How to Develop an Effective Training Program
(Training electrical maintenance employees to be qualified)

By Dennis K. Neitzel

The question is often asked; "How do I develop an effective training program?" This has always been a mystery, especially to someone who has not been formally trained in curriculum development. This article will address some of the basic concepts for developing a training program and will provide a good starting point for most companies. There are literally volumes of material and information on how to develop effective training programs on the market today. This article is not attempting to address all of the philosophies surrounding curriculum development; however, it will address most of the basic concepts.

The typical method utilized for developing an effective training program is the "Systematic Approach to Training" or SAT, which utilizes the "Instructional Systems Design" or ISD methodology for performing the analysis, design, development, implementation, and evaluation for a training program in order to meet the specific needs of a company. The ISD provides a systematic procedure for identifying the job-related skills and knowledge necessary for performance-based training.

The analysis phase of the ISD will be the primary focus of this article and will address several key elements which include the requirements for a qualified person, as well as conducting a needs assessment, job/task analysis, and job hazards analysis. Combined, these elements should provide the majority of information that would be needed to develop the training programs necessary for qualifying maintenance employees.

Qualified Person Requirements

Before the needs assessment and job/task analysis can be properly conducted the requirements for qualifying employees must be established. These OSHA mandated requirements establish the foundation for training and qualifying maintenance employees and must be considered when conducting the needs assessment as well as the job/task analysis.

Early editions of the National Electrical Code® (NEC) and OSHA 29 CFR 1910.399 defined a "Qualified Person" as: "One that is familiar with the construction and operation of the equipment and the hazards involved." [1] OSHA also states that "qualified persons are intended to be only those who are well acquainted with and thoroughly conversant in the electric equipment and electrical hazards involved with the work being performed." [2] The 2005 Edition of the NEC expanded this definition and now requires a qualified person to be "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." [3]

Since one of the three qualification requirements is to receive safety training on the hazards of the equipment, it must be addressed specifically. OSHA has provided strict regulations for safety training that go hand-in-hand with the qualification of an employee. The following information is provided in order to clarify the OSHA mandates for training employees in the electrical field.

OSHA 29 CFR 1910.269(a)(2)(i) requires employees to be trained in and familiar with the safety-related work practices, safety procedures, and other safety requirements as it pertains to their respective job assignments. OSHA also requires employees to be trained in any other safety practices, including applicable emergency procedures that are related to their work and are necessary for their safety.

Qualified employees are required to be trained and competent in:

- Skills and techniques necessary to distinguish live parts for other parts of the equipment
- Skills and techniques necessary to determine the nominal voltage
- Minimum approach distances to live parts
- The proper use of:
  - Special precautionary techniques
  - Insulating and shielding materials
  - Insulated tools and test equipment
  - Job planning

OSHA states that a person must have this training in order to be considered a qualified person. They also require the employer, through regular supervision and annual inspections, to verify that employees are complying with the safety-related work practices. Additional training or retraining may also be required if:

- The supervision or annual inspection indicate non-compliance with work practices
- New technology
- New types of equipment
- Changes in procedures
- Employees are 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.

All training is required to establish employee proficiency in the work practices and procedures. In fact, OSHA requires the employee to demonstrate proficiency in the work practices involved before the employer can certify that they have been trained. [4]

Note the statement that requires the employee to demonstrate proficiency in the work practices involved. The only way the employee can demonstrate proficiency is through a written exam and/or to actually do the work after receiving or as part of the training. Hands-on training would

be required in order to accomplish this OSHA requirement (see Fig. 1) [11].

Figure 1
Hands-On Low-Voltage Circuit Breaker Training

The OSHA Electrical Safety-Related Work Practice regulation, 29 CFR 1910.331-.335 [6], provides the same basic requirements as 1910.269 for training qualified persons. These same training requirements are also found in the NFPA 70E-2004, Standard for Electrical Safety in the Workplace. [9]

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.

Needs Assessment

Now that it is understood who a qualified person is and why they must be properly trained, the next step is to determine what the specific needs are. The needs assessment is required before any significant training can be developed and implemented. This 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. Other factors, which affect performance, must also 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.

The needs assessment should include, but not be limited to, an in-depth review of the following:

- Standard Operating Procedures (SOP)
- Department Procedures
- Technical Specifications/Standards
- Job Questionnaires
- Organization Charts
- Operating Logs
- Qualification Standards
- Unusual Occurrence Reports (UOR)

Review of these documents has a twofold purpose: 1) It enables the evaluator to learn about the general nature of the jobs being assessed, and 2) It tells the evaluator how much of the analysis has already been done. [10]

The information collected during the needs assessment will provide the starting point for the job/task and hazard analysis and ultimately the design, development, implementation, and evaluation of the training program that meets the specific needs of a company.

