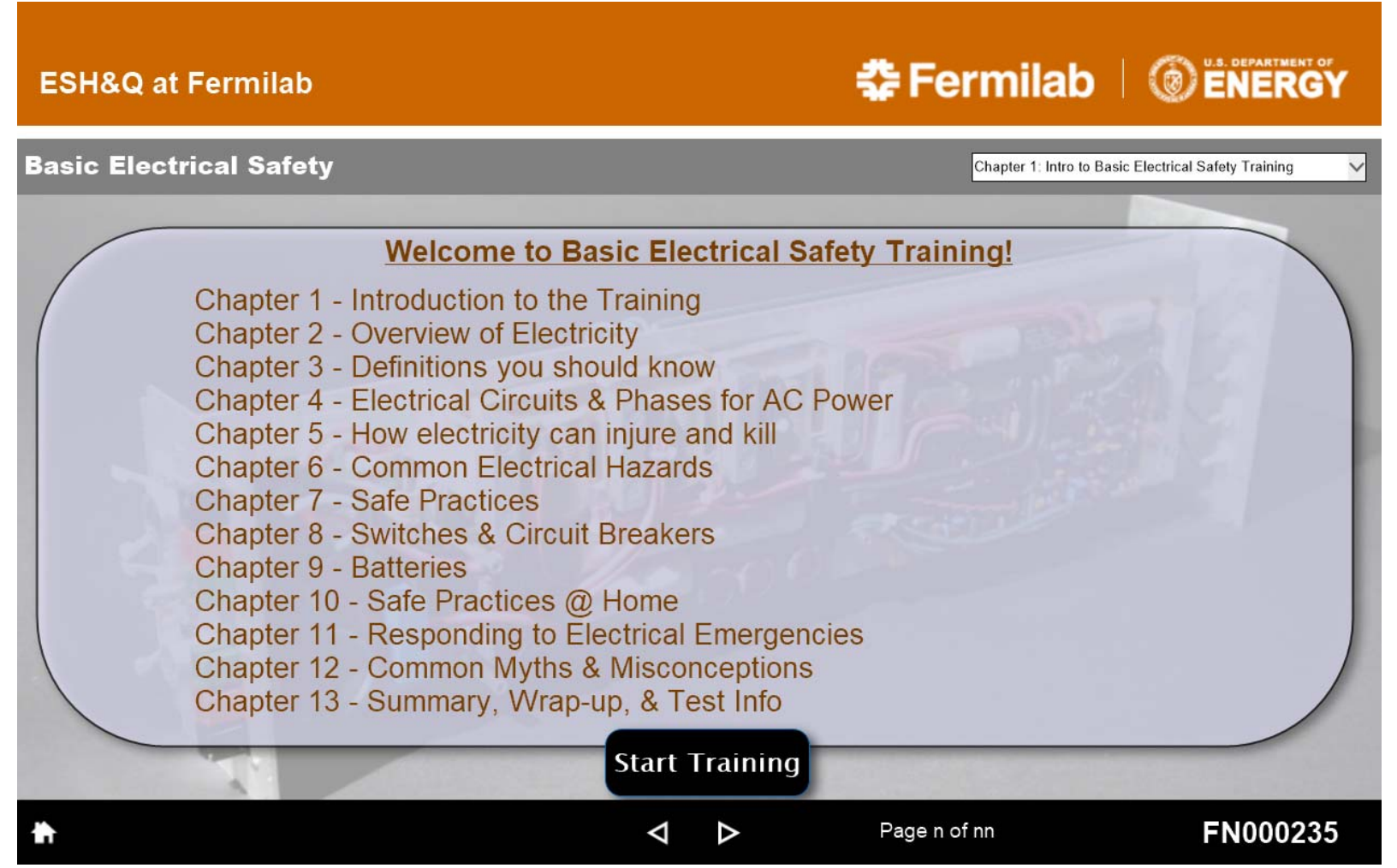

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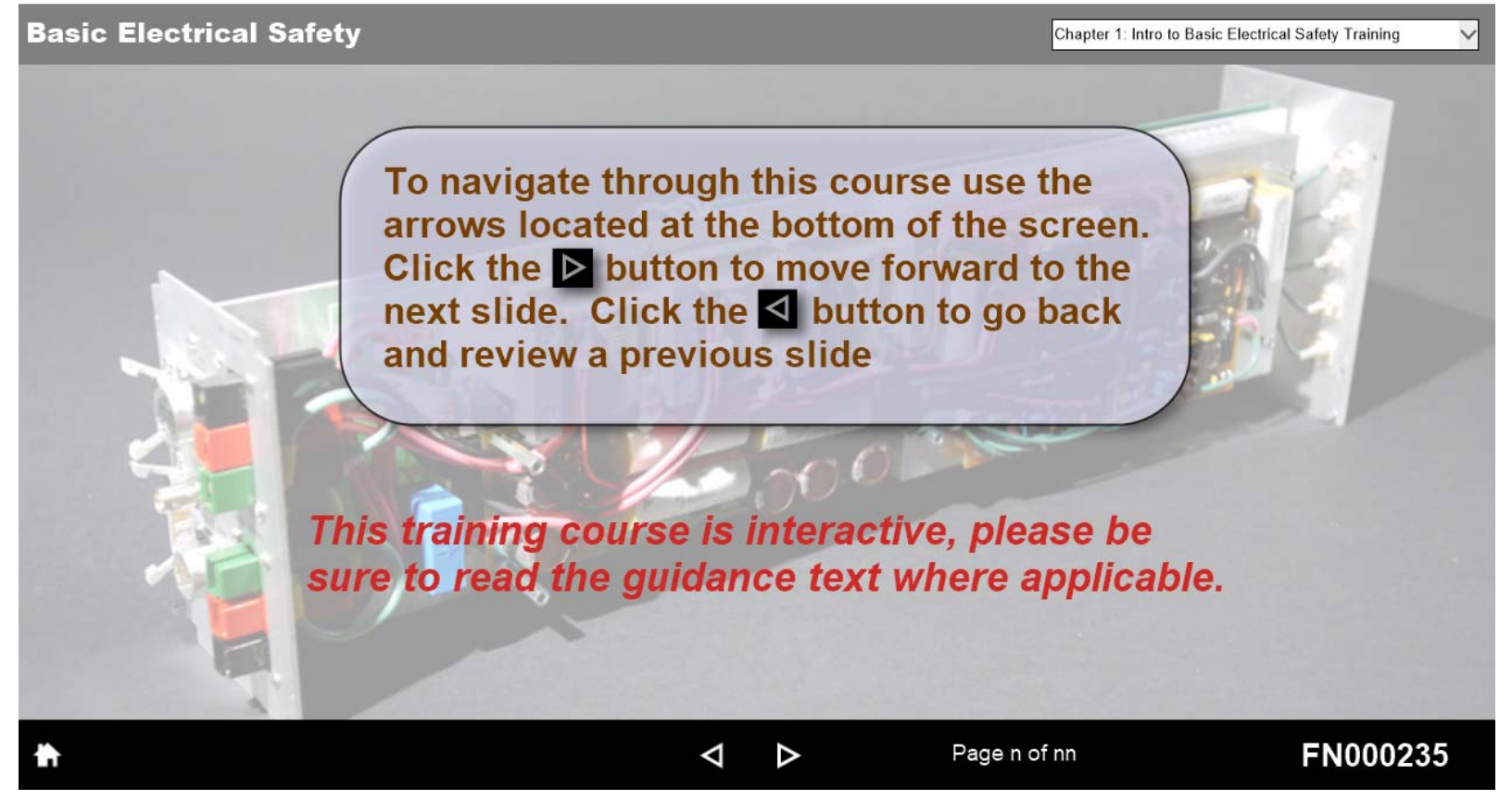

- To receive credit for this class you will be required to take a test at the end of the module.
- There are 13 chapters you must complete before requesting the test.
- Due to the length of the module, you have the option of working through the chapters at your own pace.
- If you decide to take a break and come back to the training at a later time, use the dropdown menu in the upper right corner of the page to start where you left off.

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Course Objectives

This course covers 5 main objectives...

1. Understand what electricity is and how electric power is distributed
2. Identify how electricity can injure and kill
3. Illustrate common electrical hazards
4. Demonstrate safe practices that reduce or eliminate electrical hazards
5. Understand how to respond to an electrical emergency

Upon completion of this course, you should be able to:

1. Recognize common situations that pose a risk of electrical injury and death
2. Understand safe practices that minimize electrical hazards
3. Respond safely to electrical emergencies

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This training has added applications outside of work.

The information you will learn about today is also applicable to places outside of work, like at home!

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CAUTION!

This course is NOT designed to:

1. Teach you how to work on electrical equipment

OR

2. Qualify you to work on electrical equipment

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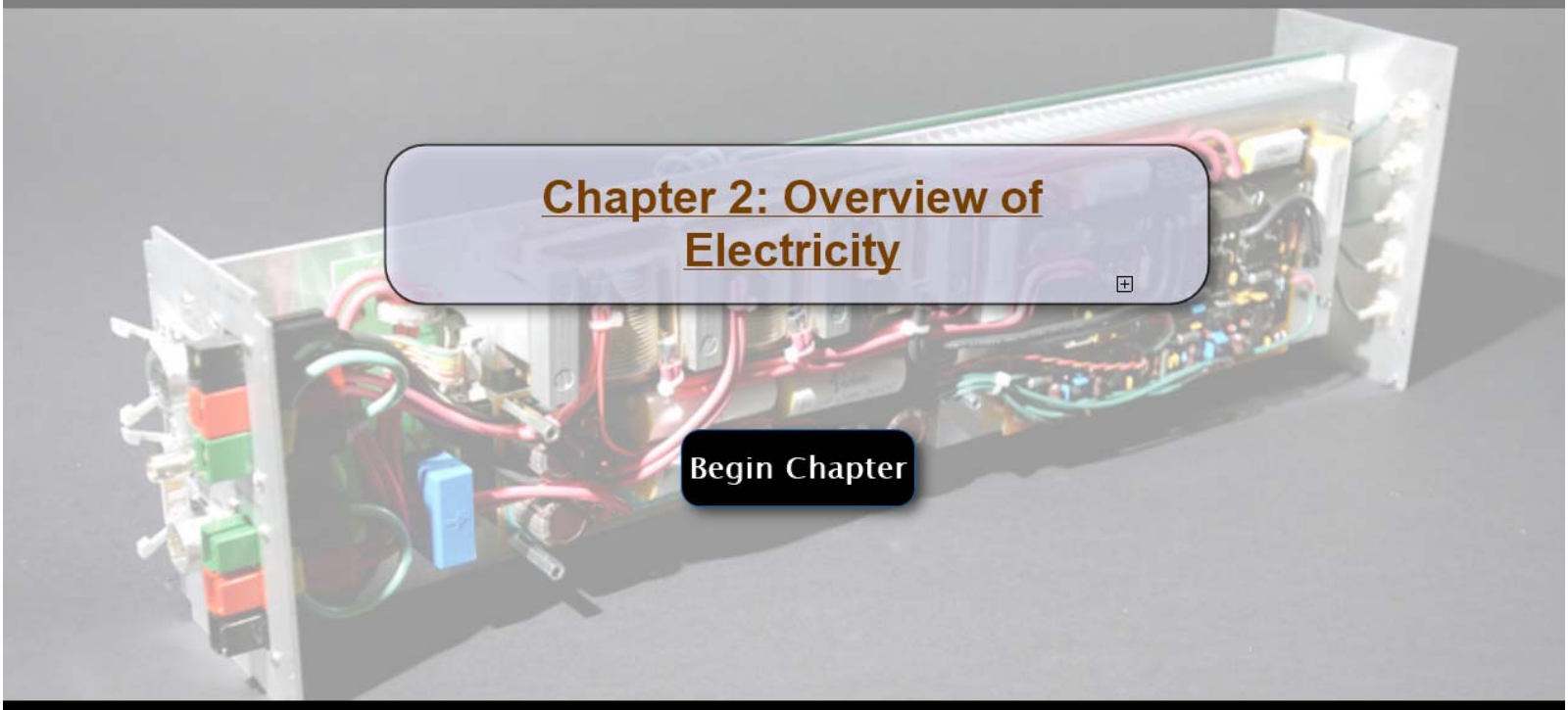
CAUTION!

Always remember:

If you spot problems with electrical equipment you should **report it immediately to your supervisor**!



Chapter 2: Overview of Electricity

Begin Chapter

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Overview of Electricity

Chapter 2 provides a brief overview of electricity.

What is Electricity?

In the last two centuries, electricity has gone from being a scientific curiosity to an indispensable part of most facets of our lives.

Electricity is all about the movement of the *electrons* that are part of every atom of matter.

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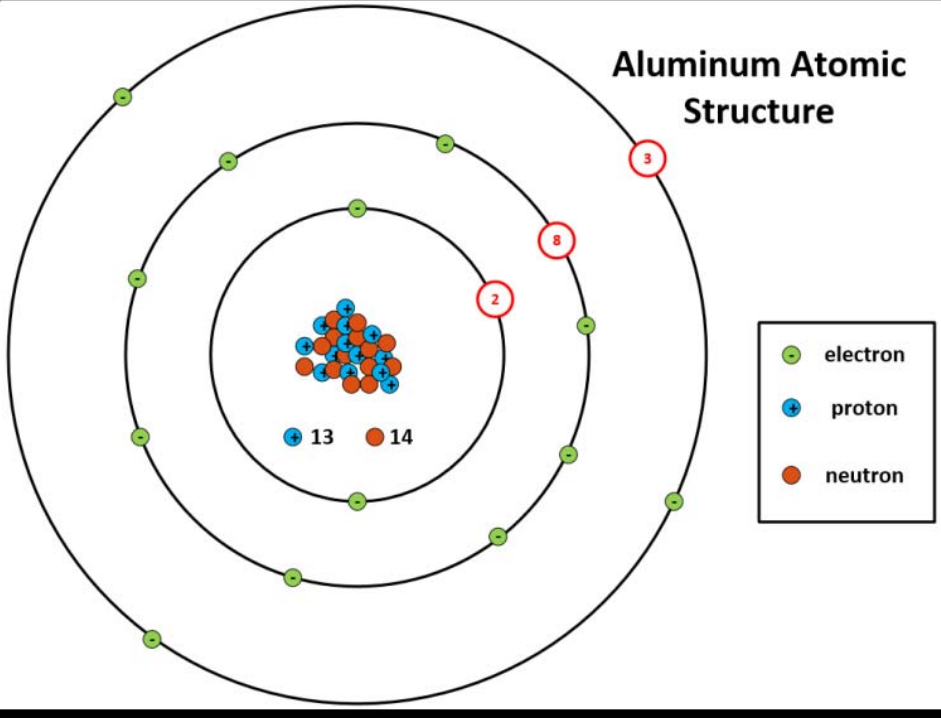
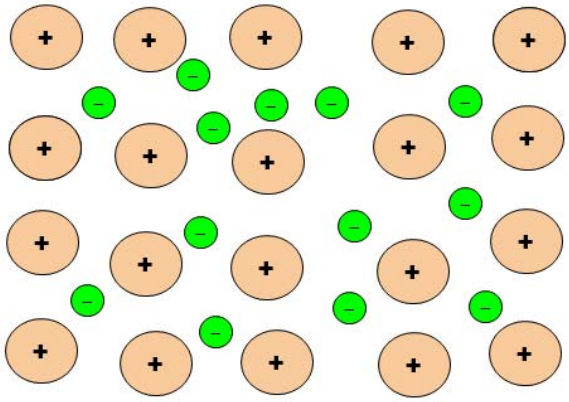
What are Electrons?

