LA-UR-16-29637
Approved for public release; distribution is unlimited.

Title: Electrical Safety Program: Nonelectrical Crafts at LANL, Live #12175

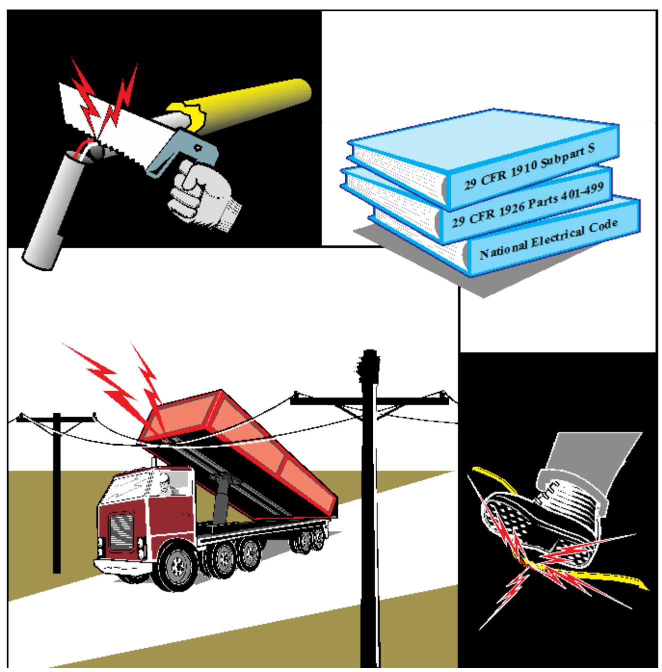
Author(s): Glass, George

Intended for: Training

Issued: 2016-12-22

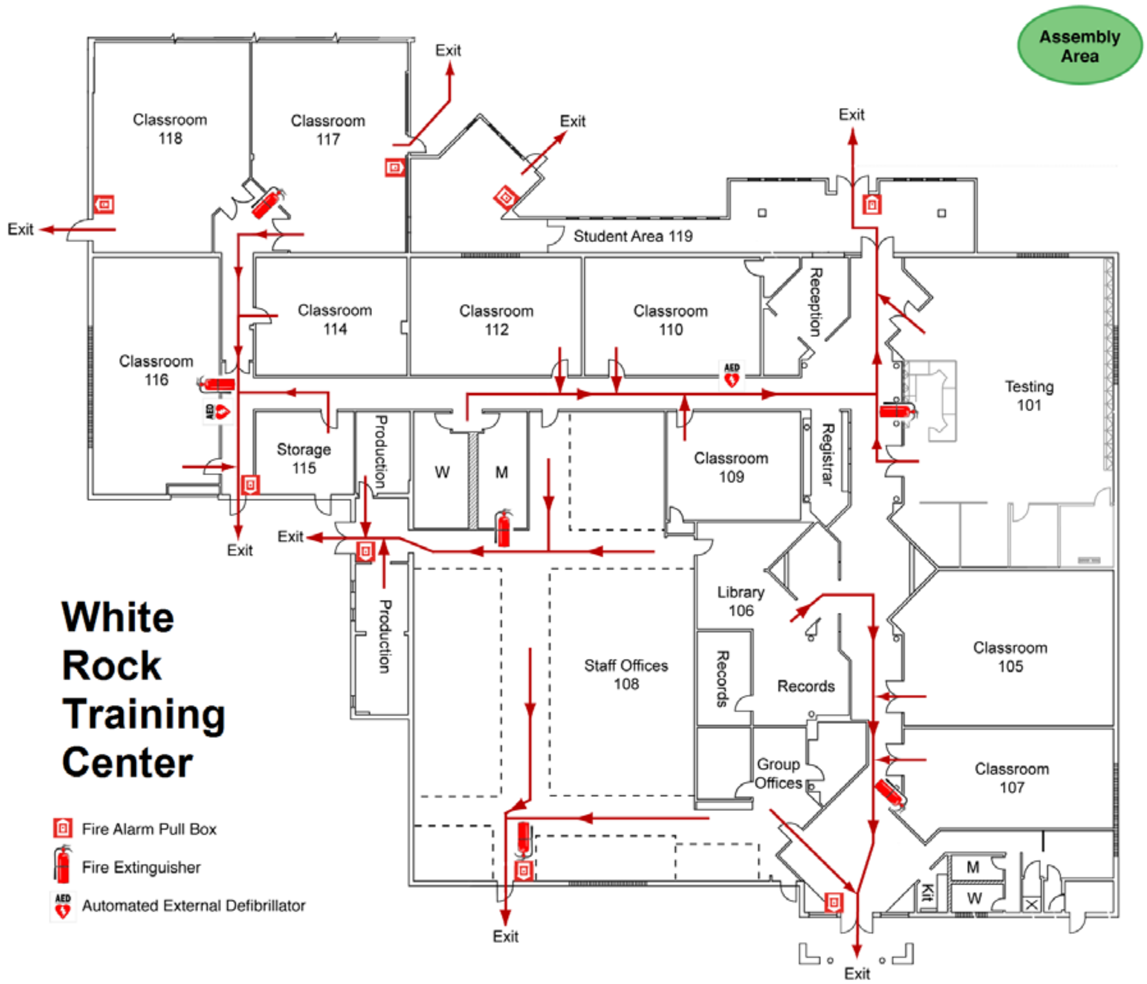
# Electrical Safety Program: Nonelectrical Crafts at LANL

***Live 12175***




***January 2017***


Los Alamos NATIONAL LABORATORY
EST. 1943
Operated by Los Alamos National Security, LLC for the NNSA




*Central Training-Institutional Training Services Group Leader:* Cynthia L. Dutro
*Instructional Designer:* George Glass
*Technical Advisor:* Lloyd Gordon, OSH-ISH
*Editor/Compositor:* Lisa Rothrock

Course 12175
January 2017

LA-UR-16-
Controlled Document Number: ESP_Nonelec_Crafts_12175_SM, R1.1

# Contents

# Introduction

## Course Overview

Los Alamos National Laboratory (LANL) and the federal government require those working with or near electrical equipment to be trained on electrical hazards and how to avoid them. Although you might not be trained to work on electrical systems, your understanding of electricity, how it can hurt you, and what precautions to take when working near electricity could save you or others from injury or death.

This course, *Electrical Safety Program: Nonelectrical Crafts at LANL* (12175), provides knowledge of basic electrical concepts, such as current, voltage, and resistance, and their relationship to each other. You will learn how to apply these concepts to safe work practices while learning about the dangers of electricity—and associated hazards—that you may encounter on the job. The course also discusses what you can do to prevent electrical accidents and what you should do in the event of an electrical emergency.

The LANL Electrical Safety Program is defined by LANL Procedure (P) 101-13. An electrical safety officer (ESO) is well versed in this document and should be consulted regarding electrical questions. Appointed by the responsible line manager (RLM), ESOs can tell you if a piece of equipment or an operation is safe or how to make it safe.

## Course Objectives

When you have completed this course, you will be able to

- recognize the basic language of electricity (voltage, current, resistance) ;
- identify electrical hazards in the workplace, including
  - where such hazards exist,
  - dangers they pose to both individuals and their work environments, and
  - ways to avoid them;

- recognize the emergency measures to take in the event of an electrical accident;
- recognize where to go for help with questions and concerns about electrical safety and safe electrical work practices; and
- apply electrical concepts and knowledge of safe work practices and emergency response procedures to a set of accident scenarios.

## Program Owner

This course was developed under the direction and technical oversight of Occupational Safety and Health Division-Industrial Safety and Hygiene Group (OSH-ISH), the functional program owner for this training.

## Target Audience

*Electrical Safety Program: Nonelectrical Crafts at LANL* (12175) is intended for any craftsperson—other than an electrician—who works around electrical equipment. In fact, all categories of crafts workers can benefit from this training.

## Training

After taking this course initially, you are required to take it every 3 years as a refresher.

## Course Limitations

This course does NOT qualify workers to perform electrical work.

## About This Course

*Electrical Safety Program: Nonelectrical Crafts at LANL* (12175) is a 3-hour, classroom-based course.

## Acronyms

| | |
|---|---|
| A | amp |
| ac | alternating current |
| AED | automated external defibrillator |
| AHJ | authority having jurisdiction |
| CFR | Code of Federal Regulations |
| CPR | cardio-pulmonary resuscitation |
| dc | direct current |
| DOE | Department of Energy |
| EEWP | energized electrical work permit |
| EMF | electromotive force |
| ES&H | environment, safety, and health |
| ESO | Electrical Safety Officer |
| FOD | facility operations director |
| GFCI | ground fault circuit interrupter |
| GFI | ground fault interrupter |
| GPR | ground-penetrating radar |
| ISM | Integrated Safety Management |
| IWD | integrated work document |
| IWM | Integrated Work Management |
| LANL | Los Alamos National Laboratory |
| NEC | National Electric Code |
| NFPA | National Fire Protection Association |
| NRTL | nationally recognized testing laboratory |
| OH | Occupational Health |
| OJT | on-the-job training |
| OSH-OM | Occupational Safety and Health Division—Occupational Health Group |
| OSHA | Occupational Safety and Health Administration |
| OSH-ISH | Occupational Safety and Health Division—Industrial Safety and Hygiene Group |
| P | procedure |
| PPE | personal protective equipment |
| PNM | Public Service Company of New Mexico |
| RLM | responsible line manager |
| RPT | relocatable power tap |
| SI-ITS | Service Innovation-Institutional Training Services Group (SI-ITS) |
| UL | Underwriters Laboratory |
| V | Volts |

## Notes . . .

# Module 1: You and Electricity

## Module Overview

Understanding the basic concepts of electricity is an important first step in keeping yourself safe from harm when working on or near electrical equipment. This module provides you with the basics of electrical energy, including electric charge and current, voltage, circuits, resistance, conductors, insulators, and grounding.

## Module Objectives

By the end of this module, you will be able to recognize

- different occupations in electrical environments,
- the language that explains the nature of electricity,
- typical electrical wiring and equipment,
- electrical hazards,
- effects of electrical shock on the body, and
- types of electrical injuries.

Examples of nonelectrical workers who work around electricity include

- riggers (iron workers),
- sprinkler fitters
- carpenters
- painters,
- mechanics
- laborers,
- sheet metal workers (pipe fitters),
- excavation workers
- operating engineers, and
- roofers.

# The Language of Electricity

## Electrical Charge and Current

All materials are made up of positive and negative electric *charges*. Electric charges exert forces on each other. *Current* is the flow of electrical charge in the form of electrons. It is measured in amperes, or amps (A). A thousandth (1/1000) of an amp is called a milliamp (mA), a unit used to describe a small current flow.

Currents of as little as 10–20 mA can cause strong electrical shocks to the body, yet we commonly work around appliances and devices that draw far more current. A 100-watt lightbulb draws about 1 A. Electric drills and other power tools draw between 2 and 8 A. Heat-producing appliances such as stoves and toasters draw even greater amounts of current.

## Voltage

*Voltage* is the measure of the electrical potential difference between two points. Electric charge will be subjected to a force pointing in the direction of lower potential. In this sense voltage is known as electromotive force (EMF), which causes current (usually as electrons) to flow through conducting materials. This EMF is measured in volts (V). Electric power producers such as the Public Service Company of New Mexico (PNM) are the most common sources of electricity at high power levels.

Batteries are a common source of electricity at low power levels. Although voltage is present in a battery or at an outlet, current does not flow until a circuit is completed. This happens, for example, when you connect an appliance to an outlet and turn it on. Circuits can be completed in other ways, some of which can have dangerous—even fatal—consequences.

Appliances are rated in terms of voltage, most commonly at 120 V or 240 V. The voltage available through an electrical outlet must match the manufacturer's voltage requirement for a given appliance. Otherwise, the appliance will fail or operate inefficiently or even cause a breaker on the circuit to cut off the flow of power.

Current (and voltage) from the power company comes as alternating in direction 60 times per second, known as ac, or alternating current. Batteries and special power supplies provide steady voltage and current, referred to as dc, or direct current.

Power lines going into a substation are at 115,000 V, and the highest going out are at 13,200 V.

The federal Occupational Safety and Health Administration (OSHA) defines hazardous voltage as anything above 50 V. The highest voltage inside your home is usually 240 V. At LANL, the supply voltage in a building is usually 480 V or less.

Power lines leading to a home or LANL building carry voltages above 600 V. They can be overhead or underground lines. You should always be aware of the location of both types of lines—overhead lines can be accidentally contacted by equipment, and underground lines can be struck during excavation or penetration.

### Circuits

A closed circuit represents a complete path of the flow of current

- from the voltage source;
- through the load (e.g., an appliance); and
- back to the voltage source.

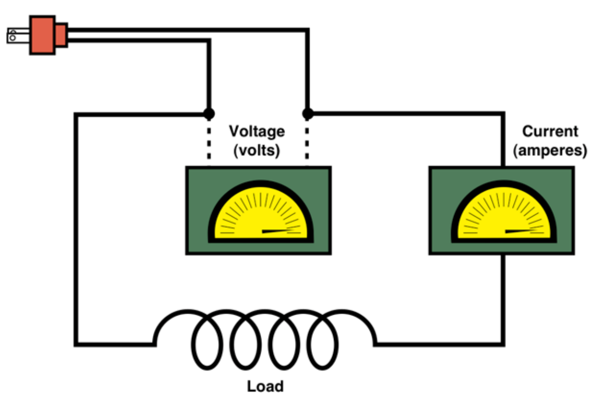
Normally, current flow can be interrupted, or broken, by a switch. Sometimes current can be broken by other actions, such as the accidental cutting of a wire.

Every electrical device draws a prescribed amount of amperage, or milliamperage (one thousandth of an amp), from its voltage source. Each device linked into a single circuit adds to the current load. Drawing too much current can overload a circuit or damage a tool or appliance.

**Resistance** is only part of a more general relationship between voltage and current. The term **impedance** is more complete because it includes the effect of phase difference between alternating voltage and current.

### Resistance

Resistance is electrical friction, or opposition to the current flow, put up by the voltage source, wires, appliance, or any other element through which electricity flows. Resistance is measured in *ohms*.




**An electrical circuit showing how voltage and current are measured with two different kinds of meters: a voltmeter and an ammeter. The load could be a lightbulb, a motor, or any electrical device that presents resistance to the flow of charge (current).**

### Relationships among Current, Voltage, and Resistance

Increasing or decreasing voltage or resistance can manipulate the flow of current, either deliberately or accidentally. Increasing voltage will increase the current; decreasing voltage will decrease the current. For example, on very hot summer days, the demand for power is exceptionally high. The power company decreases the voltage on these days, which decreases the current flow in our homes. Such decreases make air conditioning and other appliances operate less efficiently.

Increasing the resistance in a circuit also decreases current flow. Conversely, decreasing circuit resistance increases current flow. An example of this principle is the brightness control for the console lights on a car, where the current going to these lights is determined by an adjustable resistance in the circuit.

These relationships among current, voltage, and resistance are known as *Ohm's Law.*

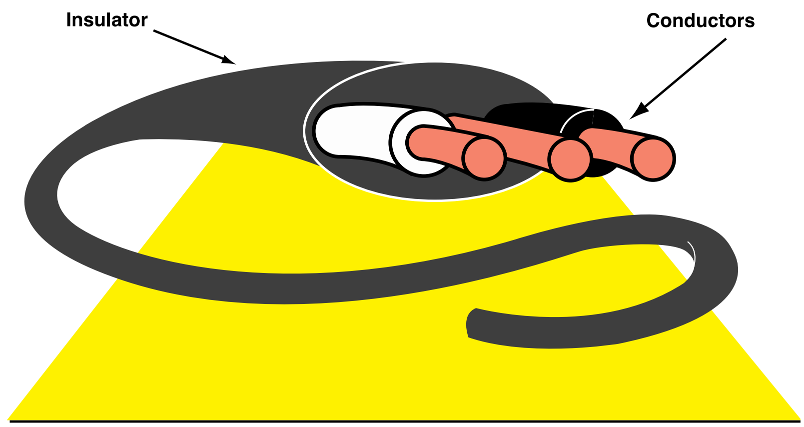
The length of an electrical wire and its diameter, or gauge, also affects resistance, i.e., the longer the wire or the smaller its diameter, the greater the resistance. Thicker wires in extension cords are capable of carrying high levels of current, which are necessary to operate heavy-duty equipment and electric heaters.

Later, you will see how resistance can affect your personal safety when you work around electrical sources.

### Conductors

A *conductor* is any substance—gas, liquid, or solid—that permits the passage of electric current. Copper is used in wiring because it is an excellent conductor. Other substances may also act as good conductors, regardless of whether they are designed for that purpose. These substances include saline water, as well as metals such as aluminum, gold, and silver. Wood is a poor conductor when dry but increases in conductivity as its moisture content increases.

