ELECTRICAL SAFETY-RELATED WORK PRACTICES

THIRD EDITION

Based on NFPA 70E® 2012 Edition

IN PARTNERSHIP WITH THE NJATC

IBEW — NECA · ATTITUDE · SKILL · KNOWLEDGE · NJATC® · FOR THE ELECTRICAL INDUSTRY · APPRENTICESHIP & TRAINING

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NATIONAL JOINT APPRENTICESHIP AND TRAINING COMMITTEE

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Foreword

Electrical Safety-Related Work Practices: NJATC's Guide based on *NFPA 70E®*

For years, many in the industry only considered electrical shock when contemplating worker protection and safe work practices. Today, however, the industry recognizes numerous additional hazards associated with work involving electrical hazards. These include, for example, the hazards associated with an arcing fault, including arc flash and arc blast. Consideration must be given to the devastating forces generated when molten copper expands to 67,000 times its original volume as it vaporizes, arc temperatures that can reach 35,000°F, pressures that can reach thousands of pounds per square foot, and shrapnel expelled from ruptured equipment at speeds that may exceed 700 miles per hour. Workers are exposed to these and other hazards even during a seemingly routine task such as voltage testing.

Working on circuits and equipment deenergized and in accordance with established lockout and tagout procedures has always been the primary safety-related work practice and a cornerstone of electrical safety. Only after it has been demonstrated that deenergizing is infeasible or would create a greater hazard, may equipment and circuit parts be worked on energized, and then only after other safety-related work practices, such as insulated tools and appropriate personal protective equipment, have been implemented. Examples of additional concerns that should be considered include worker, contractor, and customer attitude regarding energized work, comprehensiveness of an electrical safety plan, appropriate training, the role of overcurrent protective devices in electrical safety, equipment maintenance, and design and work practice considerations. These are a few of the issues that play an important role in worker safety, and are among the topics examined in this publication.

Electrical Safety-Related Work Practices has been developed in an effort to give those in the electrical industry a better understanding of a number of the hazards associated with work involving electrical hazards and the manner and conditions under which such work may be performed. These work practices and protective techniques have been developed over many years and are drawn from industry practice, national consensus standards, and federal electrical safety requirements. In many cases, these requirements are written in performance language. This publication also explores *NFPA 70E, Standard for Electrical Safety in the Workplace* as a means to comply with the electrical safety-related work practice requirements of the Occupational Safety and Health Administration.

Contents

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1 Electrical Safety Culture

Courtesy of Milwaukee Electric Tool Corp.

CHAPTER OUTLINE

- Safety Culture
- Hazard Awareness and Recognition
- Understanding Requirements
- Decisions

OBJECTIVES

1. Recognize the important role that a safety culture plays for every person and in every organization, and understand how it affects worker exposure to electrical hazards.
2. Understand that a number of decisions are made before and during the time a worker is exposed to electrical hazards, and appreciate how decisions can reduce or eliminate electrical hazards.
3. Recognize the important role that understanding and complying with requirements plays in reducing and eliminating hazards.

REFERENCES

1. National Institute for Occupational Safety and Health (NIOSH) Fatality Assessment and Control Evaluation (FACE) program
2. Occupational Safety and Health Administration (OSHA) 29 CFR Part 1910
3. OSHA 29 CFR Part 1926

CASE STUDY

A 36-year-old electrician's helper was electrocuted in a fitting room of a department store located in a suburban shopping mall. The victim and a coworker were replacing the overhead fluorescent light tubes and ballast transformers in the fitting room. The employer had a written safety program that included lockout/tagout procedures and employed a safety coordinator who conducted weekly safety meetings.

Under the direction of the foreman, the victim and a second helper started work on replacing the ballasts. The foreman reportedly shut off the power to the lights by turning off and locking out the wall switch and then checked the lights with a circuit tester. This step deenergized all but one center light fixture, which was on a separate "night light" circuit that remained on. The foreman went to check the breaker but was unable to find the switch to shut off the remaining light. He confirmed that the victim had worked on live wires, and then told the victim to go ahead with the job.