As a member of the Fermilab team, you probably have a better knowledge of basic atomic theory than the average person. You know that that every atom is composed of a nucleus composed of protons and neutrons, surrounded by a cloud of electrons, such as in an aluminum atom.



What is Alumina?

The oxygen atoms have "captured" the electrons from the outer shell of aluminum atoms to fill out all eight spots in their own outer shells, and all the electrons become tightly bound into the alumina molecules, making it very difficult to bump electrons from one molecule to another (see the Alumina picture below). With the addition of some oxygen, our aluminum atoms have become part of a good insulator instead of a good conductor.



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Generating Electricity

Electricity is not a source of power. It is a convenient way to transfer power from one place to another and easily control it.

Isn't it odd that lightning, the most common natural display of high power electricity has yet to be profitably harnessed, even though it's been over two centuries since Ben Franklin nearly killed himself to prove lightning and electricity were the same?

SRF Test Facility 07/22/2011

Generating Electricity

There are many ways to artificially produce electricity.

Friction can produce static electricity

Batteries are electro-chemical sources

Pressure, ***heat***, and ***light*** can product electricity by piezoelectric effect, thermocouples, and photovoltaic cells, respectively

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Generating Electricity

Moving electrons produce a magnetic field, a principle which we use to direct our particle beams.

Likewise, a conductor moving through a magnetic field produces an electric field.

Generating Electricity

Most electric generation today uses a source of heat (such as coal or nuclear fission) to boil water, which runs a steam turbine that turns a generator, which pushes conductors through a magnetic field to make electricity. A gas turbine, which burns oil or natural gas, can skip the boiling water step and turn a generator directly.

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Knowledge Check #1

#1 - M se:

That is the correct answer!

Continue

atom to atom

Submit Answer

**Answer the question correctly to advance to the next screen.*

Knowledge Check #2

#2 - Multiple Choice: Which energy source can be used to make electricity?

- A. Friction
- B. Chemical reactions
- C. Light
- D. Heat
- E. Conductors moving relative to magnetic fields
- F. All of the above

Submit Answer

**Answer the question correctly to advance to the next screen.*

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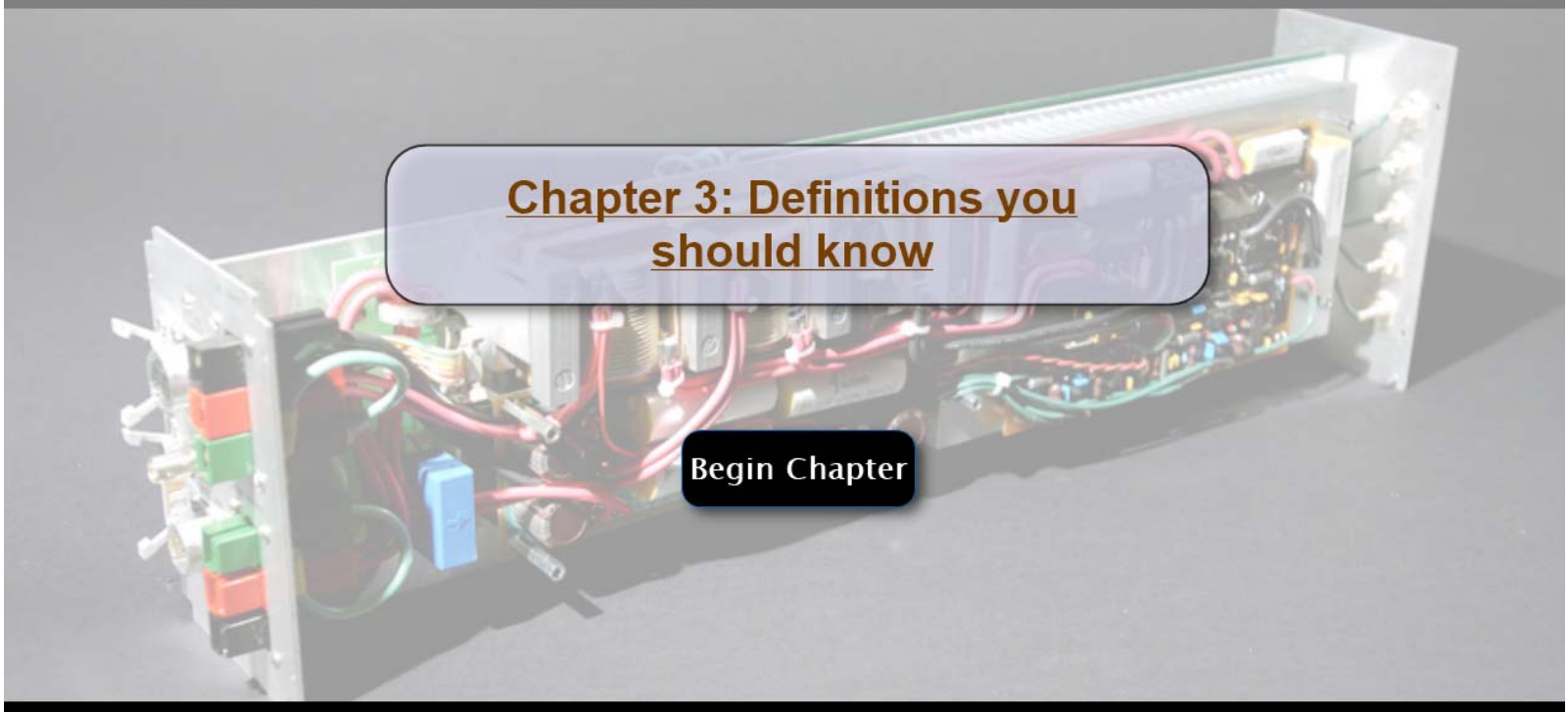

Overview of Electricity

Chapter 3 reviews the terms and definitions you should know.

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- Potential ✓
- Current ✓
- Circuit ✓
- Direct Current (DC) ✓
- Alternating Current (AC) ✓

There are several definitions you should be aware of. Click the text buttons on the left to reveal the definitions for each term.

You must click each definition to advance to the next page.

Page 1 of 4

- Resistance ✓
- Impedance ✓
- Superconductivity ✓
- Conductor ✓
- Insulator ✓

Impedance is the measure of opposition of a circuit to AC current. It is a combination of Resistance with **Inductance** (**L**, measured in Henries, **H**), which measures the opposition to a change in current flow, and **Capacitance** (**C**, measured in Farads, **F**), which measures the opposition to a change in voltage.

Capacitance and **inductance** don't affect direct currents. Because the voltage and current are always changing in an AC system, it is always affected by resistance, **inductance**, and **capacitance** together. Even a straight length of wire has **inductance** and **capacitance**.

To make life easier when working on AC power systems, all three are combined into a single property called **Impedance**, with the symbol **Z**. To make life more difficult and confusing, Impedance is also measured in Ohms, just like resistance, and represented by Omega, **Ω**, too.

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- Power ✓
- Load ✓
- Switch ✓
- Fault ✓
- Source ✓

Power and **Resistance**:

Is a high-power load high or low resistance?

Rewrite $\mathbf{P = E^2 / R}$ as $\mathbf{E^2 / P = R}$

Now check some common 120 V loads:
4 watt nightlight: $120^2 / 4 = 3600$ **Ω**
100 watt light bulb: 14400 / 100 = 144 **Ω**
1500 watt hair dryer: 14400 / 1500 = 9.6 **Ω**

High power loads have low resistance.

Grounding ✓

Bonding ✓

Combined ✓

There are several definitions you should be aware of. Click the text buttons on the left to reveal the definitions for each term.

You must click each definition to advance to the next page.

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Knowledge Check #3

#3 - Multiple Choice: Certain materials become superconductive at:

- A. Extremely high temperatures
- B. Extremely high altitudes
- C. The Fermilab director's command
- D. Extremely low temperatures

Submit Answer

**Answer the question correctly to advance to the next screen.*

Knowledge Check #4

#4 - Multiple Choice: Which measures help protect against electric shock?

- A. Grounding
- B. Bonding
- C. Both grounding and bonding

Submit Answer

**Answer the question correctly to advance to the next screen.*

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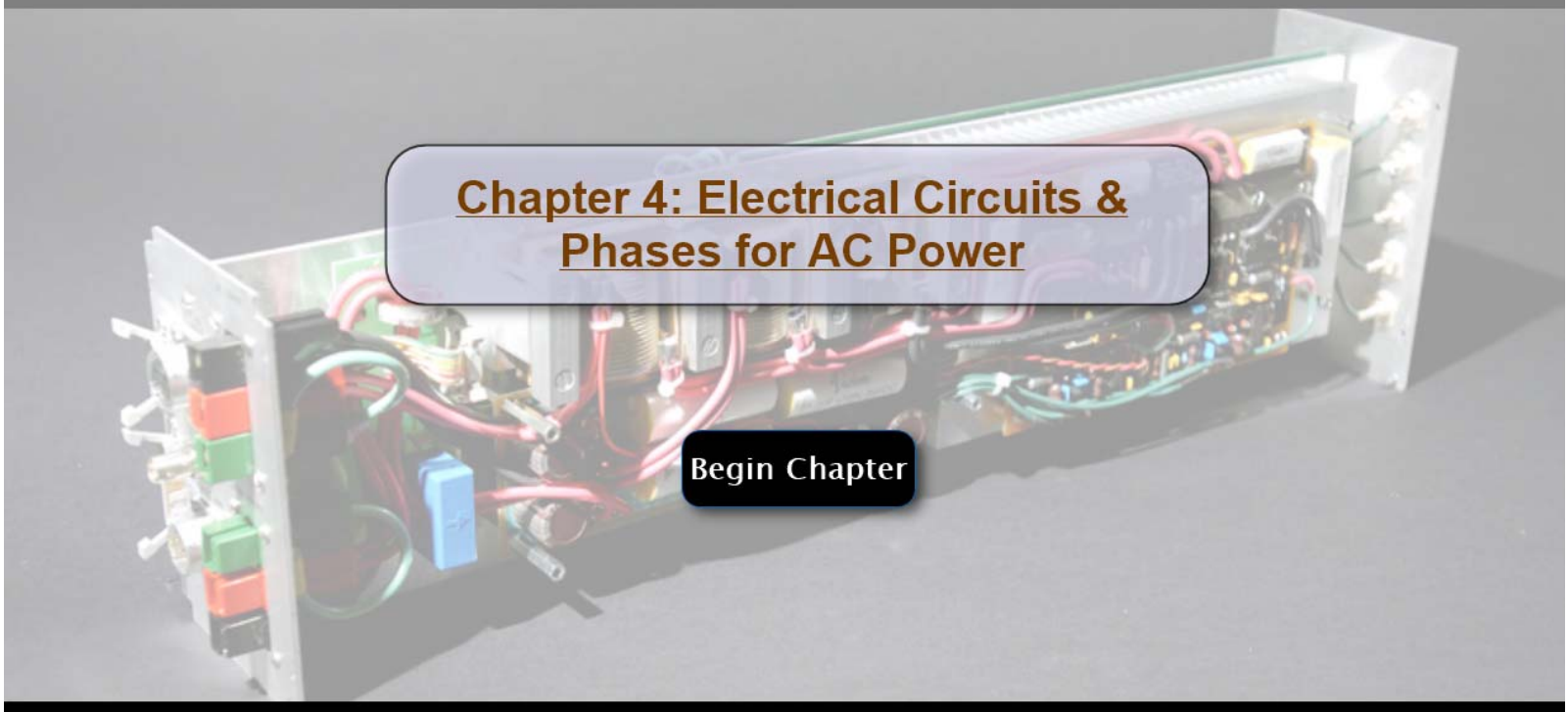

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Overview of Electricity

Chapter 4 reviews the different types of electrical circuits and phases for AC power.

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Basic Circuit ✓ Parallel Circuit ✓ Series Circuit ✓ Open Circuit ✓ Short Circuit ✓

There are several different types of electrical circuits. Click the text buttons above to reveal the definition and example for each type of circuit.
You must click each example to advance to the next page.

Single Phase ✓ Three Phase ✓

There are two types of Phases for AC Power. Click the text buttons above to reveal the definition and example for each type.
You must click each example to advance to the next page.

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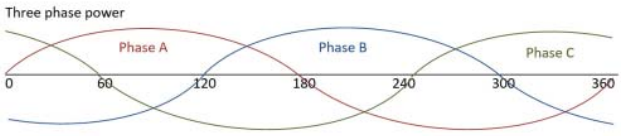
Why use three phase?

A single phase circuit needs two conductors, a three phase circuit needs three.



But a three phase circuit can deliver 1.732 (square root of 3) times as much power as a single phase circuit with only 1.5 times as many conductors.

A three phase motor is constructed so the out-of-sync phases create a rotating magnetic field that the rotor follows naturally.

A single phase circuit pulses between positive and negative "directions" once every cycle. To start a motor rotating, special construction (shaded poles) is needed, which wastes power once the motor is running.

Reserved insulation colors for electrical distribution wires:

- **Grounding**: Also known as just "**ground**", these carry current only during a fault. Only these wires may be
  - **bare**,
  - **green**,
  - or **green** with a **yellow** stripe.
  - **Blue** is used in Europe.

- **Grounded**, also known as **neutral**, is at same potential as ground but may normally carry current. Only these wires may be
  - **white**, or
  - **gray**
  - **Black** is used in Europe.