## Wiring and Electrical Equipment




**An example of typical wiring found in dwellings built after 1970.**

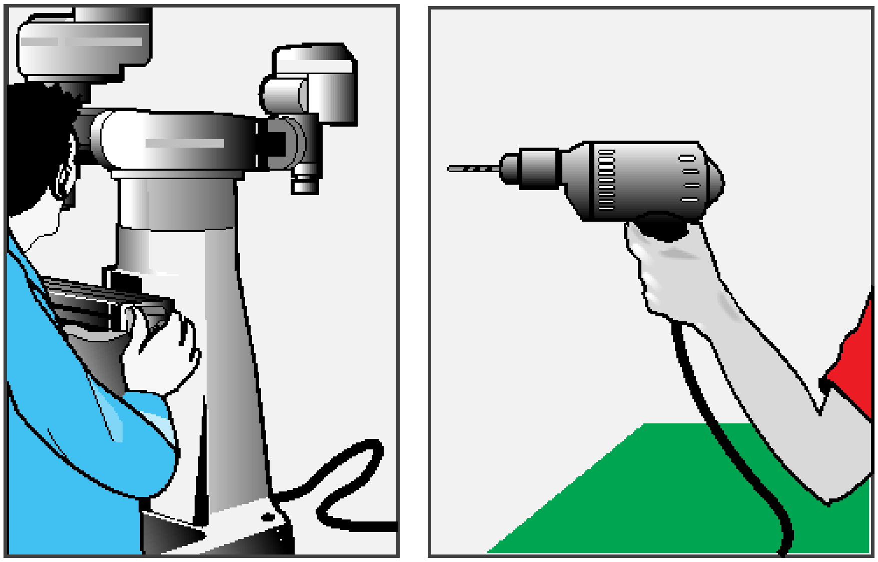
### Insulators

Electrical wires are *insulated*. This means they are wrapped in a nonconductive material to block the transfer of electric current from one wire to another, or from the wire to other conductors. Insulating materials include

- glass,
- plastic,
- synthetic rubber, and
- cotton.

### Grounding

An electrical ground directs electricity back to its source and into the earth—rather than through a person who touches the circuit—by providing a conductor with less resistance than a person's body.



**Examples of typical electrical equipment**

Electrical systems can have built-in grounds in each outlet (recognizable by their three-hole design). These accommodate three-pronged plugs, which have an internal grounding wire. Two-pronged plugs fitted with grounded adapter plugs are not recommended for use unless the adapter is properly grounded, which is normally an awkward arrangement. Adapters are not to be used at LANL.

## Exercise 1

Check your answers with the answer key on page 47.

1. Electricity is a combination of a force on electric charge due to a difference in voltage and the movement of electric charge, known as current. Current below 3 mA will only tingle but not shock a person. You may experience shock if
   a. your body is all at one voltage level
   b. your skin touches a voltage source while holding onto a grounded metal handrail
   c. you wear insulated gloves rated for the voltage source you touch with your gloved hand
   d. despite touching a voltage source, no more than 3 mA current goes through your body
2. Electricity at the Laboratory is provided at different levels of voltage. The voltage levels you should expect to encounter out of different types of wall sockets are
   a. 80, 120, 480 volts
   b. 120, 240, 480 volts
   c. 120, 208, 300 volts
   d. 24, 48, 120 volts
3. The highest voltage on a power line coming out of a substation that distributes electricity around the Laboratory is
   a. 7000 volts
   b. 13200 volts
   c. 28000 volts
   d. 115000 volts
4. If an electrical circuit is not complete
   a. all voltage levels on it will be zero
   b. it will be required to take this course over
   c. it will normally not carry any current
   d. you cannot be shocked by touching any part of it

5. A conductive path that starts from one side of a voltage source and returns to the other side of the source is called
    a. a resistor
    b. a conductor
    c. an insulator
    d. a circuit
6. Metals, even if not in wires, are good conductors of electrical current and therefore must
    a. be part of an electric circuit
    b. be kept from cutting into insulation on electric wiring
    c. not be placed next to insulated wires
    d. be painted
7. Material made from rubber or plastic can be used as an electrical insulator because
    a. it needs small voltage differences to make current to go through it
    b. thin layers (>0.01 inches thick) of it will hold off current at voltages above 600 volts
    c. it is plentiful
    d. it can be made to bend easily
8. One of the following statements is correctly stated:
    a. A 100-ohm resistor will allow several volts of current when a 300-ampere difference is put across it
    b. A 100-ampere resistor will allow several ohms of current when a 300-voltage difference is put across it
    c. A 100-volt resistor will allow several amperes of current when a 300-ohm difference is put across it
    d. A 100-ohm resistor will allow several amperes of current when a 300-voltage difference is put across it
9. Dangers directly caused by electricity in the workplace are
    a. electrocution, shock, and burns
    b. asphyxiation, shock, and burns
    c. electrocution, toxicity, and burns
    d. electrocution, shock, and lacerations

# Electrical Hazards

## Electrical Shock

Electrical shock is the passage of electric current through some part of the body. The human body has very little ability to withstand electrical shock and is easily damaged for the following two key reasons:

- people have extremely sensitive nervous systems, and
- heat concentrates in body tissues.

Both of these factors can mean disaster for anyone who comes in contact with electrical energy.

## Effects of Electrical Shock on the Body

The human nervous system is made up of thousands of circuits. These circuits carry electrical impulses and operate at very low voltages and currents—on the order of millivolts and milliamps. Contact with even very low-level electrical currents can disrupt the body’s normal functioning.

When an external current passes through the body, its effects on the nervous system, muscles, and critical organs, such as the lungs and heart, can be severe. Such impacts occur for the following reasons:

**Automated external defibrillators** (AEDs) are distributed throughout the Laboratory. Training is required to use them and is available at the Training Center in White Rock. Call 7-0059 to register.

- Electrical shock stimulates the nerves, which conduct electricity extremely well. Low currents (milliamps) produce a tingling sensation that increases to intense pain as the current increases.
- Electrical shock can override the body’s ability to control muscle function. The muscle cells become locked or clamped, sometimes causing the body to become locked onto the circuit. This condition often results in severe muscle damage.
- Electrical shock can affect the behavior of the lungs and heart; breathing may be impaired or may stop completely.
- As the current increases, electrical shock can cause heart fibrillation (erratic beating), or the heart may stop completely. Normally, the heart’s muscle fibers contract in a regulated fashion and the heart beats in a steady rhythm. Electrical shock can cause the heart’s muscle fibers to contract randomly—blood flow ceases as the heart quivers rather than beats.

- When the heart stops, blood pressure drops to zero, resulting in a lack of oxygen to the brain. Brain cells begin to die quickly under these conditions. The brain uses up available oxygen within 5–10 seconds unless cardiopulmonary resuscitation (CPR) is started or the heart is restarted.

***Note:*** *CPR will not necessarily restart the heart; rather, its primary purpose is to sustain blood flow to provide the brain with oxygen until medical assistance is available.*

### Severity of Electrical Shock

The severity of shock a person receives when trapped in an electrical circuit is affected by several factors, including

- the amount of current flowing through the body,
- the path of the current through the body, and
- the length of time the body is in the circuit.

The amount of current that can enter the body is partly determined by skin and body resistance. Just as different factors can affect resistance in a normal electrical circuit (e.g., type of metal or wire diameter), body conditions also affect resistance.

Dry skin resists electrical current passage much better than wet, broken, or injured skin tissue. Depending on the area of contact, dry skin offers between 100,000–1,000,000 ohms of resistance, compared with only 100–1000 ohms for wet skin. Sweaty palms and wet feet greatly reduce skin resistance. Standing on wet concrete or in a puddle of water greatly reduces total-body resistance.

### Path of Current through the Body

Both the current path through the body and the amount of electrical energy concentrated in body tissues help determine shock severity. Because of differences in internal body resistance, some pathways through the body are more dangerous than others. The most hazardous current paths are through the heart and brain, where resistance is lowest and damage to the bodily system can be most severe.

### Length of Time the Body Is in the Circuit

The longer the body is part of a circuit, the more dangerous the shock will likely be. Durations longer than a fraction of a second, at shock currents larger than a few milliamps, can kill.

The longer the body is in a circuit, the more likely it is that tissue will be destroyed and the heart will fibrillate.

## Exercise 2

Check your answers with the answer key on page 47.

1. A fire needs oxygen, fuel, and a heat source to get started. Electricity can provide the excessive heat when
    a. the current drawn from an electrical outlet is greater than its rated current
    b. a breaker trips
    c. a fuse burns out
    d. a ground fault circuit interrupter (GFCI) trips
2. An electrical system is considered safe if and only if it
    a. meets all the code requirements in the National Electric Code
    b. was built after 1970
    c. has a GFCI outlet on it
    d. can provide 15 amperes of current
3. Excellent conductors of electric current include
    a. all materials
    b. metals
    c. salt water
    d. pure water

4. When one's body comes in contact with a flow of electric charge (current) greater than 5 mA,
   a. electrical shock will occur
   b. burned flesh will occur
   c. only a tingle will be experienced
   d. it should be left up to a supervisor to determine if a trip to OM is necessary
5. Which of the following does NOT determine how severe an electrical shock may be?
   a. points at which current enters and leaves the body
   b. person's size
   c. amount of current passing through the body
   d. time of day
6. Which of the following are NOT bodily responses to current passing through it?
   a. loss of muscle control
   b. excessive sweating
   c. burns
   d. cardiac arrest
7. Electrical current mostly takes the path
   a. where water is
   b. of least resistance
   c. of warmest temperature
   d. that is the shortest
8. Safe work practices with electricity include
   a. plugging an electrical cord into an outlet when standing on a wet surface
   b. carrying a tall ladder vertically in the vicinity of low hanging power lines
   c. staying beyond 10 feet of exposed electrical power distribution equipment
   d. securing an extension cord to a power cord with a knot where they meet

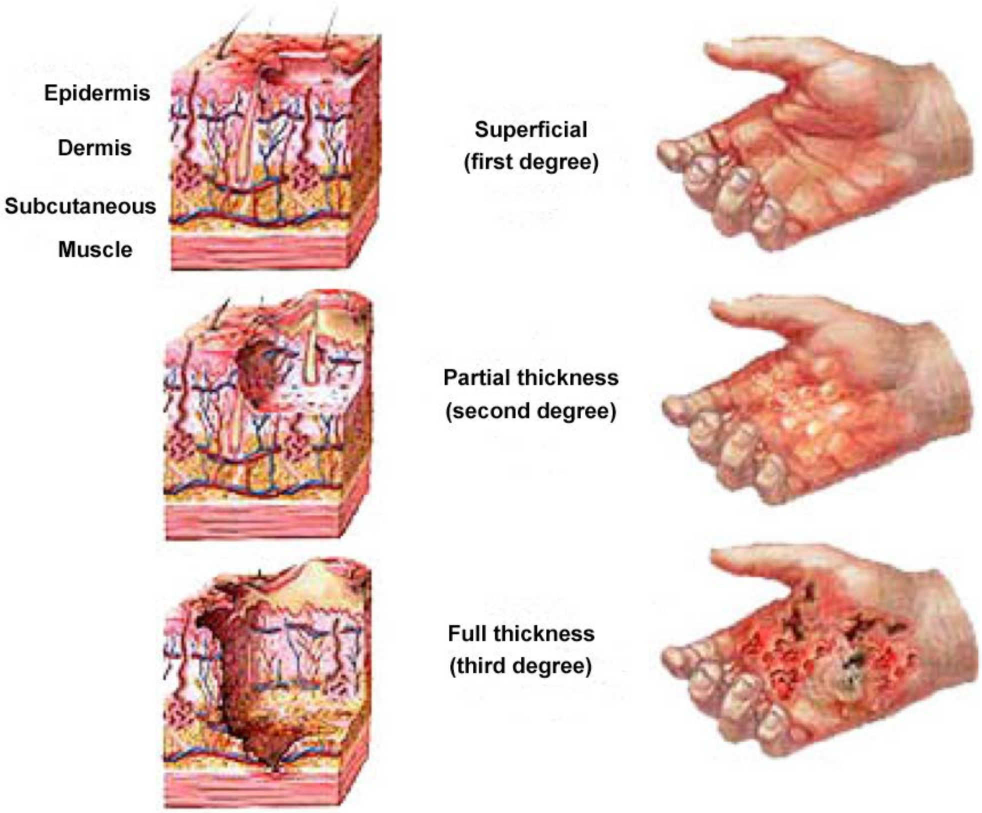
## Types of Electrical Injuries

Electrical injuries result from electrical shocks, arcs, or explosions. They fall into two categories:

- primary injuries, which often produce severe effects, including
  - burns, both internal and external;
  - nerve and organ damage;
  - loss of vision; and
  - death; and
- secondary injuries, which can involve others besides the shock victim and may be equally serious. Such injuries might include
  - broken bones from a fall or
  - traumatic injury from a thrown tool.

The passage of electrical current through the body can concentrate large amounts of heat energy in the tissues. Body tissues are highly sensitive to heat; electrical burns quickly result when electricity runs through them. Not only can large amounts of heat result from direct shock but they can also concentrate in body tissues as a result of an electric arc or blast due to

- a short circuit (a voltage source making contact with a direct path to ground),
- failed insulation, or
- a ground fault (any live part of a circuit making an unintentional path to ground).




External burns damage skin and muscle tissues. Burns at the points where current enters and leaves the body are often visible and severe. External burns can result when skin contacts electrically heated objects, such as metal electrical boxes or barriers.

Electrical burns can also occur internally, damaging muscle, blood vessels, and nerve tissue. Internal burns extend from the entry to the exit contact points. This is why limbs may need to be amputated after an electrical shock causes what appears to be a simple surface burn.

Electrical burns can also result from high-voltage arcs or explosions, which may heat surrounding gases to 20,000°F or higher. If your skin comes in contact with superheated gases, burns are a certainty. Even if you are several feet from the source of the arc, you can receive severe or fatal burns from such hot gases.

The blast associated with an electrical arc results from pressure developed by the near-instantaneous heating of air surrounding the arc and also from the expansion of metal as it is vaporized. Such blasts can be powerful enough to hurl people and objects considerable distances.

**Delayed Electrical Shock Syndrome**

Studies have identified long-term effects of electrical shock. Genetic material may be harmed as a result of a shock and can create problems weeks or even years later. Delayed symptoms may include

- paralysis,
- speech or writing impairment,
- loss of sense of taste, and
- other disorders resulting from unhealed nerve tissue.

In any case of electrical shock (except for carpet shock) prompt attendance to medical attention is required by going to Occupational Health (OH).

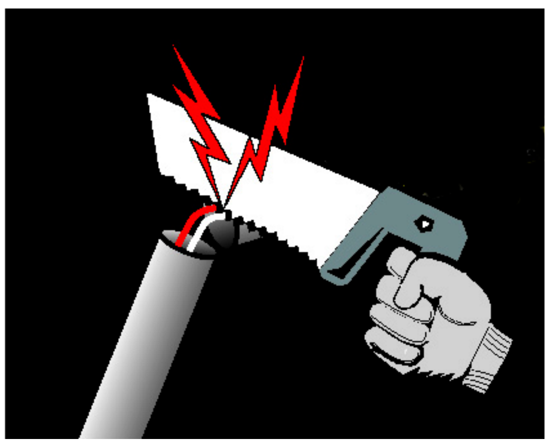
## Electrical Hazards in Construction

When you are working at or near a fuse box or electrical panel, hammering a nail or driving a screw into the electrical line that runs to the panel can result in a shock. Never assume you know the location of wires running to the panel. The building manager can help you find the lines or obtain as-built drawings. The subcontractor has machinery that can help locate power lines if drawings are not available or might be unreliable.

**Case 1: Conduit Penetration**

During demolition of an old building, a worker cut through a120-V electrical wire and received a mild shock. The foreman assumed that the electrical subcontractor had either deenergized or removed wire from the nearby conduit.

How could this accident have been avoided?

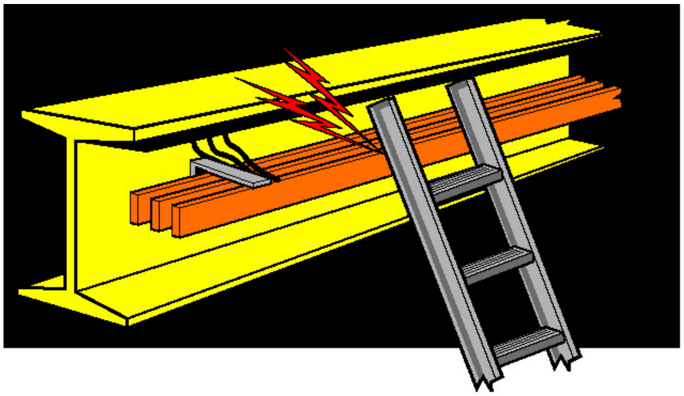


**Case 2: Fireproofing around Conduit Penetrations—Ladder Placed on Crane Bus Bar**

Two workers using an aluminum extension ladder contacted energized electric crane conductors as they were fireproofing circuit penetrations. Arcing occurred at the contact point. Although another person observed the incident, the two workers denied it had happened. Burn marks and black soot on the ladder indicated otherwise.

What should have been done to prevent this accident?

What do you think were the consequences, if any, to the workers?



## Electrical Hazards in Painting

Metal extension poles for paint rollers can be a source of electrical dangers. If a pole or roller contacts exposed wires or other electrical parts, the painter can receive a shock, especially while on an aluminum ladder.

## Electrical Hazards in Excavation

Whether you are digging a ditch or jackhammering through a concrete floor, always exercise caution. Excavating permits are required for certain jobs. These are issued after plans have been examined and hazards identified. The job supervisor should brief you before you begin work. You should also be given a copy of the permit to read and study. You are encouraged to raise safety concerns to supervisors.

All digging or jackhammering should be done only after the locations of electrical lines and all other utilities have been

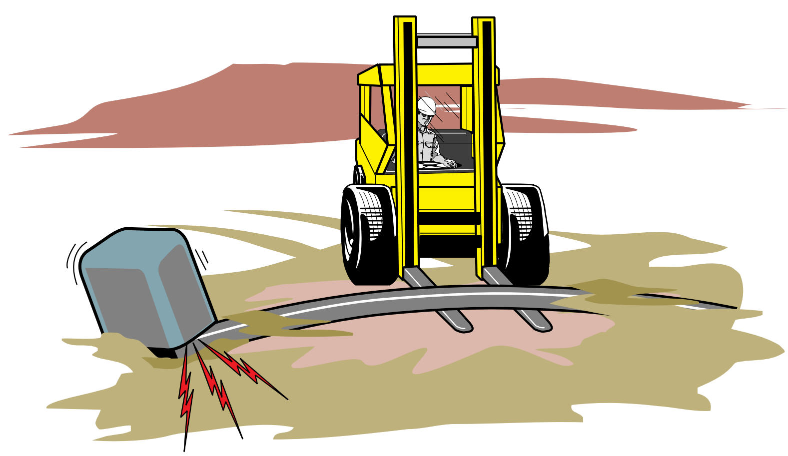
- identified,
- marked, and
- documented on an excavation permit.

