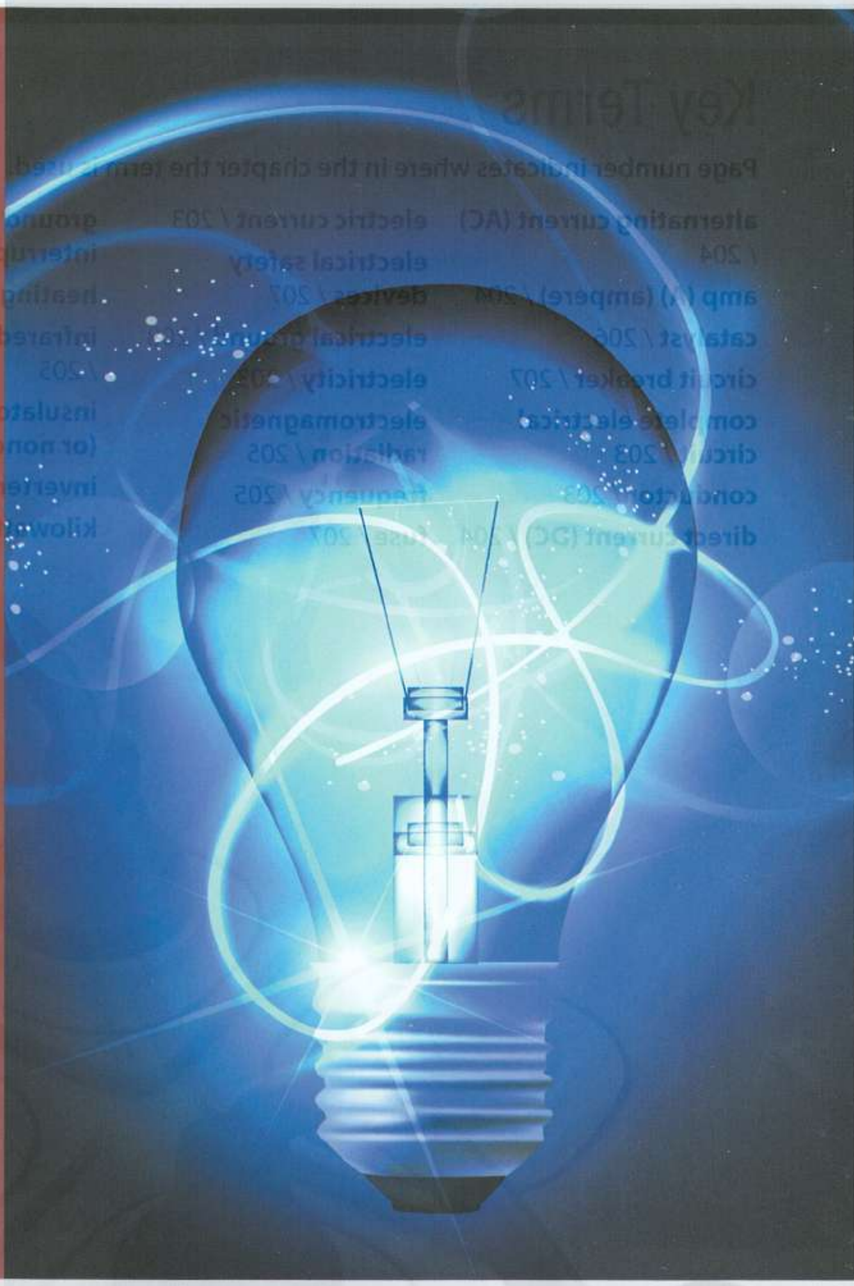
The Basics of Electricity

12

Chapter Outline

- Why Study the Basics of Electricity?
- Electricity
- Electrical Equipment Safety



Learning Objectives

After completing this chapter, you will be able to:

- ☑ **LO1** Explain the nature of electricity and list the differences between the two types of electric current.
- ☑ **LO2** List and define the units of electrical measurements.
- ☑ **LO3** Explain the relationship between a long and short wavelength, and between low and high frequency.
- ☑ **LO4** Describe how to safely use electrical equipment in the salon.
- ☑ **LO5** List and define the three different types of electrical safety devices.