The victim used a six-foot fiberglass ladder to reach the lights and began removing the tubes and ballast transformers. He was working on the ladder when he cut the energized black wire. The power entered though the victim's hands and exited to the grounded metal doorframe that he was leaning against. The victim's coworker, who was working in the stall beside him, heard the victim say, "Help me," and saw sparks flying from the wire. The coworker cut the black wire, breaking the contact and releasing the victim, who collapsed against the metal frame.

At this time, the foreman entered the room and helped move the victim to the floor. The store manager called 911; police arrived and began cardiopulmonary resuscitation (CPR). The victim was transported to the local hospital, where he was pronounced dead.

Source: For details of this case, see New Jersey FACE Investigation #95NJ080. Accessed May 29, 2012.

For additional information, visit qr.njatcdb.org Item #1184.

Introduction

Too often a culture exists in the workplace where workers are routinely allowed and expected to work on or near energized electrical circuits. This tendency to accept the risk of an electrical injury is unacceptable and must change.

This practice might be due to ignorance of laws that have been in place for decades, lack of knowledge of the severity of the hazards, or perhaps failure to realize how quickly a task situation might change and cause an energy release. It is less likely that workers, contractors, and facilities owners would allow energized work if everyone involved in the decision-making process fully understood the laws, requirements, hazards, true costs, and consequences associated with energized work.

Safety Culture

A false sense of security devalues safe practice. As a consequence, Electrical Workers may work on energized circuits owing to misperceptions of the risks involved. These paradigms are part of the electrical work culture, and may lead workers to take risks that are not in their best interest. Many do not understand the existing and potential hazards; others, who do understand these risks, do not realize how quickly a situation can change when things go wrong. The following list of statements reflects mindsets and attitudes that can lead to taking unnecessary risks:

- I don't care what the law says—I'm going to work it energized.
- I'm an Electrical Worker; working stuff hot is part of my job.
- That's what the customer expects. If my people won't do it, then they'll get another contractor.
- It's the office of the president of the company—you can't deenergize the circuit to change that ballast.
- You can't shut that assembly line down, because it will cost too much.
- There are people out of work looking for a job, so if I won't work it hot, someone else will.
- I've been doing it this way for 30 years, and nothing has ever happened to me.
- I know I should be wearing personal protective equipment (PPE), but it slows me down.
- There's no time to shut it down.
- That protective equipment is too expensive.
- What's the worst that can happen?
- It won't happen to me.

Far too many Electrical Workers believe that working on energized circuits is part of their job or is expected of them; in fact, such tasks are not part of routine electrical work. A tendency to work on or near electrical circuits while energized and accept the risk of an electrical injury creates an unacceptable culture. The need to change this mind-set must be recognized by all involved in the decision-making process. **See Figure 1-1**.

Figure 1-1. *Energized work is permitted only under limited circumstances as set forth by OSHA and NFPA 70E®.*

**NFPA-70E® is a registered trademark of the National Fire Protection Association, Quincy, MA.*

Contractors have reported feeling pressured by their customers to work on energized equipment when a shutdown is warranted. Likewise, workers have reported feeling pressured by management to perform energized work when it is not justified. Workers who accept this risk expose themselves to injury or death. They also expose the contractors and their clients to undue risks of increased insurance premiums and loss of production. In many cases, customers may not understand the total costs and risks associated with energized work.

A well-informed client understands the hazards of energized work and the financial implications associated with an electrical incident. Equipment or circuits that are not permitted to be shut down for a few minutes ultimately might be shut down for days or weeks, or even longer, due to an unplanned event such as a dropped tool or a loose part falling into energized equipment and creating an unscheduled shutdown. A well-informed client is less likely to permit energized work, much less expect it.

Hazard Awareness and Recognition

A full understanding and recognition of existing and potential hazards is crucial to ensuring that an environment is electrically safe. The following must be done at a minimum:

- Eliminate the hazard.
- Develop and implement appropriate procedures.
- Develop, conduct, and implement training for qualified and unqualified persons.

- Deenergize and follow all of the necessary steps of the lockout/tagout program and establish an electrically safe work condition unless the employer demonstrates a true need for energized work.
- Develop and implement a hazard identification and risk assessment procedure.
- Engineer out the hazards or reduce them as far as is practicable.
- Provide adequate protection against hazards when the need for energized work is demonstrated.