However, building plans may not always be complete or up to date. Therefore, you must be alert for objects such as red concrete structures buried underground. These almost always indicate the presence of high-voltage lines. Never continue drilling or shoveling if you encounter

- an obstacle not previously identified;
- one you suspect might harm you or fellow workers; or
- one that might, through your actions, disrupt service to nearby facilities.

**Case 3: Conduit Removal Using a Forklift**

A forklift operator who was removing conduit misunderstood the instructions given to him by his foreman. The conduit was to have been disconnected from the pedestal first. Instead of removing only the conduit, which had been deenergized, he mistakenly pulled both the conduit and a power pedestal from the ground. Because the power pedestal was not scheduled for removal, it had not been deenergized. When the pedestal was pulled loose, arcing occurred and the circuit breaker tripped.



How could this accident have been avoided?

How might the forklift operator have been injured?

## Electrical Hazards around Machinery

Before any maintenance can be done on a piece of machinery, such as changing the brushes on an industrial motor or the blade on a power saw, the machine must be unplugged. Simply turning the machine off does not provide sufficient protection from electrical shock. If you or someone else inadvertently switched on the machine while working on exposed parts, you could be severely injured.

## Electrical Hazards for Custodial Staff

You should not use metal-handled mops near battery banks or energized electrical devices. Water is a good enough conductor to create a shock hazard for anyone in contact with it. The building manager should be notified so that energized devices are deenergized before any mopping takes place. If so authorized, you may unplug devices.

Take extra care when using a vacuum cleaner, which can cut up loose extension and telephone cords, thereby creating hazards.

## Electrical Hazards from Overhead Power Lines

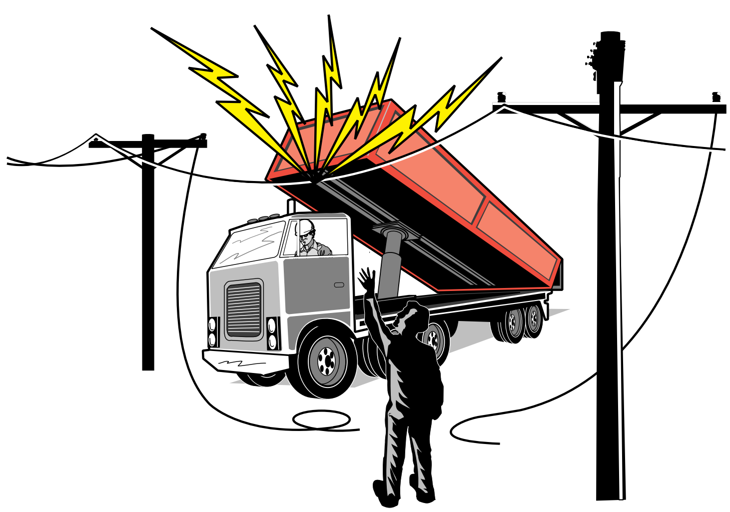
Many jobs can put workers at risk of contacting overhead power lines. These might include

- operating a crane,
- working on a roof or ladder, or
- manipulating metal poles for a variety of tasks.

Metal parts that contact overhead power lines can put workers in extreme danger of being shocked. Electrocutions accounted for 5% of worker deaths in 1994. About a third of these fatalities resulted from workers or their equipment contacting overhead power lines.

**Case 4: Dump Truck Strikes Overhead Lines**

An 18-wheel asphalt dump truck struck two overhead 13.2-kV lines while performing dumping operations. The driver, after dumping a load of asphalt, began moving the truck forward while the truck bed was fully extended. One of the lines was cut immediately and the broken ends fell to the ground. The other line caught the underside of the extended truck bed but did not break. A nearby worker heard the sound of the arc when the truck bed hit the lines and saw a big ball of fire under the front end of the truck. He yelled to the driver to stay in the truck. The driver was not injured in the accident, but the truck was badly damaged.



What would have likely been the consequences to the driver if he had stepped out of the truck and touched the ground while still touching or being very close to the truck?

Why wasn't the driver injured?

## Electrical Hazards from Lightning

Personnel doing work outdoors often face the added hazard of lightning, especially during summer months. When lightning strikes, it moves along a path to the ground and will "seek"

- metal objects,
- poles,
- trees, or
- people.

**Case 5: Lightning Strike**

A worker was inspecting a piece of heavy equipment used for road maintenance when the equipment was struck by lightning. The worker's hand was about 8 inches from the equipment when the lightning struck. He was knocked to the ground and remained dazed for a few moments. Investigators determined that the accident occurred as a result of weather conditions and that the worker could not have taken any precautions.

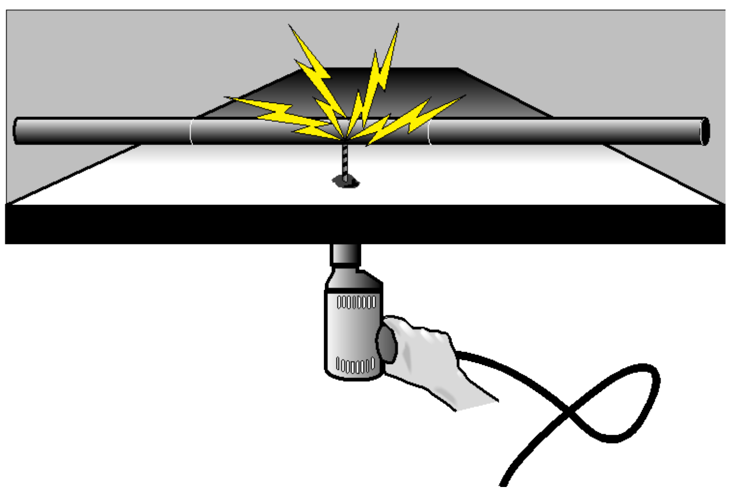
Do you agree with their findings? Why or why not?

What might have happened if the worker’s hand or other body part had been resting on the piece of equipment?

## Other Electrical Hazards

### Case 6: Out-of-Date Drawings and a Close Call

While installing a bracket in the ceiling for a heating, ventilation, and air conditioning modification, a sheet-metal worker accidentally drilled into a live electrical wire. The drawings provided with the work request did not indicate there was an electrical conduit in the concrete—such drawings are not regularly updated. The worker was not shocked because he was using a double-insulated drill.



What lessons can be learned from this incident?

## Finding Hidden Electricity

Know what is hidden before you

- drill,
- cut,
- dig,
- clear snow, or
- grade a road.

Also, investigate to detect hidden electricity by

- using as-built drawings,
- applying ground-penetrating radar (GPR),
- drilling pilot search holes to insert fiber optics, and
- consulting with professionals who know the site.

## Exercise 3

Compare your answers to the answer key on page 47.

1. Lightning is *NOT*
   a. a discharge of atmospheric electricity
   b. a spark
   c. a hazard
   d. a result of global warming
2. Lightning can *NOT*
   a. cause burns
   b. strike you while you are in a closed car
   c. kill you
   d. destroy property
3. Where should you *NOT* go if you are outside in a lightning storm?
   a. inside a house
   b. inside a large building
   c. under a tree
   d. inside a closed car

4. Avoid all of the following during a lightning storm EXCEPT
   a. using a land-line telephone
   b. taking a shower
   c. standing on open porch
   d. crouching to a low position
5. If you are outdoors and cannot get indoors, which of these should you stay clear of?
   a. metal fences
   b. your car or truck
   c. thick growth of small trees
   d. roofed shelter without walls
6. Which of the following are ways to protect yourself if caught outdoors in a lightning storm?
   a. stand under a tall tree
   b. get down on your knees keeping your head low
   c. stand very close to your buddies
   d. lie down flat

# Module 2: Preventing Electrical Accidents

## Module Overview

Workers in any craft or trade must follow safe work practices and procedures to avoid electrical accidents. This module describes electrical safety procedures and practices you can follow to protect yourself from harm.

## Module Objectives

When you have completed this module, you will be able to

- recognize the use of integrated safety management (ISM) and integrated work management (IWM),
- identify electrical safe work practices,
- recognize the importance of the pre-job brief,
- recognize why lockout/tagout is important, and
- recognize the difference between energized and nonenergized work.

## ISM and IWM


ISM is symbolized by the five-step process shown at the left. It requires workers to systematically break down each job into these five steps. Steps one through three are usually part of a pre-job brief in which all workers on the job would normally participate and provide input.

IWM requires workers to use the integrated work document (IWD) to delineate how hazards are to be controlled. All workers are encouraged to contribute to creating the IWD.

**Lessons Learned at LANL – March 2010**

- Worker used a forklift with a boom improperly to transport material from one site to another.
- The boom impacted a deenergized electrical line.
- There was inadequate site- and task-hazard analysis and a lack of worker guidance for material transports.
- The incident is a deficiency of ISM Step 2, Analyze the Hazards.

*ORPS report NA-LASO-LANL-PHYSTECH-2010-006*

### Conduct a Pre-Job Briefing

You are responsible for discussing the scope of your duties with your supervisor and coworkers before a job begins. You must

- identify the hazards,
- identify and locate the shutoffs for each affected power and energy source,
- locate suitable telephones or fire alarms to use for summoning emergency help,
- locate the exits nearest to the job site, and
- locate a fire extinguisher appropriate for electrical fires.


Know the scope and hazards delineated in the IWD and the safe work practices for the job, and follow them carefully.

In addition, if you are working in a strange facility, you should establish whether

- you have authorization to be there and have received site-specific training and a job package,
- an escort is required by the building manager or a knowledgeable worker, and
- the work area has changed since the pre-job brief because of new equipment or covers being removed.

## Safe Work Practices

### Use Personal Protective Equipment

Personal protective equipment (PPE) is one of your primary modes of defense against electrical shock or arcs. Insulating gloves should be used for work involving

- penetration,
- electrical conduits that have not been located, and
- places where electrical conduit is nearby (for example, when installing mounting anchor bolts for shelves).

The gloves you use must be appropriate for the voltage class on which you are working. Not all insulating gloves are equally able to protect you from electrical shock.

Remove any jewelry—rings in particular—that might damage or puncture the gloves and compromise their effectiveness.

Because cotton is an excellent insulator, cotton clothing is preferable when working around electrical equipment.

***Note:*** If you must use dielectric gloves in your work, you are required to take the on-the-job (OJT) training *Demonstration of Proficiency for the Use of Dielectric PPE* (Gloves) *(19653).*

### Use Protective Equipment

Wherever possible, use protective equipment such as insulated tools and insulating mats. Such insulation can protect you from shock in the event of a ground fault.

Using double-insulated tools (e.g., the plastic core of a drill motor) can also prevent a shock if a fault occurs. Use cord-connected power tools equipped with GFCIs when working in wet or conductive areas. The GFCI will interrupt the current if a ground fault greater than 4–6 mA occurs.

Use portable ladders with nonconductive side rails (fiberglass is best) when working in areas where there is any potential for exposure to

- power lines,
- electrical wires, or
- energized equipment.

### Use Safe, Properly Rated Extension Cords

Extension cords are intended for temporary use with portable appliances, tools, and similar equipment not normally used at a particular location. The following measures are guides for their use and care:

- Be sure the extension cord you use is of the proper type and rating for the job and location.
- Inspect cord insulation for wear before use; check the plugs to ensure that the wire termination covers are secure.
- Never daisy-chain (link together) extension cords. Connections can be kicked loose. Use the single, correct cord for the job.
- Unplug the cord when the job is done, and never leave it plugged in while unattended.
- Do not lift or lower equipment using the cord.
- Use cords safely to prevent tripping hazards. If a cord must be laid in a location with pedestrian traffic, it must be covered with an electrical cord cover.
- Do not run a cord through a door or window, where damage to the cord may result.
- Do not drape a cord near an open flame or use it in an area where it could be chemically or physically damaged.
- Avoid using an extension cord in a wet location. If a cord must be used in wet or rainy conditions, use a portable GFCI and only a cord approved for such use. Inspect the cord for damage before use.
- After use, remove the plug from the wall—at the outlet—and roll up the cord for storage.
- Do not use or repair damaged cords.

## Use Portable Electrical Equipment Safely

**Using Electrical Equipment –**
- Check listing
- Check for damage
- Is the use appropriate?
  - o Portable drill with taped electric cord?
  - o 100-foot extension cord to be used 10 feet from an outlet?
  - o A space heater electrically connected through a relocatable power tap (RPT) with several other devices plugged into the RPT?

The following guidelines are provided for the safe use of plug-connected equipment, such as portable drills, impact wrenches, and portable sanders:

- Be careful not to damage the equipment casing or the cord insulation. Report any damage immediately to your supervisor. Never use damaged equipment.
- Inspect the equipment before use. Place out-of-service tags on damaged equipment so others will not try to use it.
- Use cords with three-pronged plugs in the proper receptacles. Never cut off the grounding prong to accommodate a two-pronged receptacle.
- Use GFCIs when working with portable electrical equipment, particularly in flooded areas or where contact with conductive liquids is likely, such as
  - – rooftops,
  - – crawlspaces, and
  - – outdoor locations.


***Note:** OSHA requires the use of GFCIs on electrical equipment during construction activities.*

- Use electrical equipment such as a wet vacuum (wet vac) that is designed to operate safely in wet conditions.
- Make certain your hands are dry when handling plugs on extension cords or energized portable equipment.

Use equipment that carries the Underwriters' Laboratories (UL) label or has been approved by one of the other nationally recognized testing laboratories (NRTLs) or an electrical safety officer. This means that the device has been tested and meets minimum safety standards. ESO-approved equipment is tagged and documented in the Electrical Safety Program database.

### Stay Clear of Energized Equipment

Make sure that no part of your body, especially your head, touches energized equipment. Never work on energized equipment unless you are qualified to do so. See the section titled Qualified Electrical Workers at LANL under Energized Electrical Work and Lockout/Tagout for further discussion of this very important point. You must be aware of the limited approach shock boundaries and arc flash boundaries so that you never cross them.

### Refer to Updated Drawings

LANL policy requires managers to keep updated drawings of all electrical systems under their supervision. If a system or building has been modified, the drawings you work from or refer to should be current *as-built* drawings, which detail a structure's framework and its utility pathways and connections.

Old buildings may have had many additions and modifications over the years. As-built drawings may not be available. In such cases, do not trust your safety to outdated drawings. If you have been asked to perform a task that could expose you to buried electrical conduits—such as excavating a trench or ditch inside or outside a building—the facility or building manager should help you locate nearby underground power lines.

### Do Not Cross Physical Barricades


Physical barriers are erected at job sites to enclose energized equipment. Barricades can take the form of cones, labeled nonconductive tape, or signs. If barricades are not effective in controlling traffic through the work area, an attendant must be posted to control traffic.
As a nonelectrical worker, you must honor such barricades and/or an attendant.

The *safe approach boundary* is the distance you must stay from a shock hazard. Stay at least 3.5 feet from a 120-V, 240-V, or 480-V hazard. Do NOT approach downed power lines. Do not reach toward power lines with any object.

**Controlling hazards of arc welding:**

- Note that startup current is the most hazardous
- Wear radiation anticontamination clothing that satisfies the Flame Resistant performance criteria of ASTM F1506-10a.

Some facility power can produce at arc flash; stay at least 4 feet from electrical facility power equipment.

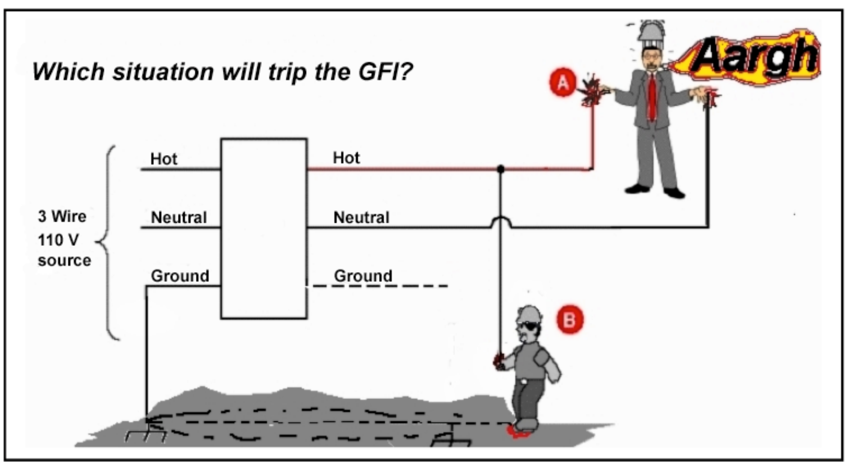
### Arc Welding

Arc welding has special hazards and requires appropriate protection. To prevent a fire from slag and sparks, work areas may have to be wet down. Take precautions to stay dry.

Startup current is the most hazardous current. Follow the equipment manufacturer's instructions for welding in electrically hazardous conditions. Consult an ESO for additional safety precautions.

## Protective Devices

*Ground fault (circuit) interrupters* (GFCIs or GFIs) are devices built into electrical cords, electrical outlets, and circuit breakers. They are designed to trip, or open, a circuit when they sense a small difference in the current between the two wires making up the circuit. A GFCI is one of the best safeguards available for preventing electrical shock.




*Circuit breakers* are switches that automatically trip open to interrupt the flow of electrical current when it overloads the circuit.