Key Terms

Page number indicates where in the chapter the term is used.

alternating current (AC) / 204
amp (A) (ampere) / 204
catalyst / 206
circuit breaker / 207
complete electrical circuit / 203
conductor / 203
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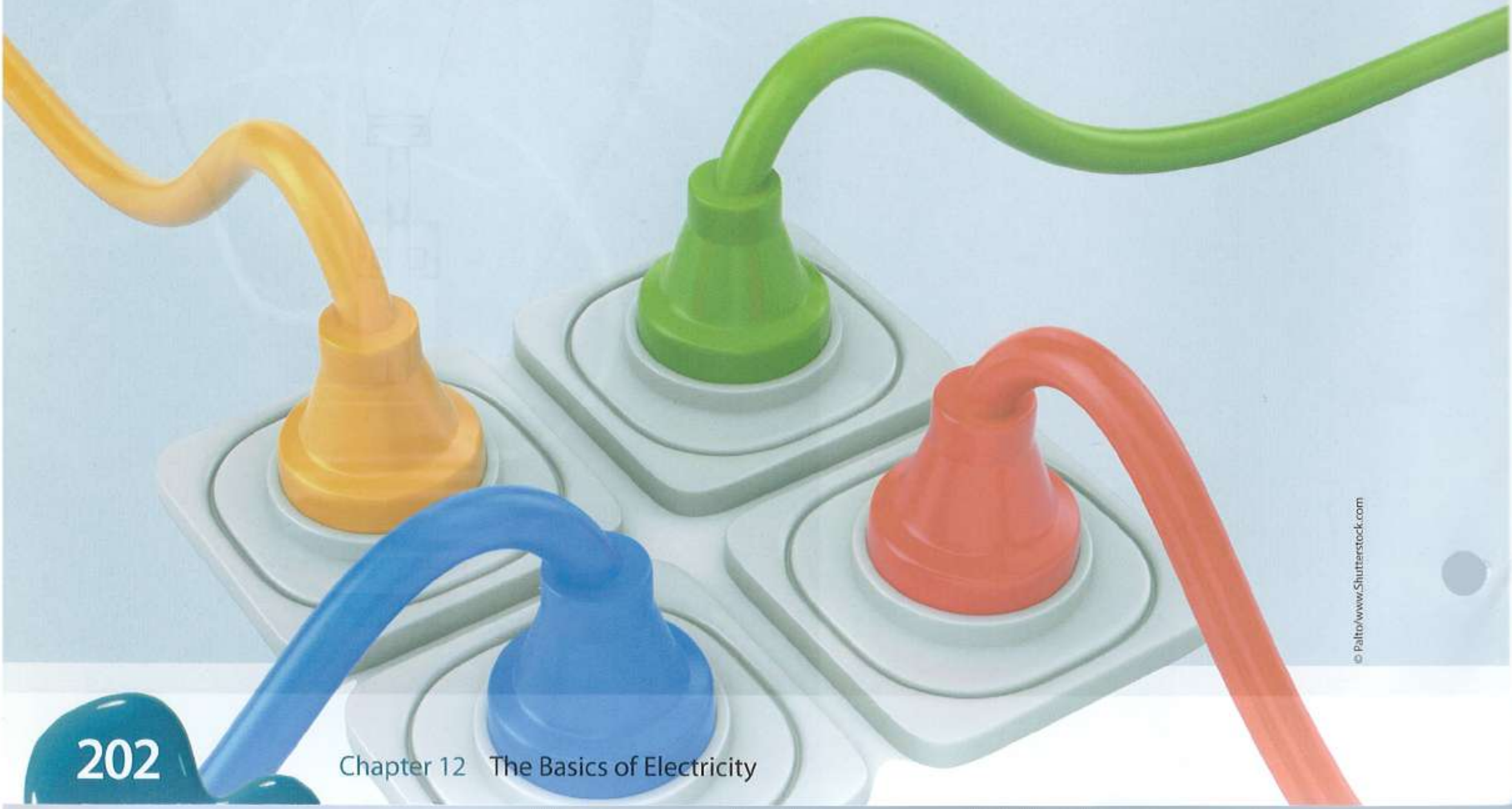


