UNDERSTANDING ARC FLASH HAZARD

When an arc fault occurs with personnel in the area, the harmful results can be devastating and deadly for those who are not properly prepared. In addition, equipment damage is usually considerable, frequently resulting in extended down time for the installation. Industry codes and standards have recently included measures to counter the effects of arc flash. These codes and standards help facility operators take preventive steps.

THE ARC FLASH HAZARD

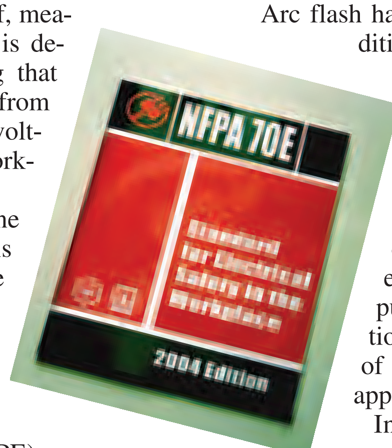
NFPA 70E-2000, Standard for Electrical Safety Requirements for Employee Workplaces, defines arc flash hazard as: "a dangerous condition associated with the release of energy caused by an electric arc". It is an explosion involving an electric arc operating at temperatures of several thousands degrees Celsius and a pressure wave created by the arc. Within a few milliseconds of arc ignition, the energy from this explosion can cause molten metal particles, equipment parts and other loose items to be expelled from the arc area in addition to the expulsion of hot, ionized gas. Extensive equipment damage frequently results in extended down time for an installation. More devastating are the trauma, hearing and eyesight loss and burns to personnel in the area, which can result in catastrophic injuries or even death.

Installed equipment can have a significant impact on the degree of hazard present. When equipment is expected to be serviced or opened while not in an electrically safe work condition, an electrical safety program is required for such maintenance including training, practices and analysis. Guidelines for practices and training are included in OSHA, 29 Code of Federal Regulations Part 1910, Subpart S with "how to" detail in NFPA 70E. NFPA 70E also provides basic information regarding arc flash analysis. IEEE 1584-2002, Guide for Performing Arc-Flash Hazard Calculations, supports NFPA 70E and provides a dependable method of performing the calculations.

Section 110.16 of the 2002 National Electrical Code (NEC) requires switchboards, panelboards, industrial control panels and motor control centers be field marked with a warning of possible flash hazard. Proposals have been made for the 2005 NEC that could require additional marking of the flash protection boundary distance and PPE Category.

FLASH HAZARD PROTECTION

There is only one sure way to protect against the potential devastating effects of arc flash and that is to de-energize the equipment before approaching it for the purposes of opening it or for working on it. NFPA 70E describes several key steps in the process of placing the equipment in an "electrically safe work condition" .Those steps include turning off the supply, locking it off, measuring to verify that it is de-energized, and assuring that stored energy such as from capacitors or induced voltage does not impact workers.



These steps are done while the equipment is not yet considered to be in a safe condition, which requires that appropriate protective precautions including use of personal protective equipment (PPE) are applied during the de-energizing process. PPE includes the clothing, gloves and headwear that help to mitigate the effects of an arc flash event for a worker who is exposed. PPE is generally determined to protect the head and body against thermal effects that would cause severe burn. It does not necessarily protect from the possible impact of any harmful light, sound, or pressure impulses, toxic gas by-products or ejected debris.

PPE is required by OSHA and NFPA 70E for operations that must be done with equipment energized, including the steps to place the equipment in an electrically safe work condition. Both OSHA and NFPA 70E acknowledge that some electrical work must be done with equipment energized when it is either infeasible to de-energize or when de-energizing would cause additional hazards. In those cases in which work is done on energized equipment, there is increased risk of arc flash.

To address those cases, NFPA 70E requires, among other things, that employees who do that work be trained and knowledgeable regarding the task and its hazard, that a specific work plan be made and used and that appropriate PPE be used based on a flash hazard analysis.

ARC FLASH ENERGY

Energy is a critical factor in evaluating the potential effect of an arc flash occurrence. These three definitions from NFPA 70E relate to energy:

Arc flash hazard: A dangerous condition associated with the release of energy caused by an electric arc.

Flash hazard analysis: A study investigating a worker's potential exposure to arc flash energy, conducted for the purpose of injury prevention and the determination of safe work practices and appropriate levels of PPE.

Incident energy: The amount of energy impressed on a surface, a certain distance from the source, generated during an arc event. (Incident energy is measured in Joules/cm2 or Calories/cm2)

The magnitude of energy available during an arc flash event is proportional to the product of the current flowing times the system voltage times the duration of the event. An analysis of the flash hazard must identify these three elements. By raising or lowering any of these elements, the available energy is also raised or lowered proportionally.

Incident energy is determined by the three basic elements (arc current, system voltage and duration). Other factors include system grounding, bus bar spacing, and whether the arc is in a box radiating in a single direction, or in open air radiating in all directions. Components or equipment parts located between the arc and a worker may also provide some shielding from the arc, if these items do not become projectiles.

Overcurrent protective devices including MCCBs have a significant influence on the incident energy. From their position in the system, they impact both the magnitude and the duration of the arcing fault current.

CALCULATION METHOD

A dependable method of performing the calculations is in IEEE 1584, Guide for Performing Arc Flash Hazard calculations. This method is based on extensive testing and solid analytical work. It requires input of the following basic items:

- Accurate bolted-fault current available at the equipment location
- System voltage
- Duration of the arc (clearing time for the overcurrent protective device)
- Whether conductors are enclosed or in open air
- Class of equipment (switchgear, switchboard, motor control center, etc.)
- Whether the system is solidly grounded, impedance grounded or ungrounded
- Distance from worker to conductor
- Gap distance between conductors

The last two items are optional with default values assigned for most common configurations where specific information is not provided.

IEEE 1584 provides equations to output the following information with input of the above items. The complexity of the equations makes solving them by hand difficult. However, IEEE 1584 provides an Excel spreadsheet with each copy of the standard that automatically performs the calculations when basic information is input. This spreadsheet allows multiple calculations to be done rapidly.

SUMMARY

Arc flash is of significant concern as evidenced by requirements in the National Electrical Code, and NFPA 70E, as well as through enforcement by OSHA. Thus, the NEC requires certain equipment to be labeled to warn of possible flash hazards and NFPA 70E requires a flash hazard analysis to determine the degree of exposure a worker may have to hazardous energy. IEEE 1584 provides spreadsheets that can be used to determine the arc flash hazard level in circuits protected by MCCBs.

These spreadsheets take into account MCCB current interruption times which significantly reduce the impact of arc flash hazards. The spreadsheets can be entered using either the known interruption time, or the generic breaker rating, and the background equations relative to the generic rating method have been explained.

Future calculations will need to be refined in order to understand the full benefit of current-limiting MCCBs which reduce the current magnitude and, consequently, further reduce the arc flash hazard. It is also noted that the focus of present calculations has been on the high arc fault levels, whereas it is critical to understand that higher incident energy can result from lower fault current.

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