When a circuit breaker trips, there are either too many appliances or pieces of equipment on the circuit (drawing too many amperes), or a device on the circuit has malfunctioned. *Fuses* perform the same function as circuit breakers. Fuses are widely used in cars, electrical equipment, and electronic circuits.

*Tool interrupters* are available from some manufacturers. These devices will stop the current whenever a tool, such as a drill or power saw, makes contact with a grounded metal rebar or conduit.

All of these protective devices can be lifesavers and should never be ignored, bypassed, or overridden.

## Exercise 4

Check your answers with the answer key on page 48.

1. A GFCI is *NOT* useful when working with
    a. equipment that uses alternating current (ac) electricity
    b. batteries
    c. ungrounded outlets
    d. voltages above 120 V
2. A GFCI is actually an outlet with a small
    a. relay inside
    b. computer inside
    c. iPad inside
    d. battery inside
3. A GFCI will shut off power to a machine or appliance when
    a. it detects as little as a 5-mA difference in current between the hot and neutral wires
    b. current through it is greater than that for which the wires are rated
    c. it has been in continuous use for a certain period
    d. the machine or appliance gets too hot

4. A mild shock can be felt from
    a. 1 mA
    b. 5 mA
    c. 30 mA
    d. a well-insulated cord while plugged into an outlet
5. To check whether a two-outlet GFCI is working while a device is plugged into it,
    a. press the test button to see if the device cannot be turned on.
    b. press the reset button to see if the device cannot be turned on.
    c. connect the other hot and neutral outputs with a wire, but be careful.
    d. just assume the GFCI is working and use it.

## Energized Electrical Work and Lockout/Tagout

### Qualified Electrical Workers at LANL

Before anyone may work on or near energized ("hot") electrical circuits, LANL requires that they be instructed and trained on energized electrical work procedures. To work on energized electrical circuits, parts, or equipment, they must be qualified as a

- journeyman electrician,
- journeyman lineman,
- electrical or electronics scientist or engineer,
- technician, or
- person having equivalent training or education.

For troubleshooting energized equipment, a worker must have appropriate education and experience and must know how to use electrical diagnostic and test equipment. Work on most energized systems requires an energized electrical work permit (EEWP), which can be obtained only by a qualified electrical worker.

In other words, if you are not a qualified electrical worker, you may not, under any circumstances, work on energized systems. That includes replacing fuses and resetting circuit breakers—situations in which a lack of knowledge and experience can be fatal.

A qualified person should be assigned to work on, or be responsible for, electrical equipment and systems in your area. Supervisors are responsible for ensuring that workers have received appropriate electrical training.

**Lockout/Tagout**

To avoid electrical injury,

- deenergize the system and
- use the lockout/tagout red-lock procedure.

Only authorized workers may lock out and/or tag out equipment. Such workers *must* be trained in P101-3, *Lockout/Tagout for Hazardous Energy Control.*

As a nonelectrical crafts worker, you would normally not be authorized to trip or reset breakers or other electrical isolating devices. To accomplish a lockout/tagout as an authorized worker, you would have to have your ESO or an electrician authorize you to perform the isolating step. The verification requiring a meter would also need an ESO or an electrician.

An authorized worker is appointed by line management and has the primary responsibility for human safety when locking out and/or tagging out

- systems,
- equipment, or
- machines

before they are

- serviced,
- maintained, or
- modified.

Never remove locks or tags that you find in the workplace unless you are the authorized worker who attached them. Locks and tags are placed on equipment for your safety and the safety of others.

**Locks and tags are used to indicate that power is not to be supplied to a device or a system.**

**Stop Work under Uncontrolled Hazardous Conditions**

If workers identify an uncontrolled hazardous situation in their own work, they must do the following:

- stop the work
- notify their supervisor
- remain in the area until a responder arrives.

If workers identify a hazardous situation in someone else's work, they must do the following:

- notify the person
- obtain an explanation
- notify the supervisor if not satisfied with the response
- remain in the area until a responder arrives.

LANL's stop-work policy, printed on your environment, safety, and health (ES&H) quick-reference badge, states, "Employees will stop work on any activity that poses a danger to health, safety, or the environment." This policy gives you the authority and responsibility to stop your work under unmitigated hazardous conditions.

According to ISM, you are ultimately responsible for your own safety; therefore, you have the right to stop work. If you identify a hazard to you or your coworkers, stop work immediately and contact your supervisor.

## *Notes. . . .*

# Module 3: Emergency Response

## Module Overview

When an electrical accident occurs, your correct response can minimize injuries and may save lives and property.

## Module Objective

When you have completed this module, you will be able to

- identify appropriate actions to take in the event of an electrical emergency,
- recognize where to get information, and
- recognize how accidents happen from your observation of the videoed cases in the “Concluding Activity.”

## Responses to an Electrical Accident

In the previous modules, you reviewed numerous examples of electrical accidents. Victims and observers of electrical accidents must be prepared by knowing how to respond to such events quickly and correctly.

When faced with an electrical accident, avoid putting yourself or others in further jeopardy. Evacuate the accident scene—and then call 911 from a safe location—if the scene contains a hazard such as an

- energized circuit,
- electrical fire,
- explosive material, or
- flammable gas.

## Steps to Follow in an Emergency

| In an electrical emergency: | |
|---|---|
| 1 | Deenergize the circuit. |
| 2 | Call for help. |
| 3 | Attend to the victim and/or start CPR. |
| 4 | Remain at the scene. |

### Deenergize the Circuit

The equipment or system should be deenergized as quickly as possible. In some cases where power cannot be shut off, some safety videos and publications suggest separating the person from the electrical source by using

- a “shepherd’s crook”;
- a clean, dry rope;
- a dry wooden stick; or
- an item of clothing (preferably cotton) thick enough to provide protection against the victim’s voltage level.

However, removing someone from a live circuit is not recommended at the Laboratory. If Step 1 is not possible, you should go immediately to Step 2 by calling 911.

### Call for Help

Ask someone nearby to call 911. If no such help is available, leave the victim briefly to call 911 from the nearest telephone or to pull the nearest fire alarm box.

***Note:*** *911 calls from LANL-issued cellular telephones are currently answered in Santa Fe. From these cellular phones, you may call the Emergency Operations Center at 7-6211, which connects to the LANL Central Alarm Station.*

### Attend to the Victim

Move the victim to a safer location *only* if remaining at the accident site would place you or the victim in further peril. Once you are safe,

- administer first aid and check the airway (clear the airway, as required);
- check for breathing; and
- check for circulation.

If you are certified to do so,

- administer CPR if there is no breathing and/or no circulation; and
- if appropriate and available, use an AED.

### Remain at the Scene

Protect the accident scene for investigators by ensuring that the scene is left undisturbed. If asked by emergency personnel, provide help and accompany the victim to the hospital. Assist the investigating team as requested.

## Reporting Electrical Shocks

Any electrical shock is classified as an injury and must be reported immediately. Notify your supervisor, who should have you escorted to Occupational Safety and Health (OSH-OH) as soon after the event as possible, even if injuries are not apparent at the time of the accident. After work hours, the escort should take you to the Los Alamos Medical Center. Do not attempt to evaluate the severity of the shock or its effects without medical consultation. An injury report will be filed for liability and insurance purposes.

***Note:*** *Electrical injuries must also be reported to the facility operations director (FOD), the office of the Authority Having Jurisdiction (AHJ), the Emergency Operations Center (7-6211), and other appropriate organizations.*

***Notes. . . .***

# Resources, References, and Answer Key

## Electrical Safety Support

Many people at LANL are prepared to help you with questions and concerns about your safety. Electrical safety officers (ESOs) are your first line of informed advice. They know the Electrical Safety program (P101-13) and can determine whether equipment you use is safe. Post this list where you can easily refer to it.

| **Electrical Safety Resources** | | |
|---|---|---|
| **Call . . .** | **at . . .** | **for information on** |
| AHJ: Electrical Safety Committee | http://int.lanl.gov/safety/esc/esc.shtml | energized electrical work or any other electrical safety questions about LANL operations. |
| Chief electrical safety officer and your ESO | | electrical practices in your area.<br>who your electrical safety officer is. |
| Occupational Safety and Hygiene-Occupation Health Group (OSH-OH) | 7-7251 | reporting an electrical injury. |
| Occupational Safety and Hygiene-Industrial Safety and Hygiene Group (OSH-ISH) | 7-5231 | electrical safety policies and regulations. |
| Service Innovation-Institutional Training Services Group (SI-ITS) | 7-0059 | Lab-wide electrical safety training requirements and course offerings.<br>Lab-wide training (electrical safety courses, lockout/tagout courses, etc.) and to obtain safety videos. |
| Your supervisor | | safety concerns. |
| Your union steward | | electrical safety policies and regulations. |

Electrical safety programs at LANL are based on regulations and requirements found in the documents listed below.

| Electrical Safety Document References | |
|---|---|
| **For information about…** | **look in…** |
| safety-related work practices, qualified electrical workers, and OSHA definitions, | 29 Code of Federal Regulations (CFR) 1910.301–399 (general industry standards) or 29 CFR 1926.401–499 (construction standards). |
| installation and maintenance standards, | The National Electric Code (NEC) (National Fire Protection Association [NFPA 70]). |
| Department of Energy's (DOE's) ES&H protection standards, | DOE Orders and NFPA 70E. |
| procedures for carrying out your job task, | IWD provided by your supervisor. |
| lockout/tagout requirements at LANL, | P101-3, *Lockout/Tagout for Hazardous Energy Control.* |
| LANL policies regarding electrical safety, | P101-13, *Electrical Safety Program.* Defines many electrical terms. |
| the effects of electrical shock to your body, electrical hazards in the workplace, and accidents affecting craftspeople, | Student materials for the training course, *Electrical Safety Program: Nonelectrical Crafts at LANL* (#12175). |

# Answer Key

### Answers to Exercise 1

1. b
2. b
3. b
4. c
5. d
6. b
7. b
8. d
9. a

### Answers to Exercise 2

1. a
2. a
3. b
4. a
5. d
6. b
7. b
8. c

### Answers to Exercise 3

1. d
2. b
3. c
4. d
5. a
6. b

## Answers to Exercise 4

1. b
2. a
3. a
4. b
5. a

# Concluding Activity

**Instructions:** The stories below are shown in a video. Follow your instructor's directions for reviewing them and answering the questions.

## The Automobile Accident

An emergency rescue crew arrived at the scene of a one-car accident. The car had hit a telephone pole and brought down the power line. No one in the car was seriously injured. The rescue crew assumed that the 7200-V power line was no longer energized. While they were treating the accident victims, one of the workers stood up into the downed power line and was shocked.

Do you think the worker survived the accident? Why or why not?

How could this accident have been prevented?

How could a similar situation occur at your workplace?

## The House Painting Incident

A painter climbed a ladder propped against the side of a house to continue painting the exterior. He was carrying a paint roller attached to an aluminum extension pole. The electrical power lines to the house dangled above his head, and his wet roller came in contact with the power line. There may also have been a blast from a ground fault. The painter was shocked and fell from the ladder.

Do you think the painter survived this accident? Why or why not?

How could the painter receive a shock when his body did not come into direct contact with the power line?

How could this accident have been prevented?

What do you think knocked him off the ladder?

## The Flooded Basement

During an intense rainstorm, a homeowner entered his flooded basement to retrieve some belongings, unaware that the fan motor on the heating unit there was still energized. He tripped on something hidden beneath the water, grabbed a water pipe to steady himself, and was shocked.

What happened next?

List three different ways this accident could have been avoided?

How could a similar situation occur at your workplace?

## The Unsuspecting Sister

A mischievous boy filmed his sister with his video camera as she was drying her hair in the bathroom. She had her back to him and turned in surprise, flinging the hair dryer into a sink half-filled with water. Annoyed, she reached into the sink for the dryer and was shocked.

Why are water and electricity such a dangerous combination?

How could this accident have been prevented?

How could a similar situation occur at your workplace?

## Washing the Car

A barefoot young man was washing and vacuuming his car in his driveway. The vacuum, which had a frayed cord, sat in the driveway while he hosed down the car. When the man switched on the vacuum, he was shocked and died.

What factors determine whether a person will live or die as a result of an electrical shock?

List at least three factors that could have prevented this accident from occurring.

How could a similar situation occur at your workplace?

## Fallen Limbs

A man returned to his house trailer after a storm. Downed limbs were scattered around the yard and on top of the house. As he reached up and grabbed a branch on the roof, he was thrown backwards by the force of an electrical shock.

Why was the man shocked when he grabbed the branch?

How could this accident have been prevented?

How could a similar situation occur at your workplace?

## Summary

- Have your equipment inspected to ensure it is in safe working order.
- Consult with your ESO and/or your supervisor.
- Use Pause/Stop work if unexpected hazards are found.
- Maintain a high level of alertness to electrical hazards.

# Taking the Quiz

To receive credit for this self-study, you must complete the associated quiz in UTrain. You can access the quiz in either of two ways.

## CRYPTOCard

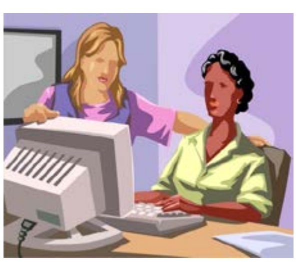
If you have a CRYPTOCard that is assigned to you with administrative authorities to LANL's Integrated Computing Network (ICN):

1. Click on the link below to return to UTrain.
2. Click on the "Return to Content Structure" button.
3. Click on the "Quiz" link to begin the quiz.

To return to UTrain, click on the following link:

http://int.lanl.gov/training/tools/wrapper/submit.html

## No CRYPTOCard



If you *do not* have a CRYPTOCard or if you have a CRYPTOCard *without* administrative authorities to LANL's ICN, you will need to locate a worker with UTrain proxy authority to grant you access to the quiz.

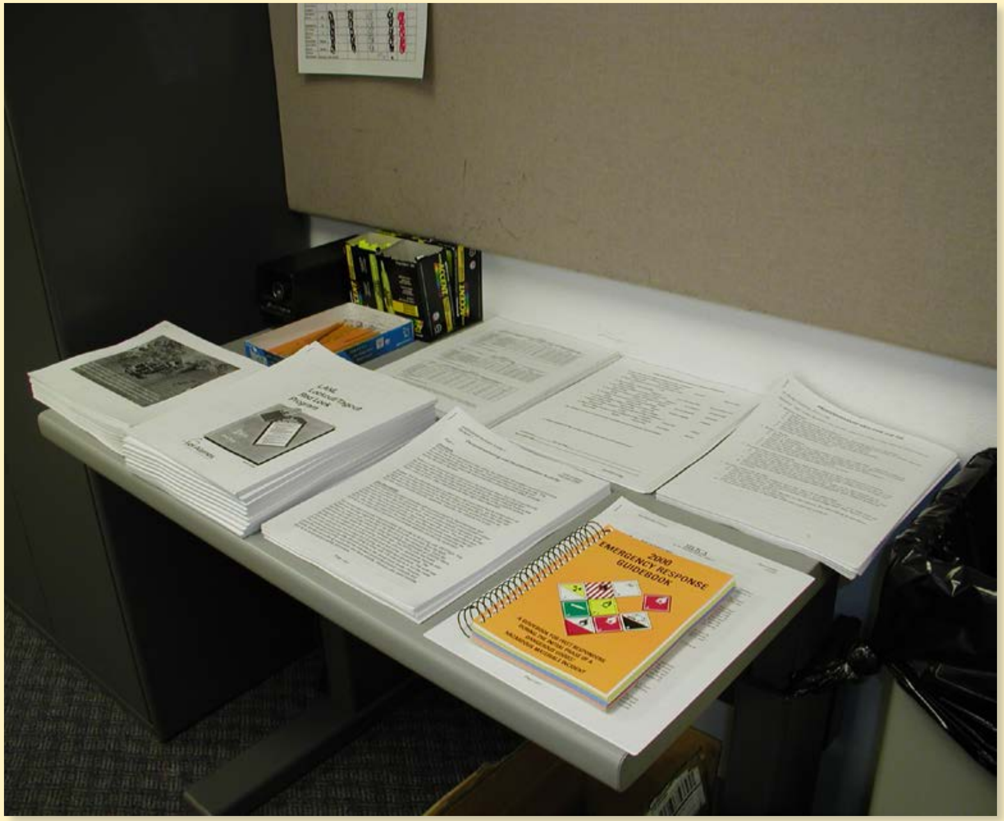
Call or email your training administrator for assistance. The following link should help you find your training administrator.

http://int.lanl.gov/services/training/admin-proctor-proxy.shtml

# Welcome to the White Rock Training Center

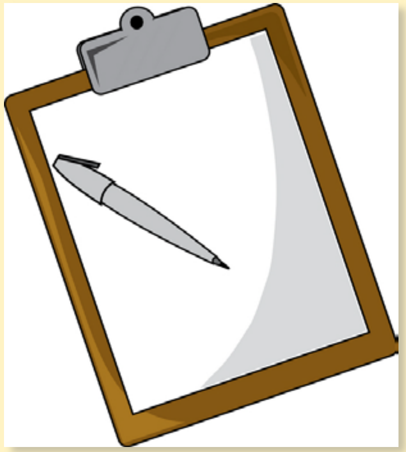
# Before You Sit Down . . .

Pick up course materials when you enter the room.