Although studying electricity may not seem like an important part of your education as a professional nail technician, a basic knowledge of electricity is essential to safely performing professional nail services.

WHY STUDY THE BASICS OF ELECTRICITY?

Nail technicians should have an understanding of the basics of electricity because it will:

- Help you safely use and maintain your electrical appliances.
- Improve your professional confidence and ability.
- Help protect you and your customer from electrical danger.

ELECTRICITY

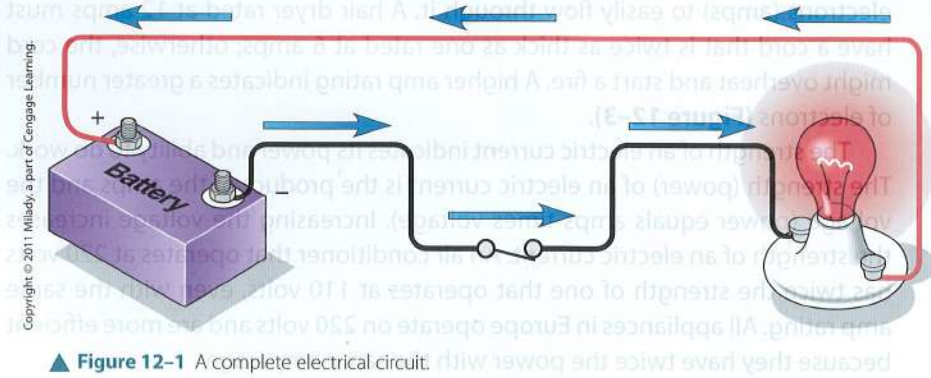
Lightning on a stormy night is a visual effect of electricity. If you plug an appliance into an electrical outlet and see sparks, you are seeing one of the physical effects of electricity. Electricity does not occupy space or have mass (weight), so it is not matter. **Electricity** (ee-lek-TRIS-ih-tee) is the movement of electrons from one atom to another along a conductor. Electricity is a form of energy that, when in motion, exhibits magnetic, chemical, or thermal effects.

All substances can be classified as conductors or insulators (nonconductors), depending on how easily an electric current can flow through them.

A **conductor** (kahn-DUK-tur) is any substance that easily allows the flow of electricity with little resistance. Most metals are good conductors. Copper is a particularly good conductor and is used in electric wiring and electric motors. Although pure water is a poor conductor, tap water and lake or ocean water is a good conductor because of the ions that are normally found in water. This explains why using electrical appliances around water is dangerous and why you should not swim in a lake or the ocean during a lightning storm.

An **insulator** (IN-suh-layt-ur) or **nonconductor** (nahn-kun-DUK-tur) is a substance that does not easily allow the flow of electricity. Rubber, silk, wood, glass, and cement are all good insulators. Electric wires are composed of twisted metal threads (a conductor) that are covered with plastic or rubber (an insulator).

An **electric current** is the flow of electricity in a complete electric circuit. A **complete electrical circuit** (kahm-PLEET ee-LEK-trih-kul SUR-kit) is a closed loop that conducts electricity and provides a return path for the current **(Figure 12–1)**.



▲ **Figure 12–1** A complete electrical circuit.

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Types of Electric Current

There are two kinds of electric current.

