy. This does not include selector switches or other control circuit types of devices.

Power Isolation Enclosure Solution

When considering safety and design flexibility during the planning stage, **Rittal's Power Isolation Enclosure solutions** provide the ability to isolate high and low voltage equipment within the confines of their respective enclosures – assisting in compliance with NFPA 70E workplace safety standards. The Rittal Power Isolation System can be used as part of a comprehensive lock out tag out (LOTO) strategy when the enclosure is coupled with the disconnect handle. Always take the application and end use conditions into consideration when determining proper equipment for arch flash safety.

The Power Isolation Enclosure System is a flexible, modular design constructed for demanding industrial applications. It allows for easy integration into many industrial applications, uses the Rittal TS 8 enclosure, is rated UL Type 12, and offers:

- Enhanced and simplified hardware installation
- A rigid trim door to accept a variety of high and low amperage operator handles
- Optional high amperage adapter plate allowing future system upgrades
- Blank adapter plate option for non-disconnect conversions or conversions that need to be made to customer specific handle positions
- Reduced width hinged trim door design for more usable panel mounting space
- Hinged and side access behind the operator handle cutout to make mounting the operator handle and connecting hardware easier
- Expandable and modular enclosure compatible with all standard TS 8 accessories.

Rittal helps to simplify the design process by creating the **Power Isolation Enclosure Selector Tool.** Easily build out a Flange Mount Disconnect (FMD) system with a mechanical interlock that prevents the doors from opening while the system is energized – all doors must be closed to turn the system's power on. Designing a custom solution can be done in a few simple steps and includes all parts required such as plinths, interconnect rods, and door handles for a complete solution.

In three easy steps the Power Isolation System can be built out including the Power Isolation Enclosure, the Disconnect Enclosure, and the optional high / low voltage enclosure. Widths and depths of each enclosure can be customized to fit specific requirements.

Step 1: Select the isolator enclosure based on the minimum disconnect space requirements

Step 2: Choose the FMD based on the required width to house the main controls and components

Step 3: Optional – Determine the high / low voltage enclosure based on the required width to house additional controls and components

Added accessories can allow for a truly customized solution unique to your application. Viewing doors, data portals, partitions, and external laptop shelves make it easier to complete the required work without risking exposure to the energized equipment inside.

Conclusion

Human error is inevitable and accidents can happen quickly, but there are measures that can be taken to mitigate arc flash exposure and reduce arc flash related injuries. Following the safety protocols developed by the leading regulatory agencies is the first step to establishing a safe work environment. Ensuring posted signage is accurate and simple for workers to understand is key to helping them wear proper clothing and use equipment rated for the arc flash risk. Providing education and training on the latest recommendations and guidance from OSHA, IEEE, and NFPA 70E will also help in establishing a safer work environment.

Additionally, engineers and panel builders can start the safety process by designing an application that helps prevent exposure to arc flash risks – keeping workers away from the hazard by preventing access to energized equipment. Power isolation solutions should always be designed based on NFPA 70E guidance and Rittal can help with enclosure selection to help mitigate arc flash. The experts at Rittal will provide recommendations based on the enclosure system designed to help protect your most important asset – your employees.

Get started today, Design Your **Power Isolation Enclosure System!**

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