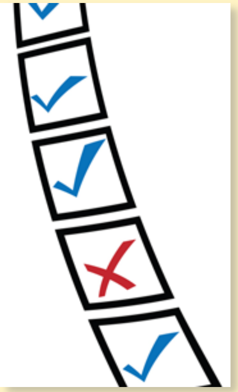


# When in the Classroom . . .

- Be sure to sign the roster.
  - print your name legibly
  - sign your name
  - print your Z number

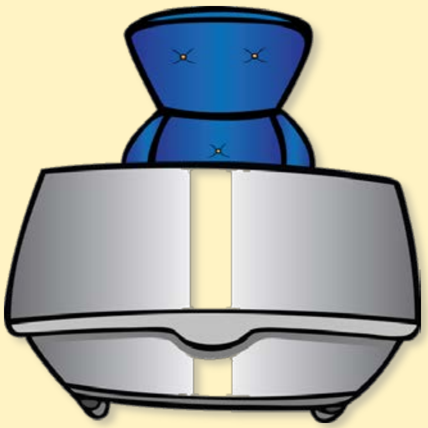


- Make sure to fill out a class evaluation. We value your feedback!



# Please Be Courteous!

- So others can exit easily, always push in your chair when you take a break or leave the classroom.



- Turn off cell phones or put them on vibrate.

# Cell Phones

- Your cell phone texting or conversation may interfere with the learning process of other students.


- Please take your phone calls to the student lobby and have your conversation there.

Yes, we're all very interested in what you're having for dinner tonight.

(Please keep phone conversations to yourself.)

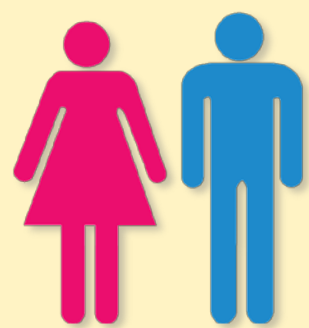
**Thank you!**

# Break Time

- Telephones are located in the front lobby just beyond the reception area.

- Soft drink and snack machines are located by the telephones.

- Restrooms are located off the hallway between the reception area and classrooms 114–118.

# Recycle Your Aluminum Cans & Plastic Bottles

- Please put trash and recyclables in the proper receptacles located in the front lobby. Please don't leave trash at your seat.

Plastic and aluminum go in here.

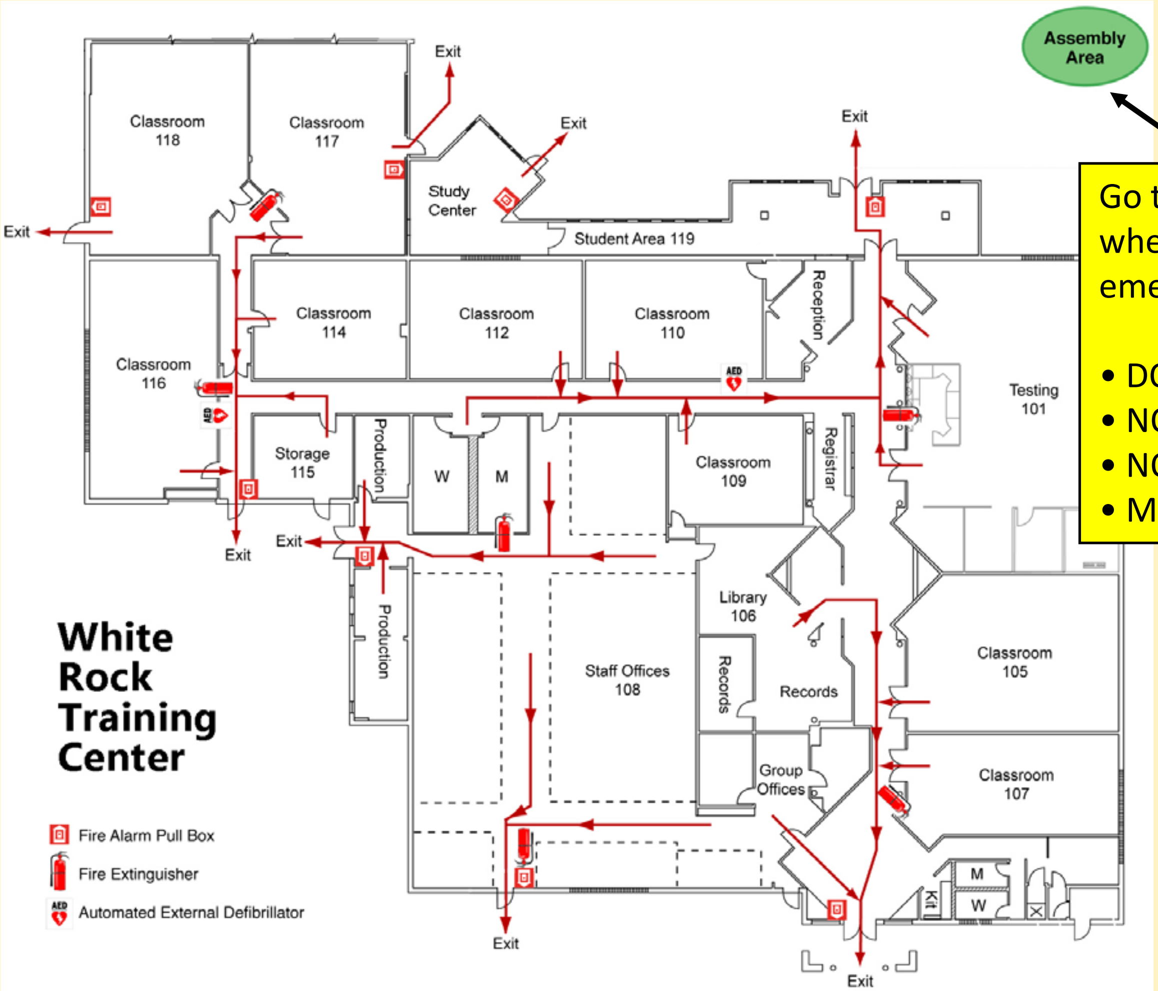
Do not put plastic or aluminum in trash cans.

# Emergency Evacuation

- If an alarm sounds, evacuate the building and report immediately to the assembly area.

- Eating, drinking, and smoking are prohibited during evacuations and at the assembly area.

# Emergency Exit Routes



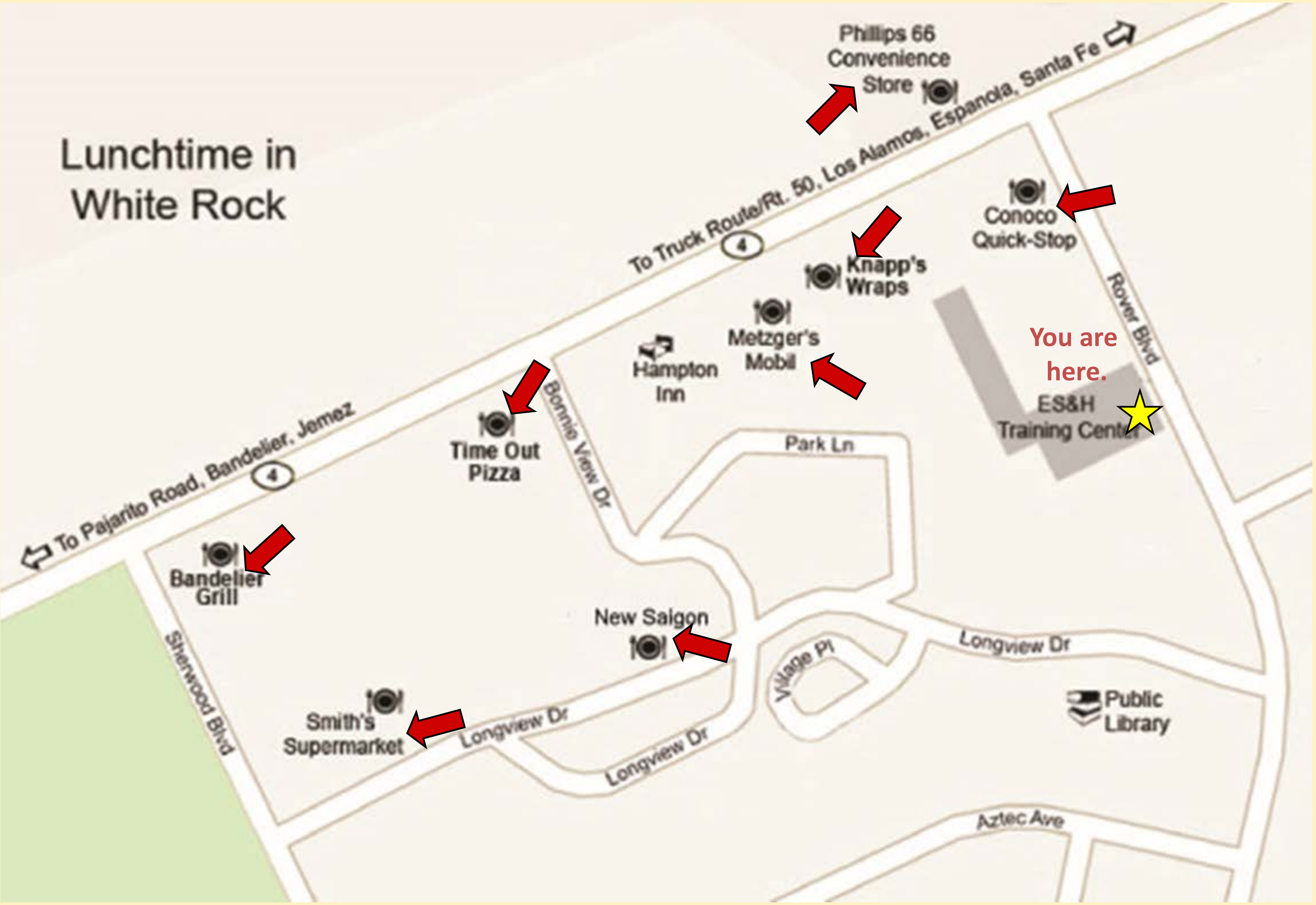

Go to the assembly area when you exit for an emergency.

- DO NOT LEAVE AREA
- NO FOOD OR DRINK
- NO SMOKING
- MINIMIZE TALKING

# WRTC Evacuation Assembly Area

After exiting the building during an emergency, assemble at the grassy knoll beside the front parking lot.

# Lunchtime in White Rock



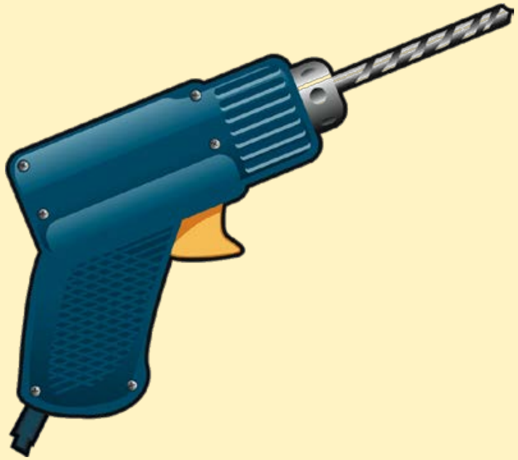
# My Clicker Is Working

A. Yes

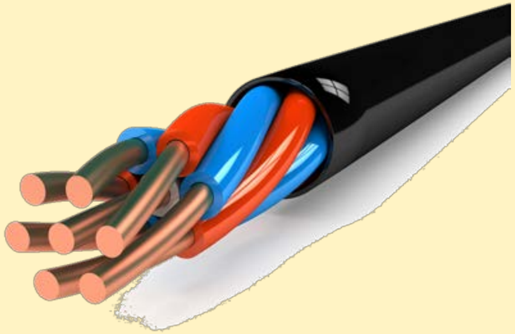
B. No

LA-UR-16-

# Electrical Safety Program Nonelectrical Crafts At LANL



## Course 12175



# Outline P. 1,2

**Module 1: You and Electricity**

- What do you do, and what does electricity do for you?
- Electrical hazards
- What electrical hazards are you exposed to?

**Module 2: Preventing Electrical Accidents**

- Electrical safe work practices
- Electrical PPE
- Recognize and manage the electrical hazards

**Module 3: Emergency Response**

- Steps to follow in an emergency
- Reporting electrical shocks

**Resources, References, and Answer Key**

**Concluding Activity**

# Module 1: You and Electricity P. 5

**Objectives:**

Recognize

- Different occupations in electrical environments
- The language that explains the nature of electricity
- Typical electrical wiring
- Effects of electrical shock on the body
- Types of electrical injuries

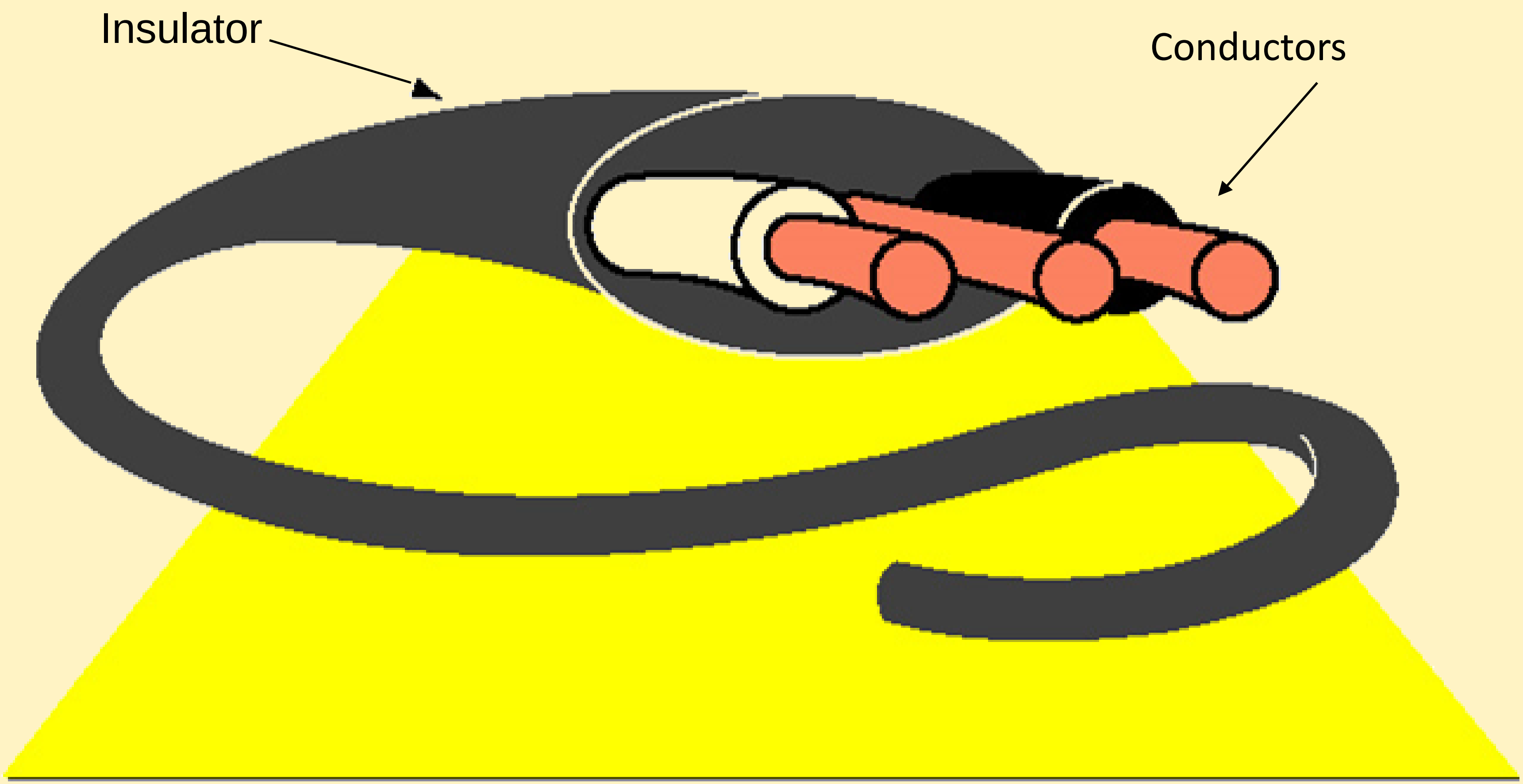
# Who Are You, and What Do You Do? P. 5

- Carpenters
- Sheet metal workers
- Pipe fitters
- Roofers
- Laborers
- Iron workers
- Sprinkler fitters
- Painters
- Mechanics
- Excavation workers
- Construction professionals who provide oversight on jobs that involve electrical hazards