1. **Direct current (DC)** (dy-REKT KUR-unt) is a constant, even-flowing current that only travels in one direction. Direct current is produced by chemical means (batteries). Flashlights, cell phones, and cordless electric drills use the direct current produced by batteries. The battery in your car stores electrical energy—without it, your car would not start in the morning. An **inverter (in-VUR-tur)** changes direct current to alternating current. Some cars have inverters that allow you to use appliances that would normally need to be plugged into an electrical wall outlet.

2. **Alternating current (AC)** (AWL-tur-nayt-ing KUR-rent) is a rapid and interrupted current, flowing first in one direction and then in the opposite direction. In the United States, this change in direction happens 60 times per second. Alternating current is produced by mechanical means (generators). Electric files, table lamps, and paraffin heaters that plug into an electrical wall outlet use alternating current. A **rectifier** (REK-ti-fy-ur) changes alternating current to direct current. Cordless electric clippers and battery chargers use a rectifier to convert the alternating current from an electrical wall outlet to the direct current needed to recharge their batteries. **LO1**

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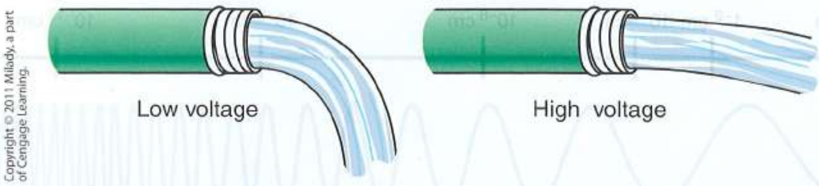
Electrical Measurements

The flow of an electric current can be compared to water flowing through a garden hose.

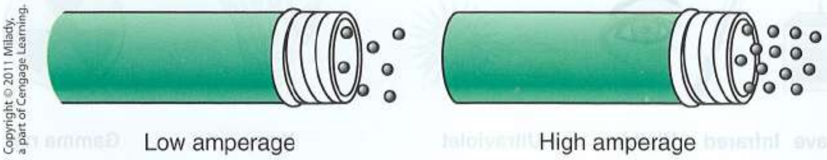
A **volt (V)** (VOLT), or **voltage** (VOL-tij), is the unit that measures the pressure or force that pushes the flow of electrons forward through a complete electric circuit, much like the water pressure that pushes the flow of water molecules through a garden hose **(Figure 12–2)**. Without pressure, neither water nor electricity would flow. Car batteries are 12 volts. Normal electric wall sockets that power an electric drill or paraffin heater are 110 volts. Most air conditioners and electric clothes dryers use 220 volts. A higher voltage indicates more pressure or force.

An **amp (A)** (AMP), or **ampere** (AM-peer), is the unit that measures the number of electrons that flow through a complete electric circuit. Just as a garden hose must be large enough to allow the amount of water to easily flow through it, an electric wire must be large enough to allow the number of electrons (amps) to easily flow through it. A hair dryer rated at 12 amps must have a cord that is twice as thick as one rated at 6 amps; otherwise, the cord might overheat and start a fire. A higher amp rating indicates a greater number of electrons **(Figure 12–3)**.

The strength of an electric current indicates its power and ability to do work. The strength (power) of an electric current is the product of the amps and the voltage (power equals amps times voltage). Increasing the voltage increases the strength of an electric current. An air conditioner that operates at 220 volts has twice the strength of one that operates at 110 volts, even with the same amp rating. All appliances in Europe operate on 220 volts and are more efficient because they have twice the power with the same amperage.



▲ **Figure 12–2** Volts measure the pressure or force that pushes electrons forward.



▲ **Figure 12–3** Amps measure the number of electrons flowing through the wire.

A **milliampere** (mA) (mil-ee-AM-peer) is one-thousandth of an ampere. The current for facial and scalp treatments is measured in milliamperes; an ampere current would be too strong and would damage the skin or body.

An **ohm (O)** (OHM) is a unit that measures the resistance in an electric circuit. Current will not flow through an electric circuit unless the force (volts) is stronger than the resistance (ohms).

