

Electrical Safety and Maintenance Training

There is nothing more important to an electrical safety program than to have a staff of technicians who have been properly trained and who are qualified to do their jobs efficiently and safely. Here are a few questions to think about: How do I know that all of my technicians are qualified? Have job/task analysis and hazards analysis been conducted? Do my technicians know what the hazards of electricity are and how to protect themselves? Have I conducted a needs assessment? Do I have a current job description for each of the crafts? So many questions; do you have any answers? You might be asking at this point, where do I start?

Before any significant training can take place, an assessment must be conducted to determine what is needed. The needs assessment involves relevant company personnel who are aware of the job requirements and all applicable codes, standards, and regulations. Information that is collected will provide insights into any past or present performance problems that must be addressed in the training program. This process can also be used to determine whether or not training is the solution to any problems that may exist. There may be other factors that might affect performance that must be recognized and considered. These other factors could include the quality of procedures, human factors, management style, and work environment. Any one or all of these factors may affect job performance and safety.

Training and Qualification Analysis

The results of the needs assessment should provide a good starting point for the job/task and hazards analyses and ultimately the design, development, implementation, and evaluation of the training program that will be needed in order to qualify your technicians. Another benefit to all this is that you will have a well defined job description for your technicians. This can also be extremely beneficial when it comes time to hire additional technicians because you have also developed a job description for posting an ad for employment.

You might be asking the question: Why do I need to do all of this? My technicians know what they are doing because they have many years

By Dennis K. Neitzel, CPE

of field experience. The answer to this is found in NFPA 70E-2004, Article 205, "General Maintenance Requirements", Section 205.1, "Qualified Persons", which states: "Employees who perform maintenance on electrical equipment and installations shall be qualified persons as required in Chapter 1 and shall be trained in, and familiar with, the specific maintenance procedures and tests required." Chapter 1, Article 100 defines a qualified person as: "One who has skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training on the hazards involved." When evaluating the qualification level of employees, remember there is a difference between ten years of experience and one year of experience repeated ten times. What classroom and on-the-job training have they received? Was the effectiveness of the training measured to ensure comprehen-

sion? Were they required to demonstrate proficiency in the work practices involved?

The quality and extent of the training program is extremely important. Studies in retention indicate that the average person will retain:

- 10 percent of what they read (books and other written course materials)
- 20 percent of what they hear (lecture)
- 30 percent of what they see (illustrations – “a picture is worth a thousand words”)
- 50 percent of what they see and hear (demonstrations and/or video)
- 70 percent of what they say (discussion – two-way communication)
- 90 percent of what they do and say (hands-on training – demonstrate proficiency)

The more extensive the training program the better qualified the employee. As can be seen by the percentages above, the most effective training programs include a combination of lecture, demonstration, and hands-on instruction. As an example, an employee attends a class on circuit breaker maintenance and testing using the following agenda: (1) the instructor explains, in lecture and discussion, all of the maintenance and testing techniques; (2) the instructor then demonstrates those techniques on a circuit breaker; and (3) the employee performs hands-on maintenance and testing of the circuit breaker using the techniques that were presented, discussed, and demonstrated. In this example, employees, on average, would retain at least 90 percent of what they were taught. This method of training has proven to be the most effective means for qualifying employees.

All this takes us back to the job/task and hazards analyses. The only way to really know whether or not an employee has been properly trained and qualified is to perform a job/task analysis as well as a hazards analysis. To do this, carefully study and record each step of a job, identify the tasks and elements that make up the job, identify existing or potential job hazards, and determine the best way to perform the job along with reducing or eliminating the hazards.

The job hazards analysis can accomplish a great deal toward reducing accidents and injuries in the workplace, but it is only effective if it is reviewed and updated periodically. Even if no changes have been made in a job, hazards that were missed in an earlier analysis may be identified while performing the individual tasks.

Any time a job/task or hazards analysis is revised, training in the new job methods or protective measures must be provided to all employees affected by the changes. Job/task and hazards analyses can also be used to train new employees on job steps and

hazards.

The Hazards of Electricity

In order to fully comprehend the requirements for an effective technician training and qualification program, we must first have an understanding of the hazards of electricity. All of the studies reviewed have revealed three major hazards of electricity which are electrical shock, electrical arc-flash, and electrical arc-blast. Each of these hazards will be addressed as to the physiological effect on the human body.

