# Arc-Flash Evaluations

Since considerable interest exists in the subject of arc-flash evaluations, we thought this would be a good topic for the current issue of *NETA World*.

*Jim White*
*Shermco Industries*

*Ron Widup*
*Shermco Industries*

## What Is the Problem?

Historically, electrical and nonelectrical workers have been aware of the hazard of electric shock. Whether one calls it getting "tingled," "zapped," "buzzed," or worse, people understand the problem. Electric shock is a hazard, but awareness has also been increasing about the additional hazard of heat produced by a short circuit and its effects on the human body. As a point of reference, over 2000 workers a year are sent to burn centers with electrical burns.

The basic problem within the industry is determining the amount of incident energy (thermal heat) to which a worker would be exposed in the event of a short circuit. This issue can be complicated since the degree of incident energy can vary greatly, not only between different pieces of electrical equipment, but within a single piece of equipment. Some of the factors affecting the thermal aspect of a hazard include:

- The color of the enclosure.
- The construction and materials of the electrical conductor.
- The distance between the worker and the arc source (a big factor to incident energy levels).
- Variations in the distance between the arcing terminals as the conductor vaporizes.
- The degree of maintenance performed on the protective devices within the circuit.

Ralph H. Lee, PE, (deceased) published a number of papers on electrical safety, and the hazards associated with electrical work were brought to the forefront. Mr. Lee was the first to develop formulae for estimating the amount of arc energy (incident energy/heat) produced by electrical arcs. He published these results in "The Other Electrical Hazard, Electrical Arc Blast Burns," *IEEE Transactions on Industry Applications*, Vol. 18, No. 3, May/June 1982.

## Where Do Things Stand Now?

Things kind of idled along until OSHA brought out its 29CFR1910.269 and 29CFR1910.335 regulations, and *NFPA 70E, Electrical Safety Requirements for Employee Workplaces,* began bringing them to the attention of the industry. Tables 3-3.9.1, 3-3.9.2, and 3-3.9.3 were published in the 2000 edition of *NFPA 70E*, which for the first time brought the problem into a form everyday electrical workers and their supervisors could understand and implement.

In November 2002, the IEEE published the IEEE Std. 1584-2002, *IEEE Guide for Arc Flash Hazard Calculations*. This guide was produced after staging a series of arc-flash incidents under controlled conditions and measuring the heat produced by them. Empirically-derived models were developed from these tests and the results published. All tests were performed using the "arc-in-a-box" formula since most work done by industrial electricians and technicians is on equipment having enclosures. A Microsoft Excel-based calculator is included with the guide and runs the calculations once data is entered.

Finally, Duke Power Company's "FLUX.exe" computer program, developed by Alan Privette, PE, is a DOS-based program that calculates the incident energy from a single-phase, open-air arc. This program is easy to use and can be modified by use of conversion factors so it can be applied to three-phase, arc-in-a-box arc-flash incidents.

## What a Mess!

One certainly cannot say there's no choice. However, neither Mr. Lee's calculations, the 1584 calculator, FLUX, nor the *NFPA 70E* tables seem to be in agreement at times. This has a tendency to undermine a person's confidence in any of them. Let's look at the various methods individually:

**Mr. Lee's calculations** were the first on the scene. Given that his work is 20 years old, does it hold up in light of today's technology and findings? Actually, even though his methods might be considered somewhat "rough" today, the IEEE 1584 Work Group found his calculations for arcs over 600 volts to be accurate. Not bad, considering that today we use computer modeling and have much more information. For systems under 1000 volts, Mr. Lee's calculations do not hold up as well, in part because arc-in-a-box calculations were not available to him.

**OSHA** doesn't provide much help in determining what to do: 29CFR1910.269(l)(6)(iii) states "The employer shall ensure that each employee who is exposed to the hazards of flames or electric arcs does not wear clothing that, when exposed to flames or electric arcs, could increase the extent of the injury that would be sustained by the employee." 29CFR1910.335(a)(1) states "Employees working in areas where there are potential electrical hazards shall be provided with, and shall use, personal protective equipment that is appropriate for the specific parts of the body to be protected and for the work to be performed." This is great for telling us what generally needs to be done but does not detail specifics.