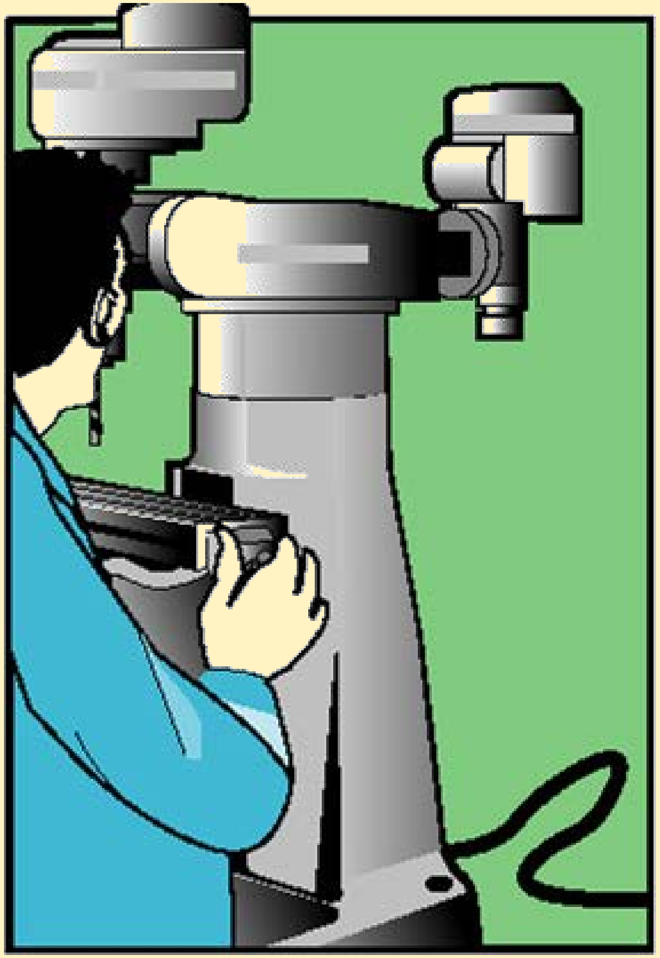
# Video

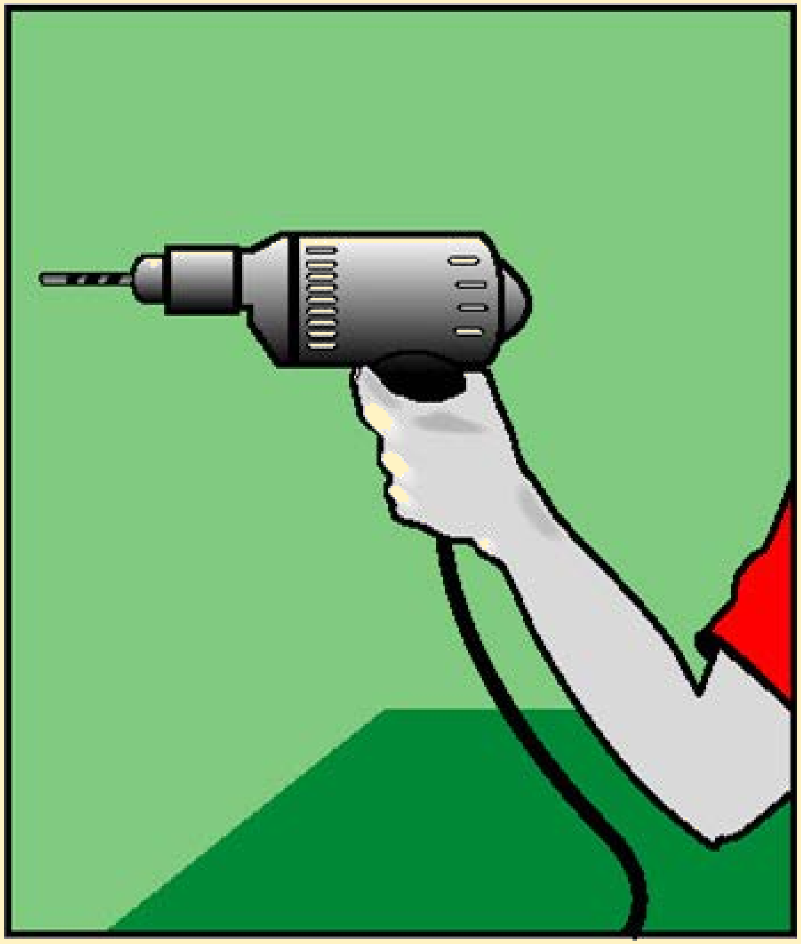
# “Electrical Principles”

# Conductors and Insulators Pp. 8-9



# Electrical Equipment P. 10





# Electrical Hazards P. 13

- Shocks
- Burns
- Arc flash

# Electrical Hazard Video

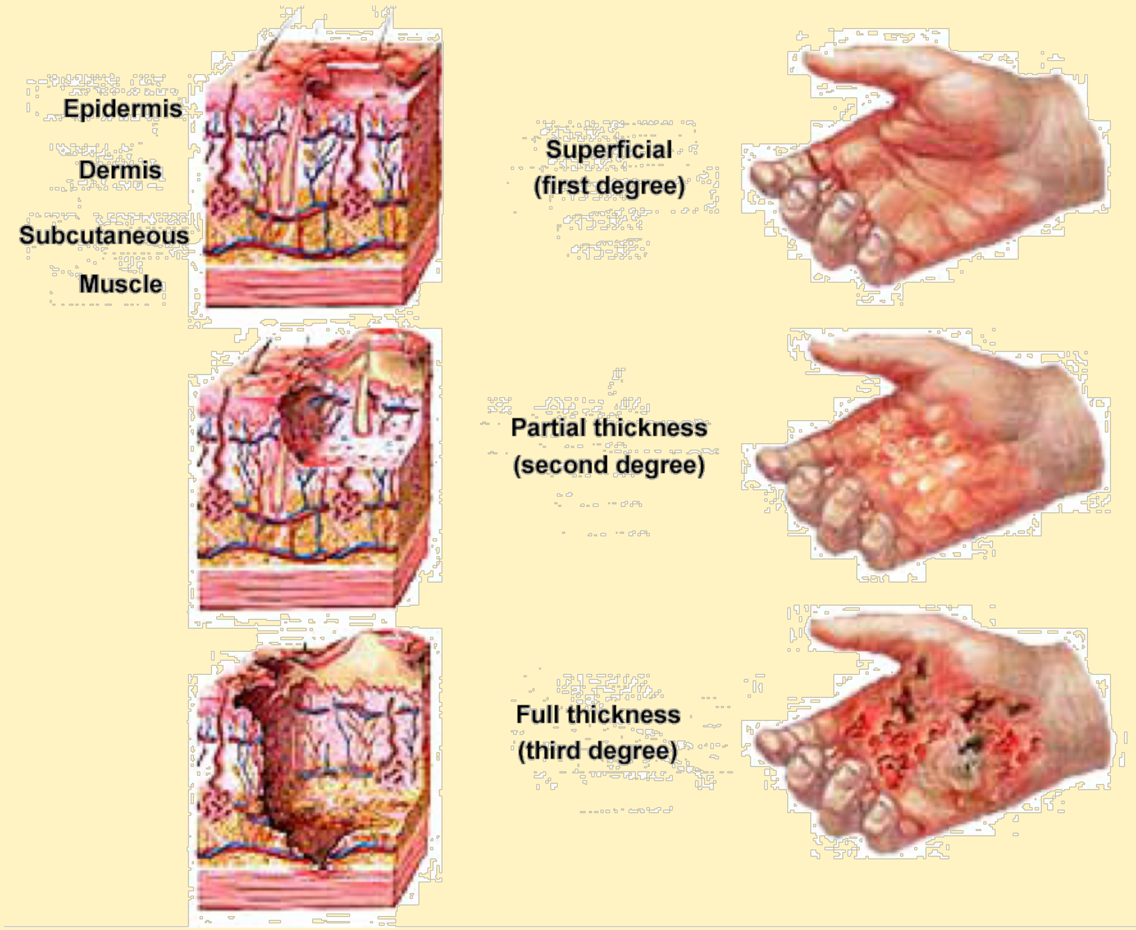
## “FATAL Shock”

# Electrical Shock Pp. 13-14

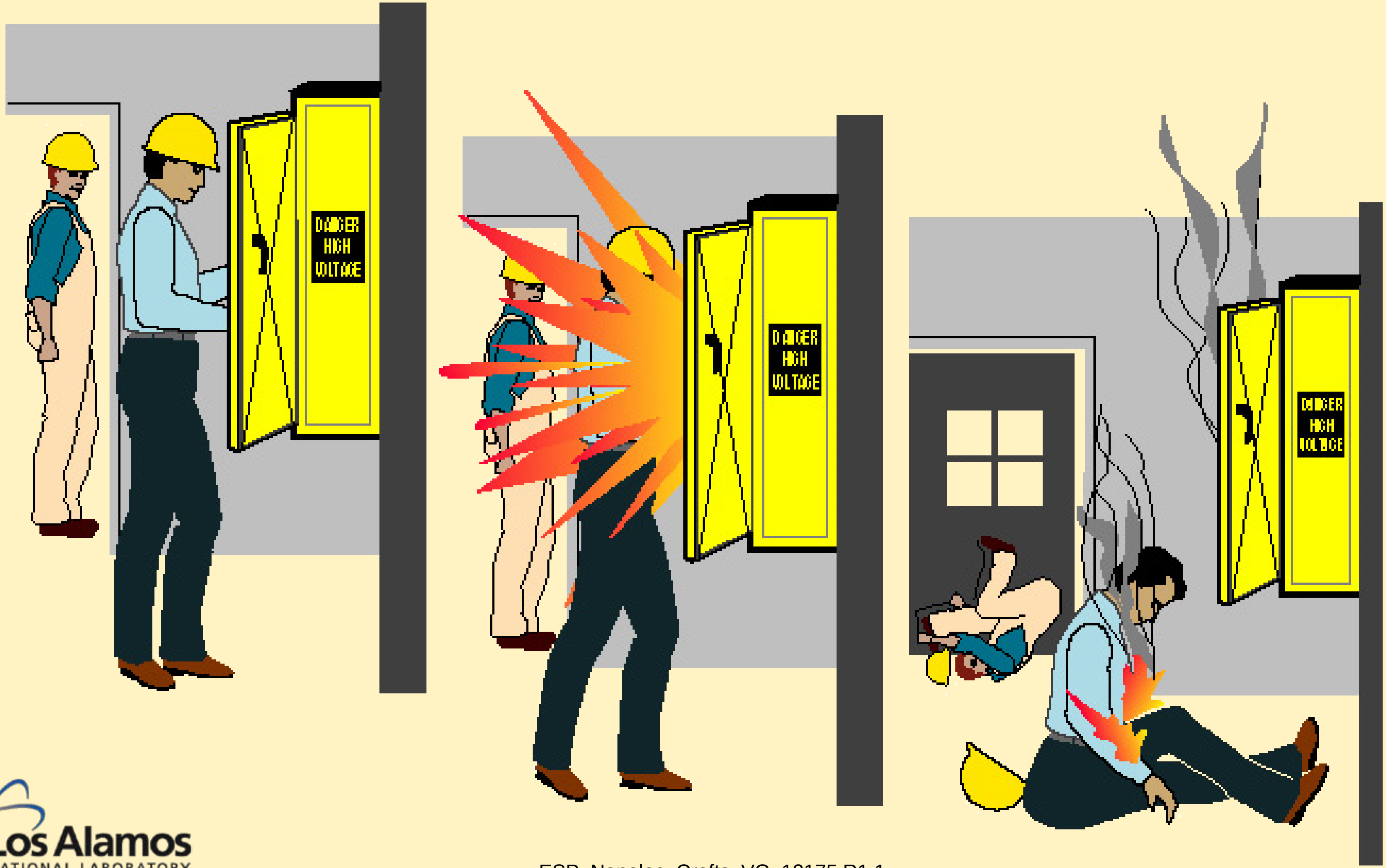
- Shock is when current travels through the body.
- Shock can damage:
  - The brain
  - The heart
  - Nerves
  - Muscles
- Death from electrical shock is called electrocution

# Electrical Burns





# Electrical Blast 



# Video

# Arc Blast with Dummies

# Delayed Electrical Shock Syndrome P. 19

- Injury or death can be immediate or delayed
- Immediately report all shocks except carpet shock
- Immediately seek medical attention when shocked or otherwise injured in an electrical incident

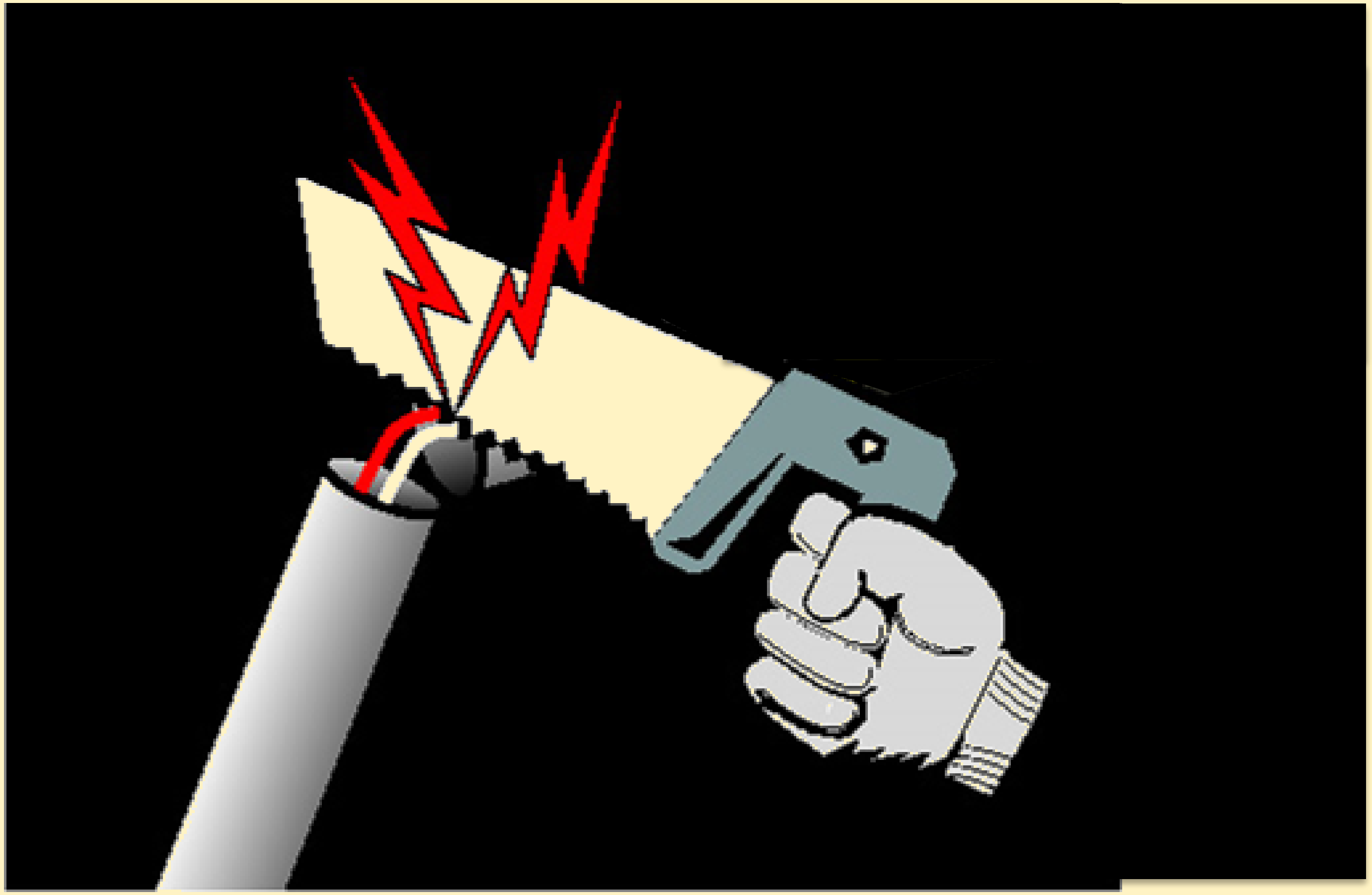
# Common Electrical Hazards Pp. 20-26

# Electrical Hazards Pp. 20-26

**Which electrical hazards are you exposed to?**

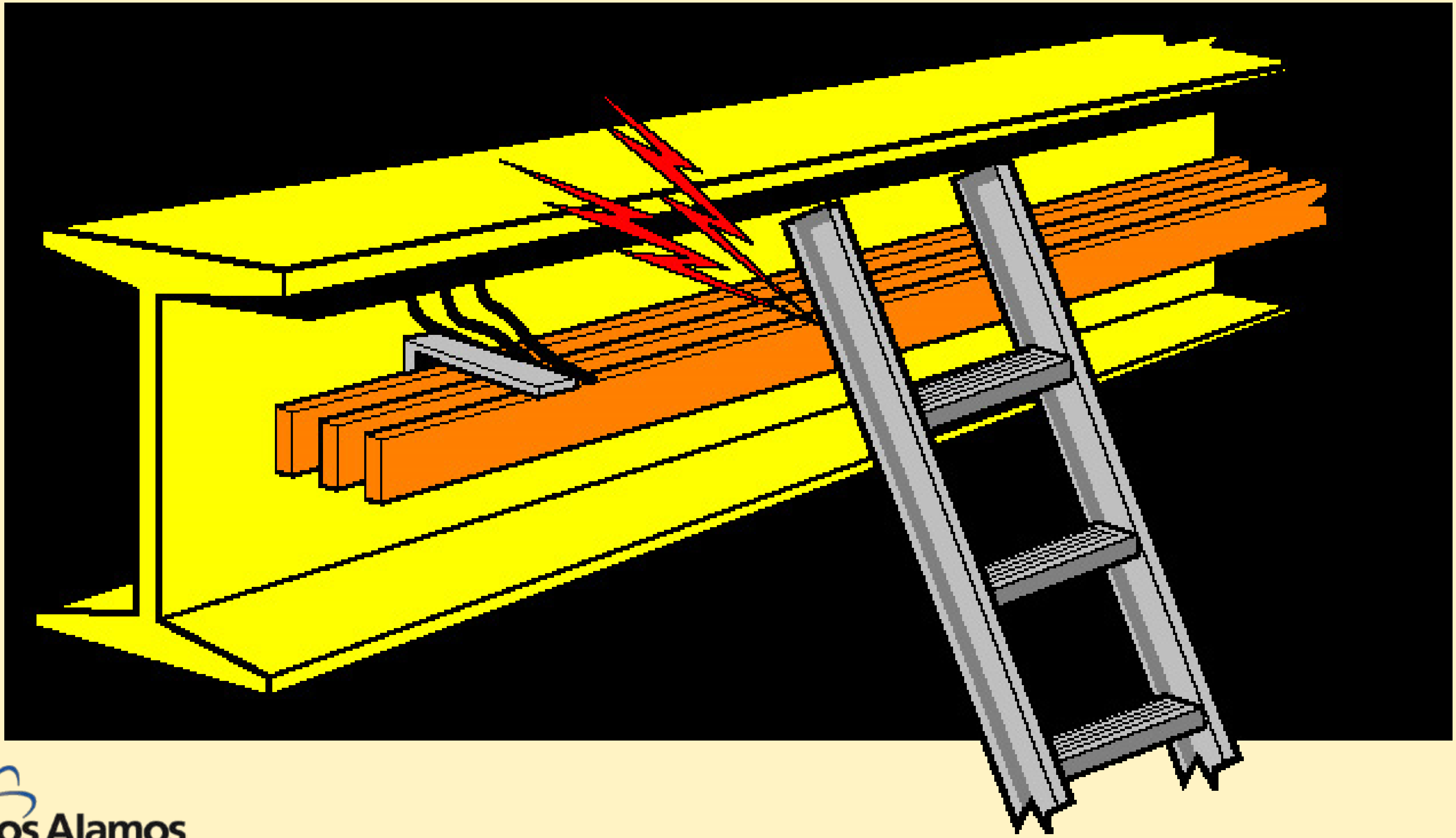
- In electrical equipment
  - Your equipment
  - Facility equipment
- When arc welding
- Wet environments with electricity
- Near uninsulated, overhead conductors
  - Contact with cranes, scaffolding, ladders, trucks, etc.
- Where hidden electricity exists
  - Buried conductors, conductors in walls, floors, etc.
- During lightning events

