Knowledge makes all the difference in arc flash mitigation

Introduction

Benjamin Franklin once said, “An investment in knowledge always pays the best interest.” Often credited with discovering electricity, Franklin well understood that knowledge is power. And when it comes to arc flash mitigation, his words couldn’t be more fitting.

Though more than 35 years have passed since arc flash and the hazards of incident energy exposure were first publicized, arc flash mitigation continues to be a challenging issue for electrical engineers. Over the last ten years, more than 20,000 workers have been injured in workplace electrical accidents. While electrical hazards are not the leading cause of on-the-job injuries and accidents, they are disproportionately fatal and costly. These injuries not only disrupt the lives of the workers and their families, but also impact the productivity of employers. In fact, you don’t have to be in direct contact with an energized conductor to be harmed by an arc flash event, as it can cause serious injury or death at distances up to 8 feet and cause burns at distances up to 20 feet. Additionally, it can cause extensive equipment damage and affect business continuity.

The National Fire Protection Association (NFPA) 70E Standard for Electrical Safety in the Workplace, the National Electric Code (NEC), IEEE 1584, OSHA workplace safety regulations, manufacturer literature and equipment label warnings all provide information, guidance and instruction on implementing arc flash protection measures. Arc rated PPE provides a level of protection to workers. NFPA 70E requires equipment to be placed in an electrically safe work condition before electrical work is done. Yet, with all the increased awareness, safety standards and precautions put into place in recent years, normal testing and troubleshooting can still result in causing or being exposed to an arc flash event.

The reality is that it doesn't take much to create an arc flash event. They can be triggered in any number of ways - aging or poorly maintained equipment, a loose connection, human error, vermin, humidity or even dust. An arc flash incident can occur when routine maintenance work is being performed. "Human error is a major cause – leaving a wrench while working on energized equipment. Aging equipment can also cause arc flash incidents," says Jamie Jurin, Digital Consulting Engineer Specialist with Square D, who has performed numerous arc flash studies over the years.

The good news is that the risk to workers from an arc flash event can often be lessened and managed by doing some due diligence up front. However, when taking into account the many complexities and various sources of information on arc flash mitigation standards and practices, as well as all the solutions available, it's no wonder engineers are increasingly confused and challenged in designing arc flash protection and safety into electrical systems. "There is a lot of uncertainty about what products are actually currently available and what's available in the future. It's confusing," explains Robert Fuentes, Consulting Engineering Specialist with Schneider Electric and IEEE member. "There's so much that can be used – from less expensive, simple solutions to fully automated complex versions."

Knowing all the options

One of the biggest challenges is simply knowing what all the options are. In addition, different types of arc flash mitigation solutions require different levels of equipment and investment. "There are a lot of products out there. It requires serious digging through everything to know how to approach all the options," adds Antony Parsons, Engineering Manager at Schneider Electric and IEEE member.

When addressing applications involving Medium and Low Voltage equipment, it's possible, though, to simplify the process for selecting the best arc flash mitigation strategy by first defining clear safety goals and establishing criteria for electrical system design and upgrades. Following a few simple steps can smooth the decision-making process and provide specifiers with the tools they need to make the most suitable, well-informed recommendation.

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The best course of action in mitigating arc flash events is to start at the beginning of a project, in the earliest phase of the electrical system design process. Adopting safety-by-design principles from the beginning allows for the latest safety measures and codes to be built into the design, saving CapEx and OpEx costs while lowering risk. "Having to retrofit solutions into existing systems is not ideal. It would be advantageous if specifying and design engineers consider safety in the early stages of a project. It makes a difference in the safety and the cost," says Parsons. Though a number of solutions are available for retrofitting existing facilities, they involve additional cost in field modifications, likely downtime and possible replacement of otherwise functional equipment.

Having an informative conversation with the client at the beginning of a design can eliminate major problems down the road. Competing priorities may be an issue, when in reality you may not need to compromise equipment over personnel safety or prevention measures over cost. Spending more to make a workplace safer for workers and equipment may be well worth the cost upfront. Because sustainability is a major concern, engineers need to consider where they can get the most bang for the buck.

According to Baldur Krahl, Director of Strategic Medium and Low Voltage Customers at Schneider Electric and 30 years of experience in the electrical industry, "Specifiers and engineering customers typically mention three areas of concern when seeking the best arc flash mitigation strategy:

1) They'd like something simple that can protect personnel and equipment – preferably something without a lot of moving parts.
2) They need something reliable that can keep dust and rodents out with diagnostics that can indicate how well it's working, and
3) They want something affordable, that delivers on value and addresses both the code and the customer's needs, as engineering solutions can be expensive."