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Reserved Insulation Colors

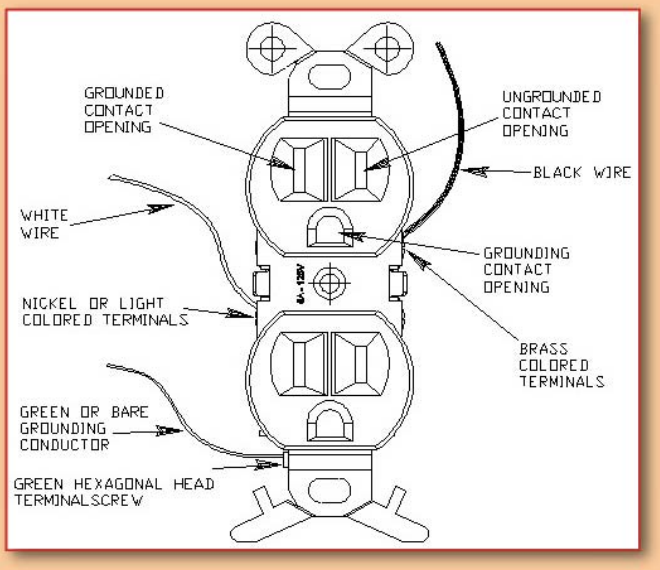
**Click on the Picture below for more info*

Receptacle wiring

- Proper receptacle wiring is essential to safely operate utilization equipment.

Three wires

- Green or bare grounding wire to the **hexagonal green screw**. By code, you must *not* rely on the mounting screws alone to make the grounding connection
- Grounded neutral white or grey wire to white screw
- Ungrounded "hot" wire to **yellow brass screw**



Common Electrical Services

*Click on each picture below to reveal common electrical service types**

**You must click each picture to advance to the next page.*

Reset

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Ground Fault Interrupters

#1

#2

Ground Fault Interrupters (GFCI) save many lives every year!

- GFCIs open the circuit.
- 2 examples of GFCIs (left)

1. GFCI Protected Outlet
2. GFCI Pigtail

Knowledge Check #5

That is the correct answer!

Continue

power

otors

Submit Answer

Answer the question correctly to advance to the next screen.

Knowledge Check #6

#6 - Matching: Match the electric service to the customer:

Click on the electric service in the left column and then click the matching customer in the right column.

120 volt single phase	large industrial
120/240 single phase	Residential or light commercial
208 or 480 volt three phase	large commercial or small industrial
High voltage three phase	Traffic signal

Answer the question correctly then advance to the next screen.

Knowledge Check #7

#7 - Multiple Choice: A wire with red insulation can be used for:

- A. The grounding (a.k.a "ground") wire
- B. The grounded (a.k.a "neutral") wire
- C. Both A and B
- D. Neither A or B

Submit Answer

*Answer the question correctly to advance to the next screen.

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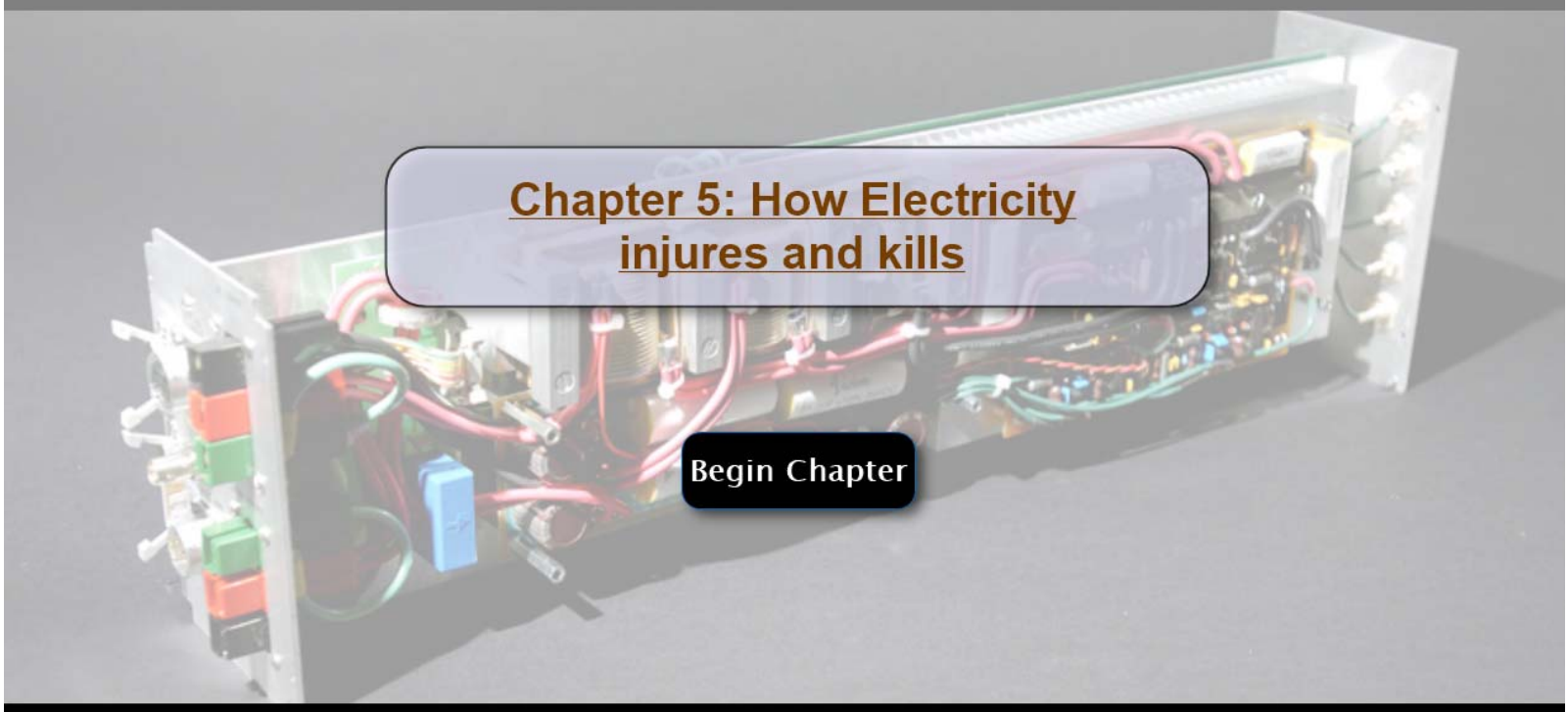

Overview of Electricity

Chapter 5 reviews the dangers of electricity and how it can injure or kill.

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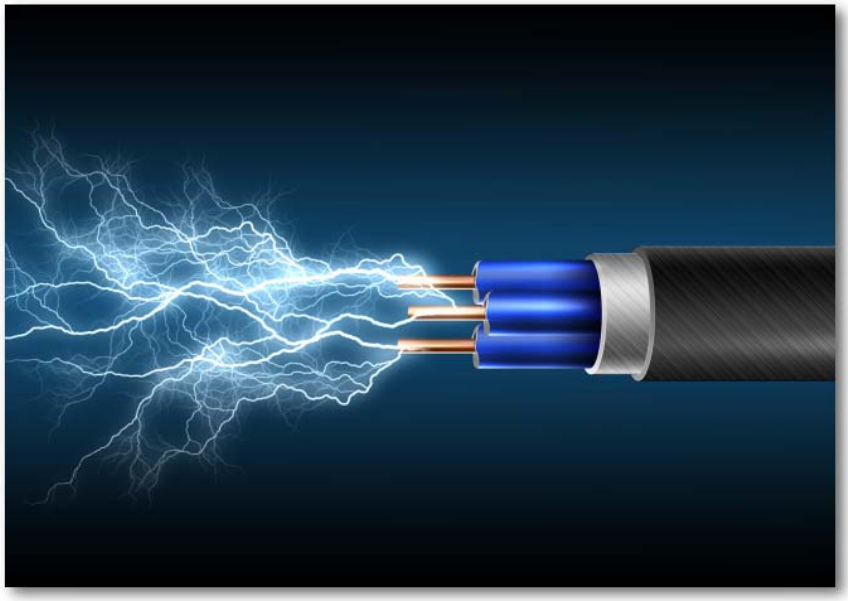
Electrical Hazards

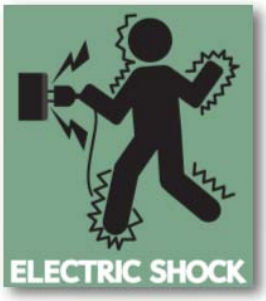
Electrical accidents are responsible for a disproportionate number of fatalities.

Approximately one worker is electrocuted **every day**.



Electrical Hazards

*The **four** physiological effects of electricity include:*



Electric Shock

Electrical Burns

Arc Flash & Arc Blast

Indirect injuries like falls

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Electrical Hazards

Keep in mind...

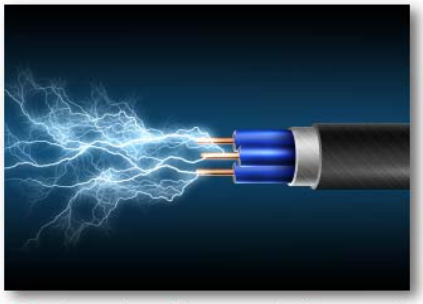
Four fifths (4/5) of direct electrical injuries are from arc flash and arc blast, **not shock!**

Electric Shock

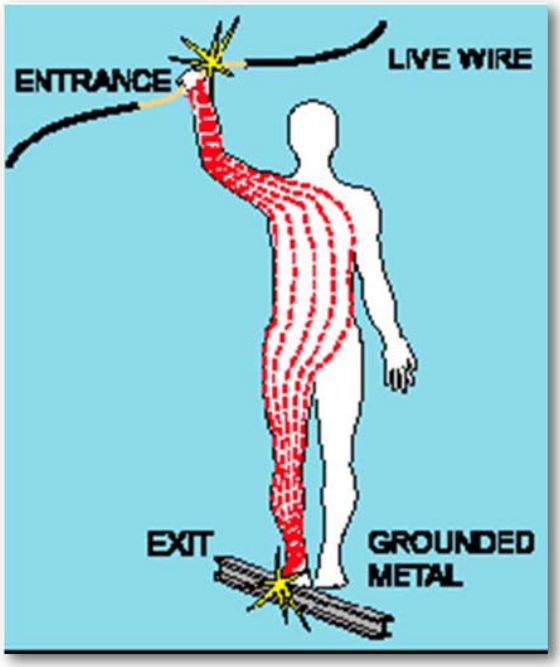
Electric shock is current passing through the body.

The Shock severity depends on 3 factors:

*Click the picture below to view the 3 factors**



**You must view all 3 factors to advance to the next screen.*



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Electric Shock

- < 1 ma ✓
- > 3 ma ✓
- > 5 ma ✓
- > 10 ma ✓
- > 30 ma ✓

Electric Shock

- > 50 ma ✓
- > 100 ma ✓
- > 4000 ma ✓
- > 15000 ma ✓

Over 15,000 ma: 15 amp fuse blows

Over 15 thousand milliamperes must flow before a 15 ampere fuse or circuit breaker will open. This is the smallest common fuse or circuit breaker size for office and home wiring.

A fuse or circuit breaker cannot be relied upon to protect you from shock!!!

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Sources of Electrical Shock

50 volts is all that is needed to generate a potentially fatal current in an adult.

12% of electrocutions are caused by 120 volt sources like common office and home circuits.

A 50 volt electric shock can be fatal to an adult. 12% of electrocutions are caused by 120 volt sources, like common receptacle and lighting circuits. The electrical industry has expended considerable effort in the last 20 years to change a culture that questioned the competence of an electrician who would hesitate to work on live 120 volt circuits.

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Electrical Burns

They are the most common non-fatal injury resulting from electric shock.

They typically occur on **hands**, with **feet** in second place.

Electrical Burns produce unusually deep tissue damage that requires **immediate medical care** to avoid complications like gangrene that can result in **amputation**.

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Electrical Burns

Unlike other thermal burns in which the damage is restricted to the surface of the body, electrical burns can occur anywhere and everywhere along the current path.

Bacteria that are commonly found in untreated gangrene can release poisons that may be **fatal**.

Arc Flash & Arc Blast

Arc flash and arc blast cause **80%**

of workplace electrical injuries.

The injured person does not have to even have direct contact with the electrical equipment!

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Arc Flash & Arc Blast

Electric current passing through air produces conductive ionized gas at up to 35,000° Fahrenheit (19,500° Celsius)

An arc flash event begins with a spark that ionizes the air, which then forms a conductive path through which electric current continues to flow. This current produces an extremely hot gas plasma.

Rhenium has the highest boiling point of 5,596 °C. Tungsten is next-highest at 5,555 °C

Arc Flash & Arc Blast

Like an electric welding arc, the visible and ultraviolet light from the arc can cause:

- temporary or permanent blindness
- form optical cataracts
- and "sunburn" the skin

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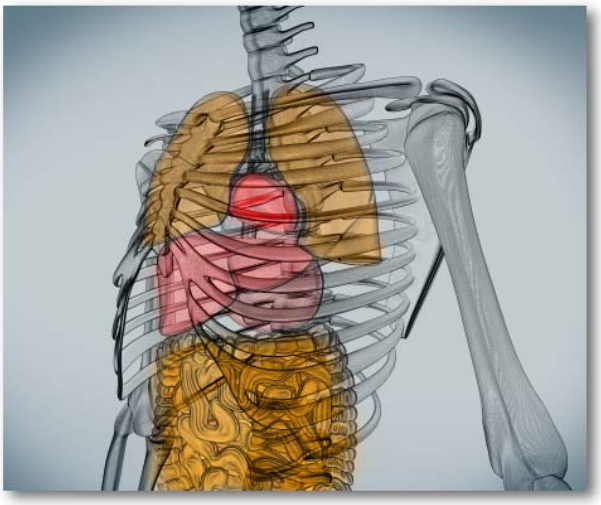
Arc Flash & Arc Blast

The infrared "heat" radiation can burn the skin and ignite clothing.

If the clothing is synthetic, it can melt into the skin, a most painful condition with a slow, difficult recovery.

Arc Flash & Arc Blast

The sudden intense heat vaporizes metal and produces an explosive effect that can launch shrapnel, pierce eardrums, and shred internal organs, particularly the lungs.



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Arc Flash Scene

This is the scene of an arc flash event at a DOE lab.

The scorch mark on the rubber mat shows the size and intensity of the fireball.