Electrical shock

It takes a very low value of current flowing through the human body to cause death or serious physical harm. Many studies have been performed in this area with different values of current that causes each effect. The following chart shows average values of current and the effects as taken from the published studies:

| Current | Effect |
|---------------|---|
| 1 mA | Barely perceptible |
| 1-3 mA | Perception threshold (most cases) |
| 3-9 mA | Painful sensations |
| 9-25 mA | Muscular contractions (can't let go) |
| 25-60 mA | Respiratory paralysis (may be fatal) |
| 60 mA or more | Ventricular fibrillation (probably fatal) |
| 4 A or more | Heart paralysis (fatal) |
| 5 A or more | Tissue burning (fatal if vital organ) |

Physiological Effects of AC Current on the Body

Electrical arc-flash

There are two different issues with this hazard, the arc temperature and the incident energy. The main concern with the arc temperature is the flash flame and ignition of clothing. At approximately 203⁰F (96⁰C) for one-tenth of a second (6 cycles), the skin is rendered incurable or in other words a third-degree burn. Onset of a second-degree burn occurs with only 1.2 cal/cm² of incident energy. It does not take a very high temperature or very much energy to cause extreme pain and discomfort or even death to the employee.

Electrical arc-blast

The pressures developed by an electrical arc can be extremely high. One study noted that copper, when vaporized, expands at a factor of 67,000 times, which one expert estimated was the same expansion as that produced by dynamite. Doors or covers must be securely latched before operating a switch or circuit breaker. Technicians or operators must place their

body in the safest position possible before operating the equipment. Never stand directly in front of electrical equipment when it is being operated, racked-in, or racked-out.

Regulatory Requirements

Although proper training and qualification of employees is the right thing to do, many employers have stated that training is just too expensive or that their employees know what they are doing and therefore don't need any additional training. These same employers have also stated that they will do it only if they have to. OSHA has provided strict guidelines for safety training that go hand-in-hand with the qualification of an employee. Training is an *OSHA mandate* for all employees who are required to work on or near exposed energized circuits and parts of electrical equipment, operating at 50 volts to ground or more. The following quotes are provided in order to inform the reader that training is not an option, and to assist in gaining a better understanding of these mandates:

OSHA 29 CFR 1910.269(a)(2) "Training. (i) Employees shall be trained in and familiar with the safety-related work practices, safety procedures, and other safety requirements in this section that pertain to their respective job assignments.

OSHA continues with this requirement by requiring qualified employees to be trained and competent in:

- The skills and techniques necessary to distinguish exposed live parts from other parts of the equipment
- The skills and techniques necessary to determine the nominal voltage of the circuits and equipment
- The minimum safe approach distances to exposed live parts
- The proper use of:
 - Special precautionary techniques
 - Insulating and shielding materials
 - Insulated tools and test equipment
 - Job planning

In addition to this, OSHA states that a person must have this training in order to be considered a qualified person. The employer is also required, through regular supervision and annual inspections, to verify that employees are complying with the safety-related work practices. Additional training or retraining may be required for any of the following:

- The supervision or annual inspection indicates noncompliance with or lack of understanding of

the work practices

- New technology
- New types of equipment are installed
- Changes in procedures
- Employee is required to use work practices that they normally do not use

OSHA also considers tasks that are performed less often than once per year to necessitate retraining before the performance of the work practices involved. This retraining may be as simple as a detailed job briefing prior to the commencement of the work or it may require more in-depth classroom instruction along with on-the-job training.

Note the statement above that requires the employee to demonstrate proficiency in the work practices involved. The best way that the employee can demonstrate proficiency is to actually do the work after receiving the training or as part of the training. Hands-on training would be required in order to accomplish this OSHA requirement.



Hands-On Training

The OSHA Electrical Safety-Related Work Practices regulation, 29 CFR 1910.331-.335, Electric Power Generation, Transmission, and Distribution, 29 CFR 1910.269, and NFPA 70E-2004, Section 110.6, all have similar requirements for training.

As can be seen by the above statements, proper training is a vital part of the worker's safety and proficiency as well as being a mandated OSHA requirement.

Conclusion

Electrical power systems today are often very complex. Protective devices, controls, instrumentation, and interlock systems demand that technicians be trained and qualified at a high technical skill level. Safety and operating procedures utilized in working on these systems are equally as complex, requiring technicians to be expertly trained in all safety practices and procedures.

OSHA Regulations require employers to document that employees have demonstrated proficiency in electrical tasks. Employers must certify that their employees are qualified and that this certification is maintained for the duration of the employee's employment.

Dennis K. Neitzel, CPE, is the Director of AVO Training Institute, Inc., Dallas, Texas and is a Principle Committee Member for the NFPA 70E, Standard for Electrical Safety in the Workplace. He is also co-author of the Electrical Safety Handbook, McGraw-Hill Publishers. Please contact Mr. Neitzel at dennis.neitzel@avotraining.com for more information.