A **watt (W)** (WAHT) is a measurement of how much electricity is being used in one second. A 40-watt light bulb uses 40 watts of electricity per second.

A **kilowatt (K)** (KIL-uh-wat) is 1,000 watts. The electricity in your house is measured in kilowatts per hour (kwh). A 1,000-watt (1-kilowatt) appliance uses 1,000 watts of electricity per second. ✓ **LO2**

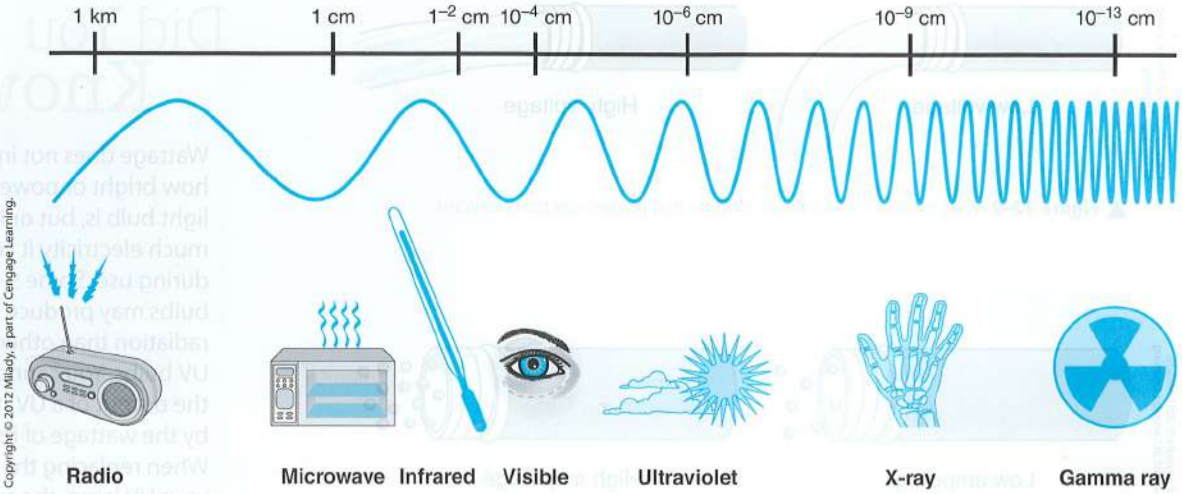
Did You Know?

Wattage does not indicate how bright or powerful a light bulb is, but only how much electricity it consumes during use. Some 9-watt UV bulbs may produce less UV radiation than other 4-watt UV bulbs. You cannot judge the output of a UV nail lamp by the wattage of its bulbs. When replacing the bulb in your UV lamp, the replacement should be the same wattage as the original. Do not try to save money by buying a cheaper replacement bulb or the quality of your service may suffer.

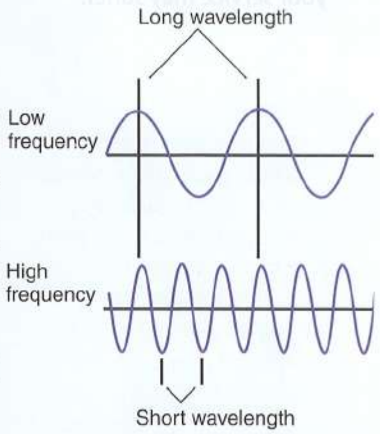
Electromagnetic Radiation and Heat Energy

Visible light is **electromagnetic radiation** that can be seen **(Figure 12–4)**. Electromagnetic radiation is also called *radiant energy* because it carries, or radiates, energy through space on waves. These waves are similar to the waves caused when a stone is dropped on the surface of the water. The distance between two successive peaks is called the **wavelength**. Long wavelengths have low **frequency**, meaning that the number of waves is less frequent (fewer waves) within a given length. Short wavelengths have higher frequency because the number of waves is more frequent (more waves) within a given length **(Figure 12–5)**.