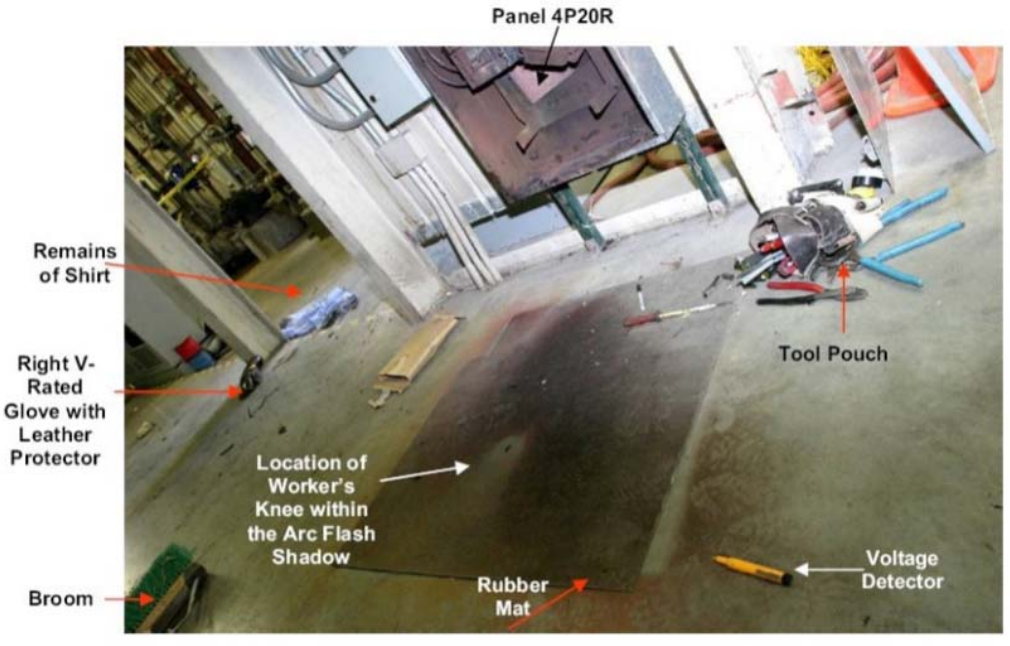

Figure 2-3. The insulating mat with the outline of BSE-1's knee in the arc flash shadow

Arc Flashed Clothing

This picture shows the remains of the victim's clothing and PPE.
Note that the front of the shirt was completely incinerated and the charring of the leather gloves and safety glasses. Like the shirt, the front of the pants became ashes.

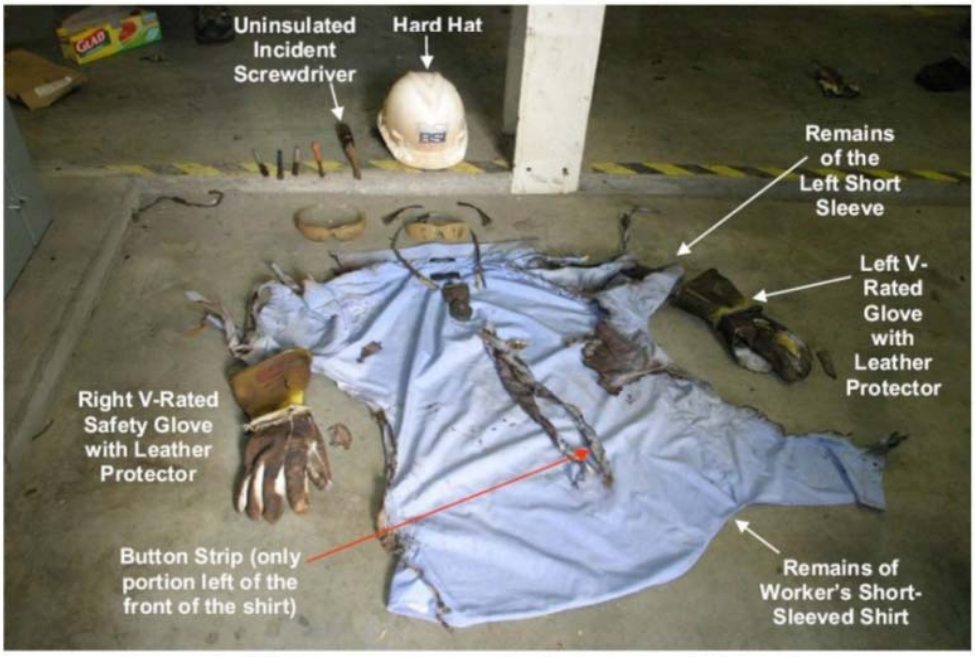

Figure 2-6. BSE-1's burned shirt and his flash-damaged PPE and tools

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Knowledge Check #8

#8 - True or False: A fuse or circuit breaker in my house or workplace will prevent me from getting a fatal shock.

- A. True
- B. False

Submit Answer

**Answer the question correctly to advance to the next screen.*

Knowledge Check #9

#9 - Choose all that apply: Which of these will affect the severity of a shock?

- A. Amount of Current
- B. Duration of the shock
- C. Path through the body
- D. Time of day
- E. Presence of management personnel

Submit Answer

*Answer the question correctly to advance to the next screen.

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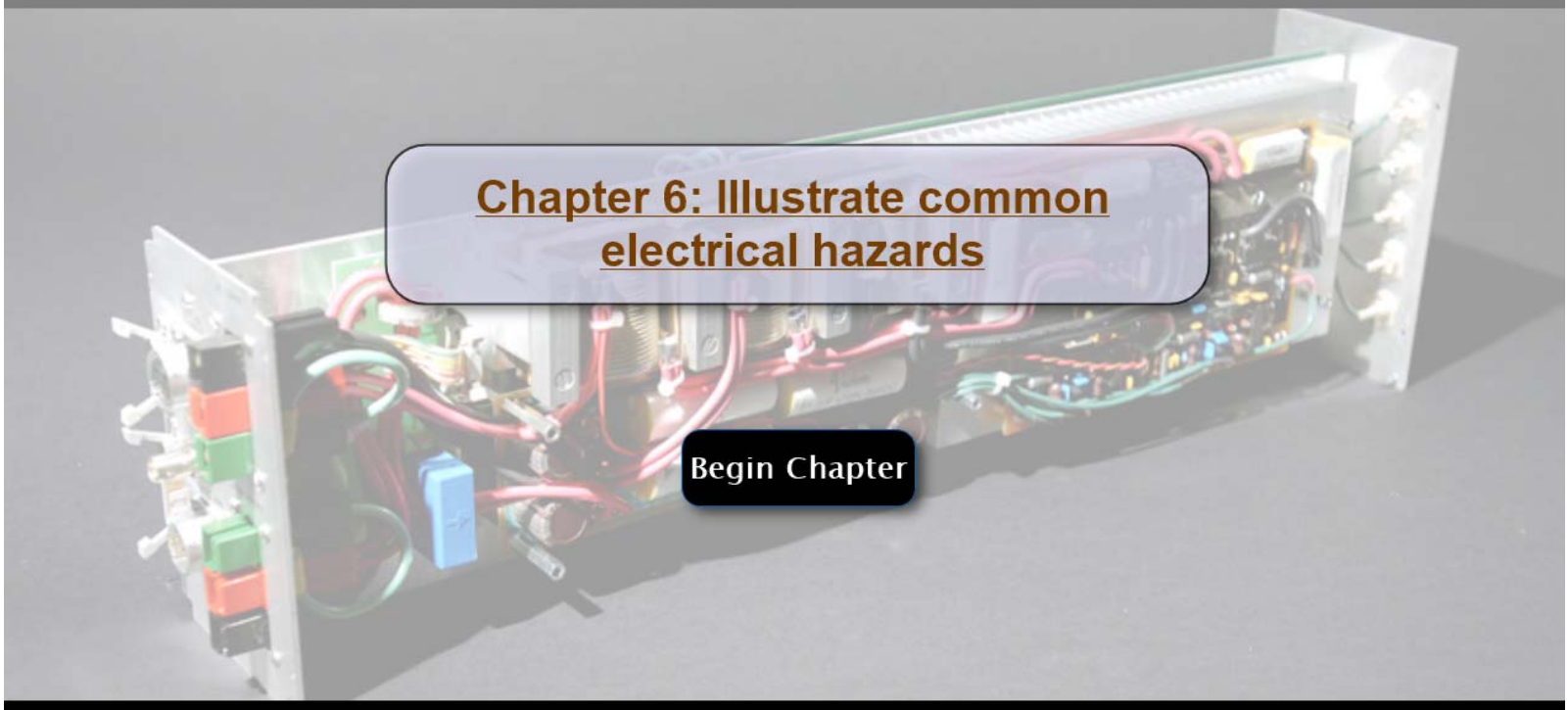
Knowledge Check #10

#10 - Choose all that apply: Arc flash injuries are caused by:

- A. Heat
- B. Intense light
- C. Pressure wave
- D. Defamation of character
- E. Volatile organic compounds

Submit Answer

*Answer the question correctly to advance to the next screen.



Chapter 6: Illustrate common electrical hazards

Begin Chapter

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Preventing Electrical Accidents

Chapter 6 looks at how electrical accidents can be prevented by reviewing numerous examples and best practices.

Hazard Recognition: Adequate Space

One of the best ways to prevent electrical accidents is to give qualified workers **adequate space to do their job**.

The National Electrical Code requirements for working space vary with voltage and site conditions, but for systems under 600 volts you are likely to encounter, the "**four yardstick**" guideline is good visual method to quickly determine if working space in front of electrical equipment is adequate.

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Hazard Recognition: Adequate Space

Always remember:

Imagine a space one yardstick wide (a yardstick is slightly shorter than a meter stick), one yardstick deep, and two yardsticks high in front of the electrical equipment.

If there are obstacles in this space, the working space is likely too small for safe work.

Hazard Recognition: Adequate Space

Examples: Working Space and Exit from Working Space

- Four yardstick (or meterstick) guideline
- Exit path is 2 feet wide by 6-1/2 feet high (0.6 meters wide by 2 meters high, or 60 cm wide by 200 cm high)

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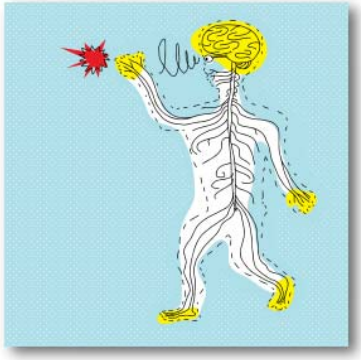
Hazard Recognition: Energized Electrical Conductors

Another basic electrical safety principle is to physically separate energized electrical conductors from unintentional human contact.



Hazard Recognition: Energized Electrical Conductors

If doors and covers are missing, or there are holes large enough to push a pencil through:

1) **avoid contact** with the compromised equipment

2) **report it to your supervisor!**

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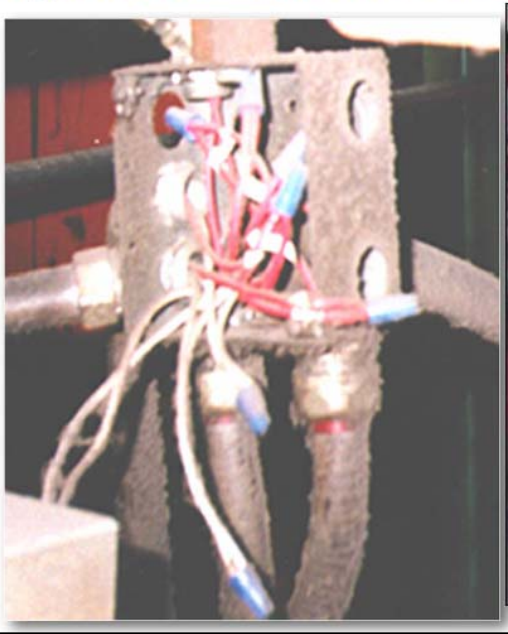
Hazard Recognition: Energized Electrical Conductors

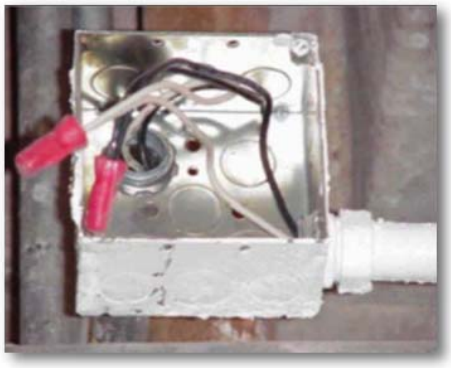
Examples: Open enclosures with exposed energized parts

- Missing doors, covers, and "knockouts"
- Holes in panelboards where circuit breakers used to be



Hazard Recognition: Energized Electrical Conductors

Examples: Similarly, missing covers or portions of lighting fixtures can also expose conductors and energized parts.



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Hazard Recognition: Energized Electrical Conductors

Examples: Physical damage to electrical equipment can cause energized parts to be exposed, can energize exposed parts that shouldn't be energized, and may shut down equipment.

Damage may be caused by corrosion as well as impact.

Hazard Recognition: Energized Electrical Conductors

Always remember:

Assume all exposed electrical wiring is energized.

Avoid contact with the compromised equipment and **report it to your supervisor**.

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Hazard Recognition: Electrical Cords

Electrical cords can present hazards to personnel – and vice versa.

Hazard Recognition: Electrical Cords

Any cords crossing traffic areas **must have a proper shielding cover**.

Placing cords across corridors and other areas with pedestrian traffic presents a **tripping hazard** to people and risks damage to the cord.

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Hazard Recognition: Electrical Cords

Avoid placing cords across corridors and other areas with pedestrian traffic, **even in your own office, lab, or shop**.

In places where the traffic is expected to be infrequent and light, it may be acceptable to secure a cord with duct tape.

Hazard Recognition: Electrical Cords

In certain industrial and lab spaces, and in construction zones, heavier traffic may be present.

Protective cord covers must be used in these areas and must be rated for the largest expected vehicles.

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Hazard Recognition: Electrical Cords

Cords must not be run through doorways or windows.

This inflicts concentrated abrasion on the cord, which will re ure failure. This is why electr uire receptacles to be installe le of buildings near exterior d

Click the picture:
You must click the picture to advance to the next page

Hazard Recognition: Electrical Cords

Examples: Tripping and Abrasion Hazards

- Don't create or permit tripping and abrasion points
- Do not cover cords with rugs or carpet. This traps heat, increases the odds the cord will be damaged, and decreases the odds the damage will be seen.

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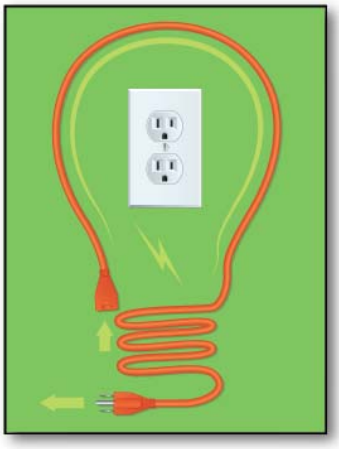
Hazard Recognition: Electrical Cords

Always remember:

Click the picture:

You must click the picture to advance to the next page.



Hazard Recognition: Electrical Cords

Always remember:

Frayed or otherwise damaged cords should be removed from service promptly.