A comparison can be made between the hazards of driving an automobile and the hazards associated with working on or near energized electrical equipment. Protective systems such as seat belts and air bags were developed to reduce the likelihood of injury or death; likewise, personal protective equipment (PPE) was developed to increase Electrical Worker safety. Such protections have a key limitation, however; they are effective only when they are actually used.

It is much the same with the hazards associated with working while exposed to electricity. Electrical Workers will continue to be exposed to electrical hazards if they do not take appropriate steps. Potential hazards in this environment include fire, falls and falling objects, electrical shock, and the hazards associated with arcing faults, including arc flash and arc blast. An *arcing fault* is a fault characterized by an electrical arc through the air. *Arc flash* is a dangerous condition caused by the release of energy in an electric arc, usually associated with electrical distribution equipment. **See Figure 1-2**. An arcing fault, for example, could be initiated by a dropped tool or by operation of equipment that has not been maintained properly. Electrical Workers may believe that the chance of such a lapse is unlikely; however, it may need to happen only once to result in injury or death. If used, protective systems, work practices, and protective equipment can reduce or eliminate exposure to the hazards. Workers may still suffer injury or death if circuits and equipment are not worked on in an electrically safe work condition. An *electrically safe work condition* is defined in *NFPA 70E* as follows:

Electrically safe work condition. A state in which an electric conductor or circuit part has been disconnected from energized parts, locked/tagged in accordance with established standards, tested to ensure the absence of voltage, and grounded if determined necessary

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Figure 1-2. *Shock, arc flash, and arc blast subject workers to a number of hazards.*

From the Cooper Bussmann Safety BASICs Handbook *with permission from Cooper Bussmann.*

The hazard of electrical shock has been recognized since the dawn of electricity. The industry has evolved and made great strides to protect against electrical shock through the use of ground-fault circuit interrupters (GFCI) and rubber protective goods such as insulating gloves and blankets. A *GFCI* is defined in *NFPA 70E* as follows:

Ground-Fault Circuit Interrupter (GFCI). A device intended for the protection of personnel that functions to deenergize a circuit or portion thereof within an established period of time when a current to ground exceeds the values established for a Class A device. (Informational Note: Class A ground-fault circuit interrupters trip when the current to ground is 6 mA or higher and do not trip when the current to ground is less than 4 mA. For further information, see ANSI/UL 943, *Standard for Ground-Fault Circuit Interrupters.*)

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These products are effective when used and maintained properly. Even with these advances, however, injury and death still occur from electrical shock. **See Figure 1-3**. The Bureau of Labor Statistics (BLS) data for electric shocks in nonfatal cases involving days away from work for the period 1992–2001 indicate that there were an average of 2,726 cases annually in private industry.

Arc flash and arc blast constitute lesser-known hazards; electrical burns happen frequently. The BLS data for nonfatal cases involving days away from work for the period 1992–2001 indicate an average of 1,710 electrical burns per year (peaking at 2,200 in 1995)

BACKGROUND

The following passage demonstrates one way that acceptance of risk and the culture in place today could have evolved. The current culture's outdated work practices might be the result of the way Electrical Workers were taught in the past. Readers should contemplate the guidance that was once given to Electrical Workers. The recommended practice at that time actually was to check for voltage using the fingers.

Historical Methods for Testing Voltage

As late as the mid-1900s, Electrical Workers performed testing for voltage procedures, employing a variety of less desirable techniques when viewed from today's perspective. On lower voltages typically found on bell, signal, and low-voltage control work, the presence of voltage (or pressure, as it commonly was called) could be tested using the "tasting method":

- A method of stripping the ends of the conductors from both sides of the circuit and placing the ends of these conductors a short distance apart on the tongue could be used to determine the presence of voltage.
- The "testee", or more appropriately, "tester" would experience a burning sensation followed by a slight salt taste. Depending on the amount of voltage present, holding one of the conductors in the bare hand and touching the other to the tongue could also be used. In this case, the body was acting as a voltage divider, lessening the burning sensation on the tongue.

Other variations of voltage testing included standing on wet ground when one end of the voltage system was grounded, while touching the tongue with the other terminal of the voltage source. This also was an "approved method." Individuals using this method often stated that once these test methods were performed, the end result was not often forgotten.