Within the visible spectrum of light, violet has the shortest wavelength and red has the longest. The wavelength of **infrared radiation** (IR) is just below red and below the visible spectrum of light. The wavelength of ultraviolet (UV) radiation is just above violet and above the visible spectrum of light. Infrared and ultraviolet rays are not really light at all. They are the



▲ **Figure 12–4** The electromagnetic spectrum.



▲ **Figure 12–5** Long and short wavelengths.

wavelengths of electromagnetic radiation that are just beyond the visible spectrum. See **Table 12–1**.

A **catalyst** (CAT-a-list) speeds up a chemical reaction and is used to make chemical reactions happen more quickly. Some catalysts use heat while others use ultraviolet (UV) radiation. For example, UV-cured nail enhancements use **ultraviolet** (UV) (ul-truh-VY-uh-let LYT) **radiation**. Ultraviolet radiation is electromagnetic radiation with a wavelength shorter than that of visible light, but longer than X-rays. These frequencies are invisible to humans, but visible to a number of insects and birds.

UV radiation has a shorter wavelength, more energy, and does not penetrate as deeply as visible light.

It is important to protect UV curing products from light. Nail enhancement products that are exposed to sunlight or artificial room lighting can cure inside the container and become less effective. The same can happen when heat-curing monomers are kept in a hot car, store window, or other warm area. The heat may also cause the product to discolor or cure prematurely while still in the original container. ✓ **LO3**

Table 12–1 THE RELATIONSHIP OF WAVELENGTH AND FREQUENCY

LONG WAVELENGTHS	SHORT WAVELENGTHS
Low frequency	High frequency
Penetrate deeper	Penetrate less
Have Less energy	Have more energy

ELECTRICAL EQUIPMENT SAFETY

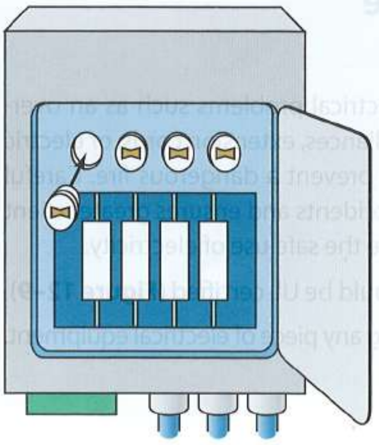
When working with electricity, you must always be concerned with your own safety, as well as the safety of your clients. All electrical equipment should be inspected regularly to determine whether it is in safe working order. Careless electrical connections and overloaded circuits can result in an electrical shock, a burn, or even a serious fire. ☑ LO4

Electrical Safety Devices

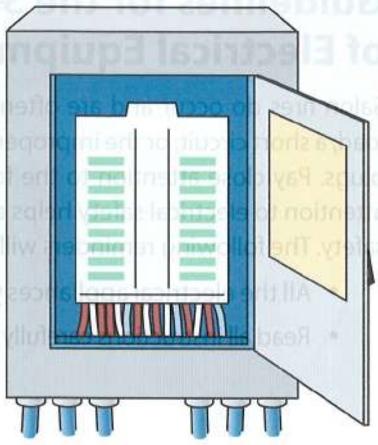
Electrical safety devices are designed to detect and protect you from an overload, a short circuit, or an improper ground caused by faulty wiring or water.

A conductor that is not large enough to carry the electrical current passing through it will overload the circuit and overheat. A **heating element** converts electricity into heat by providing resistance to an electric current. The heating element in your heating mitts or paraffin heater heats up because it is not large enough to carry the electric current that passes through it. Heating elements are designed to overheat and are safe when used properly, but when the electrical wires in a wall or an appliance cord overheat, they can cause a fire. Electrical safety devices like a fuse or circuit breaker are designed to detect an overload and disconnect the current to prevent overheating and starting a fire.