They no longer provide the protection they initially offered, and may be unable to carry their rated load anymore.

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Hazard Recognition: Electrical Cords

If you have not been trained how to correctly repair a cord, you don't know how to do it safely!

Twisting the wires together, even if you use wire nuts, and wrapping them with electrical tape is **unacceptable**.

It is always safer, and in most cases less expensive, to **replace a damaged cord** than to try to repair it.

Hazard Recognition: Electrical Cords

Examples: Frayed and damaged cords

- If you can see anything inside the outer jacket, remove the cord from service promptly
- Wrapping the cord with tape is not an adequate repair

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Hazard Recognition: Plugs & Receptacles

Plug and receptacle damage also can cause hazards.

Hazard Recognition: Plugs & Receptacles

A plug or connector has to make two kinds of connections:

Electrical and Mechanical

The mechanical connection between the cord's jacket and the plug's body prevents tension on the cord from pulling the electrical connections apart.

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Hazard Recognition: Plugs & Receptacles

Always remember:

You must click the button to advance to the next page.

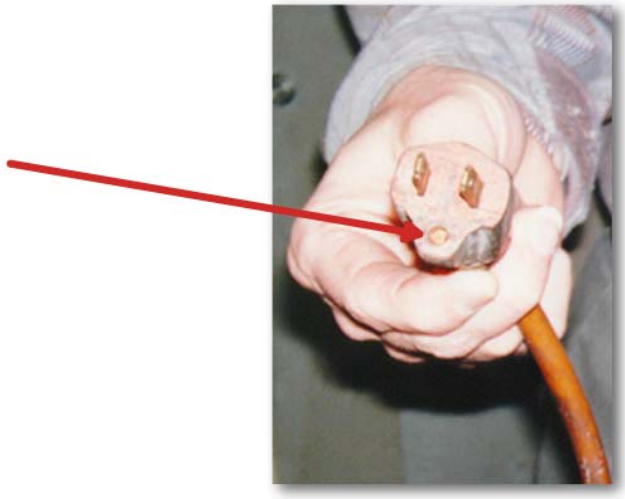
If the mechanical conn... remove the cord fro... Click Here

If you find a plug with the ground prong (or for that matter, any pin) missing or damaged take it out of service, by cutting off the damaged plug if possible.

Hazard Recognition: Plugs & Receptacles

Examples: Plug and receptacle damage

- Never use a cord with a damaged grounding prong
- A plug must have a good mechanical connection to the cord jacket so the wires are not under tension
- Promptly remove damaged cords from service



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Hazard Recognition: Plugs & Receptacles

Examples: Plug and receptacle damage

- Grasp the plug body to remove it from a receptacle. Never pull on the cord.
- Never use a damaged receptacle. **Report it instead.**

Hazard Recognition: Plugs & Receptacles

Always remember:

The mechanical connection between the cord jacket and the plug body is not designed to carry the force needed to remove the plug from the receptacle.

If you feel it is unsafe to touch the plug body for any reason at all, **seek assistance from qualified electrical personnel**.

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Hazard Recognition: Overhead Electrical Hazards

Overhead electrical components also can cause hazards.

Hazard Recognition: Overhead Electrical Hazards

helpful tips

For common "primary" overhead distribution, such as found in the Fermilab Village, keep yourself and anything you may be holding at least

10 feet, or 3 meters

away, plus some additional distance to accommodate inadvertent movement.

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Hazard Recognition: Overhead Electrical Hazards

helpful tips

Some of the industrial and experimental buildings on the Fermilab site have overhead traveling cranes.

These cranes draw power from bus bars that run close to and parallel with the crane's movement. These bus bars typically carry

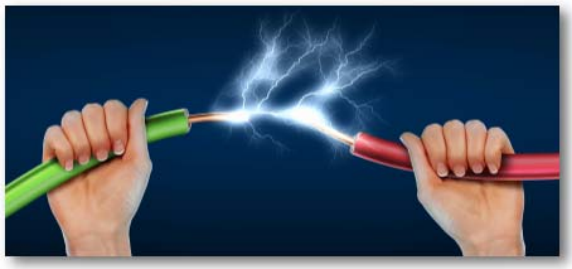
480 volts.

Stay clear of these bus bars as well, and allow yourself additional distance to accommodate inadvertent movement.

Hazard Recognition: Overhead Electrical Hazards

Always remember:

⚠ Pole-mounted utility wires are not insulated and operate at **thousands of volts.**



You do not have to touch them to get hurt!

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Hazard Recognition: Electrical Work Areas

Examples*: Electrical work areas

- #1: Stay outside of work areas where marked and when verbally instructed. Click Here #1
- #2: Keep well clear when workers are wearing personal protective equipment (and you're not!). Click Here #2

**You must click both examples to advance to the next page.*

Hazard Recognition: Electrical Work Areas

Always remember:

There may be additional electrical hazards present when work is being done by qualified electrical personnel.

For their safety as well as yours, keep clear of their work area.

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Hazard Recognition: Other Electrical "Red Flags"

The next few slides highlight other "red flags" that electrical equipment is not functioning correctly.

Red Flags!

- # 1 ✓
- #2 ✓
- #3 ✓
- #4 ✓
- #5 ✓

There are several "RED FLAGS" to be aware of. Click on each number to the left to reveal the answers. You must click each number to advance to the next page.

Page 1 of 2

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Red Flags!

- # 6 ✓
- #7 ✓

There are several "RED FLAGS" to be aware of. Click on each number to the left to reveal the answers. You must click each number to advance to the next page.

Page 2 of 2

Hazard Recognition: Other Electrical "Red Flags"

Always remember:

Report these conditions immediately so they can be economically corrected in a planned and scheduled manner.

Waiting until a failure takes place could result in additional "collateral damage."

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Knowledge Check #11

#11 - Multiple Choice: If I am going to run an extension cord across my workspace, I should NOT:

- A. See if I can rearrange my workplace so I don't need the extension cord.
- B. Ask for a permanent receptacle to be installed if the cord isn't for brief, temporary use.
- C. Cover the cord with a rug to prevent tripping.
- D. Put the cord inside a cord protector.

Submit Answer

**Answer the question correctly to advance to the next screen.*

Knowledge Check #12

#12 - Multiple Choice: I should request that a receptacle be replaced if:

- A. The receptacle face is cracked.
- B. The receptacle or the wall plate is discolored or charred.
- C. The receptacle does not grip a plug firmly.
- D. The receptacle or plug inserted in it is warm to the touch.
- E. The receptacle makes a buzzing or crackling sound.
- F. All of the above.

Submit Answer

**Answer the question correctly to advance to the next screen.*

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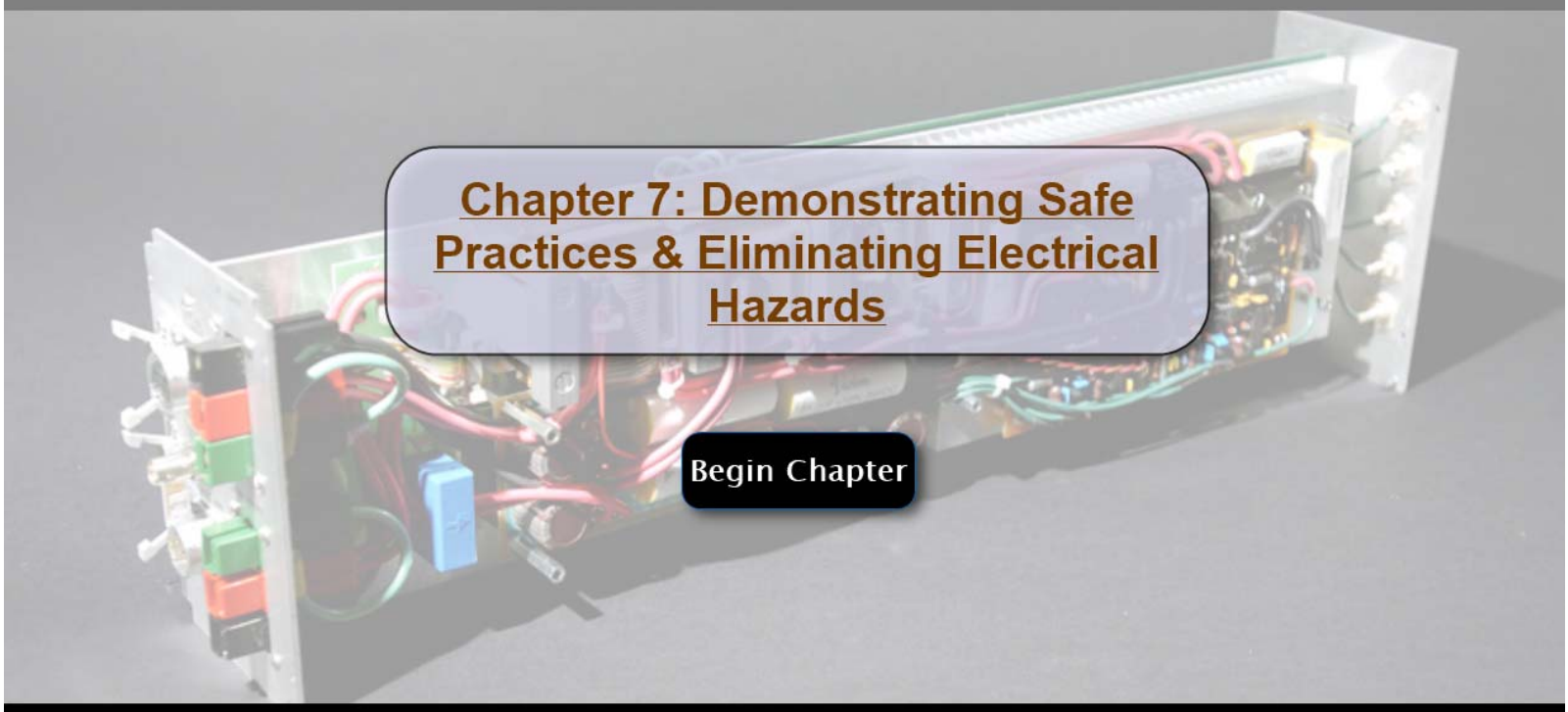

Demonstrating Safe Practices

Chapter 7 demonstrates safe practices that reduce or eliminate electrical hazards by reviewing numerous examples of unsafe conditions and safe practices.

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Examples of Unsafe Conditions - Intro

These next pages review numerous examples of unsafe conditions you could encounter.

Helpful tips and points you should always remember are also highlighted.

Examples of Unsafe Conditions

Example #1:

The box shown here is not "listed" by the manufacturer to be used as portable equipment.

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Examples of Unsafe Conditions

Example #2:

Power strips: One of the most common electrical problems at the lab is **misuse of power strips**.

Most extension cords and power strips are not designed for large loads, instead they are designed to serve multiple low-power computer equipment loads.

Examples of Unsafe Conditions

Always remember:

Check the fine print and **do not put heavy loads on power strips**!

Heavy loads include space heaters, kitchen appliances, copiers, and laser-type printers.

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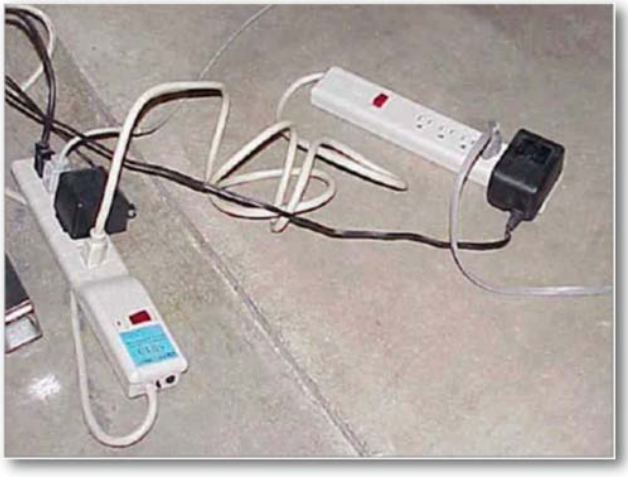
Examples of Unsafe Conditions

Example #3:

Extension Cord and Power Strip "Daisy Chains"*



*"Daisy chaining" is connecting more than one extension cord or multi-outlet device to a single permanent receptacle. Multi-outlet devices include bench- or rack-mounted "plug-mold" receptacle strips and extension cords with multiple receptacles, as well the ubiquitous power strips. The only exception is when a "plug-mold" receptacle strip is hard-wired directly to its own dedicated circuit from the building's power distribution system.

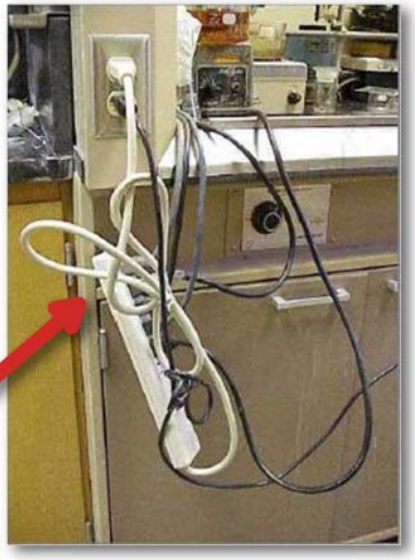
Examples of Unsafe Conditions

Example #4:

Extension Cord and Power Strip
"Daisy Chains"

Power strips should be supported by building structure or furniture.

The weight of the power strip should not be borne by its cord or the cords plugged into it.



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Examples of Unsafe Conditions

Example #5:

Flexible Cords

The National Electrical Code restricts the use of flexible cords because they are **more vulnerable to damage** than other wiring methods.

Examples of Unsafe Conditions

- # 1 ✓
- #2 ✓
- #3 ✓
- #4 ✓

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Examples of Unsafe Conditions

Always remember:

- ✓ No "temporary" extension cords
- ✓ No flexible cords to or between outlet boxes.
- ✓ No flexible cords in concealed areas or under carpet
- ✓ No flexible cords fastened to structure
- ✓ No flexible cords on hot or sharp objects
- ✓ No flexible cord plugs inaccessible behind furniture
- ✓ No plugs supporting excessive weight

Examples of Unsafe Conditions

Example #6:

"**Clotheslines**"

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Examples of Unsafe Conditions

Example #7:

"**Tripwires**"

Examples of Unsafe Conditions

Always remember:

Cables, whether carrying power or signals, should not be suspended or laid on the floor where a walking person could come in contact with the them.

These situations create opportunities for injury to personnel and damage to the cords and the equipment to which they're attached.