# Conduit Is Designed to Contain Wires     P. 20



# Crane Exposed Conductors

Pp. 20-21



# Exposed Conductors

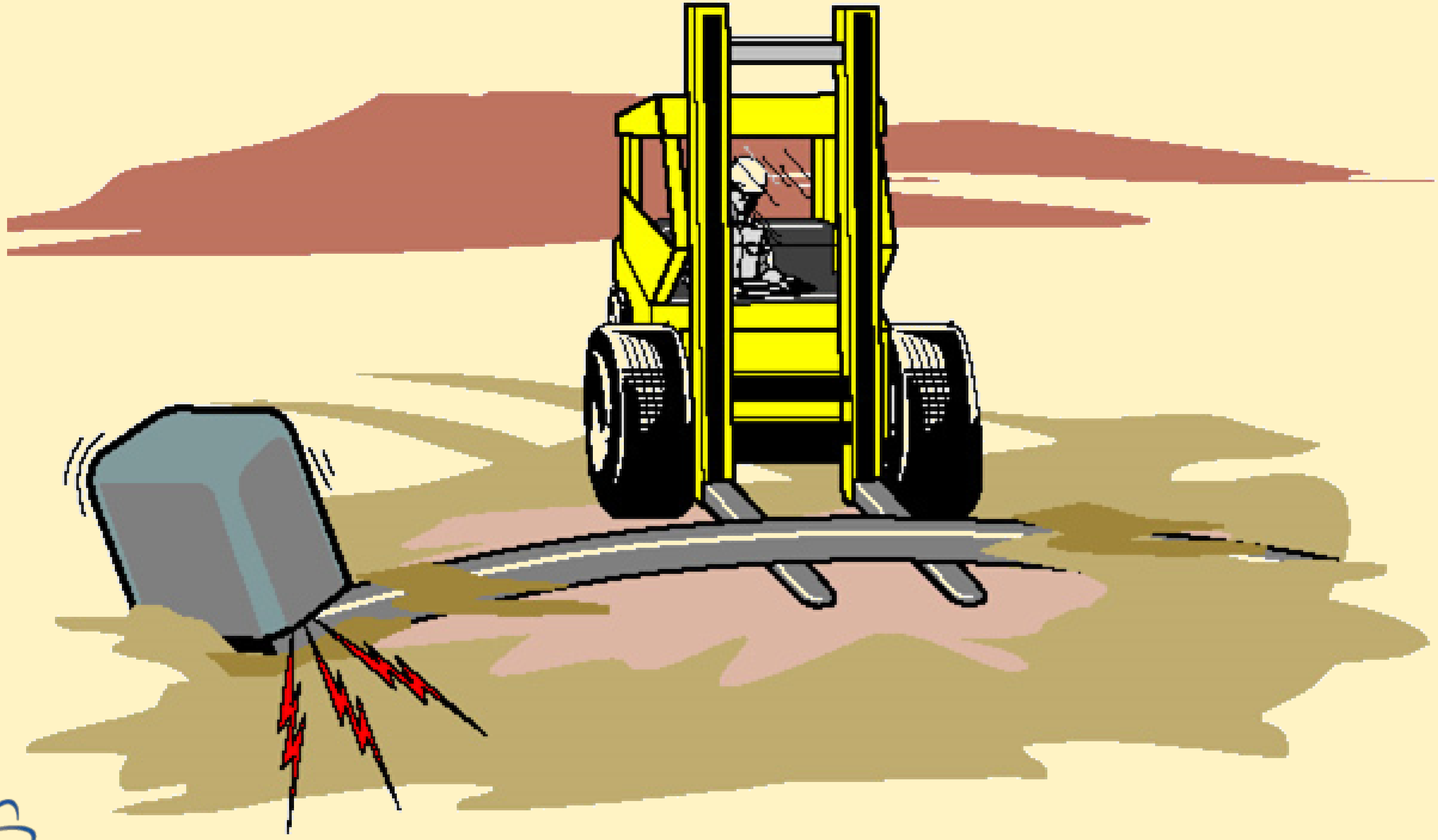
Pp. 20-21

- High voltage
- Exposed bus

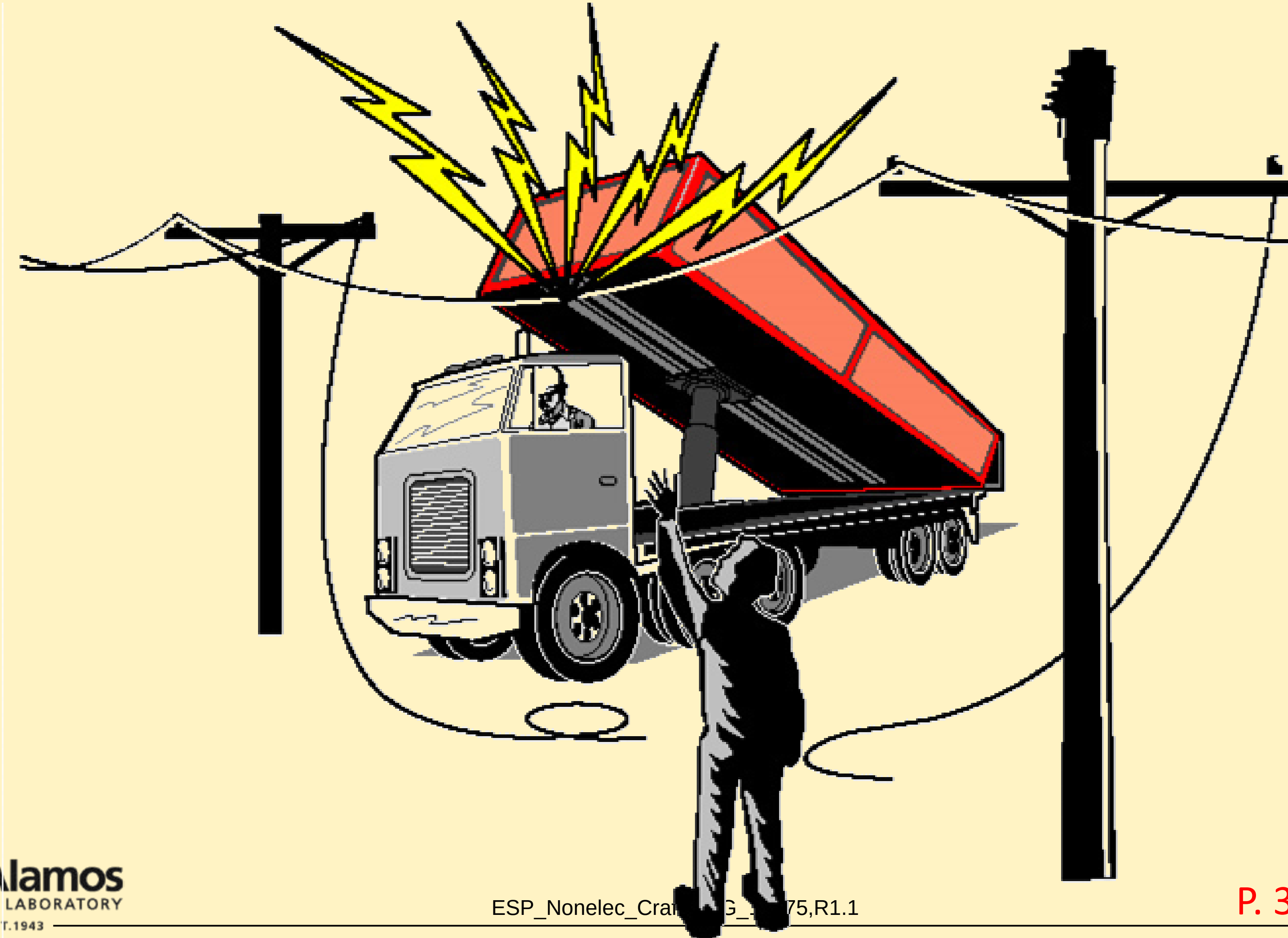
# Substation with 115-kV and 13.2-kV exposed power lines. P. 24

Los Alamos

# Conduit Removal Miscommunication P. 22



# Dump Truck Strikes Overhead Lines P. 24

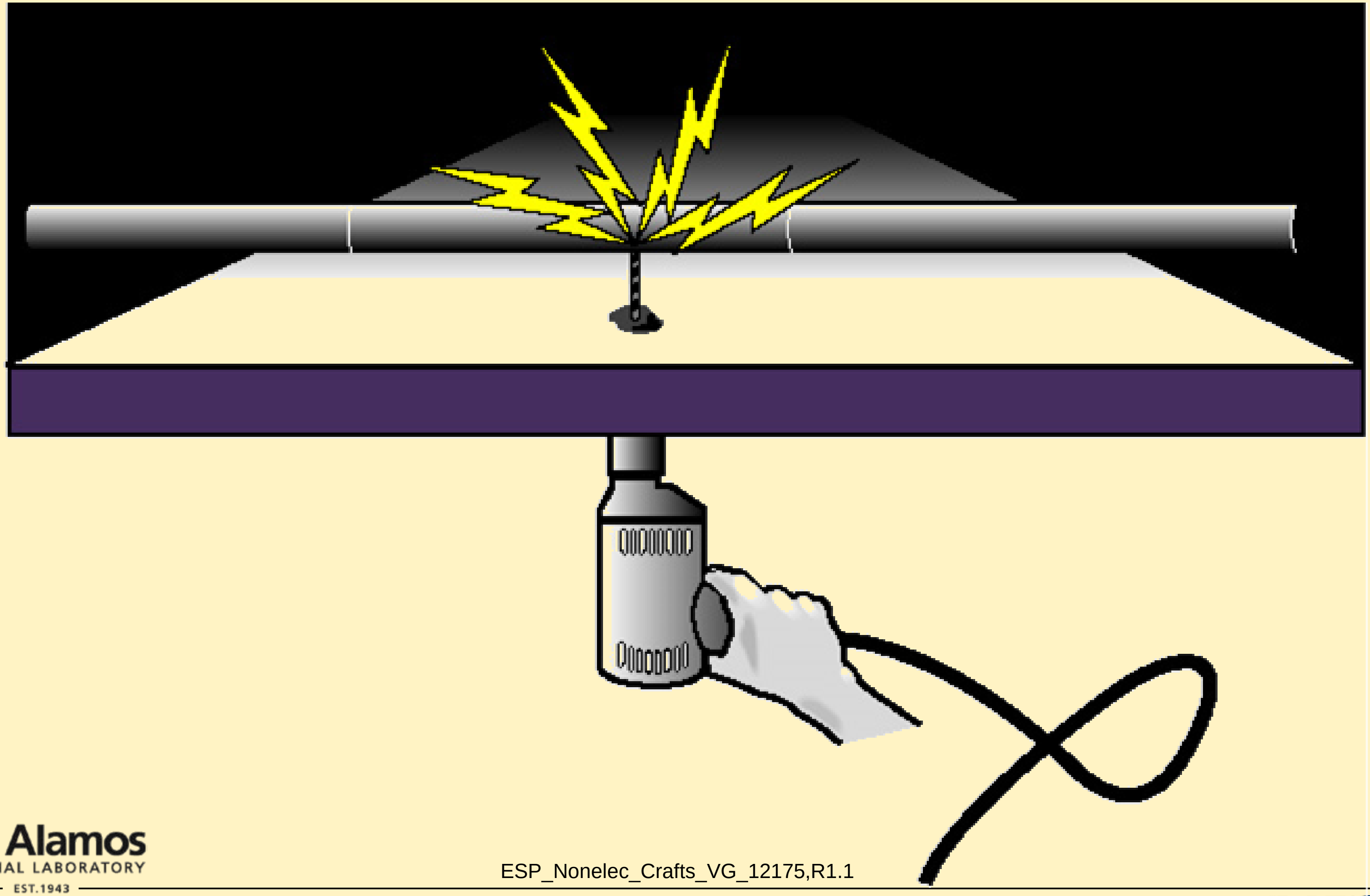


P. 32, 33

# Video

# "When Lightning Strikes"
# Safety Shorts

# Out-of-Date Drawings and a Close Call   P. 26



# Finding Hidden Electricity P. 27

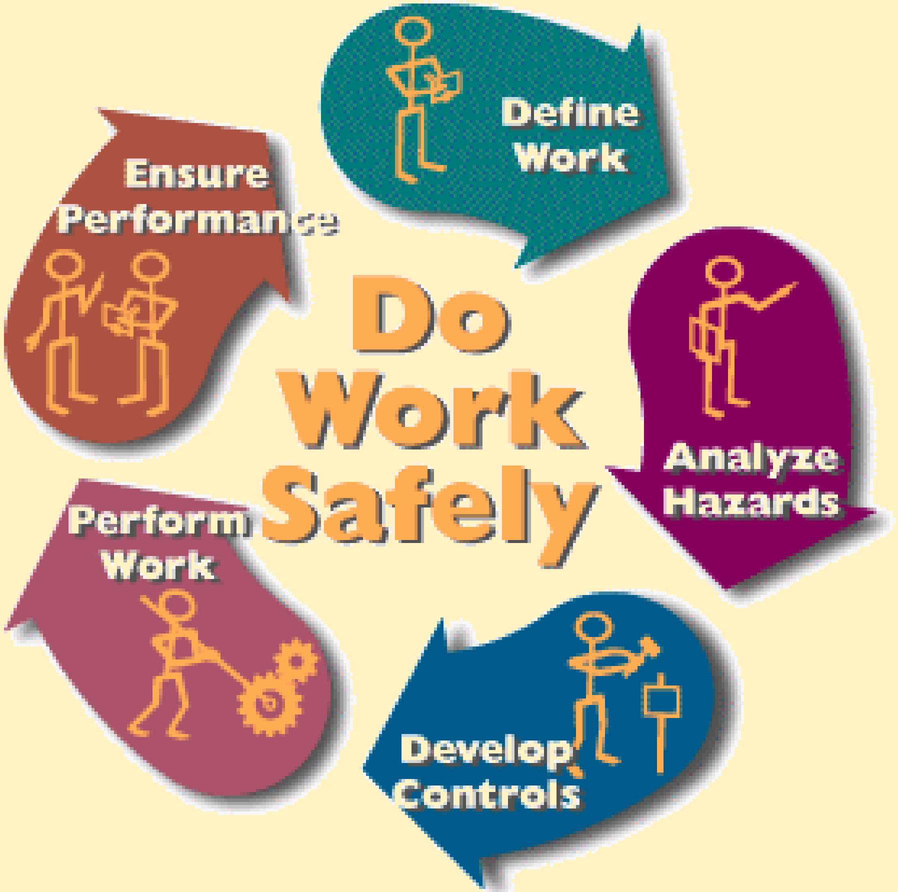
- Know what is hidden before you:
  - Drill
  - Cut
  - Dig
  - Clear snow
  - Grade a road
- Investigate
  - Use as-built drawings
  - Apply ground-penetrating radar (GPR)
  - Drill pilot search holes to insert fiber optics
  - Consult

# Objectives:

- Recognize the use of integrated safety management (ISM) and integrated work management (IWM)
- Identify electrical safe work practices
- Recognize the importance of the pre-job brief
- Recognize why lockout/tagout is important
- Recognize the difference between energized and nonenergized work

# ISM and IWM P. 29

## Always apply the ISM process:



# ISM and IWM (cont) P. 29

- ISM
- IWM
- Pre-job brief
- Nonenergized vs energized

# ISM and IWM (cont) P. 29

- IWM is LANL's implementation of ISM
- Ensure the right people are involved
- Document the steps indicating the hazards and their controls (IWD)

# ISM and IWM (cont) P. 29

**A lessons learned at LANL – March 2010:**

- Worker used a forklift with a boom improperly to transport material from one site to another.
- The boom impacted a deenergized electrical line.
- There was inadequate site and task hazard analysis and lack of worker guidance for material transports.
- The incident is a deficiency of ISM Step 2, Analyze the Hazards.

ORPS report NA--LASO-LANL-PHYSTECH-2010-0006

# Conduct a Pre-Job Briefing P. 30

- Do you understand the work?
- Does the scope of work match the IWD?
- Do you understand how the hazards are controlled?

# Conduct a Pre-Job Briefing (cont) P. 30

Things to look for in a strange facility:

- Do you have authorization to be there, and did you receive
  - Site-specific training?
  - A job package?
- Escort
  - Building manager?
  - Knowledgeable worker?
- Has the work area changed since the pre-job brief?
  - New equipment?
  - Covers removed?

# Safe Work Practices P. 31

- Is everything as you expected it to be?
- Maintain your controls:
  - Are you wearing appropriate PPE?
  - Have you checked for the integrity of the equipment?