**FLUX.exe** is easy to use. However, it applies only to open-air, single-phase arcs, although people have suggested various conversion factors to correct for three-phase, arc-in-a-box situations. Many people use and have confidence in this method, and it has stood the test of time. Our experience, however, has been that when multiple correction factors are added, accuracy is difficult to maintain. If FLUX errs on the safe side, workers may wind up wearing so much protective gear they cannot perform the job satisfactorily or safely. Yet if workers are inadequately protected, they could be seriously injured.

***NFPA 70E*** is being updated for 2003, even though it is coming out in 2004. The tables included in the 2000 edition are being carried over to the 2003 edition with some adjustments. These tables have been a boon to electrical workers in the field because they provide a quick, easy reference for determining what protective clothing and equipment may be required. One caveat is that the tables must be applied within their specified ranges. For example, the category, "600V Class Switchgear (with power circuit breakers or fused switches)" refers the user to Note 5, which says "65 kA short-circuit current available, up to 1.0 second (60 cycle) clearing time."

The jobs listed in *NFPA 70E* and the corresponding hazard/risk categories must be within the amount of arc energy created during an arc flash. If less arc energy than this is created during a specific incident (as is typical), it would be reasonable to use the tables. If the arc energy is higher, the worker will be underprotected. In the example given above, it isn't just the 65-kiloampere current that has to be considered, but the clearing time as well. One second is a fairly major clearing time for short-circuit protection, but perhaps no fault protection exists in the circuit or it's not properly coordinated.

**IEEE 1584-2002** is the most recent and most comprehensive guide to arc-flash evaluations, but some have doubts about its accuracy. It has undergone peer-review, but hasn't been available for long in the workplace. Most people will need to use the included calculators to get benefit from IEEE 1584-2002, but the equations are also included in many plug-ins for short-circuit and coordination software.

## What's a Poor Guy to Do?

What's left to do but fall back and punt? Technicians at Shermco have also had to grapple with the various types of methods and what our customers and we should use. Since Shermco performs engineering studies (arc-flash evaluations being one of them), we wanted to take an approach that provides the best protection and will work in a job-site situation.

The direction we've taken is to adapt IEEE 1584-2002 as the primary arc-flash calculation method. This applies any time someone is actively working within the flash protection boundary. However, for certain activities such as racking breakers, we refer to *NFPA 70E* for guidance. We believe this provides a balance of safety for our employees and customers that can be both defensible and logical. Some situations may exist where the arc energy is too high to work at a standard distance (as specified by IEEE 1584-2002). In these cases, moving the worker back some distance may be all that is required to provide him/her the level of protection necessary.

Any method is going to require knowledge of the available short-circuit current, clearing times, and work distance in order to be useful. One can estimate the short-circuit current by calculating what the closest transformer can deliver. Clearing times can be estimated from the IEEE 1584-2002 tables. Work distance can also be estimated, although, given that safety is of paramount importance, perhaps work distance should actually be measured. One other point is of critical importance — the hands will be much closer to the equipment than one's body, and anything at a $90^0$ angle to the arc receives the full arc energy.

## Summary

Employers and technicians should look at the various methods for evaluating arc flash. This science is still coming of age, so some disagreement exists as to which method is best. Whichever method or combination of methods is chosen, be certain it makes sense for the specific job. A lot rides on that decision.

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James R. White is nationally recognized for technical skills and safety training in the electrical power systems industry. He is currently the Training Director for Shermco Industries, a NETA Full Member company. Jim has spent the last twenty years directly involved in technical skills and safety training for electrical power system technicians.

Ron. A. Widup, Executive Vice President/General Manager of Shermco Industries, Inc. has over 20 years of experience in the low-, medium-, and high-voltage switchgear and substation market. He is a principal member of NFPA technical committee 70E (Electrical Safety Requirements for Employee Workplaces) and a member of NEC Code Panel 11. He is past president of NETA and currently a member of the Board of Directors and Standards Review Council. He is certified as a NETA Level IV Senior Test Technician.