Safe Work Practices: A Real World Implementation

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***Abstract*—New regulations require electrical safety training for virtually everyone except secretaries and janitors. A program that has been successfully used for non-electrical, non-engineer personnel is described. The types of hazards are identified. The reasons, concerns, fears, and alternatives are presented with case histories and common pitfalls. The equipment terminology and hands-on experience provide insight into a real world environment.**

I. Introduction

In the present work environment, there is considerable interest in safe work practices around electrical equipment. Much of the concern is for non-electrical workers that may become exposed to electrical systems in their normal activity.

With the legal impetus [1, 2] and the corporate structure of many companies, it is easy to become bogged in rhetoric and paper shuffling. It is imperative that we not lose sight of the purpose of work safety. The people must be the primary consideration for any practices established in the work place.

Electrical safety must be addressed in at least three different contexts. The training and response to each of these is very different.

High energy hazards involve arcs and flashes that may result in burns. These are primarily thermal effects. The person must be in proximity but need not touch the equipment to be exposed to the hazard.

The distance depends on the capacity of the source. The maximum available arc power in watts is one-half of the maximum bolted fault volt-amperes at a given point. Fig. 1 shows the distance from a source versus the capacity rating which will cause a hazardous burn in 0.1 sec [3].

Distance (in)	MVA (all voltages)
20	0.54
24	0.78
30	1.21
36	1.75
60	4.86
120	19.4

Fig. 1. Distance—capacity of burn sources.

Arcing creates a very high temperature in the range of 20,000°K (35,000°F). A correlation between much lower temperatures and time of exposure for the skin is shown in Fig. 2 [3, 4] at the top of the next page. Only with distance of separation and appropriate protective clothing can the phenomenal high source temperatures be reduced to a level that the body can tolerate.

Shock hazards are those that cause transfer of electrical energy into the body. These are primarily nervous and muscular responses. The person must come in contact with an electrical circuit to be exposed to the hazard. Above a threshold voltage, the hazard is primarily dependent on the current flow in the body as shown in Fig. 3 [5].

Radiation hazards are passive reactions. These may arise without any awareness of exposure. These hazards are not normally within the workers purview. Other documents identify the practices in this burgeoning area [6].

Clothing hazards may be a result of electrical difficulties. The clothing may melt or burn resulting in additional problems. Although not a hazard in itself, clothing is an important consideration for any electrical safety equipment.

The safety considerations are addressed in a program that has been successfully used. Case histories and examples of common pitfalls relate actual experiences that are typical of many work-places.

II. Reasons

Most people are not familiar with electrical concepts. As a result they create or tolerate potentially hazardous conditions. Independent of regulatory requirements, there is a social, ethical, and moral obligation to reasonably protect people and to provide them with adequate information to protect themselves. In addition, there are laws in many jurisdictions which require that safe practices are instituted in routine operation.

One company has taken a very aggressive position in electrical training for their non-electrical operators. Their program will be evaluated in some detail.

Electrical systems have become a part of almost every commercial and industrial installation. This creates the necessity for electrical safety of virtually everyone except secretaries and janitors. Even these employees are involved if low voltage power devices are included. A preview of grounding, extension cords and overloading circuits should be a part of their normal job training.

Safety away from the work place affects performance and quality of life. Therefore, this facet must also be included in any successful safety considerations. Hence, everyone must have a fundamental understanding of electrical safety. As the exposure increases, the level of training and understanding necessarily increases.

It is not long-term effective to take a negative approach to safety. Simply stating "don't do that" sparks the naturally