Job/Task Analysis and Job/Task Hazard Analysis

This section will address the final two elements of the analysis phase of the ISD. Establishing proper job procedures and training programs is one of the benefits of conducting a job/task analysis (JTA), as well as a job hazard analysis (JHA). 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. [10]

Job/Task Analysis

A review of the information collected during the needs assessment will help to write the initial job description. The description should contain the following components [10]:

- Job Title
- Qualification requirements for the job
- General description of job requirements
- Description of the job position within the organization, including lines of supervision and assistance available to the employee.
- Description of job environment
- Listing of tools and equipment used in the job
- Listing of resource documents and references used in the job
- Inventory of tasks

The most difficult part of the job description to develop is the task inventory, which is a listing of all tasks that make up the job.

A task is defined as an observable, measurable unit of work which has a definite beginning and end. A task can be a performed in a relatively short period of time (i.e., minutes, hours, or days), and is independent of other actions. Figure 2 contains guidelines for writing task statements [10].

REQUIREMENTS		EXAMPLE
Clarity	Use wording that is easily understood.	"Compare written description to actual performance." **NOT** "Relate results to needs of field."
	Be precise. Use words that mean the same thing to all personnel in the job classification.	Minimize the use of vague words like "check, coordinate, assist".
	Write separate, specific statements for each task.	"Supervise file." "Maintain files." **NOT** "Have responsibility for maintaining files."
Completeness	Use abbreviations only after spelling out the term.	"Closed Cycle Cooling System (CCCS) may be followed by "Start up the CCCS."
	Include both form and title number when the task is to complete a standard form, unless all that is needed is the general type of form.	"Complete Task Description Worksheet (Form No. XXX)."
Conciseness	Be brief. Short phrases are preferred.	"Write production and control reports." **NOT** "Accomplish necessary reports involved in the process of maintaining production and control procedures."
	Begin with a present-tense action word (subject "I" or "you" is understood).	"Clean" or "Write."
	Indicate an object of the action to be performed.	"Clean **engine**." "Write **report**."
	Use terminology that is currently used on the job.	"Use most recent NRC documentation."
Consistency	Avoid stating a person's qualifications, such as experience or education.	"Load computer tape." **NOT** "Has one year computer training."
	Omit items on receiving instruction, unless actual work is performed during training.	"Give instruction." **NOT** "Attend lecture."

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Figure 2
Guidelines for Writing Task Statements

Tasks themselves are made up of discrete, manageable steps, or elements. Elements may or may not require sequential performance. To avoid confusing tasks and elements with one another, the evaluator should remember the following distinctions:

- A task is *always performed* for its own sake in the job situation. An element *never is*.
- Each task is *independent* of other tasks. Each element is *dependent* on other elements. An element is relatively meaningless outside the group of elements that make up a task.

When organizing task lists, the evaluator may sometimes find it helpful to categorize groups of tasks into duty areas. For example, a facility electrician may have duties in electrical utilization equipment and systems, power generation, distribution equipment and systems, and substation maintenance and testing.

All of the duty areas and tasks performed by a single worker comprise a job. A facility electrician is an example of a job. Figure 3 illustrates the hierarchical arrangement of these terms [10].

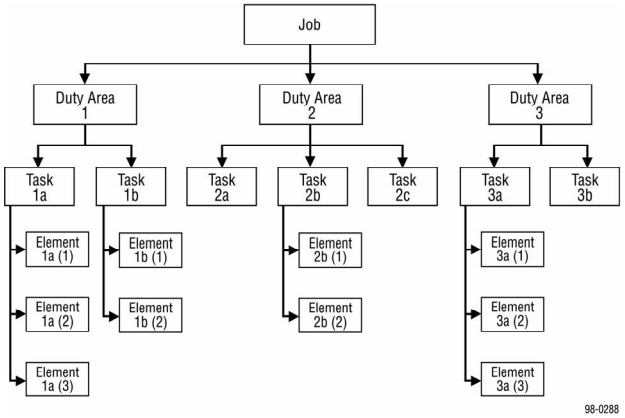

Figure 3
Hierarchical Arrangement of Jobs, Tasks, and Elements

The next step is to verify the accuracy of the job description by interviewing/surveying job incumbents. The primary concerns of the verification process are to ensure that:

1) All tasks performed by all levels of personnel, who do the job, are included in the task list, and
2) The task statements are consistent with the guidelines in Figure 2.

It is important to consult a number of different people in the verification process, since different individuals will paint different pictures of the job.

