Preventing Arc Flash Injuries - 03/20/2006 - by Jim White

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By following a few logical steps to develop an understanding of arc flash hazards, you can help to prevent injury to yourself and those around you.

In the electrical industry, and the workplace in general, the phrases "arc flash" and "hazard risk analysis" are generating much interest and attention. Many managers and supervisors are asking "why the interest" and more to the point, many are saying, "I don't see how this affects me or my people. We have never had an arc flash incident."

The best reason for increased awareness and understanding of arc flash hazards is to prevent injuries. At the 11th annual IEEE-IAS Electrical Safety Workshop, statistics presented from a National Institute for Occupational Safety and Health study showed that during the period from 1992 through 2001, there were 44,363 electrical-related injuries involving days away from work. The number of nonfatal electrical shock injuries was 27,262, while 17,101 injuries were caused by electric arc flash burns.

Another fact brought out by the NIOSH study is that electrical burn injuries cause a longer stay away from the job when they do occur. It should be noted that even though burns were 38 percent of the total, they caused a disproportionate number of days from work.

Step No. 1 – The Arc Flash Hazard Analysis

Now that we have the need for protecting our workers from arc flash hazards, what do we need to do? In the area of arc flash protection, the first thing we need to do is determine if a danger exists. The National Electrical Code, also known as NFPA 70E, states in Article 130.3: "A flash hazard analysis shall be done in order to protect personnel from the possibility of being injured by an arc flash. The analysis shall determine the flash protection boundary and the personal protective equipment that people within the flash protection boundary shall use."

So, the first step on the list is to determine if the work being done is within the flash protection boundary (FPB). The FPB can be calculated using the equations given in 70E or by using one of the many software programs, both freeware and commercial, which are available. An Internet search will reveal many of the sources available.

In many cases, especially where the available short-circuit current is 10,000 amps or less, the FPB may only be a few inches. Some examples of low-energy flash protection boundaries (using 9,600 amps of available short-circuit current and protected by a molded-case circuit breaker):

480V - 3 phase 7.1 inches
277V - 1 phase 4.1 inches
208V - 3 phase 4.7 inches
120V - 1 phase 2.7 inches

In these instances, proper PPE would include voltage-rated gloves and protectors, safety glasses or goggles, 12-oz/yd^2 cotton or flame-resistant clothing and safety shoes. The key in these examples is that the available short-circuit current is less than 10,000 amps. If a circuit is fed by an AWG 12 or less wire and is supplied by a general-purpose circuit breaker or fuse (10,000 A interrupting rating), it would match the above figures. If the available short-circuit current is higher, then the FPB will increase as well. More PPE would be required to match the hazard.

Step No. 2 – Gather the Information

The next step is to gather the information needed to perform the calculations. Several pieces of information are required, including:

- Available short-circuit current at the point of contact
- Nominal voltage
- Maximum total clearing time of the protective devices
- Working distance
- Type of ground system being used
- Type of protective device (including model numbers and settings)

This is the same information that is available from your short-circuit analysis and coordination study. Be certain that this information is correct and up-to-date or all your effort from here on out is wasted.

Step No. 3 – Perform an Arc Flash Study

This third step calculates the incident energy that would be received by the worker at the point of contact. The IEEE 1584-2002 Guide for Performing Arc Flash Hazard Calculations can be used to determine the FPB, the incident energy at working distance and the PPE required. It is used as a plug-in for many of the commercially available engineering software packages on the market.

The incident energy provided by the study will be given in calories/cm2. The calories/cm2 provided by the study needs to be reviewed to determine if adequate PPE is available. Incident energy, while quantified in calories/cm2, is defined in NFPA 70E as "the amount of energy impressed on a surface, a certain distance from the source, generated during an electrical arc event. One of the units used to measure incident energy is calories per centimeter squared (cal/cm2)."