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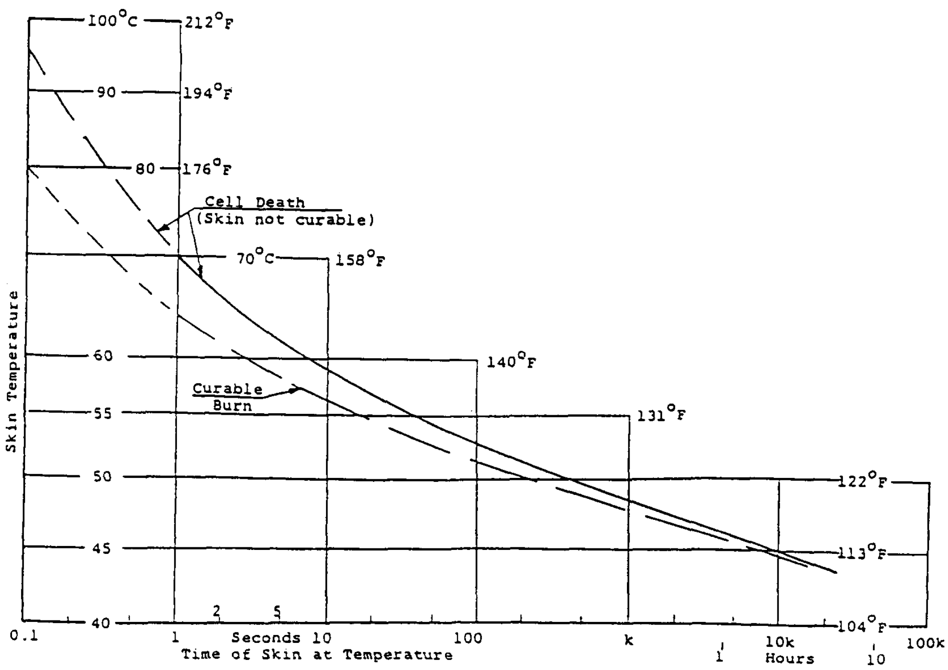

Fig. 2 Effect of time and temperature on skin.

Current (Amps)	Physiology Effect
.001	Sensation to mild shock
.008	Painful shock to most people
.015	Paralysis of muscles-can't let go-breathing restarts if circuit broken
.020	Possible damage to nerve tissue and blood vessels
.050	Onset of ventricular fibrillation
.10	Death probable

Fig. 3. Effects of current on the body.

inquisitive nature. It also leaves room for doubt in situations not precisely addressed.

A more successful long-term procedure is to provide basic understanding. Then give the individual an active part in the safety process.

The best tool to achieve understanding is hands-on experience. Other active visuals can be beneficial. Passive processes such as watching a film and reading are less effective. If these are used, there must be a forum for asking questions and getting reasonable answers from qualified instructors.

III. Concern

There has traditionally been considerable concern about providing non-electrical employees with electrical training.

There is a fear that a little knowledge is dangerous. This assumes a person with some knowledge will be more inclined to take unwarranted risks. With proper education about risks, abilities, and limitations, it has been shown this apprehension is unjustified.

Another concern is that electrical training will raise legal exposure. This assumes the person would come under consideration as an authorized electrical personnel. With appropriate training in relationship to the job, this concern is not valid.

Another concern is that electrical training will necessitate an enhanced job description for the employee. When the training is provided in the context of performing the present job safely and effectively, this potential problem is also resolved.

IV. Program

The amount of training required is directly related to the exposure level. Furthermore, with enhanced training, the expectation from an employee can be increased. This is not a change in job description, but a change in the effectiveness of accomplishing the task.

An electrician that works on energized 12,000 volt lines obviously needs more training than a painter that may be near the wiring entering a building.

The requirements for an operator come in the middle ground. The operator is not qualified as an electrician. However, he is required to start and stop large horsepower motors. In addition, the job includes changing fuses. By necessity, this is performed on de-energized equipment. Regardless, energized lines still exist above the safety disconnect switch in the control panel.

This job practice has been safely used in the industry for over forty years. Nevertheless, as with most practices, consistency of performance is achieved only with adequate training and a defined procedure such as a check-list.

The amount of time required to reach a safe proficiency level depends on the background of the worker and the quality of the instruction. Although much shorter time can be used, one

Day	Topics
Monday AM&PM	Fundamentals, terminology, equipment descriptions
Tuesday AM	Safety tool usage, checklist
Tuesday PM	3-in-group practice on demo equip Alternate group problem solving Grounding and wiring methods
Wednesday AM	3-in-group practice on field equip Other group observe safety videos
Wednesday PM	Fuse performance/motor operation
Thursday AM	Individual field test with instructor
Thursday PM	Controls
Thursday Even	Remedial training for discrepancies
Friday AM	Hazards and response, shock, fire

Fig. 4. Training program.