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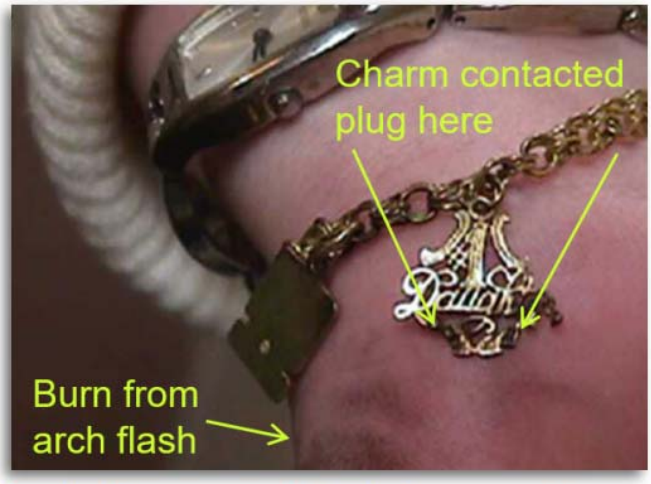
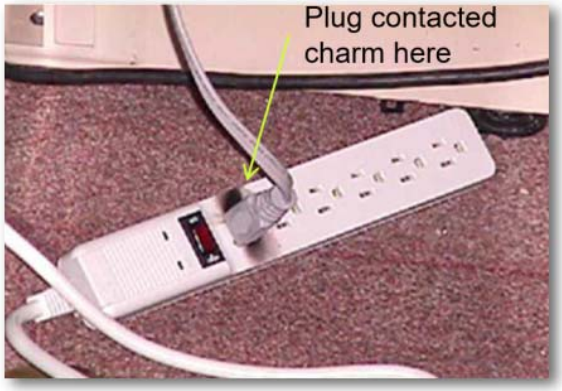
Examples of Unsafe Conditions



Example #8: Conductive Apparel Hazards



Conductive apparel, including most types of jewelry, can initiate electrical injury, or can make a shock incident more severe by providing a low-resistance connection to the body.

Examples of Unsafe Conditions

Always remember:

Removing or covering loose conductive apparel is **recommended** when handling electrical cords and plugs.

Removal of all conductive apparel, including rings, is **required** where energized conductors will be exposed!

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Examples of Safe Practices - Intro

This chapter concludes with a review of numerous examples of safe practices you should know.

Helpful tips and points you should always remember are also highlighted.

Examples of Safe Practices

Ground Fault Circuit Interrupters, a.k.a GFCIs

✓**GFCIs** measure the difference between current on the two conductors and trip when the **difference is over 4-6 mA**.

✓GFCIs are **required** for cord-connected tools and receptacles in **exterior locations** and **within 6' of water** or in **wet or damp locations**.

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Examples of Safe Practices

Ground Fault Circuit Interrupters, a.k.a GFCIs

In most cases, a GFCI that trips repeatedly is protecting you. There are some unusual conditions, such as an extremely long circuits, or ones that have capacitive, inductive, or high-harmonic waveforms, that can cause false GFCI trips. **These require the help of qualified electrical personnel to correct**.

Examples of Safe Practices

Always remember:

Verify operation of a GFCI with the test button prior to the first time you use it and at least monthly thereafter.

Correct any deficient conditions if a GFCI trips repeatedly by **contacting qualified electrical personnel** for assistance.

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Examples of Safe Practices

Cords & Receptacle Covers

Electricity and water are a hazardous combination for humans, yet there are applications, such as sump pumps, where the benefits make mitigating the hazard worthwhile.

The picture on the left is an example of what not to do...

Examples of Safe Practices

Cords & Receptacle Covers

There are two types of receptacle covers for wet locations. The more familiar flat cover, shown here, is **only for temporary use** when an operator is present.

If you have a cord plugged into an outlet like this, you must unplug it and close the cover when you leave the immediate vicinity or when precipitation starts.

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Examples of Safe Practices

Cords & Receptacle Covers

The newer "weatherproof-in-use" covers, like the one shown here, allow a plug to be inserted in the receptacle and guides the cord through a hole in the bottom of the cover.

A cord may be left plugged into a receptacle under this cover when unattended or when there is precipitation. Of course, **any loads connected to the other end of the cord must be rated for operation in wet conditions**.

Examples of Safe Practices

Always remember:

Any cord used in a wet location must be rated for use in wet locations.

Click Here*

*You must click the "Click Here" button in order to advance to the next page.

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Examples of Safe Practices

Electricity & Water

Water improves the electrical connection of most objects, including you!

Contacting electrical equipment with **wet** or **sweaty hands**, or when you are in contact with wet surfaces increases the power of any **shock** you might receive.

Electrical equipment submerged in water may energize the water rather than tripping the circuit breaker or fuse.

Examples of Safe Practices

Always remember:

Click Here*

**You must click the "Click Here" button in order to advance to the next page.*

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Examples of Safe Practices

Utilization Equipment

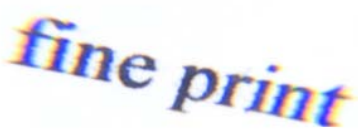
The detachable power cords common to personal computer equipment and many instruments and power supplies come in several wire gauges.

Users must select cords with adequately-sized conductors for the loads they will serve.

- 18 AWG: 1200 Watts
- 16 AWG: 1560 Watts
- 14 AWG: 2160 Watts

Examples of Safe Practices

Utilization Equipment



On the back or underside of electrical equipment and in any user's manual that came with it you will find "**fine print**." It's there for two reasons.

- First is that some of that information is required to get the UL or ETL listing.
- The second reason is it limits the manufacturer's liability.

If you do something the manufacturer said not to do, it's off the hook if something goes wrong. So too is Fermilab unless your supervisor instructed you to do it.

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Examples of Safe Practices

Utilization Equipment

✓The most common restrictions forbid use in damp or wet locations or very high or very low temperatures.

✓Also check where air vents are and do not block them. Heat producing appliances may have minimum distances from walls, ceilings and other combustible materials.

Examples of Safe Practices

Always remember:

Click Here*

*You must click the "Click Here" button in order to advance to the next page.

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Examples of Safe Practices

"Listed" Equipment

You may have received training and seen posters regarding "Suspect and Counterfeit Items" here at Fermilab.

Electrical goods are especially vulnerable to counterfeiting because their critical and expensive components are often hidden from view and even if they are visible, the deficiencies are not often obvious to the untrained eye.

Examples of Safe Practices

"Listed" Equipment

Except for custom equipment needed to meet unique operational or experimental needs, Fermilab **requires** that electrical equipment be "**listed**."

Certified testing laboratories such as UL and ETL, collectively referred to as Nationally Recognized Testing Laboratories, or NRTLs, maintain lists of the equipment that have been submitted to them and have passed certain tests established by industry groups, professional organizations, government, or some combination of these.

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Examples of Safe Practices

"Listed" Equipment

NRTL's permit the manufacturers of "listed" equipment to affix the NRTL's logo, or "seal," to identical copies of the equipment that was tested and passed.

Getting a product tested is never inexpensive, nor is it quick, so there is a financial incentive to not only counterfeit the products, but to counterfeit the seal as well. That is why many of these **seals now include holograms** and other anti-counterfeiting features, just like currency.

Examples of Safe Practices

"Listed" Equipment

Examples of certified logos and seals:

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Examples of Safe Practices

"Listed" Equipment

The Fermilab stockroom carries some common electrical items such as power strips, extension cords, and cord protectors.

You are **strongly encouraged** to use products that are available from the stockroom rather than purchasing them yourself.

Examples of Safe Practices

Consumer electrical equipment used at Fermilab (and other U.S. workplaces) **must be listed and labeled** by a Nationally Recognized Testing Lab. Seal must be **UL**, **ETL**, or include "**US**" or "**NRTL**".

Be wary of any "**too** Click Here* deals or merchandise that appears deficien rfeit. Even genuine equipment may be cheaply made, especially if it was inexpensive.

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Examples of Safe Practices

1 ✓

#2 ✓

#3 ✓

#4 ✓

Click on each # on the left to reveal the tip. You must click each # to advance to the next page.

Examples of Safe Practices

Always remember:

Click Here*

*You must click the "Click Here" button in order to advance to the next page.

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Examples of Safe Practices

Receptacle Wiring

A plug-in tester similar to this one is a safe, accurate device for use by unqualified personnel.

This tester identifies the more hazardous miswiring conditions. It **will not detect** swapped grounding (ground) and grounded (neutral) wires.

This tester is available through the stockroom # 1145-500000

Chapter 8: Demonstrating Safe Practices - Switches & Circuit Breakers

Begin Chapter

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Demonstrating Safe Practices - Switch & Circuit Breaker

Chapter 8 demonstrates safe practices for using switches (**not applicable to light switches**) and circuit breakers.

Demonstrating Safe Practices - Switch & Circuit Breaker

#1 - safety switch

#2 - circuit breaker

Keep in mind...

The examples in this chapter cover switches like the safety switch seen in the first picture (**not light switches**) and circuit breakers as seen in the second picture.

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Examples of Safe Practices

Switch & Circuit Breaker Operation

- # 1 ✓
- #2 ✓
- #3 ✓
- #4 ✓

You may operate a switch or circuit breaker if your supervisor or job description authorizes you to do so.

All of the covers are held in place with all the screws and latches provided by the manufacturer.

Examples of Safe Practices

Switch & Circuit Breaker Operation

When you have turned a switch or breaker off:

**Click each picture to reveal the answer. Both must be viewed to advance to the next page.*

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Examples of Safe Practices

Switch & Circuit Breaker Operation

Before turning a switch or breaker on:

**Click each picture to reveal the answer. Both must be viewed to advance to the next page.*

Page n of nn

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Examples of Safe Practices

PPE Do's:

There are 4 required pieces of personal protective equipment shown in this picture.

Roll over* the following areas to view what the 4 required PPE are:

1. Hand
2. Head
3. Body

**All 3 areas must be viewed to advance to the next page.*

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Examples of Safe Practices

Switch & Circuit Breaker Operation

PPE Don't's:

#1

#2

There are a few PPE don't's that you should be aware of. Click each # on the right to reveal the answers.

All #'s must be viewed to advance to the next page.

Examples of Safe Practices

helpful tips

Switch & Circuit Breaker Operation

Step to the side – present as little of your body to the potential arc flash as possible.

Face away – don't place your eyes at risk.

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Examples of Safe Practices - Switch & Circuit Breaker

Always remember:

Do not operate a switch or breaker if...

CLICK HERE #1

Report deficiency to your supervisor if...

CLICK HERE #2

*You must click both "Click Here" buttons in order to advance to the next page.

Knowledge Check #13

#13 - Choose all that apply: The PPE required for operating a disconnect switch or circuit breaker are:

- A. Insulating shoes or boots
- B. Safety Glasses
- C. Long sleeve shirt and long pants
- D. Filtering facepiece (dust mask)
- E. In-the-ear hearing protection
- F. Ear muffs
- G. Leather gloves

Submit Answer

Answer the question correctly to advance to the next screen.

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Knowledge Check #14

#14 - True or False: I need to follow these procedures to operate a light switch.

- A. True
- B. False

Submit Answer

Answer the question correctly to advance to the next screen.

Chapter 9: Demonstrating Safe Practices - Batteries

Begin Chapter

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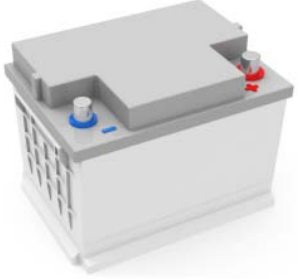
Examples of Safe Practices



Safe Battery Use Practices

- Electric batteries seem very safe, yet in our portable electronics such as smartphones, laptops, and personal music players, batteries are precisely engineered devices that lock up large amounts of potential chemical energy in a very small space using lightweight materials.
- Batteries are made of highly reactive chemicals that are stable until the energy is desired.

Examples of Safe Practices

Safe Battery Use Practices

Batteries present three types of hazards, click on each hazard* to view the details.

Energy Release

Flammability

Physiological Hazard

View Again / Reset

**Each hazard must be viewed to advance to the next page.*

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Examples of Safe Practices

Always remember:

Click each battery below to view safe battery use practices*

#1 #2 #3 #4 #5

**You must click each button in order to advance to the next page.*

Knowledge Check #15

#15 - True or False: The materials and chemicals in batteries could never hurt me.

- A. True
- B. False

Submit Answer

**Answer the question correctly to advance to the next screen.*

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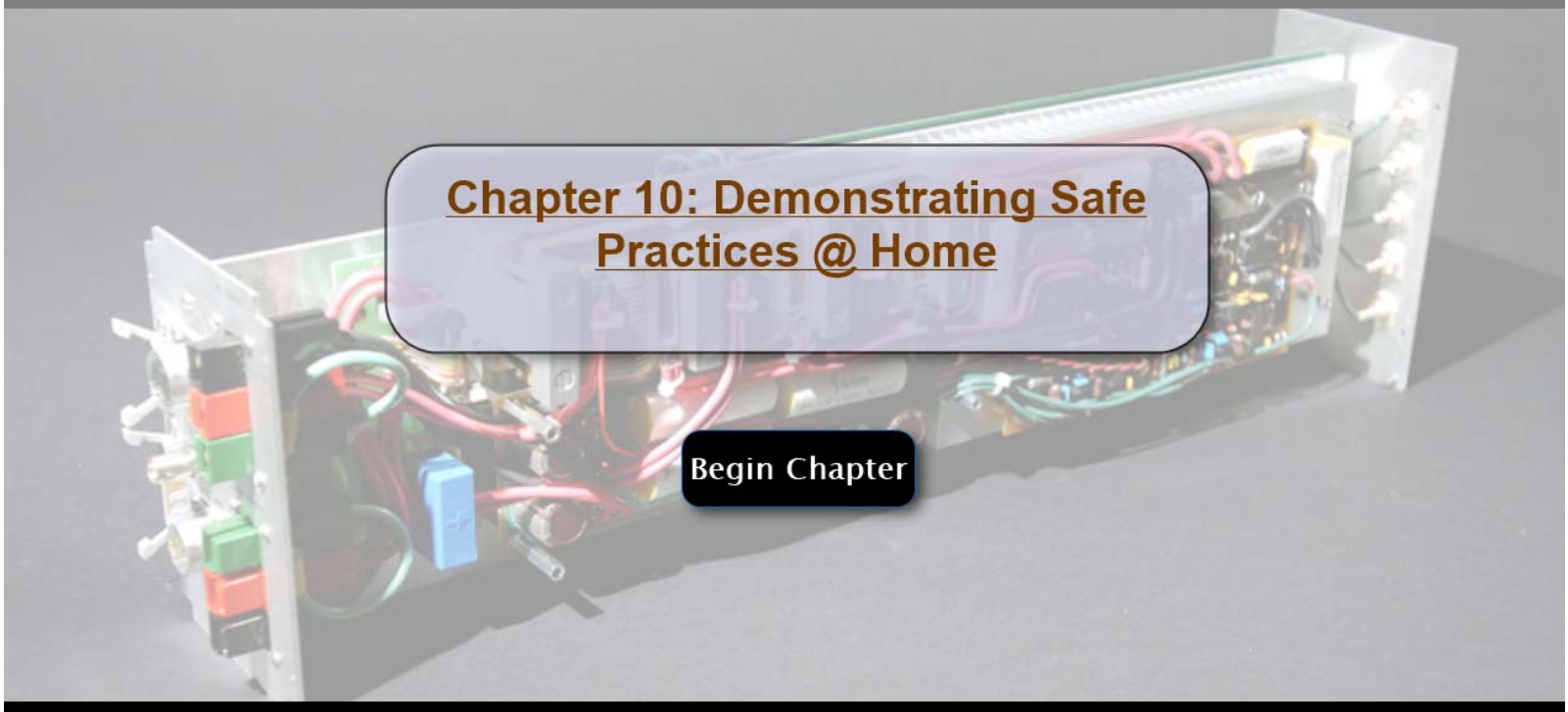

Chapter 10: Demonstrating Safe Practices @ Home

Begin Chapter

Examples of Safe Practices

Specific Safe Practices @ Home

Many of the practices described in this training also apply to residences!