On higher voltages typically found in building power applications, the "finger method" was employed as an acceptable method of determining the presence of voltage in circuits of 250 volts or less:

- Electrical Workers would test the wires for voltage by touching the conductors to the ends of the fingers on one hand. Often, due to skin thickness, skin dryness, and calluses, the Electrical Worker would have to first lick the fingers to wet them to be able to sense the voltage being measured.

This method was billed as easy and convenient for determining whether live wires were present. The individual Electrical Worker's threshold for pain determined whether or not this was an acceptable method for everyday use. Some Electrical Workers supposedly had the ability, depending on the intensity of the sensation, to determine the actual voltage being tested.

Source: American Electrician's Handbook: A Reference Book for Practical Electrical Workers, *5th edition, by Terrell Croft (revised by Clifford C. Carr). Copyright © 1942 by The McGraw-Hill Companies, Inc. Reprinted by permission of The McGraw-Hill Companies, Inc.*

Considering these historical aspects of electrical work, it is no wonder that today's culture often does not appreciate and implement safe work practices. Safe work practices today do not allow procedures such as the "tasting method" and the "finger method" to test for the presence or absence of voltage.

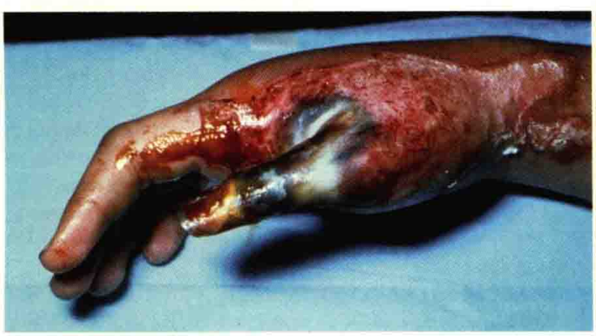

Figure 1-3. *The consequences of exposure to electrical hazards are often traumatic.*

© Charles Stewart & Associates

in private industry. That averages out to nearly one worker suffering the consequences of electrical burns every hour, based on a 40-hour work week. These data were instrumental in advancing electrical safety in general and *NFPA 70E* in particular during that time period.

BACKGROUND

The following passage contains excerpts from a procedure that once was considered an appropriate method of CPR. Like other practices and procedures, CPR has evolved over time. Clearly, electrical safety-related work practices, like all practices and procedures, require updating over time.

Cardiopulmonary Resuscitation: Accepted Practice in the Early 1900s

A review of several of the techniques used as methods of resuscitation show that medical technology has come a long way since the early 1900s.

The primary method of treating an individual who had experienced heart failure and/or respiratory arrest was simple. This primary method required two rescuers to perform the resuscitation procedure:

- After placing the victim on his or her back, one rescuer would grab and wiggle the victim's tongue, while the other rescuer would work the victim's arms back and forth to help induce breathing.

While possibly resuscitating some stricken individuals, a secondary approach was to be used should the first method fail:

- In cases where manual inflation of the lungs was attempted with no success, an attempt to cause the victim to gasp for air was performed. To initiate this gasping, the rescuers would insert two fingers into the victim's rectum, pressing them suddenly and forcibly towards the back of the individual.

Needless to say, it is not hard to understand why today's CPR methods provide more favorable results for both the victim and the rescuer.

Source: The Fire Underwriters of the United States, Standard Wiring: Electric Light and Power. *H. G. Cushing Jr., New York, NY, 1911.*

OSHA Tip

Occupational Safety and Health Administration (OSHA) 29 CFR 1910.333(a)(1)

Deenergized parts. Live parts to which an employee may be exposed shall be deenergized before the employee works on or near them, unless the employer can demonstrate that deenergizing introduces additional or increased hazards or is infeasible due to equipment design or operational limitations. Live parts that operate at less than 50 volts to ground need not be deenergized if there will be no increased exposure to electrical burns or to explosion due to electric arcs.

70E Highlights

An electrically safe work condition is defined in *NFPA 70E*® as "a state in which an electrical conductor or circuit part has been disconnected from energized parts, locked/tagged in accordance with established standards, tested to ensure the absence of voltage, and grounded if determined necessary."