The interview/survey is intended primarily to verify with job incumbents the accuracy and validity of the task list. Do the tasks reflect the job as it really is? For the tasks that do, the job incumbent is asked to assess ratings in the following categories:

- Importance
- Difficulty of performing
- Difficulty of learning
- Frequency of performing
- Time spent performing

The rating system is based on Figure 4, and the results for all tasks are compiled on the Figure 5 form [10].

TASK RATING SYSTEM

IMPORTANCE OF TASK

Minimum: 1. Consequences of improper performances are "negligible"
2. Consequences of improper performances are "low"
3. Consequences of improper performances are "about average"
4. Consequences of improper performances are "high"
Maximum: 5. Consequences of improper performances are "extremely high"

DIFFICULTY OF PERFORMING TASK

Minimum: 1. "Very easy" to perform
2. "Somewhat easy" to perform
3. "Moderately difficult" to perform
4. "Very difficult" to perform
Maximum: 5. "Extremely difficult" to perform

DIFFICULTY OF LEARNING TASK

Minimum: 1. "Easy" to learn
2. "Less difficult" to learn
3. "Difficult" to learn
4. "More Difficult" to learn
Maximum: 5. "Extremely difficult" to learn

FREQUENCY OF PERFORMING TASK

0. Never
Minimum: 1. Rarely
2. Seldom
3. Occasionally
4. Often
Maximum: 5. Very often

RELATIVE TIME SPENT PERFORMING TASK

0. Never
Minimum: 1. 0 – 20% of time
2. 20 – 40% of time
3. 40 – 60% of time
4. 60 – 80% of time
Maximum: 5. 80 – 100% of time

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Figure 4
Task Rating System

Job Position: _____

Tasks	IMPORTANCE OF TASK	DIFFICULTY OF PERFORMING TASK	DIFFICULTY OF LEARNING TASK	FREQUENCY OF PERFORMING TASK	RELATIVE TIME SPENT PERFORMING TASK	Comments

Note: Use this table to summarize the assessment data collected during the job analysis interviews.

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Figure 5
Task Assessment Summary

Tasks that, according to the interview/survey, do not belong on the list are omitted from the job description. Those that were incorrectly stated are rewritten. Any vital tasks that are overlooked are added to the list and assessed.

Next, the revised task listing is submitted for assessment and validation to the management of the referent organization. The same procedure as that described for job incumbents is used. Again, the listing is revised as necessary.

The next step is to select tasks for training/detailed analysis. This is a critical step because it obligates resources for both curriculum development and actual training.

Four criteria are used in the process of selecting tasks for training/detailed analysis:

1) The percentage of incumbents performing the task
2) Average rating of task importance
3) Average rating of task difficulty
4) Average rating of frequency of task performance

Numbers for each criterion are based on the interview/survey results.

Figure 6 is a flowchart that can serve as a general guide in the task selection process. Each task is put into the chart on the left, branching according to its difficulty, importance, and frequency. The task output is on the right at one of the 18 positions shown. Each position reads either "Train Extensively," "Train," or "Don't Train."

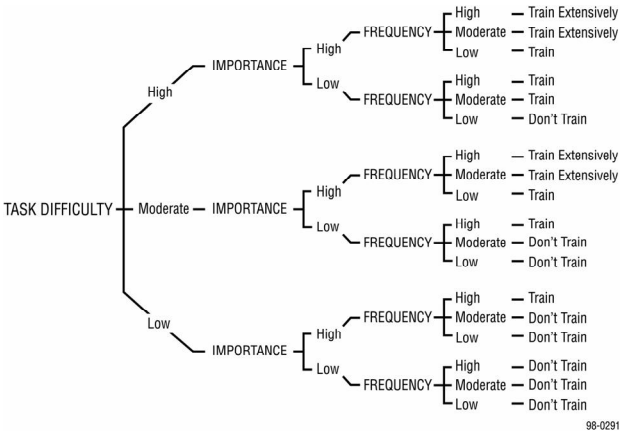

Figure 6
Criteria for Selecting Tasks for Training

For a task with a "Don't Train" output in Figure 6, no formal training is required; often, a trainee can learn the task while performing the job. "Train" requires some type(s) of formal training such as classroom lecture, on-the-job training, training manuals, etc. "Train Extensively" requires more intensive formal training [10].

This essentially concludes the job analysis phase of the job/task analysis. The task analysis must now be conducted. The principal purpose of the task analysis is to determine the skills and knowledge, which the job incumbent must have in order to perform tasks safely and efficiently. The recommended method for obtaining task analysis information is to interview Subject Matter Experts (SME).

A skill is defined as an action required in order to perform a task that involves coordination of body movements. In a sense, it is nothing more than the application of a worker's knowledge. Knowledge is defined as an understanding of facts, principles, or concepts, including the cognitive process necessary to process information.

