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EXECUTIVE SUMMARY

Mitigation Methods for Arc Flash Hazards: Enhancing Personal Safety

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KEY TAKEAWAYS

- Arc flash events can lead to significant human and financial consequences.
- The IEEE empirical model suggests changing system parameters to reduce AFIE.
- The arc hazard control hierarchy offers five levels of safety control, from ideal to least effective.
- NEC 2014, Article 240.87 offers several low-voltage equipment substitution recommendations.
- To find the best solution conduct an arc flash analysis.
- The IEEE and NEC are both considering changes in the next two years to improve safety.

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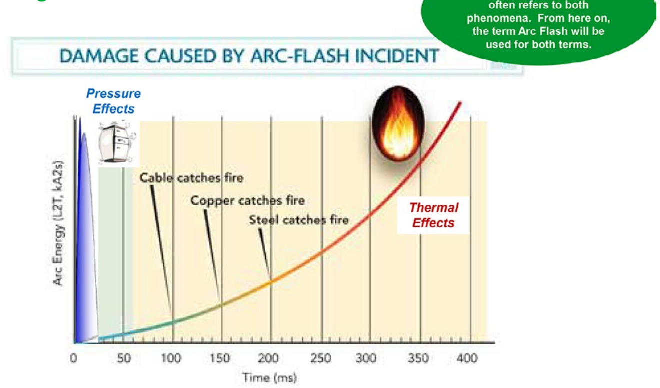
OVERVIEW

Arc flash hazards have been a key electrical safety concern for more than 30 years. The Institute of Electrical and Electronics Engineers (IEEE), National Electric Code (NEC), and National Fire Prevention Association (NFPA) have all developed regulations and recommendations to help decrease the number of occurrences and the impacts of these dangerous electrical events. Important changes to the IEEE and NEC regulations are coming within the next few years intended to further mitigate arc flash events.

Figure 1: Arc Flash Characteristics



CONTEXT

Speakers from Schneider Electric discussed the stages of the arc flash incident, the parameters than can reduce the event, and the arc hazard control hierarchy. Proposed changes to the IEEE and NEC codes were shared.

KEY TAKEAWAYS

Arc flash events can lead to significant human and financial consequences.

Every day, between 5 and 10 arc flash explosions occur in electrical equipment in the United States. Annually, 2,000 patients are admitted to burn centers due to arc flash events.

> It's not if you have an arc flash event. It's when you have an event.
>
> *Terry L. Schiazza*

These dangerous electrical events begin with a pressure event: the arc blast, but within milliseconds lead into the more commonly thought of arc flash thermal events, where cable, copper, and steel catch fire. Because of the exponential relationship between the energy involved in the event and the time, the longer the arc flash event goes on, the more damage involved.

The IEEE empirical model suggests changing system parameters to reduce AFIE.

The IEEE 1584 empirical model offers a guide for performing arc flash incident energy (AFIE) calculations. These calculations include several parameters that can be changed to reduce the incident energy: system voltage, bolted fault current, the gap between conductors, and arcing time.

Changing arcing time is the best way to impact AFIE: decreasing the arcing time can reduce the clearing time of an incident to reduce the energy.

Lowering the bolted fault current leads to a lower arcing current, and the arcing current determines the arcing time. A lower arcing current can mean that overcurrent protective devices, which define arcing time, may take longer to trip due to inverse time-current characteristics.

The two other parameter changes (system voltage and the gap between conductors) are generally not practical. In most environments, it is often not practical to change the system voltage. Increasing the gap between conductors could reduce the incident energy, but it requires equipment construction changes, which most equipment manufacturers are unlikely to make.

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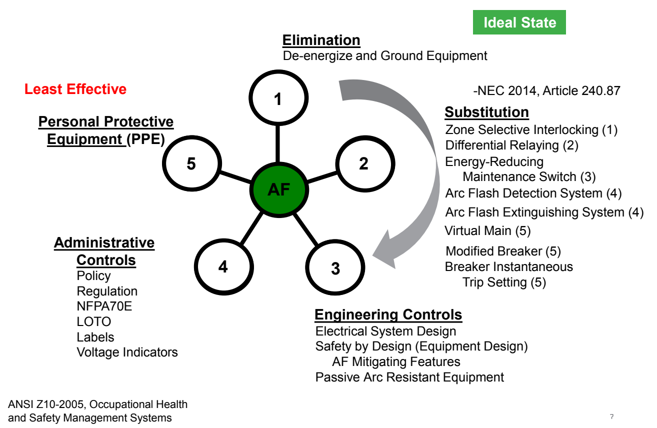
The arc hazard control hierarchy offers five levels of safety control, from ideal to least effective.

The ANSI-Z10 standard provides five levels of arc hazard safety control, from most to least effective for medium and low-voltage applications.