Knowing the right questions to ask

Knowing the right questions to ask in the first place can ease confusion for specifiers and help identify the optimal options for a client's given situation. Using the latest *NEC* as an initial guide, engineers can begin by asking some key basic questions. "What are the minimum requirements? And what more do we need beyond that? It's a complex discussion, but an important discussion that needs to happen between an engineer and their client," says Robert Fuentes, a Consulting Engineer Specialist with Schneider Electric.

Consider the following questions to get the conversation started with a client:

- **Are you interested in safety measures beyond those required by code and why?**
- **What type of maintenance tasks will you be performing or having contractors perform on electrical equipment? How often?**
- **What levels of PPE (incident energy) are acceptable for the following tasks associated with electrical equipment?**
  - *Testing / inspection / verification*
  - *Operation of electrical equipment*
- **What systems are critical to operations and business continuity?**
- **How long can you deal with an outage to critical systems?**
- **Do you know the available methods of mitigating arc flash hazards and their pros and cons?**
  - *CapEx and OpEx costs*
  - *Operational impacts*
  - *Solution performance and complexity impacts*
- **What CapEx and OpEx costs are acceptable for increased safety and business continuity over code requirements?**
  - *Operational cost impacts*
  - *Probability and potential costs associated with risk*

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Many of these questions can easily get glossed over in initial design discussions, or sometimes never asked at all. "The electrical system design must include code compliance, energy efficiency and reliability - safety can end up being an afterthought. It would make things a lot easier if safety was thought of first," asserts Parsons. Giving clients the opportunity to take all these factors into consideration before any mitigation purchase decision is made will go a long way in ensuring more positive outcomes. Determining how the equipment will be used and prioritizing the need for protection of both personnel and equipment is vital input into any successful system design.

"Some customers want to continue to use their older equipment, but you want a benchmark on your equipment from its inception and most don't have that benchmark. Which is why we strongly recommend asset/condition management systems from the beginning," says Krahl. Naturally, customers from different industry segments, such as oil & gas or healthcare, with varying degrees of operational levels, performance needs and safety requirements will point specifiers to different solutions. "Ultimately, it's about protecting people. How do we keep workers from getting hurt? What happens to the person who happens to be nearby? If an arc flash incident occurs, how will management respond to it?" stresses Tim Faber, Circuit Breaker Product Architect at Schneider Electric, IEEE member and holder of more than 20 US and European patents. "Reliability also needs to be discussed, because an arc flash event can be very disruptive."