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Examples of Safe Practices

Specific Safe Practices @ Home

- A good practice for homeowners is to exercise their circuit breakers.
- Moving the breakers' mechanical mechanisms by hand helps ensure that they will work correctly to clear a fault condition.
- Homeowners with screw shell fuses should tighten fuses annually.

Examples of Safe Practices

Specific Safe Practices @ Home

- Some houses built prior to 1960 may have two-wire electrical circuits without the safety ground.
- Receptacles will look like the picture shown here.
- The only way to correct this condition is to rewire the entire home.

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Examples of Safe Practices

Specific Safe Practices @ Home

Houses built between 1965 and 1975 may have aluminum wiring.

- Aluminum is distinguishable because of its silvery-white appearance compared to copper's brownish-orange color. Overheated aluminum may appear black.
- The Consumer Products Safety Commission (CPSC) has stated that "Homes wired with aluminum wire manufactured before 1972 ['old technology' aluminum wire] are **55 times more likely to have one or more connections reach "Fire Hazard Conditions"** than is a home wired with copper."
- If your house has, or you suspect it may have, aluminum wiring, **seek the help of a qualified electrician**.

Examples of Safe Practices

Always remember:

#1: Do not do this...

CLICK HERE #1

#2: But, it is OK to do this...

CLICK HERE #2

**You must click both text boxes in order to advance to the next page.*

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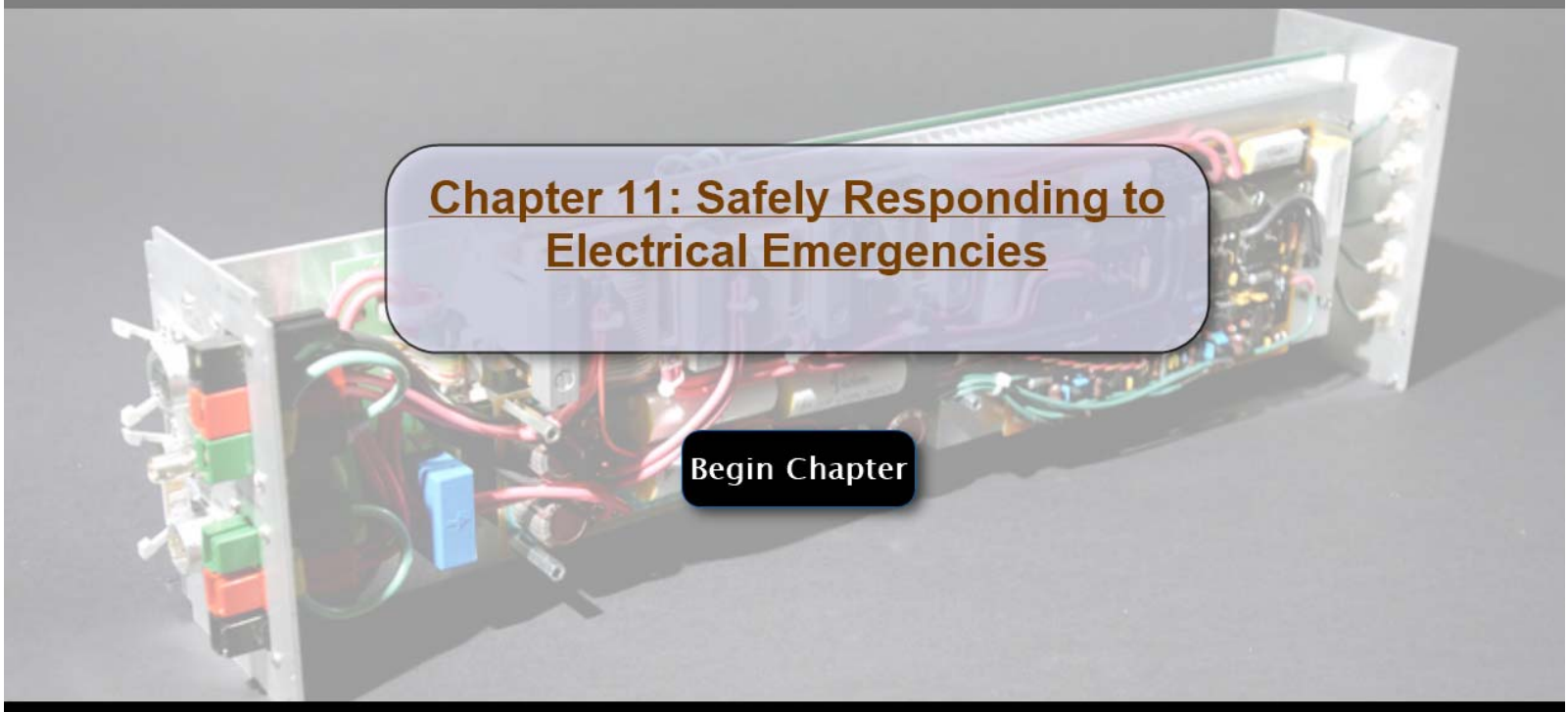

Chapter 11: Safely Responding to Electrical Emergencies

Begin Chapter

Instructions for Safe Response

Chapter 11 provides instructions and guidelines to follow when responding to electrical emergencies.

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Instructions for Safe Response

Always remember:

Your safety ALWAYS comes FIRST!*

**You must click each word in order to advance to the next page.*

Instructions for Safe Response

This next section within the chapter reviews specific electrical emergencies and explains how you should respond in each situation.

Helpful tips and points you should always remember are also highlighted.

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Instructions for Safe Response

Emergencies for Lights, Switches, Receptacles, and Plug-ins

Instructions for Safe Response

Safe Response #1:

Emergencies for Lights, Switches, Receptacles, and Plug-ins

- If you are not in imminent danger, the most effective action is **removing the power from the equipment**.
- If you can safely reach the plug of a malfunctioning cord & plug connected device, and the plug looks normal, **unplug it.**

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Safe Response #2:

Emergencies for Lights, Switches, Receptacles, and Plug-ins

- Next option is to **turn off the circuit supplying the power**. This is one reason why the lights switches and receptacles are labeled with panel and circuit numbers.
- In any event like this, **report it promptly to your supervisor** or building manager.

Do not plug a load back in or turn circuit breakers back on.

Instructions for Safe Response

Emergencies for Lights, Switches, Receptacles, and Plug-ins

- Know where the electrical disconnect switches and panelboards are in your work area.
- If you observe a non-life-threatening condition, such as light smoke, buzzing, or arcing, unplug the failing device or turn off the circuit breaker serving the load.
- If there is smoke or even a remote threat to your safety, move to safety and call x3131.

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Instructions for Safe Response

Arch-Flash Emergencies

Instructions for Safe Response

Arch-Flash Emergencies

Safe Response #1:

- If it looks like some electrical equipment has blown up and injured someone, get trained help. Instruct a nearby co-worker to **call extension 3131 or 630-840-3131** or make the call yourself if you are alone.
  - Provide information to the emergency response operator, and
  - follow directions from the emergency response operator.

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Instructions for Safe Response

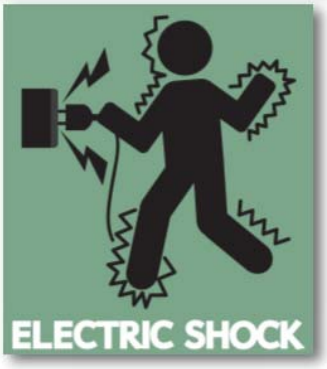
Arch-Flash Emergencies

Safe Response #2:

- **Check to be sure the victin is not in contact with energized equipment**.
  - If victim is clear of electrical equipment, start CPR if they are not breathing.
  - If victim is not clear of electrical equipment, proceed as if it is an electric shock emergency (next emergency situation explained).

Instructions for Safe Response

Electric Shock Emergencies



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Instructions for Safe Response

Electric Shock Emergencies Under 600 Volts

Safe Response #1:

- In an electrical shock emergency that does not involve overhead power lines or the ground-mounted electrical boxes or transformers, **first check if the victim is clear of any electrical parts or equipment that might be energized**.
  - If the victim is touching anything energized **call x3131**, and...

DO NOT TOUCH THEM!

Instructions for Safe Response

Electric Shock Emergencies Under 600 Volts

Safe Response #2:

- If it is obvious what is delivering the shock, remove the power by **unplugging the device or turning off switches and circuit breakers**.

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Instructions for Safe Response

Electric Shock Emergencies Under 600 Volts

Safe Response #3:

- If power cannot be disconnected and area is dry, use a wood pole, leather belt, or similar insulating object to **pull person from the energy source**.
  - Once free of energy source, call x3131 for help and start CPR if required.

If the area is wet or you cannot find a non-conductive object, wait for the emergency responders.

Page n of nn
FN000235

Instructions for Safe Response

Downed Power Line Emergencies

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Instructions for Safe Response

Downed Power Line Emergencies

Safe Response #1:

- **DO NOT move** unless you are in imminent danger. If you must move, follow the *step potential* instructions provided in upcoming pages.

Get trained help. Call extension 3131 or 630-840-3131.

Instructions for Safe Response

Downed Power Line Emergencies

Safe Response #2:

- **Warn others** to stay away from the downed line.
  - You cannot tell if a downed line is de-energized.
  - Stay at least **50 feet (17 meters)** away from a downed power line.

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Instructions for Safe Response

Downed Power Line Emergencies

- If someone is disabled near or in direct contact with the power line, DO NOT approach them.
- You do not have the tools or training to be able to help them.
- Sometimes even the first responders won't have the right tools, like an incident in Holley, New York described on the next page.

Instructions for Safe Response

Downed Power Line Emergencies

Example: Holley, New York, September 13, 2008, as reported by Time-Warner Cable News

- Stephen Annucci, 39, of Rochester had just finished unloading concrete at a produce processing warehouse. Annucci was cleaning his truck after the delivery when the boom on the truck hit a power line.
- Responders could not help Annucci right away because of the live power lines. It took the power company about an hour to shut the power off.
- It took only seconds for the responders to get to Annucci once the power was off, but it was too late.
- Annucci was transported to the hospital where he later died.

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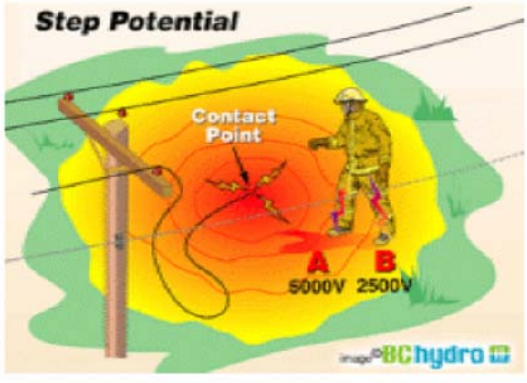
Instructions for Safe Response

Downed Power Line Emergencies: Step Potential

- So what's the big deal with moving away from a downed power line? ***Step potential***.
- If you separate your feet, there may be enough voltage difference to drive a shock current up one leg and down the other. Step potential can kill you.
- The next page explains what to do to avoid step potential.



Instructions for Safe Response

Downed Power Line Emergencies: Step Potential

Safe Response:

- **Keep feet together and shuffle away** from the line.
- Cross curbs and other obstacles by "bunny hopping," keeping your feet together.
- Never let one foot's heel get ahead of the other foot's toes.
- Keep your balance, touching the ground with your hands can deliver a step potential shock as well.

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Instructions for Safe Response

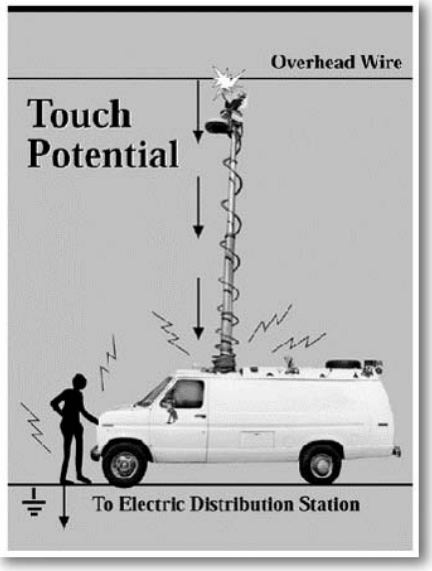
Downed Power Line Emergencies: Touch Potential

Another way that power lines can kill is ***touch potential***.

Safe Response:

Keep at least **50 feet away**

from any object in contact with the downed line, including vehicles, buildings, fences, and people.



Instructions for Safe Response

Downed Power Line Emergencies: Touch Potential

- Qualified electrical workers use "hot sticks" to avoid touch potential risks and increase distance from electrical hazards.
- Hot sticks are specially rated fiberglass poles.
- Trying to move a power line with a broomstick, rake or other household tool can **kill you**.

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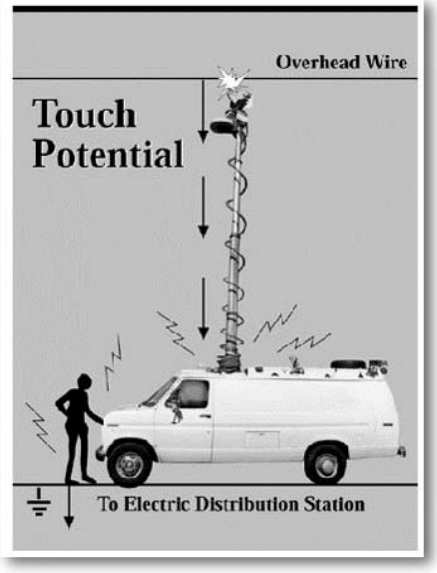
Instructions for Safe Response

Downed Power Line Emergencies: In a Vehicle

If you find yourself in the rare situation of being a vehicle in contact with a downed wire, you are at least momentarily safe. You're like a bird perched on a wire. As long as you touch nothing else, you're safe.