Figure 2: Arc Hazard Control Hierarchy



1. **Elimination.** Complete elimination of the hazard is the first and most ideal safety option. The best way to physically remove the hazard is to de-energize the electrical equipment and properly ground it.

> The ideal state would be to physically remove the hazard or to eliminate the hazard.
>
> *Terry L. Schiazza*

2. **Substitution.** NEC 2014, Article 240.87 discusses options available for replacing the hazard. This article focuses specifically on low-voltage equipment.
3. **Engineering controls.** Personnel are isolated from the hazard. This includes designing the electrical system to reduce the energy created during an event, designing equipment with safety in mind, and incorporating safety features. Passive arc-resistant equipment, also known as passive containment energy redirection, is another control that contains the energy and then exhausts it away from personnel.
4. **Administrative controls.** Policies, regulations, standards, labels, and other tools and techniques that change the way people work on or around electrical equipment provide a level of safety.
5. **Personal protective equipment (PPE).** Although PPE is an important measure, it should not be the only measure used to protect personnel.

NEC 2014, Article 240.87 offers several low-voltage equipment substitution recommendations.

Schiazza discussed low-voltage equipment substitution recommendations in NEC 2014, article 240.87.

- **Zone selective interlocking.** Improves the clearing time of an arcing event, which can reduce the arcing event energy. Ideal for multiple breakers, such as in low- or medium-voltage switchgear.
- **Bus differential relaying.** Another method used to reduce clearing time. More applicable in medium-voltage applications as it is easier to mount the current transformers.
- **Energy-reducing maintenance switches.** Often the least expensive way to reduce arc flash hazards. Current code does not discuss performance, making it difficult to measure the overall impact.
- **Arc flash detection systems.** Discussed as part of the active arc flash system section in the article, these detection systems typically look for a flash of light and a spike of current to detect an arcing event. When an event is detected, the system triggers an upstream trip device.

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- **Arc flash extinguishing systems.** Discussed as part of the active arc flash system section in the article, these systems use fast-acting switches to replace the arcing path with a conductive non-arcing path. After the arc is extinguished, the normal circuit protection devices will function and detect and interrupt the fault.

Technology that surfaces during the three-year NEC revision cycle is also considered potentially acceptable as a substitution. New technologies not explicitly discussed in the code won't automatically be accepted; discussions around their impact need to occur with the jurisdiction in authority.

Schiazza identified three technologies that became available after the NEC 2014 revision that can be considered as potential substitutions: the virtual main, the modified breaker, and the breaker instantaneous trip setting.

To find the best solution conduct an arc flash analysis.

Although there are a number of substitution methods available, it is important to find the one that best matches the equipment and need. This can be done by conducting an arc flash analysis.

> To determine benefit from any of the arc energy reduction methods, have an arc blast study done and know what your available arcing current is.
>
> *Chad Kennedy*

Figure 3: Arc Flash Analysis Questions

Arc Flash Analysis Considerations
– Type of equipment
– Voltage class of the equipment
– Method attributes, such as whether it lowers the incident energy
– Recovery time after an incident
– Amount of damage generated by the incident
– Relative cost of the incident

Most substitution methods can be retrofitted to existing equipment. Arc-resistant equipment typically cannot be retrofitted, but arc-resistant switchgear, low-voltage medium-voltage may become industry standard in the future.

The IEEE and NEC are both considering changes in the next two years to improve safety.

The IEEE and NEC are considering revisions to existing standards that will further improve safety provisions around arch flash hazards.

The IEEE is in the process of updating standard C37.20.7: IEEE Guide for Testing Metal-Enclosed Switchgear Rated Up to 38 kV for Internal Arcing Faults. The 2015 revision included a product annex (proposed, figure 4, below), which identified the different electrical equipment that could meet the arc-resistant standard rating.

Figure 4: IEEE C37.207 Product Annex: Proposed 2015 Revision

Annex Listing
– Annex D: Metal-enclosed low-voltage power circuit breaker switchgear (IEEE Std C37,20.1)
– Annex E: Metal-clad switchgear (IEEE Std C37.20.2)
– Annex F: Metal-enclosed interrupter switchgear (IEEE Std C37.20.3)
– Annex G: Outdoor equipment (IEEE Std C37.20.1, IEEE Std C37.20.2, IEEE Std C37.20.3)
– Annex H: Motor control centers (UL 845)
– Annex I: Medium-voltage AC controllers (UL 347)
– Annex J: Switchboards (UL 891)
– Annex K: Metal-enclosed bus (IEEE Std C37.23)\

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The first draft of the proposed NEC 2017 includes:

- **110.16(b): Arc flash hazard labelling.** This change would make the markings already recommended by the NFPA70E legally enforceable.
- **240.87(b): Method to reduce clearing time.** Adds the use of an instantaneous trip setting that is less available than an arcing current and an instantaneous override that is less available than an arcing current to the substitution methods.
- **240.67: Arc energy reduction.** This new article would provide documentation and methods to reduce clearing time for circuit breaker scenarios where the ampere rating of the fusible switch is 12000 A or higher. If adopted, this requirement would become effective on January 1, 2020.