Concept	Measured	Fluid	Electric
Driving potential	across	pressure	voltage
Quantity moved	through	flow rate	current
Duration	difference	time	time

Fig. 5. Electrical analogs.

Concept	Perceived	Fluid	Electrical
Ratio	opposition	friction	impedance
Product	accomplish	power	power
Events time	difference	elapsed	power factor

Fig. 6. Electrical calculations.

group expanded their program to one week. A significant part of the effort was in hands-on practice.

Fig. 4 is an outline of the week's routine and provides an overview of the program [7].

V. Terminology

A major safety problem arises through a misunderstanding of terms and concepts. This is particularly true for electrical items.

Most individuals are apprehensive about electricity primarily due to a perceived hazard and a confusion in terminology. Electricity is not comprehensible through the normal five senses. One cannot see, smell, taste, hear or feel electricity but one time. Electrical items must be compared to other known, tangible ideas.

The best analogy correlates the electrical activity to fluid movement. There is no loss in technical accuracy using analogs. Since there are only three items that can be measured, the comparison is straightforward.

The comparison carries even farther since there are only three basic terms to calculate. These are ratio of potential and flow, product of potential and flow, and difference in time between events.

The fundamental calculations can be expressed in equation form. For most safety training, no more complex calculations will be encountered.

$$\text{Ratio} = \text{Impedance} : Z = V/I$$
$$\text{Product} = \text{Power} : S = V * I*$$
$$\text{Difference} = \text{events} : \text{Time1} - \text{Time2}$$

Power factor is a term many have heard, but few comprehend. It can be explained as the difference in time between the voltage (pressure) and the resulting current (flow rate).

One additional point generally aids in electrical understanding. Electrical energy is not used directly. Electricity is only used to transfer energy from one type energy converter to another converter. For example, a generating plant may convert natural gas energy to rotating mechanical energy, which in turn is converted to electrical energy. This electricity is transferred by power lines to another energy converter such as a motor. The motor converts the electrical energy to rotating mechanical energy for use.

VI. Equipment

With the basic terminology, the operation of the motor and control panel can be completely described. The control panel functions and component sizes are necessary ingredients if the operator must enter the control panel.

The first value the operator must know is the motor current. This value determines the size of control panels, fuses, overloads, wire, transformers, and capacitors. Once the operator understands this concept, it becomes straight forward to determine if correct safety items such as fuses and grounds are installed.

Having to use tables for look-up of information can be frustrating in a plant environment. A very simple procedure can be used to determine the correct size of fuse for a particular motor.

The National Electrical Code [8] permits dual-element, time-delay fuses for motors. These may be sized up to 1.75 times the motor current. For a particular environment, a more conservative decision is usually made. For example, control panel fuses may be sized at 1.25 times and the disconnect fuses at 1.5 times.

By illustrating the values as a ratio, operators are able to quickly and correctly ascertain the correct fuse size in every installation.

Care should be taken to not exceed the permissible fuse sizes. Improper coordination may prevent a fuse from operating safely and properly. The result is frequently a fire.

VII. Safety Equipment

The potential hazards are directly related to the voltage level and horsepower. The high energy hazards arise as these values increase. Shock hazards increase primarily with proximity. For these reasons, operators should be restricted to investigating lower energy problems.

All battery operated dc power systems should be considered as high energy. The thermal runaway caused by faults or incorrect voltage charging can cause explosions. Any battery that approaches 100°C has a potential for exploding.

Three distinct levels of ac voltage are identified for electrical safety considerations. Systems operating at less than 150 volts only require separation or avoidance of contact. Systems operating up to 600 volts require gloves and other related safety components to provide separation. Systems above 600 volts require a complete safety suit and shielding for the individual.

In general, non-electrical personnel should not be allowed to evaluate equipment over 600 volts. To restrict the high energy exposure, activity should be restricted to equipment less than 100 horsepower. Fortunately, the majority of industrial and commercial installations fall within these categories. Larger equipment investigation should be left to electrically trained, experienced, and authorized workers.