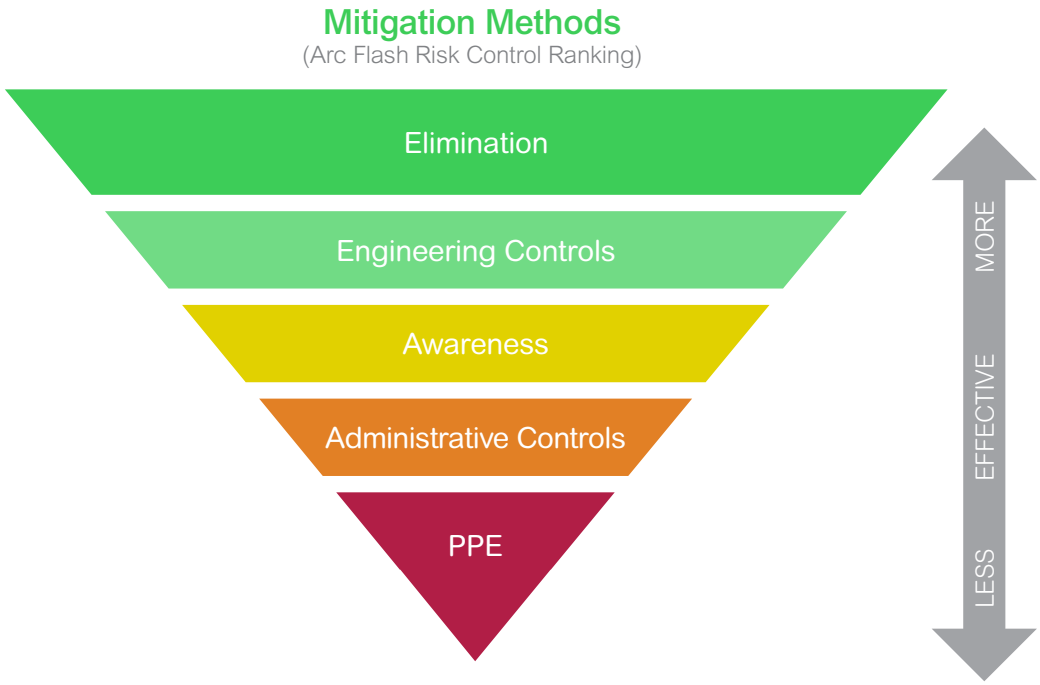
Knowing the requirements

Industry standards from IEEE (IEEE 1584) and the NFPA provide guidelines for assessing and managing the risks risks associated with arc flash incidence. NFPA 70E is the standard that provides guidance on evaluating risk from electrical hazards, safe work practices and the use of electrical PPE. And though training employees on risk assessment, risk control methods and protocols, warning labels on equipment and the proper arc rated PPE are all critical, there are still ways to further reduce the risk of injury to workers and equipment.

OSHA 1910.332 (d) (1) and NFPA 70E require an arc flash risk assessment, which includes doing an evaluation of the environment and work tasks to determine if a worker may be exposed to a hazard. Arc flash studies are a critical component since they are required in order to estimate the severity of the hazard. An arc flash study calculates the incident energy, arcing current and arc flash boundary at various points in the system. These results are then utilized to identify the area where the arc hazard reduction is required.

While PPE is only one of several ways to minimize and manage the risk of arc flash injury to an individual, unfortunately, some consider it the main way to mitigate arc flash injury risk. However, in actuality, it may be the least effective protection strategy. Relying solely on PPE while performing electrical work can result in an arc flash related injury. Many working on electrical equipment do not have the adequate safety training to recognize all the potential hazards and don't always follow all the NFPA 70E requirements and standard procedures. In addition, higher levels of PPE can make many tasks hard to accomplish, costly and more prone to error.

Based on the American National Standards Institute (ANSI) Z-10 standards, a hierarchy of arc flash risk control methods from least to most effective, ranks PPE as the least effective or last line of defense.



Obviously, eliminating the hazard entirely is the best possible scenario and the most effective approach, but not practical considering electrical power distribution systems are ubiquitous and impossible to avoid working on altogether. The same goes for substituting a less hazardous approach – it's not usually possible or practical. Administrative controls and awareness are important to the arc flash mitigation process as they help employees learn to modify their behavior to lessen the danger to themselves and equipment. But the source of the risk itself is not reduced and does not change.

Engineering controls can be instrumental in reducing the available incident energy, or at least reduce a worker's exposure to it. If the incident energy is lowered enough, the level of PPE required can be reduced. Engineering controls can improve reliability because higher incident energy can increase equipment damage. In addition, the *National Electric Code* requires engineering controls be implemented for any low-voltage circuit breaker 1200A or larger. As of January 1, 2020, similar requirements for fused circuits were enacted.

Knowing what you don't know

Just as important as knowing what to look for in arc flash mitigation and protection is knowing what you can't always anticipate. Many solutions are designed to reduce the severity of an arc flash incident, but don't reduce the potential of their occurrence. These include fast-acting fuses, circuit breakers and relays, maintenance switches and arc flash protective relaying. According to Parsons, arc flash maintenance switches, a popular solution, can clear an arc flash more quickly. However, a maintenance switch on a main breaker may not protect someone performing checks on that breaker, instead providing protection for workers or equipment farther downstream. Even in the lockout/tagout process of testing for deenergized equipment, exposure to arc flash hazards is still possible for a worker.

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It's just as important to ask what a solution isn't doing as it is to ask what it does do. Because equipment brochures can lack information and be vague, it's critical to understand what the solutions really do and DON'T do. "As the industry grows, engineers may not be aware of all the options. Options that may have sounded good, such as 'arc resistant gear' actually only protect the person near the equipment. This can be an expensive option, especially when equipment is not protected with arc flash energy reduction solutions. Better options may be available for the application," attests Jeff M. Miller, P.E., Manager of Specifier Channel for Schneider Electric.