FAQs

Does Arc Resistant Equipment prevent you from having an arc flash event?

No; Arc flash events can and do occur in Arc Resistant equipment. Arc Resistant equipment is designed to contain and redirect the energy from the arcing fault to provide a degree of protection to workers interacting with it.

What are zones of protection and how do they impact the arc energy reduction provided?

"Zones" of protection are associated with protective devices so that they react to only faults inside the zone, and do not react to faults outside the zones. For example, a circuit breaker cannot detect faults upstream of its location. Understanding the zone associated with a given device is critical to understanding specifically where and to what level protection is provided.

Will the arc reduction means allow a reduction in the level of PPE required?

Potentially, if energy levels are reduced enough to allow for use of a lower class of protective clothing.

What does VAMP stands for?

VAMP is a Schneider Electric arc flash relaying product that operates on a combination of light and current to detect arcing faults very quickly. Click Here to learn more about VAMP Arch Flash Protection Systems.

The 2015 version of the NFPA 70E removed PPE Levels from the arc flash labels unless you are using the table method. So, you are saying that the new 2017 NFPA 70 (NEC) is going to require the PPE Level and require all 2015 updated studies to be re-labeled?

NFPA 70E-2015 does not allow for labels to show both an incident energy and PPE Category. But the idea of Site Specific PPE Levels is introduced, and can be used along with incident energy levels. Refer to NFPA 70E Section 130.5.

What is the minimum PPE equipment required by the 2014 ARC flash safety requirements?

A5: Always refer to NFPA 70E for guidance on PPE selection. The minimum requirement depends on the potential incident energy exposure. NFPA 70E-2015 recognizes that some tasks may not expose workers to an arc flash hazard, which means no PPE is required.

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How do you reduce the category of the line side of the main switch from the utility transformer?

In general, to reduce incident energy levels at any given location, a device upstream must trip to clear the fault quickly. Utility fuses or relays typically do not react very quickly to arcing faults in the customer gear. If adding extra protection ahead of the equipment is not possible, then looking at "avoidance" solutions, such as remote operation, can help protect the worker.

What are the main causes of arc flash events?

Main contributing factors would include worker error such as improper lockout/tagout process, improper equipment maintenance, contamination or foreign objects in gear, or improperly applied equipment.

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BIOGRAPHIES

Terry L. Schiazza

Business Development Manager, Schneider Electric

Terry L. Schiazza is a Business Development Manager for Schneider Electric. His primary focus is on portfolio positioning and management, product launches, and business development. Since joining Square D in 1980, Terry has held numerous positions and is a member of- IEEE/PCIC Chemical Subcommittee, AIST Energy Applications Technology Committee and Standards Working Group member of IEEE C37.20.7.

With more than 35 years of professional experience in sales, marketing strategy, and offer development, Terry is recognized as a subject matter expert in Arc Flash and Motor Control Centers. He earned the AIST Farrington Award in 2013 - Association of Iron & Steel Technology (AIST). He has co-authored several papers such as:

- *Electronic Motor Circuit Protectors*—A fresh perspective on sizing circuit protection for branch motor circuits in a low voltage motor control center. Co-authored published IEEE (paper No. PCIC-2008-31) presented at the 2008 Petroleum and Chemical Industry Committee (PCIC) conference in Cincinnati.
- *New Approach for Intelligent Motor Control Centers*. Co-authored published AISTech 2012 Proceedings (paper 25222113) presented at the 2012 Association for Iron & Steel Technology Conference in Atlanta.

Terry earned a Bachelor of Mechanical Engineering from Georgia Institute of Technology in 1980, a Bachelor of Science (BS) Human Resources Management from Southern Wesleyan University in 1980, and a Masters in Human Resource Development from Clemson University in 1991.

Chad Kennedy

Industry Standards, Schneider Electric

Chad Kennedy is the Manager, Industry Standards for Power Equipment for Schneider Electric, a Fortune Global 500 company specializing in energy management. Also, known for its heritage brand of Square D, the global leader in electrical distribution, power and control solutions for residential, commercial, industrial, and original equipment manufacturer markets.

In this role, Chad is responsible for managing company activities relating to product standards for Renewable Energies and Power Equipment products. He currently serves on NEC Code-Making Panel 13 and on numerous UL product standard STPs, CSA Technical Subcommittees, IEEE PES Switchgear committees and NEMA technical committees for power equipment. Chad also serves as the chair for the NEMA – IECI Sharp Edges Task Force.

Chad is a resident of Columbia, South Carolina, USA. He holds Bachelor of Science and Master of Science degrees in Electrical Engineering from the University of South Carolina and is a registered Professional Engineer in the state of South Carolina.