With the constraint of 600 volts and 100 horsepower, a reasonable set of safety tools can be identified for each operator. The primary tools are understanding, accountability, and responsibility of the operator. In addition, basic equipment consists of the following items. These are gloves, voltage tester/continuity tester, and fuse puller. It is assumed all the equipment has the proper ratings.

GLOVES: Electrical insulating gloves are a necessary ingredient for working around equipment rated up to 600 volts. Significant precautions should be explained. Each operator should be responsible for his own set of gloves. Sharing of such a critical safety item should be avoided. Even with gloves, the worker should be prohibited from working on energized equipment. The gloves should be inspected and or replaced at least annually. The period will be shorter for equipment used frequently. The major precaution is *gloves only protect the hands*. Other parts of the body are still vulnerable.

TESTERS: The device is used to verify that the equipment is de-energized and voltages do not exist on parts of the system. Many voltage testers indicate adequately with both leads connected. At least one is available that indicates a line is hot if only one lead is touched [9]. The level is indicated when the second lead is connected.

To check for fuse quality and for open wiring, a continuity tester is required. Often these are rendered inoperative or fail when used on an energized circuit. The device identified previously has the continuity tester as an integral part of the voltage tester. Hence inadvertent exposure to voltage does not damage the continuity tester or place the operator at risk.

Old style volt-ohm-meters (VOM) are out of date technology for simply checking power and fuses. They should be history for this purpose. Do not permit low grade testers from the local electronics store be used for industrial power applications. These do not have adequate insulation. Issue the correct tester and prohibit the use of other equipment.

FUSE PULLER: It must be emphasized that a fuse puller be used to remove and install all fuses. Virtually no controller allows adequate clearance for safe access without a puller. These are generally sized up to 60 amps or 100 amps. Some fuse clips require a screw be loosened to permit removal of the fuse. With this exception, the use of fingers, pliers or screwdrivers to remove fuses should be *verboten*.

RECOMMENDATION: It is critically important for non-electrical people to identify the correct, safe tool. He must recognize which tool to use, where to use it , and when not to use it.

Sharing of tools is a major concern. Do not use someone else's safety equipment. You do not know how it has been abused, nor how it has been maintained.

VIII. Batteries

The high energy hazards associated with battery power was driven home on a recent project. While investigating the requirements for intrinsic safety certification of a computer we are manufacturing, the certification agency (CSA) related an experience with batteries we had considered using [10].

The battery was a UL recognized, D size, lithium, 3 volt battery. Tests were being conducted during March, 1992. The batteries had undergone a charger test which was stopped when the temperature reached 100°C. Subsequent tests were conducted with two cells used to charge a third. After twenty minutes, the charged cell exploded.

Fortunately, all the investigators were out of the room. The coordinator stated it was the loudest explosion he had heard in over twenty years of testing. The entire 25 × 25 foot room was filled with caustic vapors [11]. Further research revealed at least one individual killed from a similar problem in England.

Battery systems that may be misconnected when changed, may be improperly connected when charged, or may fault when a switch is closed should be serviced only by qualified individuals with proper equipment. In addition, never substitute a battery using a type different from the original equipment recommended by the manufacturer. This is critically important in systems that are recharged.

IX. Lockout/Tagout

One of the regulations that must be addressed in any energy related safety discussion is lockout/tagout [2]. The procedure directs control of energy storage devices that may contribute energy even when the equipment is not operating. As a result, the equipment is locked in the de-energized position. A tag is attached to the control point to identify work is being performed on the equipment.

These guidelines should be followed religiously to prevent oversight in performing the service activities. The plan requires notification, shutdown, isolation, tagging, control, and verification. These procedures are incorporated in the training checklist. A summary of the necessary steps can be included on the tag as shown in Figure 7.

X. Anecdotes

Anecdotes illustrate the importance of proper equipment and the critical need for understanding.

During the entire training program it must be emphasized that the operator is not being trained as an electrician. This is accomplished in several ways. Repeatedly during the class, the group is reminded "I am not an electrician, but I am one fine operator." On the last day of class, a hard hat sticker is presented with this message.