Along with gaps in protection lie some commonly held misconceptions which also add to the problem of implementing the best possible arc flash mitigation strategy, such as:

There is no arc flash danger if there are no exposed energized conductors or circuit parts.
Though the probability of an arc flash event may be low, an arc flash hazard may exist if a person is interacting with the equipment in such a manner that could cause an electric arc, such as removing panels and dead fronts, inserting or removing draw-out circuit breakers, bus plugs and MCC buckets, or opening and closing disconnects and breakers.

"Some costly methods are not always the most effective. Sometimes simpler can be better."

The more experienced the contractor, the fewer the mistakes.
People make mistakes. And, experience can sometimes work against people in the form of complacency, "I've done this a hundred times and I've never been injured". All kinds of things can be a distraction and take someone's attention away, and a critical mistake can be made in an instant. It's imperative to de-energize any live parts of equipment that will be worked on, before anyone touches or comes near them.

The more money you spend on mitigating arc flash incidents, the more protection you'll receive. In other words, you get what you pay for.
"The easiest way is to meet code requirements, but it may not be the best way. The code doesn't consider cost effectiveness or associated equipment damage and return to operation. Engineers should question which solutions are better, which are cheaper? Which work best for the application? Some costly methods are not always the most effective. Sometimes simpler can be better," says Miller.

Working closer to the source is more effective. It's hard to work effectively farther back from the equipment source.

Actually, the more distance, the better. You don't need to be right on top of the equipment to work on it – the ability to work remotely and put more distance between you and a potential arc flash occurrence is critical. The farther you move away from an arc source, the less energy your body receives, decreasing rapidly for every foot put between you and the source.

Knowing what works

By following good design practices and doing an arc flash analysis, it's possible to reduce the potential for dangerous arc flash events while also reducing the exposure by implementing the most effective, proven protocols, best practices and equipment. Options can include maintenance switches that reduce the arc energy, virtual main systems that can sense an arc and disconnect, optical arc flash protective relays and zone selective interlocking that allows faster fault clearing.

Recent innovations in arc flash mitigation include avoidance solutions that remove the worker from close proximity of the potential hazard. Remote operation via Bluetooth and remote racking are both avoidance solutions that get personnel outside the arc flash boundary. Because the incident energy declines the farther away you are from the source, these types of solutions can help avoid hazards that sometimes result in serious injury to the worker. The potential damage to the equipment itself is not reduced.

Containment solutions include arc-resistant switchgear that protects workers standing next to or over the equipment. Arc resistant equipment, such as Schneider Electric's Masterclad™ arc-insulated, arc resistant drawout switchgear is built to ANSI C37.20.2 standards to improve personnel protection and provides switching, control and protective applications at medium voltage levels for large, complex power distribution and control.

There is also innovative technology that is designed to offer improved protection to both equipment and workers "There are innovative solutions, such as line side protection with passive reduction, that are shifting the protection paradigms, not only providing barrier technology that helps reduce the likelihood of arc flash events happening in the first place," says Krahl,"but, also offering higher level of quipment protection by reducing energy incident levels if an arc event is to occur. And this solution with equipment is actually lower in cost than other solutions."

Knowing where to turn

There is no single arc flash mitigation solution that fits every potential situation. The arc flash risk assessment heavily depends on an individual's ability to understand the electrical system and distinguish solutions based on his or her experience, expertise and knowledge. That's why it's important to seek out consulting engineers and specialists with expertise and familiarity with all the different aspects of arc flash mitigation. Ideally, they should be brought in at the outset of a facility's or operation's electrical system design. Electrical equipment manufacturers employ application engineers who are especially knowledgeable and can help to discern and identify the best possible solution strategies for a particular situation. Specifiers need accurate, unbiased information and need to be able to rely on experts they can trust, as their advice can be critical to the decision-making process on design options. Consulting engineers have knowledge of standards requirements and access to the latest developments in arc flash mitigation and equipment.

A safe electrical work environment that complies with regulations reduces liability, reduces operating and equipment costs, and most importantly, reduces injuries. Awareness and education about the dangerous nature of arc flash events have steadily increased over the years, but there is still much to learn and understand about the different options available to develop an arc flash mitigation strategy that empowers personnel to be safer and companies to be more productive and profitable. arc flash mitigation strategy. Not unlike the adoption of seatbelts and airbags, new electrical industry safety standards will keep evolving, requiring adoption and compliance as new information and advances on arc flash prevention and protection continue to emerge. And as they do, knowledge will make all the difference.

For more information on Schneider Electric arc flash mitigation strategies for your future application, contact your nearest Schneider Electric representative.

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