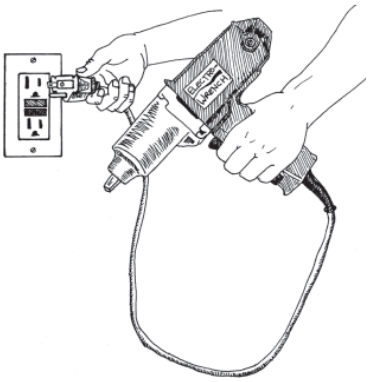
ACTIVITY OPTION A **Student Copy**
Wet Conditions / Ground Fault Circuit Interrupters

Source: Central New York (COSH) Susan Harwood Training Grant #SH-16586-07-06-F-36

In your small group, read fact sheets A1 and A2, and the following scenario. Then answer the questions that follow.

- You're an experienced worker in building maintenance, helping a new worker to learn the job. The task involves cleaning up a flooded basement. The new worker has started setting up electrical cords and tools for the job. You tell her, "Hold on a minute, let's check out the wiring first." Then you say, "No, we can't do this without GFCI protection. I'll tell you why."



1. What would you tell your new co-worker?

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2. What can you do to correct this problem for now?

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3. What is the best way to deal with this in the future?

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4. What work practices help protect you against electrical hazards?

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Examples of accidents related to wet conditions/ground fault circuit interrupters

A journeyman HVAC worker was installing metal duct work using a double-insulated drill connected to a drop light cord. Power was supplied through two extension cords from a nearby residence. The individual's perspiration-soaked clothing/body contacted bare exposed conductors on one of the cords, causing an electrocution. No GFCI's were used. Additionally, the ground prongs were missing from the two cords.

Factsheet A1 – Using Electrical Equipment in Wet Locations

Using electrical tools or equipment in wet areas can be a hazard. If your skin is dry, it has quite a lot of *resistance* (measured in *ohms* or Ω). However, if your skin is wet for any reason (rain, sweat, standing in a puddle of water), the skin's electrical resistance drops dramatically. The amount of electrical **current**, in *amps,* that flows through your body **goes up when resistance** in *ohms* **goes**
down. Amps = Volts/Ohms.

The Current in **Amps** = Voltage in **Volts** DIVIDED BY Resistance in **Ohms**.
HIGHER VOLTAGE = more current (if resistance remains the same).
LOWER RESISTANCE = more current (if voltage remains the same).
HOW MUCH CURRENT DOES IT TAKE TO KILL ME?

It doesn't take much, especially if it passes through your heart. Currents above about *75 milliamps(mA)* can cause a condition called *ventricular fibrillation***.** (A milliamp is 1/1,000 of 1 amp.) If your heart goes into fibrillation, it beats very rapidly – but it doesn't pump any blood – because it's not beating in its normal rhythm. If your blood can't carry oxygen to your brain, you'll experience brain
death in 3 to 4 minutes. The way to get you back involves another electric shock, from a *defibrillator.*

If your skin is wet and you get your body across 120 volts of electricity, it's very likely that you'll have a current of 100 mA or more flowing through your heart. ***Currents ABOVE* 10 *mA*** can cause *muscle paralysis.* You may not be able to let go of energized tools or equipment. ***Shocks that are longer in duration are more severe.***

Electrical systems must be wired with either *fuse*s or *circuit breakers.* These devices are known as *overcurrent protection* and they are rated in amps. Most common household circuits are wired for 15 amps or 20 amps. **Overcurrent protection devices protect wiring and equipment from overheating and fires.** They may – or may not – protect you from electrical shock. If the current isn't high enough, the fuse won't blow or the circuit breaker won't trip. You could be shocked or killed without ever blowing a fuse or tripping a circuit breaker.

Factsheet A2 – GFCIs to the Rescue

A great breakthrough in electrical safety came with the invention of the *ground fault circuit interrupter (GFCI).* A *ground fault* occurs when electrical current flows on a path where it's not supposed to be. Under normal conditions, current flows in a circuit, traveling from the source, through the device it operates, called the *load,* and then back to the source. [See Activity 2 for more about wiring of electrical circuits.]

Current (amps) flows out to the load from the "hot" side (which is generally at 120 volts AC) and returns on the "neutral" side (which is at zero volts). Under normal conditions, these two currents (hot and neutral) are equal. If they are not equal, because of *current leakage* (current returning on a different path than the neutral conductor), we get a ground fault. This can occur if current flows through your body and returns to the source through a path to ground. **Electricity will take ANY available path to return to its source.** We want it to return only on the neutral.