- A **fuse** (FYOOZ) is a single-use safety device designed to provide protection from an electrical overload or short circuit. A fuse is a deliberate weak link in an electric circuit designed to break and disconnect the current when it detects an overload or short circuit caused when faulty equipment or too many appliances are connected to an electric circuit. To reestablish the circuit, disconnect all appliances, check all the connections and insulation, and insert a new fuse **(Figure 12–6)**.
- A **circuit breaker** (SUR-kit BRAYK-ar) is a resettable electrical safety device that automatically shuts off an electric current at the first indication of an overload or short circuit. A circuit breaker is similar to a fuse, but a circuit breaker can be reset instead of replaced. To reestablish the circuit, disconnect all appliances, check all the connections and insulation, and reset the circuit breaker **(Figure 12-7)**.



▲ **Figure 12–6** Fuse box.



▲ **Figure 12–7** Circuit breakers.

Did You Know?

If an electric plug or the cord of an appliance feels warm to the touch, it is a sign of an electrical overload and danger. Overheating is a sign of faulty wiring or too many appliances connected to a circuit. Always turn off the electricity and disconnect any appliance at the first sign of overheating.

CAUTION:

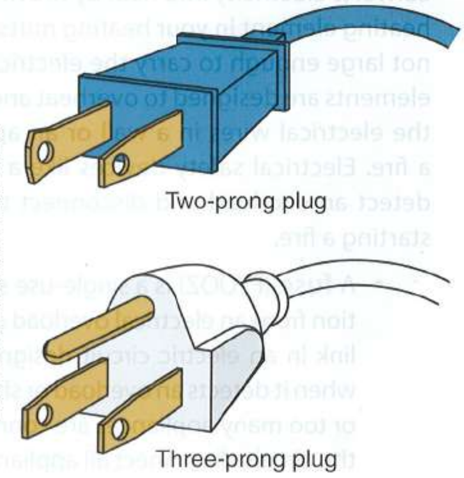
Underwriter's Laboratory (UL) certifies the safety of electrical appliances. UV nail lamps, pedicure chairs, heating mitts, and electric files should be UL approved. This certifies them to be safe when used according to the manufacturer's directions. Always look for the UL symbol on electrical appliances and take the time to read and follow the manufacturer's directions.

- A **ground fault circuit interrupter (GFCI)** is a resettable safety device that is designed to provide protection from an unsafe ground. GFCIs are attached to the plug of electrical appliances and installed in wall sockets in bathrooms, kitchens, and other areas where water may be present. GFCIs detect leakage in a circuit and disconnect the current to prevent electricity from passing through the body of a person who is grounded from an improper ground or from contact with water. GFCIs are located in the plug of an electrical appliance or installed in wall sockets in order to disconnect more quickly than a fuse or circuit breaker.

Electrical Ground

An **electrical ground** (ee-lek-TRIK-ul GROWND) completes an electrical circuit and carries the current safely away. A ground is another important safety measure that promotes electrical safety. All electrical appliances must have at least two electrical connections. The *live* connection supplies current to the circuit. The ground connection completes the circuit and carries the current safely away to the ground. If you look closely at electrical plugs with two rectangular prongs, you will see that one is slightly larger than the other. This guarantees that the plug can only be inserted one way and protects you and your client from electrical shock in the event of a short circuit.

For added protection, the electric plugs on some appliances have a third circular prong that provides an additional ground. This extra ground is designed to guarantee a safe path of electricity if the first ground fails or is improperly connected. Appliances with a third circular ground offer the most protection for you and your client **(Figure 12–8)**.

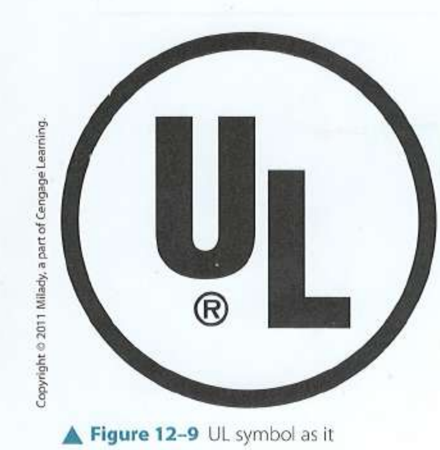


▲ **Figure 12–8** Two-prong and three-prong plugs.