# Safe Work Practices - PPE P. 31

To use PPE for hazardous electricity, you must

- Have the proper training
- Have a PPE inspection program
- Be authorized to do work requiring PPE
- Do the demonstration of proficiency for PPE (item 19653 in UTRAIN)

# Safe Work Practices (cont) P. 32

## Extension Cords:

- Check the cord for damage
  - ✓ Damaged insulation
  - ✓ Broken ground pin

- Never plug an extension cord into another extension cord or into a relocatable power tap (RPT, a multi-outlet device)

- The NRTL label could be missing, but as long as the cord does not have a homemade look, it is most likely an NRTL-approved cord. If suspect, consult with your ESO or supervisor.

# Examples of Damaged Cords

# Using Electrical Equipment P. 33

- Check listing
- Check for damage
- Is the use appropriate?
  - Portable drill with a taped electric cord?
  - A 100-foot extension cord to be used 10 feet from an outlet?
  - A space heater electrically connected through a relocatable power tap (RPT) with several other devices plugged in to the RPT?

# Safe Work Practices (cont) P. 34

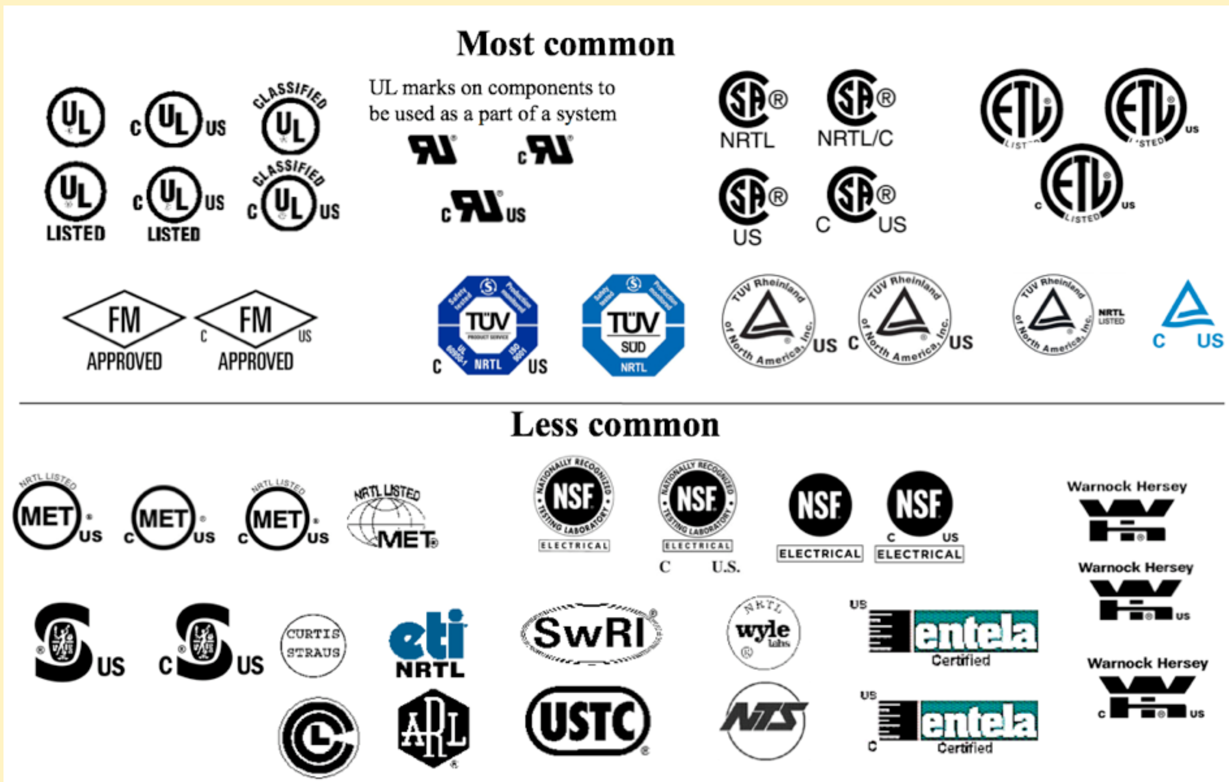
## Use safe electrical equipment

- Use NRTL-listed equipment
- Use ESO-approved equipment
- Do not use damaged equipment
- Prevent damage during use
- Follow the manufacturer's directions

# Safe Work Practices (cont)

## Nationally Recognized Testing Laboratories (NRTL)

The following symbols are NRTLs for electrical equipment recognized by OSHA



# Safe Work Practices (cont) P. 34

## ESO-approved equipment

Old label – 1999 - 2010


New label – after 2010


If equipment:

- Plugs into the wall
- Does not have an NRTL label
- Does not have an ESO sticker

Then:

- Do not use it
- Talk to your ESO

## You cannot find an NRTL symbol on the electric drill you have been given to use. You should

- A. under no circumstances use the drill
- B. send the drill to salvage
- C. continue using the drill as planned
- D. contact your facility ESO or operations manager

- [Default]
- [MC Any]
- [MC All]

# Safe Work Practices (cont) P. 35

Are you aware of

- Shock approach boundaries (distance you may approach shock hazards)?
  - Stay at least 3.5 feet for 120, 240, and 480 V
  - Do not approach down power lines
  - Do not climb toward or reach toward power lines with any object
- Flash protection boundary?
  - Some facility power can produce an arc flash
  - Stay at least 4 feet away from electrical facility power equipment

## Controlling hazards of arc welding:

Methods of avoiding shocks when working in areas that have been wet down to prevent slag and sparks from initiating a fire:

- Stay dry: wet floors require extra shock protection
- Follow the equipment manufacturer's electrical safety instructions for welding in electrically hazardous conditions.
- Consult an electrical safety officer (ESO) for additional precautions.

# Safe Work Practices (cont) P. 35

**Controlling hazards of arc welding**:

- Note that startup current is the most hazardous
- Wear radiation anticontamination clothing that satisfies the *Flame Resistant* performance criteria of ASTM F1506-10a.

# Protective Devices 

- Water conducts electricity
- If you are wet, you are more easily shocked
- GFCI is designed to protect you in wet situations
- Always test GFCI before use


# Video

## "A Welcome Interruption . . . GFCI"

## Safety Shorts

## 6:20 minutes

# GFCI Question

A GFCI outlet

A. is guaranteed to protect you under all circumstances
B. never needs to be tested
C. should always be tested before it is used
D. should be tested only when no other user is working with another outlet served from this GFCI

# Energized Work and Lockout/Tagout

- To do energized electrical work requires special qualifications
  - Education
  - Training and experience
  - Authorization
- Lockout/tagout is used to control machines and equipment during service, maintenance, or modification
- You DO apply your lock, even if you are a nonenergized electrical worker.

# Breaker Operation Requirements

# For Nonenergized Electrical Workers

# Breaker Operation

What is Operation?

- Normal switching to turn on and off power to feeder, circuits, or equipment
- Resetting tripped circuit breakers

There are special requirements for resetting tripped Over Current Protection Devices (OCPDs).

# Breaker Operation--Special Requirements

- May be reset only if it can be done safely
- Cause of the trip must be known
  - Overload, ground fault, or short circuit
- Cause must be remedied and problems corrected before operation begins
- Cannot be reset more than once without supervision provided by an ESO, Electrical Inspector, or Electrical Engineer who is competent in the application of NFPA 70E
- *Example: space heater is plugged in/turned on, breaker trips, cause is known, remove space heater from circuit, reset breaker.*

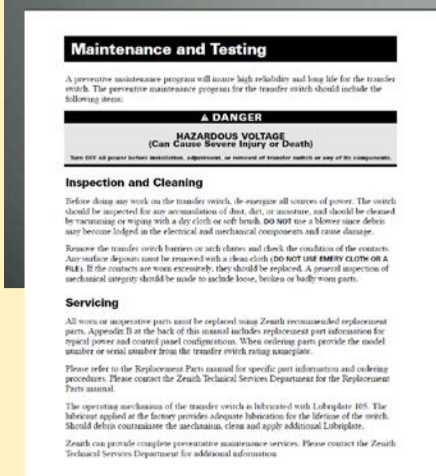
These are NOT new Requirements!

# Breaker Operation--Equipment Conditions

- Properly maintained, properly installed, and has no impending failure means the following: NEW from 2015 NFPA 70E
  - Equipment has been maintained in accordance with O&M Criterion 504 and is labeled as such or equipment has been determined to meet manufacturer's Maintenance Requirements.
  - Equipment is properly installed, e.g., no unused openings, no missing screws, and meets NEC requirements.
  - Equipment has no recognized impending failure, e.g., no damage to the equipment has occurred, the overcurrent protection device being operated is not in a "tripped" position without a known cause being remedied, and problems are corrected.
  - The equipment doors are closed and secured.
  - All equipment covers are in place and secured.

*Note: When operating equipment for the first time after it has undergone installation, repair, modification, or maintenance, the equipment should be considered to have NOT MET the equipment conditions as listed above, and a risk assessment must be performed per the guidance below.*

# Breaker Operation--Properly Maintained?

**Maintenance and Testing**

A preventive maintenance program will insure high reliability and long life for the transfer switch. The perventive maintenance program for the transfer switch should include the following items:

**DANGER**

**HAZARDOUS VOLTAGE**
**(Can Cause Severe Injury or Death)**

Turn OFF all power before installation, adjustment, or removal of transfer switch or any of its components.

**Inspection and Cleaning**

Before doing any work on the transfer switch, de-energize all sources of power. The switch should be inspected for any accumulation of dust, dirt, or moisture, and should be cleaned by vacuuming or wiping with a dry cloth or soft brush. **DO NOT** use a blower since debris may become lodged in the electrical and mechanical components and cause damage.

Remove the transfer switch barriers or arch chutes and check the condition of the contacts. Any surface deposits must be removed with a clean cloth (**DO NOT USE EMERY CLOTH OR A FILE**). If the contacts are worn excessively, they should be replaced. A general inspection of mechanical integrity should be made to include loose, broken or badly worn parts.

**Servicing**

All worn or inoperative parts must be replaced using Zenith recommended replacement parts. Appendix B at the back of this manual includes replacement part information for typical power and control panel configurations. When ordering parts provide the model number or serial number from the transfer switch rating nameplate.

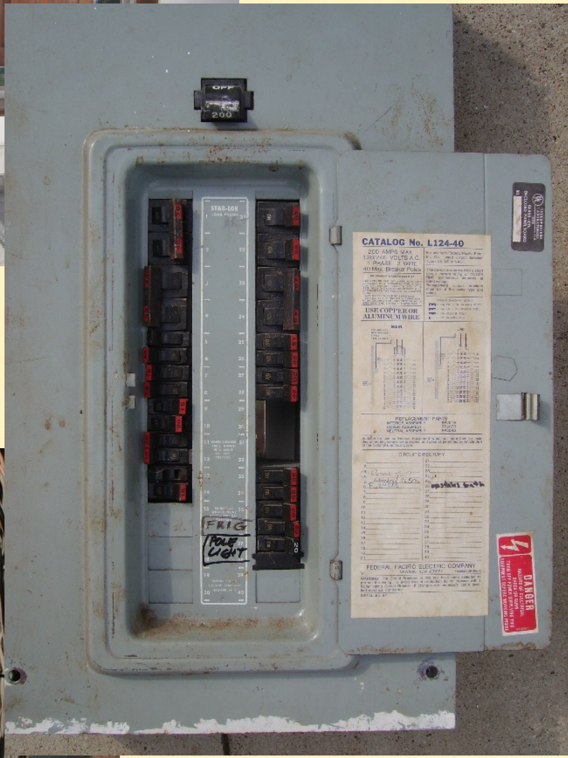
Please refer to the Replacement Parts manual for specific part information and ordering procedures. Please contact the Zenith Technical Services Department for the Replacement Parts manual.

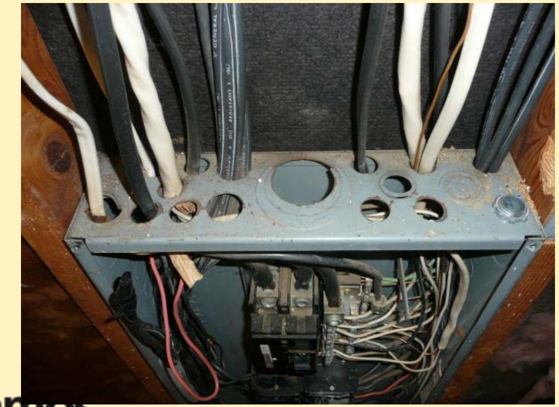
The operating mechanism of the transfer switch is lubricated with Lubriplate 105. The lubricant applied at the factory provides adequate lubrication for the lifetime of the switch. Should debris contaminate the mechanism, clean and apply additional Lubriplate.

Zenith can provide complete preventative maintenance services. Please contact the Zenith Technical Services Department for additional information.

When in doubt, contact your Facility ESO, contact your Equipment Owner, or refer to the Maintenance/Operation Manual.

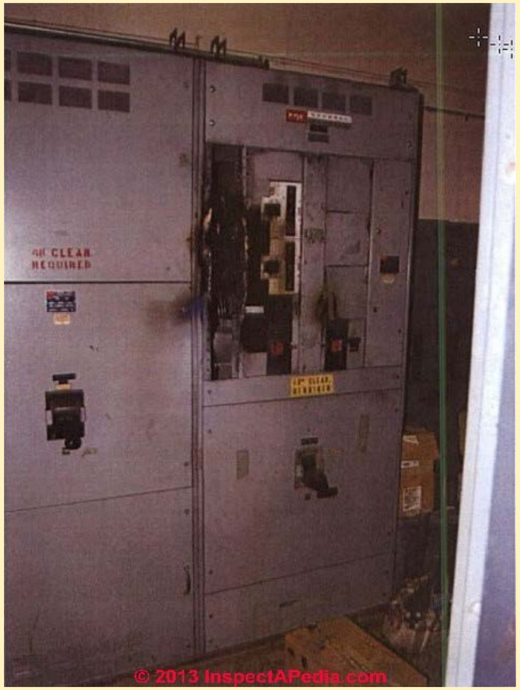
# Breaker Operation--Properly Installed?

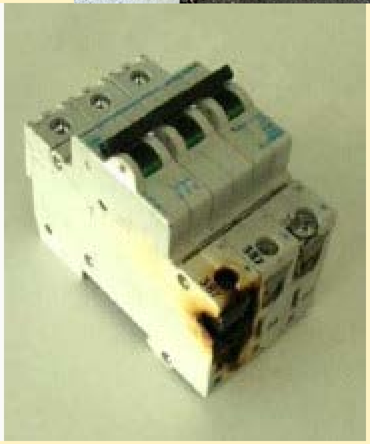


When in doubt? Contact Electrical Inspectors

# Breaker Operation--Evidence of Impending Failure?



# Breaker Operation

**Conditions for a Nonenergized Electrical Worker to operate a breaker or disconnect switch**

ALL of the above required equipment construction and operating conditions are met:

- No parts are exposed so that there is no shock or arc flash hazard; and
- the equipment has been installed to safely handle the available fault current that may be imposed on it.

# Breaker Operation (cont)

## However

Inspection must be performed by an electrical worker trained to recognize if the equipment is properly maintained, is properly installed, and has no impending failure. If the inspection passes:

- No PPE is required and
- No physical stance is recommended

# Breaker Operation (cont)

**What Conditions Disallow Nonenergized Electrical Workers from Operating Breakers or Disconnects?**

- When a breaker or disconnect switch does NOT meet ALL of the equipment conditions.
- Also if:
  - Risk Assessment: Moderate Risk (Class X.2 & X.3); High Risk (Class X.4 & X.5)
    - An increased risk to a shock and/or arc flash hazard (exposed parts, unused openings, available fault current ratings may be exceeded, etc.)
  - A Shock and Arc Flash Risk Assessment must be performed before operating and documented in a Form 2193 or IWD.

# Stopping Work

**Stop work and restart requirements**

- If workers identify a hazardous situation in their own work, they must
  - Stop or pause the work
  - Notify their supervisor, foreman, ESO, or FOD
  - Remain in area until a responder arrives
- If workers identify a hazardous situation in someone else's work, they must
  - Notify the person
  - Obtain an explanation
  - Notify the supervisor if they are not satisfied with the response
  - Remain in the area until a responder arrives

# Module 3: Emergency Response P. 41

Objectives:

- Identify actions to take in an electrical emergency
- Recognize where to get information
- Observe videoed accidents

# Emergency Response

**Respond**

- Report incidents and injuries
- Report near misses

# Steps to Follow in an Emergency P. 42

- If someone is locked on a circuit below 240 V
  - Unplug the equipment
  - Deenergize the circuit
  - You may choose to remove the person from the circuit using an insulating object between you and the victim
- Shocked and does not look or act fine?
  - Call 911
  - If trained, attend to the victim (CPR/AED, first aid)
  - Call the RLM
- Shocked but looks and acts fine?
  - Call the RLM
  - The RLM will transport to OccMed

# Video

# "Handling Emergencies"

# Resources P. 45

- Electrical Safety Officers
- Electrical Inspectors
- Occupational Medicine
- Occupational Safety and Health (OSH-DO)
- Your supervisor

**What is an electrical safety officer (ESO)?**

- All ESOs are appointed by their RLM
- They understand the electrical safety program
- They can tell you if a piece of equipment or an operation is electrically safe or how to make it safe.

# Video Exercise Pp. 49-54

## Video

## “Take Electricity Seriously”

# Summary P. 54

- Use equipment that is listed or approved and in good condition
- Questions - Consult with an ESO or your supervisor
- Unexpected hazards - Use Pause/Stop Work
- Stay alert