In addition, the only tools authorized for use on electrical equipment are those noted above. The individual is reminded to leave his hands in his pockets and all tools in the box. This premise prevents the operator from being tempted to try "slight" modifications.

Prior to the structured training, there were many "interesting" personal experiences.

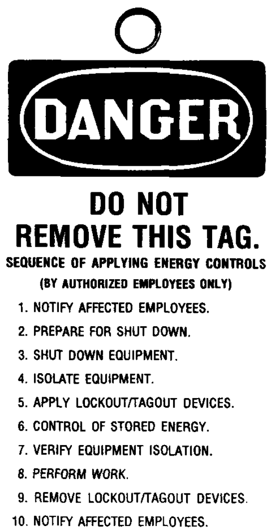

Fig. 7. Tag with instructions.

I AM NOT AN ELECTRICIAN BUT I AM ONE FINE OPERATOR

Fig. 8. Hardhat sticker

Archie was a foreman for another company. He was asked to hold a voltmeter for an electrician while taking readings. The tests were being conducted in a 2400 volt control panel. The meter was a standard unit with standard leads. When the leads were placed on the circuit, the leads were blown apart from the meter. Archie customarily smoked a pipe. When the meter blew apart, he actually bit the pipe stem in two. Then he slowly turned to the electrician, handed him the meter, and stated matter of factly "Don't *EVER* ask me to help you again!"

A number of things were done improperly. Untrained personnel should not be working on electrical equipment. The equipment should theoretically have been de-energized. However, the purpose of the test was to determine the voltage, so it must be energized. The proper test instrument must be used. Standard meters and leads are rated at only 600 volts even if the scale is marked to 5000 volts. This low rating prevents their use on medium voltage circuits without proper leads.

All these conditions are valid reasons to restrict the typical operators from evaluating any equipment above 600 volts and 100 horsepower.

An operator experience also illustrates the necessity of proper training and certification. The operator was checking the fuses in a control panel for a 15 horsepower motor. He turned off the disconnect and opened the door. Then he checked the fuses using a "flashlight" type continuity tester. He placed the tester leads across the fuses while they were still in the controller. When the tester was placed across a blown fuse, the device disintegrated.

A number of problems existed. First, the disconnect did not completely open which allowed the fuses to be energized. Second, the operator did not verify that the circuits was de-energized. Next, fuses should always be removed from the circuit for testing. When the tester was placed across the blown fuse, the motor tried to start with current flowing through the tester. The 1.5 volt battery and lamp did not provide a very good path. Hence the light was blown apart. These are valid reasons to have a checklist and to require the use of only certain testers.

Two operator injuries in another company also illustrate the necessity of understanding the additional problems associated with classified (hazardous) areas and proper clothing. The operators entered a treater building that normally would be expected to have vapors in the room. After being in the room for a few minutes, one of the operators started to turn on a light switch. A flash fire erupted from the vicinity of the light switch. Both operators were burned. A major contributing problem was the synthetic clothing that was worn. This material melted resulting in increased contact burns. Where properly fitting, tight woven cotton was worn, the skin was not injured.

Several problems are observed. Although the electrical installation was supposedly installed for a classified area, there was apparently a failure. Second, where gases are known to be, either from smell or from a haze, stand clear of the area when energizing any electrical equipment. Third, always wear proper clothing that will protect the individual should a fire occur. Finally, training must include discussion about those areas that present additional potential hazards, such as classified locations.

During a series of classes, a survey was made. The question was, "Have you or has anyone you know personally ever experienced a door being blown open when a motor was started?" The results were surprising. Over 60% of the people had personal experiences with this problem.

With this strong image, it became very easy to explain the benefits of the proper method and position to stand for starting motors. This is perhaps one of the most important aspects of electrical training for operators.

Another informal survey was conducted by looking in the tool box of electricians. The majority has had a screwdriver or test wires with arc burns. These are experienced individuals. Nevertheless, it points up the importance or periodic training to correct careless or bad habits.