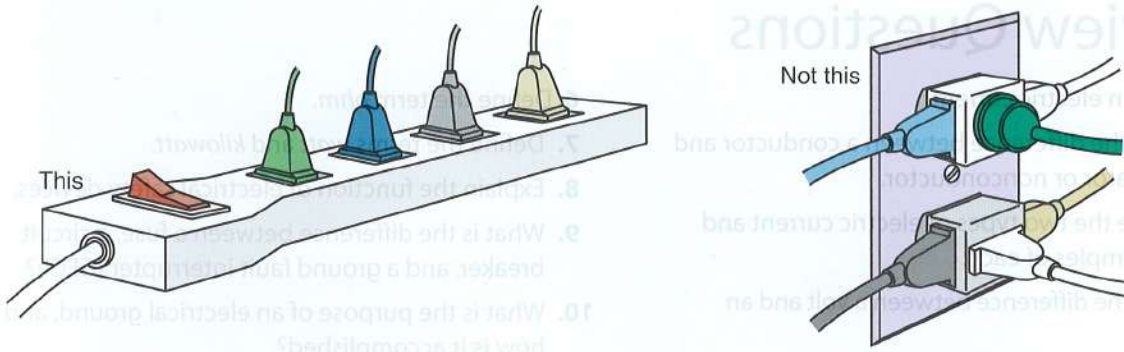
Guidelines for the Safe Use of Electrical Equipment

Salon fires do occur and are often due to electrical problems such as an overload; a short circuit; or the improper use of appliances, extension cords, or electric plugs. Pay close attention to the following to prevent a dangerous fire. Careful attention to electrical safety helps eliminate accidents and ensures greater client safety. The following reminders will help ensure the safe use of electricity.

- All the electrical appliances you use should be UL certified **(Figure 12–9)**.
- Read all instructions carefully before using any piece of electrical equipment.



▲ **Figure 12–9** UL symbol as it appears on electrical devices.



▲ **Figure 12–10** One plug per outlet.

- Disconnect all appliances when not in use for safety and to conserve electricity. Many appliances consume electricity even when they are turned off.
- Inspect all electrical equipment regularly.
- Keep all wires, plugs, and electrical equipment in good repair.
- Use only one plug for each outlet; overloading may cause a fire **(Figure 12–10)**.
- Avoid contact with water and metal surfaces when using electrical appliances. Do not handle electrical equipment with wet hands.
- Do not leave your client unattended while he or she is connected to an electrical device.
- Keep electrical cords off the floor and away from people's feet; gettir tangled in a cord could cause you or your client to trip.
- Do not attempt to clean around electric outlets while equipm plugged in.
- Do not touch two metal objects at the same time if either is cor d to an electric current.
- Do not step on or place objects on electrical cords.
- Do not allow electrical cords to become twisted; this can cause a short circuit.
- Disconnect appliances by pulling on the plug, not the cord.
- Do not attempt to repair electrical appliances unless you are qualified to do so. ☑ **LO5**

UTION:

ver tamper with wiring or electrical plugs to get them to fit into an outlet for which they were not designed.

Review Questions

1. Define an electric current.
2. Explain the difference between a conductor and an insulator or nonconductor.
3. Describe the two types of electric current and give examples of each.
4. Explain the difference between a volt and an amp.
5. What determines the strength or power of an electric current?
6. Define the term *ohm*.
7. Define the terms *watt* and *kilowatt*.
8. Explain the function of electrical safety devices.
9. What is the difference between a fuse, a circuit breaker, and a ground fault interrupter (GFCI)?
10. What is the purpose of an electrical ground, and how is it accomplished?
11. List at least five steps to take to ensure electrical safety.