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Trauma Following Electrical Events

An examination of multihazard electrical incidents and the incident effects on survivors is provided in a paper delivered by Mary Capelli-Schellpfeffer, MD, MPA, of CapSchell, Inc., at the 2004 IEEE IAS Electrical Safety Workshop. Excerpts from Dr. Capelli-Schellpfeffer's paper are provided here.

The clinical spectrum of electrical incident effects on survivors ranges from the absence of any external physical signs to severe multiple trauma. Reported neuropsychiatric difficulties can vary from vague complaints seemingly unrelated to the injury event by their distance in time or apparent severity to effects consistent with anoxic brain injury accompanying an electrical trauma. In addition to physical limitations, complaints commonly described in electrical incident survivors include hearing loss, headache, memory changes, disorientation, slowing of mental processes, agitation, confusion, irritability, affective disorders, and post-traumatic stress disorder (PTSD; severe anxiety resulting from a traumatic experience).

The evaluation and treatment of electrical incident survivors can be variable, as there is little information available to provide rigorous decision making around the mental health care of these patients. Opinions differ about the nature and cause of patient symptoms, and the relationship between symptoms and factors like trauma severity, litigation, or premorbid personality. Not all survivors develop cognitive and emotional difficulties, and no consistent relationship has been established between characteristics, such as age, injury-related characteristics (e.g., voltage, current source, work error), and neuropsychological test performance.

Questions remain as to how electrical exposure affects central nervous system function. The pattern of neuropsychological effects suggests diffuse cerebral injury. Moreover, the effects of electrical incidents may produce emotional disturbance through damage to the limbic system or hypothalamic-pituitary axis. It is noteworthy that from the therapeutic perspective, it has been appreciated that the medical application of electric current in proximity to the brain during electroconvulsive therapy (ECT) affects mental status, psychiatric condition, and neuromuscular function. While the biologic mechanisms for the individual responses seen following ECT remain to be articulated, persistent alterations in patients' neuropsychiatric condition following ECT are well documented and in effect, often represent desired clinical outcomes.

Regarding electrical incident clinical effects in survivors, a study [Pliskin, Capelli-Schellpfeffer, et. al., 1998. Neuropsychological sequelae of electrical shock. *Journal of Trauma* 44 (4):709–715] analyzed the experience of the largest reported series of electrical injury survivors with neuropsychological complaints. All patients had peripheral electrical contacts (i.e., shock) with no evidence on history or examination of direct mechanical electrical contact with the head. A total of 45 males and 8 females were included in the final analysis. These individuals had a mean age of 38.5 years (range, 22 to 70 years) and a mean educational level of 13.1 years (range, 8 to 18 years).

The mean time between injury and completion of the measures used in this study was 11.2 months (range, 0.2 to 66.7 months). Twenty of the 53 patients were employed as electricians or line operators at the time of injury. There were also 7 mechanics or railroad workers, 5 office workers, 3 factory workers, 3 service technicians, 2 food service workers, 2 police officers, as well as 11 individuals with other occupations. Forty-four patients were injured on the job, and 9 were injured during nonvocational activities. At the time of follow-up contacts, 30 (56.6%) patients were working again, 18 (44.0%) patients were unemployed or retired, 1 patient was deceased, and 4 patients could not be contacted. Twenty-one of the 53 patients were injured by voltage sources less than 1000 volts (39.6%), and 27 patients sustained voltage exposures greater than 1000 volts (50.9%). Forty-four patients were hospitalized for observation or to receive initial treatment for their injuries (83.0%), while 9 patients were released after initial evaluation. Twenty patients underwent surgery for their injuries (37.7%), 32 patients received either nonsurgical treatment or no treatment, and the treatment history for 1 patient was unknown. Sixteen of the 53 patients (30.2%) sustained a loss of consciousness as a result of their electrical accident, and 4 patients (7.5%) experienced cardiac arrest. Twenty-nine patients complained of ringing in their ears (tinnitus) (18%), and 5 patients reported a loss of hearing (3%). In the 49 patients for whom complete data were available, there was no significant relationship between the reported neuropsychological symptoms, Beck Depression Inventory, self-rated memory complaints, and injury experience parameters, including voltage exposure, loss of consciousness, trauma