A group of technicians and electricians were mixed in with operators during a recent training program. When it came time for the certification test, the electricians did not fare well. Their familiarity and comfort with working on the equipment caused them to be casual and skip critical safety steps. It is imperative that effective procedures be instituted to periodically look over the shoulders of these craftsmen.

XI. Hands-On

Operators are hands-on type workers. Hence, training must strongly emphasize actually doing the tasks. A very effective technique has been developed.

First, the procedures are explained and illustrated using demo equipment in a classroom environment. A checklist is provided. Natural pride is immediately challenged. Many individuals feel checklists are a crutch. It can be explained that airplane pilots with many years of experience use a checklist every time they enter the cockpit. By the end of the week, the complete checklist will be memorized from practice, but it is always available and to be used without intimidation. The complete checklist is shown in the Appendix. A reduced version is included on the tag as shown in Figure 7. This part of the program covers one and one-half days.

The next part of the procedure involves a team approach. Groups of three go through the procedures using demo equipment. Each individual goes through the procedure with the partners critiquing the process. Problems are given to the groups that can not be on the equipment at the time. This half-day is concluded with additional discussions about grounding and wiring.

The next morning, the groups of three go through the procedures in an actual field operating location. In addition to the team members critiquing, a qualified instructor watches every activity to assure safety is always paramount. When actual equipment is encountered, a seriousness immediately grasps the operators.

The number of instructors and units that can be used will always be restricted. The groups that are not part of the present sequence watch electrical safety videos. These are a mix of subjects. One is a re-emphasis of the electrical safety procedures. One is a blood-and-guts account of actual incidences. Another is a more light hearted approach to safety. After viewing the videos, the operators are very prepared to listen to practices that can protect them.

The third afternoon, the discussion returns to the classroom. Types of fuses and application are discussed. Fast blow, dual-element, low-peak, and instrument fuses are identified. A comparison is made with circuit breakers and their limitations. Different motors and their application are presented. This includes open-drip, totally-enclosed, and explosion-proof. The requirements and limitations are illustrated.

Thursday morning begins early in the field. Each person individually goes completely through the procedure with an instructor. The instructor completes a check-off of the performance, while it is being conducted. The instructor tries to be unobtrusive since this is the certification process for the workman before he returns to the job. At the end of the check-off, the employee and the instructor both sign the record.

The afternoon is again devoted to class time discussing controls and their relationship to motor operation. This is an important ingredient for operators who must discern and understand the operation of their facilities. It provides a basis for relating the different functions within the plant whether electrical, mechanical, or pneumatic.

Following the controls discussion, a session is devoted to observations about the certification. Minor points are clarified. Those that had greater difficulty are required to return for a remedial session. This has come to be referred to fondly as "D-Hall" after the discipline time some experienced in high school. In this session, questions and problems are resolved. With limited exceptions, virtually all operators successfully completed certification after this personal time.

The final morning is devoted to reinforcement. Discussions center on potential hazards and the individual response. These include responses to shock, fire, and explosions. Although detailed reactions cannot be addressed, reminders of shock levels, CPR procedures, and appropriate fire extinguisher use are presented.

During the discussion, the importance of proper clothing for protection is presented. Tight woven cotton material is generally preferred for most operations. The material does not melt or flash readily when exposed to elevated temperature and flames.

XII. Clarifications

The program described is very comprehensive. It is not necessary for every company and group of employees. It has proved to be very effective and cost effective.

The first and premier benefit has been for the workmen. Many *misconceptions and misunderstandings* have been eliminated. The responsibility has been consistently defined and demonstrated. When questioned about doing a chore outside their area of understanding, they now can confidently respond about the limits on their ability without risk of challenge. Furthermore, the understanding encourages communications when recognizing others' problems.

The safety record and response has been enhanced. Many problems have been identified and corrected resulting in increased productivity and ultimately reduced operating cost.

The operators are often remote and isolated from other employees. Their skills and interpretive ability now permit the operator to effectively describe problems remotely. Through telecommunications, the operator can adequately relate the information so service technicians can bring the appropriate equipment.