One of the issues that often comes up when performing these calculations is that of the working distance. IEEE 1584 provides recommended working distance for use in its calculations, but in real life, we are not that precise. A change of just a few inches can make a tremendous difference in the incident energy received by the worker. This fact can be used when the incident energy is too high for available PPE by increasing the distance from the component or part to the worker. At times, increasing the distance by 6 inches could reduce the incident energy 30 percent or more. This cannot be applied in many situations, but can be for tasks such as racking circuit breakers in and out of their cubicle. Longer racking handles or remote racking devices, which increase the overall working distances, can be used to decrease incident energy to a tolerable level.

Step No. 4 – Choose the Proper PPE

Proper PPE selection is critical to protecting the worker from injury. After performing the incident energy calculations, the cal/cm2 derived must be compared with the PPE being considered. Prior to 2000, there were not clear markings on flash protective equipment to show what the actual arc rating was. After that date, NFPA 70E required that PPE used as arc flash protection be marked with the arc rating in cal/cm2 on the label. Unfortunately, 70E did not specify that the face shield material be rated for the same heat as the rest of the PPE. This was resolved in the 2004 revision of the 70E, which requires that the face shield provide the same arc rating as the rest of the flash protection.

The incident energy received by the worker must be reduced to no more than 1.2 cal/cm2 to the trunk of the body. As an example, holding your finger over a match for 1 second produces approximately 1.0 cal/cm2 of incident energy. On people, 1.2 cal/cm2 is considered to be the amount of heat required to just produce the onset of a second-degree burn to unprotected skin. Even though the worker is wearing arc flash protective equipment, he can still receive burns if the heat is high enough. The heat passing through the PPE can be high enough to melt the elastic in undergarments. A good rule of thumb is to use PPE that has an arc rating equal to or greater than the calculated incident energy.

Step No. 5 – Mark Your Equipment

The 2002 revision of NFPA 70 requires that new equipment be field marked to warn of the hazards if the cover is removed. This is stated in Article 110.16: "Flash protection, switchboards, panelboards, industrial control panels and motor control centers that are in other-than-dwelling occupancies and are likely to require examination, adjustment, servicing or maintenance while energized shall be field-marked to warn qualified persons of potential electric arc flash hazards. The marking shall be located so as to be clearly visible to qualified persons before examination, adjustment, servicing or maintenance of the equipment."

FPN No. 1: NFPA 70E-2000, Electrical Safety Requirements for Employee Workplaces, provides assistance in determining severity of potential exposure, planning safe work practices and selecting personal protective equipment. FPN No. 2: ANSI Z535.4-1998, Product Safety Signs and Labels, provides guidelines for the design of safety signs and labels for application to products.

This applies to all equipment installed after January 2002. Why should we worry about labeling? OSHA has a Multi-Employer Worksite Policy directive (CPL 2-0.124) that makes it clear that the equipment owner (you) are just as responsible for contractor safety as are the contractors. If you allow contractors on your job site, you have approved their safety procedures and policies. Because of this, the smart move is to be proactive, especially where known hazards exist. Your employees, as well as contracted workers, cannot always be counted on to know the hows and whys of arc flash protection. Many workers just don't understand or lack the training and knowledge needed to properly choose the right PPE. Labeling your equipment ensures that those who work on power system equipment will be aware of the shock and arc flash hazard involved and what flash protective equipment is required.

Step No. 6 – Train Your Workers

As I mentioned previously, OSHA and NFPA 70E require that workers be qualified in order to work on or near energized electrical systems. In order for the arc flash study to be effective, workers must be trained in what the labeling means and how to apply the information on the equipment. One of the first things OSHA does during a site inspection or an accident investigation is to review the training records for the company. Lack of training often is cited as a reason for large fines .

Who needs training? Virtually everyone. Unqualified workers must be trained on the hazards of electricity and how to avoid them and qualified workers must meet the above requirements and other specific requirements given in 29 CFR 1910.332 and 29 CFR 1910.269.

Some companies that provide on-the-job training do a poor job of documenting that training. If you don't document it, it never happened. Include the training date, the employee's name and the topics covered, and have the attendee initial or sign saying he actually took the training.

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