Task analysis involves much more than pinpointing required skills and knowledge for the task. It focuses on all-important aspects of the task, including:

- All the steps or elements required for task performance
- The conditions under which the worker must perform the task
- Standards for adequate performance

An integral part of the analysis phase is continuing evaluation. Data collected must be evaluated regularly for consistency with changes in the needs of the facility and personnel.

It is important to note that the information from the job/task analysis does not necessarily include all steps for every job in the industry. It is important that the analysis be conducted for every job function in the company in order to identify all of the steps necessary to work efficiently and safely.

The following is a summary of the recommended steps for conducting a Job/Task Analysis:

- Review available job information using existing procedures, standards, reports, etc., to learn the general nature of the job.
- Write an initial job description. The most difficult part of the job description to develop is the task inventory, which is a listing of all tasks that make up the job.
- Identify the tasks. A task is defined as an observable, measurable unit of work.
- Organize task lists. The evaluator may sometimes find it helpful to categorize groups of tasks into duty areas. The tasks performed in a given duty area, by a worker(s), would comprise a job.
- Select tasks for training and/or detailed analysis.

Job/Task Hazard Analysis

A job/task hazard analysis can provide a great deal of information and direction toward reducing accidents and injuries in the workplace, but it is only effective if it is reviewed and updated periodically. The frequency of review and update will vary from weeks, months, or even years. OSHA identifies several areas to be considered that would require review and update, which include; new technology, new types of equipment, or changes in procedures. [4] Even if no changes have been made in a job/task, hazards that were missed in an earlier analysis could be detected. It is recommended that at least an annual basic review be conducted; in fact, OSHA requires several annual reviews such as for energy control procedures [7] and for work on electric power generation, transmission, and distribution lines and equipment. [4]

The following are the recommended steps for conducting a Job/Task Hazard Analysis:

- Select jobs/tasks for analysis and prioritize them by hazardous conditions and frequency performed.
- Before beginning the job/task hazard analysis, look at the general conditions under which the job/task is to be performed and develop a checklist.
- Most jobs/tasks can be broken down into steps.
- After you have recorded the job/task steps, examine each step to determine the hazards that exist or that might occur.
- Determine the probable cause of the hazards.
- Recommend safety procedures and personal protective equipment (PPE).
- Revise the Job/Task Analysis as necessary based on the hazards.

Performing a "hazard analysis' is not an option. OSHA 29 CFR 1910.132(d)(1) requires that *"The employer shall assess the workplace to determine if hazards are present, or are likely to be present, which necessitate the use of personal protective equipment (PPE)"* [8]

NFPA 70E-2004 specifically requires a "Shock Hazard Analysis" and a "Flash Hazard Analysis" be performed to determine the level of the hazards and to establish the "Shock Protection Boundaries" as well as a "Flash Protection Boundary" in order to properly select personal protective equipment and clothing for employees that may be exposed to these hazards by working within the established boundaries (see Fig.7 & 8) [9] [11].

Figure 7
Flash Hazard Analysis Determines the Level of Protection Required on this Motor Control Center (Category 2, 8 cal/cm^2)

Figure 8
Category 4, 40 cal/cm^2 protection required for this Low-Voltage Circuit Breaker Cubicle work, based on the Flash Hazard Analysis

In addition to this assessment OSHA also requires, under 1910.132(f)(1), that: *"The employer shall provide training to each employee who is required by this section to use PPE."* [8]

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

Training Methods Overview

OSHA has provided the industry with several good mandated reasons for the training and qualification of employees. There are also many benefits to having well trained and qualified employees. One of the major benefits expressed by industry is the reduction of unscheduled down time. Another major benefit is the safety of each of their employees. The more extensive the training program the better qualified the employee. It has been proven that the most effective training programs include a combination of lecture and hands-on instruction. As an example; an employee attends a course on circuit breaker maintenance and testing using the following agenda:

1) The instructor explains, in lecture, 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 and demonstrated.

In this example, employees, on average, would retain at least 90% of what they were taught. This method of training has proven to be the most effective means for qualifying employees.

Performing a thorough needs assessment and then conducting an in-depth job/task and hazard analysis will provide the required information for developing a comprehensive training program. This process will provide the means to properly train electrical maintenance employees to be qualified.

Conclusion

The goal of any training program is to develop and maintain an effective and safe work force. Utilizing the SAT and ISD methodology can help accomplish this goal.

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. OSHA's intent here is to ensure that the training is well documented; a notation in the employees training record would suffice for in-company training. If the employee attends training outside of his/her company, a Certificate of Completion would serve as acceptable documentation that the training was successfully completed. A copy of the certificate should be maintained in the employees training record.

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