Another benefit has accrued to both the company and the employees. The workman have repeatedly expressed appreciation that the company was interested enough in their welfare to commit the time and resources to their safety and well being.

XIII. Overcoming Opposition

Any aggressive program will have nay sayers. Considerable concern was initially expressed by a variety of groups and individuals.

The major concern was that electrical training was too specialized and sophisticated to be understood by anyone without lengthy training and experience. This particularly came from electricians and some engineers. After representatives of these groups participated in the program, this opposition was resolved.

Some supervisors were concerned about changing job responsibility for the operators when they are given any electrical training. This is somewhat like saying anyone taking driver's training will be qualified as an 18-wheeler, long-haul driver. After supervisors also participated in the program, they became strong advocates of the training for their workmen.

ELECTRICAL TRAINING FOR NON-ELECTRICAL PERSONNEL
CERTIFICATION CHECKLIST

	OK	NO	COMMENT
Check tester on known circuit.			
Check your gloves.			
Is panel over 600 volts? (DO NOT OPEN panels rated over 600 v.)			
Visually check ground wire.			
Lightly tap controller w/back of hand.			
Physically check ground wires.			
Stand to side of box.			
Turn H-O-A to "off".			
Turn disconnect switch "off". (Remember even when "off" there are still live wires into the switch.)			
Turn remote safety switch "off", if installed. (Stand to side of box.)			
Initiate Lockout/Tagout Procedure.			
Set brake on unit.			
Open panel door.			
Remove jewelry including rings, watches, lighters, and keys.			
Put on gloves. (Gloves only protect the hands. Other parts of body may come in hazardous contact with live circuits.)			
Verify disconnect, top & bottom or fuses/breaker are open. **(If voltage exists at bottom of fuse, close panel, call electrician.)**			
Look for burned or loose wires. (If bad, close door, call electrician.)			
Use fuse puller to remove fuse, top first.			
Check fuse with continuity tester.			
Replace blown fuse with correct type and size.			
Use fuse puller to install fuse, top first.			
Check relays.			
Manually check overload.			
Close panel door.			
Remove gloves.			
Install latches.			
Remove Lockout/Tagout by procedure.			
Stand to side of box.			
Turn on Disconnect.			
Turn on H-O-A switch.			
Motor operating, you had a good day. (Do not attempt unauthorized repairs.)			

***Leave tag when electrician is called.**

REMARKS: ______________________________

____

The employee did (not) successfully inspect and follow safety procedures for operating the electrical panel.

Date	Employee	Inspector

Fig. 9. Safety risks.

Any safety program, especially electrical, must have the support and respect of the management, technical, and operating employees. When this mutual interest is addressed, an effective, productive program can be established.

XIV. Fears

The natural apprehension and respect for electrical power for most people is actually a fear in some individuals. We have encountered those in the program that are terrified of the idea of associating with and doing any work around electricity. Seriously, a few have been concerned about changing light bulbs.

Addressing these fears and even terror must be done carefully. Embarrassment and ridicule are not appropriate. When these individuals are identified, quiet, personal reassurance and encouragement must be given.

Since it has became obvious that apprehension and anticipation is a common problem, a radical, safe, but effective method can routinely be used. During the normal process of checking fuses, the wires above a disconnect are energized. Part of the procedure is to check the voltage to verify the disconnect is open. This is done while the person is wearing electrical insulating gloves. The task is to encourage the skittish individual to trust his safety equipment. Each was required to move an energized, but completely insulated wire so he could see the disconnect. This small procedure dramatically increased the confidence in the equipment.

It has been demonstrated repeatedly that the knowledge and understanding gained from effective training is the best weapon against fear and resulting mistakes.

XV. Certification

In the present litigating environment, records and shields are a routine part of business. Furthermore, there must be an independent evaluator when continued employment in a particular job is at stake.

CRITICAL C's

Comfortable
Casual
Complacent
Conceit
Conditions
Circumstances
Careless

Fig. 10. Critical C's.

For these and other reasons, safety training is commonly conducted by organizations external to a company. Some companies take the isolation to the point they will not allow use of employees for any part of the process, except the human resources coordinator.