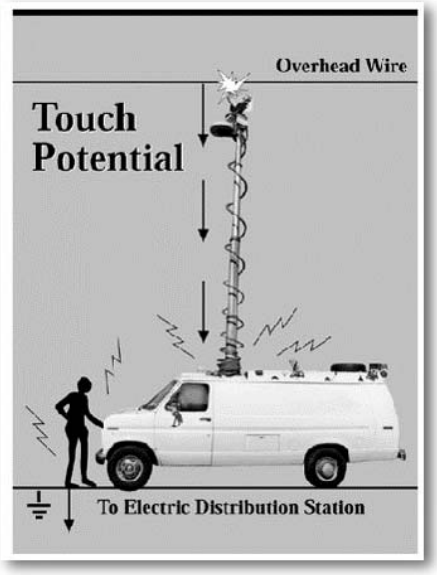


Instructions for Safe Response

Downed Power Line Emergencies: In a Vehicle

Safe Response:

- Summon help and stay in the vehicle. Once help arrives, follow their instructions.
- If the vehicle is an immediate hazard, open (or break) a window, remove any loose articles of clothing, climb out onto vehicle to the place you can most safely jump to the ground.
  - Keep your feet together! Shuffle away from the vehicle. Don't close the door!



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Instructions for Safe Response

Downed Power Line Emergencies: In a Vehicle

If you are in a vehicle in contact with a downed line, you are a "bird on a wire"...

you can touch the vehicle or the earth, **but not both!**

Instructions for Safe Response

Distance and Electrical Hazards

- Most electrical hazards, whether shock or arc-flash, are a "point source." If you **double your distance from the hazard**, you **reduce your exposure** to the hazard by 75%.
- For a downed line, keep shuffling until you get **not less 50 feet (17 meters) away** for energized objects, such as chain-link fences or vehicles.
- For low voltage hazards, **10 feet (3 m) is a good guideline**, as long as you're not on metal floorplate or grating. Follow specific directions from emergency responders.

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Knowledge Check #16

#16 - True or False: If a downed power line is not arcing or sparking, it is de-energized and safe to touch.

- A. True
- B. False

Submit Answer

**Answer the question correctly to advance to the next screen.*

Knowledge Check #17

#17 - Put in correct order: If a cord-connected appliance is smoking, what should I do?

Click the step number in the left column then click the corresponding description in the right column.

Step #1	• Once the situation is safe again, promptly report the incident to supervision.
Step #2	• If I can't safely unplug it, turn off the circuit breaker
Step #3	• If I can't get to or find the circuit breaker, move to safety. Call x3131.
Step #4	• Unplug the appliance

**Answer the question correctly then advance to the next screen.*

Knowledge Check #18

#18 - True or F eceiving an electric s

That is the correct answer!

Continue

Submit Answer

**Answer the question correctly to advance to the next screen.*

Knowledge Check #19

#19 - Put in correct order: If a colleague appears to be receiving an electric shock, what should I do?

Click the step number in the left column then click the corresponding description from the right column.

Step #1	• If I removed the source of the shock from the person, start CPR if they are not breathing.
Step #2	• If I can't turn off the power, and the area is dry, use a wood pole or leather belt, or other insulating object to pull them off of the source of the shock.
Step #3	• If I can't remove them from the source of the shock, call X3131 or 630-840-3131.
Step #4	• Remove the source of the shock by unplugging or turning off the circuit breaker.

Answer the question correctly then advance to the next screen.

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Myths & Misconceptions

The last chapter reviews common myths and misconceptions you should be aware of.

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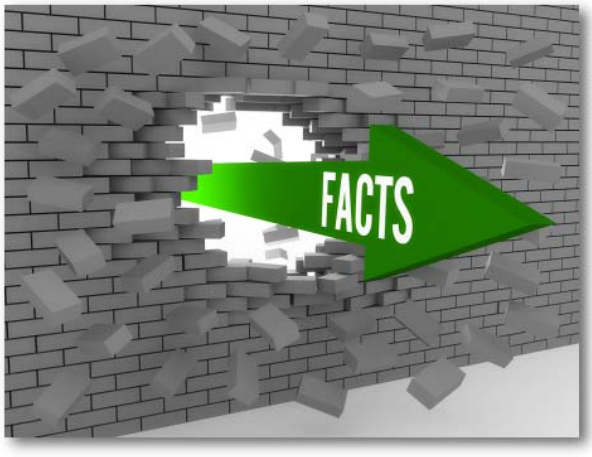
Myths & Misconceptions

Myth #1: Electricity takes the path of least resistance.

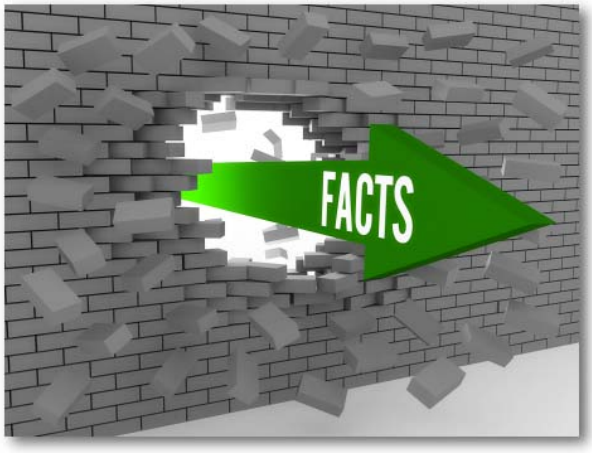
Click the picture below to view the facts! You must click the picture to advance to the next page.



Myths & Misconceptions

Myth #2: Electricity wants to go to ground.

Click the picture below to view the facts! You must click the picture to advance to the next page.



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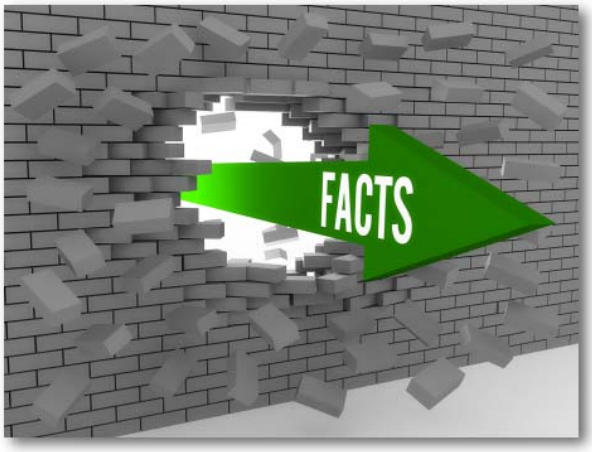
Myths & Misconceptions

Myth #3: If an electric tool falls into a sink or tub of water, it will short out and kill the circuit.

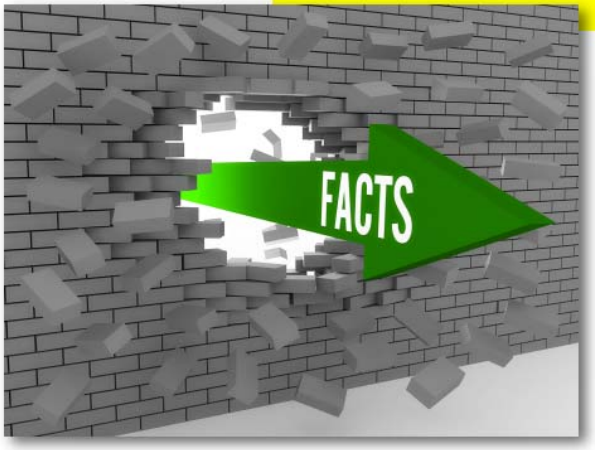
Click the picture below to view the facts! You must click the picture to advance to the next page.



Myths & Misconceptions

Myth #4: AC reverse polarity is not hazardous.

Click the picture below to view the facts! You must click the picture to advance to the next page.



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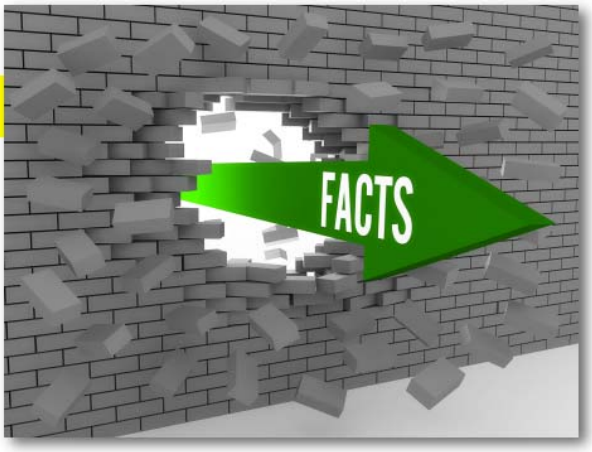
Myths & Misconceptions

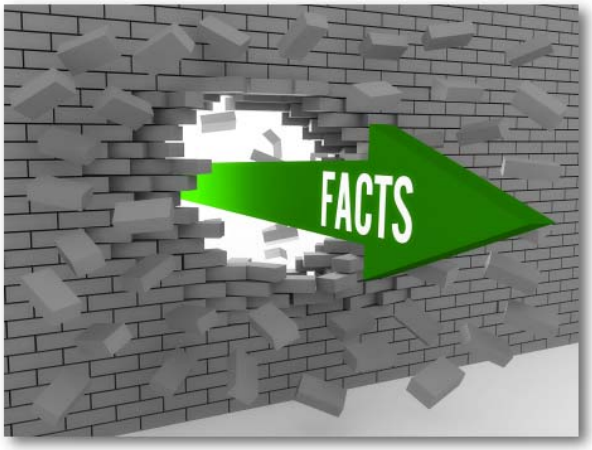
Myth #5: It takes high voltage to kill; 120 volts is not dangerous.

Click the picture below to view the facts! You must click the picture to advance to the next page.



Myths & Misconceptions

Myth #6: Extension cords and power strips are just as good as regular receptacles.



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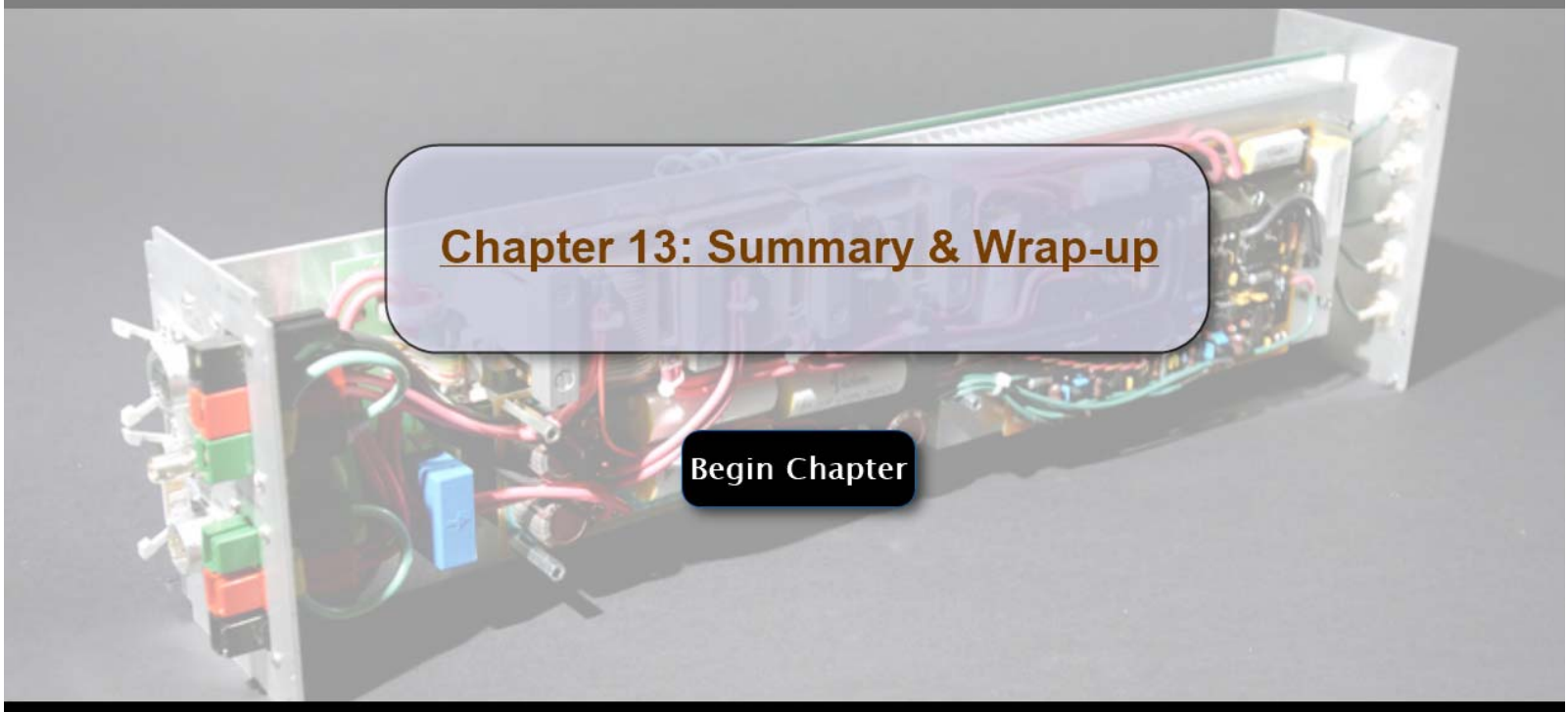

Course Objectives Summary

This training focused on 5 objectives:

#1: Understand what electricity is and how electric power is distributed

#2: Identify how electricity can injure and kill

#3: Illustrate common electrical hazards

#4: Demonstrate safe practices that reduce or eliminate electrical hazards

#5: Provide instructions for safely responding to an electrical emergency

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Contact & Questions...

If you have questions or require more information, please contact:

- Your direct Supervisor
- Your Division Safety Officer (DSO)
- Or you can find more information on the Electrical Safety Foundation, Inc. website @ www.esfi.org

Test Your Knowledge!!!

In order to complete this training and receive credit in TRAIN, you will have to take and pass (with a score of 80% or better) a test.

Please CLICK HERE to request the test.