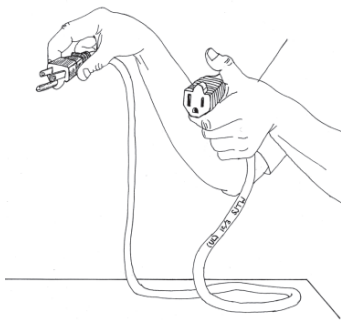
The ground fault circuit interrupter (GFCI) works by using the above principles. It measures total current on the hot side and total current on the neutral side of the circuit. They are supposed to be equal. If these two currents differ from each other by *more than 5 milliamps* (plus or minus 1 mA), the GFCI acts as a fast-acting circuit breaker and shuts off the electricity within 1/40 of 1 second. You can still feel this small amount of current, but it will quickly shut off.

GFCIs are manufactured in many forms. The most common one is the GFCI outlet. However, there are also GFCI circuit breakers, plug-in GFCI outlets and GFCI extension cords, as well as GFCIs hard-wired into devices such as hair dryers. All types have **"Test"** and **"Reset"** functions. **The GFCI must trip when you press the "Test" button. It must also energize the circuit when you press "Reset." If either test fails, you must replace the GFCI in order to be protected!**

Activity Option B **Student Copy**
Extension Cords, Copper and Current

In your small group, read fact sheets B1 and B2, and the following scenario. Then answer the questions that follow.

SCENARIO:
You're at work one day and a co-worker starts screaming: It looks like his saw is smoking, it smells like it's burning and his extension cord is getting hot enough to burn his hand. You walk over, take one look at the scene and start shaking your head. "Well, I know what your problem is, and I'll explain if you stop shouting," you tell him.



1. What is your explanation to the worker?

2. What are some steps to deal with this issue?

3. What is the best way to correct the problem?

Factsheet B1 – Wire Size and Ampacity

In terms of conducting electrical current, size matters: the size of the electrical conductor. Take a look at the following table regarding *ampacity,* the current carrying capacity of a conductor in amps. You'll notice two things: the **amount of current** a wire can safely carry **increases** as the **diameter** (and area) of the wire increases and as the number of the **wire size decreases**. Welcome to the American Wire Gauge (AWG).

AWG Copper Wire Table

Copper Wire Size (AWG)	Diameter (mils)	Area (Circular mils)	Ampacity in free air	Ampacity as part of 3-conductor cable
14 AWG	64.1	4109	20 Amps	15 Amps
12 AWG	80.8	6529	25 Amps	20 Amps
10 AWG	101.9	10,384	40 Amps	30 Amps
8 AWG	128.5	16,512	70 Amps	50 Amps

BUT I DON'T WANT TO BE AN ENGINEER...

Hey, neither do I, but this stuff is important. Notice that a #8 wire is ***twice the diameter,*** but ***four times the area*** of a #14 wire. There are a couple of practical applications here. For one thing, the gauge of the wire determines the rating of a fuse or circuit breaker in amps. A circuit wired with #14 copper will get a 15 amp circuit breaker. A circuit with #12 copper can get a 20 amp breaker; #10 copper can be 30 amps, and so on.

The second thing to consider is that it's possible to create a fire hazard by *overloading an extension cord.* This occurs when too much current is fl owing in a conductor that's not heavy enough for the electrical load in amps. The circuit can be properly wired and its circuit breaker correctly rated, but if too much current flows through an extension cord whose wires are too small, the cord will heat up. Sometimes there is also a *voltage drop* over a longer extension cord, which could damage your tools.

Factsheet B2 – Extension Cord Facts

With the wide use of power tools on construction sites, flexible extension cords often are necessary. Because they are exposed, flexible, and unsecured, they are more susceptible to damage than is fixed wiring. Hazards are created when cords, cord connectors, receptacles, and cord- and plug connected equipment are improperly used and maintained. **Here are some factors on extension cord safety noted by OSHA.**

Strain Relief

- To reduce hazards, flexible cords must connect to devices and to fittings in ways that prevent tension at joints and terminal screws. Flexible cords are finely stranded for flexibility, so straining a cord can cause the strands of one conductor to loosen from under terminal screws and touch another conductor.

Cord Damage

- A flexible cord may be damaged by door or window edges, by staples and fastenings, by abrasion from adjacent materials, or simply by aging. If the electrical conductors become exposed, there is a danger of shocks, burns, or fire. Replace frayed or damaged cords. Avoid running cords over sharp corners and edges.

Durability

- The OSHA construction standard requires flexible cords to be rated for hard or extra-hard usage. These ratings are derived from the National Electrical Code, and are required to be indelibly marked approximately every foot along the length of the cord. Examples of these codes are: S, ST, SO, and STO for hard service, and SJ, SJO, SJT, and SJTO for junior hard service.

Grounding

- Extension cords must be 3-wire type so they may be grounded, and to permit grounding of any tools or equipment connected to them.

Wet Conditions

When a cord connector is wet, electric current can leak to the equipment grounding conductor, and to anyone who picks up that connectors if they provide a path to ground. Such leakage can occur not just on the face of the conductor, but at any wetter portion. Limit exposure of connectors and tools to excessive moisture by using watertight or sealable connectors.