The use of external safety coordination allows separation from personalities and an independent, non-prejudicial evaluation of an individual's performance. This is crucial when his life and health may potentially be at risk.

Another critical part of the certification process is consistency and the employee knowing what to expect. The best tool is a written manual for future reference [7]. During the process a checklist is imperative. This states exactly what is expected and illustrates when there are deficiencies. One type check list is shown in Appendix I.

Another necessary ingredient is the complete understanding and support between management and the trainer that individuals who do not safely make the grade will be so notified. With this detailed program and hands-on, personal approach, one would expect everyone to successfully complete the program. However, because of a variety of conditions, this will not happen. Those must be aware of their deficiencies for their protection.

An additional note about certification. This cannot be a *once is forever* approach. Because everyone slips into a routine and can acquire bad habits, safety procedures must be periodically reviewed.

The seven big "C's" cause otherwise knowledgeable and skilled craftsmen to expose themselves to safety risks. A grade of C is generally regarded as average. However, average is not good enough in safety considerations. There is zero tolerance for errors. The only way these critical factors can be overcome is by regular refresher training and recertification.

The time between training depends on the individual skills, exposure, and frequency of performing the task. Some chores require routine change-out, while others require a routine testing, and still others seldom require any activity. Since there are a number of variables, many companies will establish review on a calendar basis. Annually or biennially seem to be the preferred time. As a comparison, commercial airline pilots are certified every six months while typical private pilots go through a review every two years.

XVI. Does It Work?

The success of any program comes after the classroom. It may take many years to discern any long term effect or trend in improvement. However, other feedback can be used to measure effectiveness in a shorter term.

The interest and conversational feedback from non participants provides a valuable, unbiased tool. Contractors and individuals from other companies have commented about the changes they have seen in attitude and productivity as a result of effective, involved participation in a safety program.

XVII. Can It be Done Differently?

The procedure illustrated is only one of a number of alternatives. Depending on the worker's involvement with electricity, variations are appropriate. A person that is simply in the vicinity of electrical wiring, requires significantly less involvement than a person expected to change fuses.

OSHA [1, 10] regulations specify minimum training that is required. The short time periods are obviously related to a particular location or type installation and the hazards to avoid. In no way are these times adequate to train someone to do a particular job.

For example, a painter must have some explanation and understanding if he is to be expected to perform his craft around wires entering a building and around control systems. Simply telling him to avoid the circuit is not adequate. He must appreciate some distinction in voltage levels and high energy equipment. This does not require a detailed knowledge. The regulations require at least 0.5 hours. This is only the time to show the workman the potential hazards. This time will likely be repeated on each new job. The time to provide a broader understanding that covers more situations is in the order of hours.

Another level would be mechanical and technical skills that may have electrical equipment associated with their work. The minimum on time for each job is one hour. Four to twelve hours is generally adequate for more general training that carries between jobs.

The category of operator that changes fuses is not specifically addressed in the regulations. Operator training for these group can be adequately performed in two to three days. The difference between that and the optimum week long program described is primarily in detail and personal attention. At least one practice and one actual checklist procedure is preferred. Some of the information on controls and systems can be reduced. A variation of the general overview and the safety summary should also be components of any program.

Another effective tool is to customize the program for each company. Every group has a personality and philosophy that should be enhanced by any safety program. To achieve this specialization, the safety coordinator should spend some time with the management, technical, and operating personnel to determine "how its now done".

The time is well spent by providing a camaraderie and appreciation of the present programs and needed enhancements.

XVIII. Summary

Safety and electrical training are not an option. There are legal as well as moral, ethical, and social responsibilities to reasonably provide information for protection of people. Both high energy and shock hazards must be identified.

The amount of training required depends on the frequency and level of exposure to electrical systems. Secretaries and janitors require minimal discussion. Three different levels are identified for non-electrical skills. These can be grouped as painter level, mechanic level, and operator level. Minimum time is required for these services.

Operators that must check fuses require more training. A hands-on approach is most effective. The time is divided between class time for explanations and actually doing the task. Checklists and appropriate safety equipment are essential. Periodic follow-up checks are necessary to correct weak habits and as a safety reminder.

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