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# Arc Flash Protection

In the beginning of the history of mankind, lightning arc flashes were the only electrical hazard. As electricity was generated to light and power our houses and workplaces, contact with the energized source resulted in shock hazard. As the demand for power grows, compounded by higher fault current potential, arc flash hazards increase electrical safety concerns. Man has learned to avoid lightning and shock hazards, but has he learned how to reduce the risks of this later hazard?

In an effort to understand arc flashes and to protect industrial workers, organizations like the NFPA and IEEE with input from electrical equipment manufacturers have developed guidelines for electrical safety in the work place. They have been addressing arc flash in particular through extensive testing and evaluations of arcs in open air and in enclosures. Their conclusions have helped to predict the amount of energy released during an electrical arcing fault and, thus, to calculate the amount of available energy that results in skin burn at specific distances.

These organizations have published and continue to update their guidelines and recommendations. The manual entitled *IEEE Guide for Performing Arc-Flash Hazards Calculations*, IEEE 1584-2002 is one of these guidelines.

The other guideline is *Standard for Electrical Safety Requirements for Employee Workplaces*, NFPA 70E-2000.

When a facility evaluates its electrical system's arc flash potential, the results of making arc flash calculations are two-fold:

1.) A determination is made of the minimum distance from an arcing fault in which exposed bare skin will not receive an incurable burn. This is called the Flash Protection Boundary, using terminology coined in the NFPA 70E.

2.) Energy levels are identified that could exist due to an arcing fault at various distances from the arc point.

The intent of the evaluation is to restrict any personnel not wearing fire resistant clothing from approaching exposed, energized conductors at a distance *less* than the Flash Protection Boundary. On the other hand, personnel approaching the exposed, energized conductors *within* the Flash Protection Boundary can be protected from burn in suitable Fire Retardant Clothing (FRC) should a fault occur. Additional minimum required PPE is based on a job hazard analysis. See NFPA 70E, Chapter 3.

Implementing Arc Flash Protection will take both time and money. Ideally, this cost may be avoided by simply not working on or near exposed, energized electrical conductors. This approach is certainly encouraged by OSHA in the *General Industry Regulations* (29 CFR Part 1910), Subparts R and S. Simply lock it out!

What are considerations for expending the time and money to provide arc flash protection when work is required on or near exposed, energized electrical conductors?

## Standards and Requirements

The NFPA 70E-2000 safety standard is being reissued as 70E-2003. This document reportedly calls for "A study investigating a worker's potential exposure to arc flash energy. [The study will be] conducted for the purpose of injury prevention and the determination of safe work practices and appropriate levels of PPE". The flash hazard analysis shall determine the flash protection boundary and the personal protective equipment that people within the arc flash boundary must use.

Basic information is required to make the study:

a) Bolted fault current at the location of the exposed, energized conductors
b) Voltage
c) Working distance
d) Time to clear fault

Additional information may be needed; for example, to define whether or not the location is confined within a box.

Altruistic intentions may not motivate the implementation of the NFPA 70E requirements. Workers' safety can be increased by applying the analysis and providing the necessary PPE. The reality of delaying a risk assessment is that the costs of a single injury to a worker by an arc flash can be staggering — in terms of physical pain and long term injuries, and in terms of money to provide medical attention and to compensate for damages. Some examples are given in IEEE 1584.

Either there is some resistance to devote time and money to make the studies, or maybe it is just frustration. In reviewing OSHA's General Industry Regulations (29 CFR Part 1910), Subparts R and S concerning electrical Safety Related Work Practices, it does not appear that arc flash protection is required for employees. At the conference, a question was asked about OSHA's requiring implementation; the response was that NFPA 70E is incorporated by reference into the law. I am not a lawyer and will not pretend to know all of the rules, but NFPA 70E specifically is not included in the list in 1910.6's "Incorporation by reference". The National Electric Code NFPA 70 is included by reference and rule 110.16 which requires electrical equipment to have a flash protection warning label warning label: the fine print note refers to NFPA 70E.

It has been argued that the requirements of NFPA 70E-2003 are to be challenged because the effects of the pressure wave are not remedied by the PPE and, therefore, "the standard does not improve the safety for specifically designated employees" and should not be promulgated as a national consensus standard per 1910.1. Managing an arc flash hazard control program based on the study is a real concern. Implementing the provisions of NFPA 70E reduces the risk and/or extent of worker injury and will be the norm at some point, in my opinion.

## Arc Flash Analysis Program

The *IEEE Guide for Performing Arc-flash Calculations*, IEEE Standard 1584-2002, is based on numerous tests. It provides empirically based calculations for the flash protection boundary and for incident energy at various distances from a fault. Arcing faults occurring in free space and in various enclosures (similar to motor control centers and switchgear enclosures) can be represented.

IEEE provides a software spreadsheet with IEEE 1584-2002 for making arc flash calculations. A number of system analysis software programs can perform the arc flash calculations based on a system study. Making arc flash calculations in association with a system study simplifies the data entry, and minimizes the time necessary to make the calculations. Also, tables are provided in NFPA 70E to estimate incident energy and to determine the required PPE. Employing these tables can be useful in some locations, and may minimize calculation requirements.

Choosing a clearing time based on a system study rather than just guessing at a clearing time provides more meaningful results. One might assume that adding the breaker clearing time to some arbitrary relay operation time will yield accurate predictions of incident energy at a given point. Experience has shown that an accurate determination of system impedances often reduces the fault current and changes the operating point on the protective device, resulting in longer fault duration and significant increases in the incident energy. A calculation at 85 percent of anticipated fault current is recommended just to see if a reduction in fault current significantly affects the incident energy calculation. Changes in the type of a fuse or in relay settings may be beneficial in reducing exposure to workers under fault conditions. The effect of current-limiting fuses in a system may significantly reduce the potential energy produced in an incident. It was recommended to consider changes to a system if a worker could be exposed to incident energy greater than about 37 calories per square centimeter.

Selecting the working distance to use in the study is also a bit confusing. Table 1, which follows, lists approach distances that are given in the OSHA, IEEE, and NFPA standards that were previously mentioned. Most of the studies that I have observed use the working distances identified in IEEE 1584 even though workers are permitted closer approach. We have used the more conservative 18 inches to determine incident energy, and to select PPE.

Signs are available for displaying flash boundary information on electrical equipment as required by 110.16 of the National Electrical Code. See ANSI Z535.4-1998 for guidelines.

## Summary

The release of NFPA 70E-2003 Standard for Electrical Safety Requirements for Employee Workplaces is bound to bring controversy and questions about implementation. I believe that it will also improve safety and reduce injuries for electrical workers that work on or near exposed, energized electrical conductors. ▲

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Table 1
Approach Distances

| | 1910.333 Table S5 *Approach Distance* | 1910.269 Table R-6 *Approach Distance* | NFPA 70E Table 2-1.3.4 *Restricted Approach Boundary* | NFPA 70E Table 2-1.3.4 *Prohibited Approach Boundary* | IEEE 1584 Table 3 *Typical Working Distances* |
|---|---|---|---|---|---|
| 480 Volts | 10.0 Feet | Avoid Contact | 1.0 Feet | 0.08 Feet | 2 Feet |
| 2300 Volts | 2.0 Feet | 2.08 Feet | 2.16 Feet | 0.58 Feet | 3 Feet |