INTRODUCTION TO ELECTRICITY

The technical term electricity is the property of certain particles to possess a force field which is neither gravitational nor nuclear. To understand what this means, we need to start simply.

Everything, from water and air to rocks, plants and animals, is made up of minute particles called atoms. They are too small to see, even with the most powerful microscope. **Atoms consist of even smaller particles called protons, neutrons and electrons**. The nucleus of the atom contains protons, which have a positive charge, and neutrons, which have no charge. Electrons have a negative charge and orbit around the nucleus. An atom can be compared to a solar system, with the nucleus being the sun and the electrons being planets in orbit.

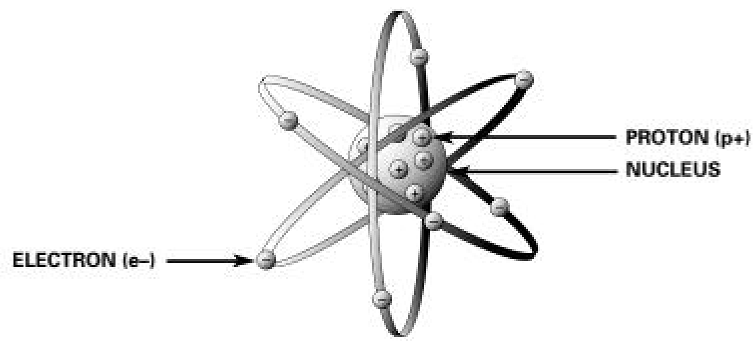

FIGURE 1: PARTS OF AN ATOM

Electrons can be freed from their orbit by applying an external force, such as movement through a magnetic field, heat, friction, or a chemical reaction.

A free electron leaves a void, which can be filled by an electron forced out of its orbit from another atom. As free electrons move from one atom to another, an electron flow is produced. **This electron flow is the basis of electricity**.

The cliché, "opposites attract," is certainly true when dealing with electrical charges. Charged bodies have an invisible electrical field around them. When two like-charged bodies are brought close together, they repel each other. When two unlike charged bodies are brought closer together, their electrical fields work to attract.

Characteristics

When we look at the flow of electricity, we need to look at its characteristics. There are three main characteristics of electricity:

- *Current* (symbol I)
- *Voltage* (symbol E or V)
- *Resistance* (symbol R)

Current

The flow of free electrons in the same general direction from atom to atom is referred to as current and it is measured in *amperes* ("amps" or "A"). The number of electrons that flow through a *conductor*'s cross-section in one second determines amps. Current can be expressed in a number of different ways, such as:

Quantity	Symbol	Decimal
1 milliampere	1 mA	1/1000 A
1 ampere	1 A or 1 amp	1 ampere
1 kiloampere	1 kA	1000 amperes

When discussing current, the direction of current flow needs to be considered. There are two different theories about this:

- *Conventional Flow*
- *Electron Flow*

Conventional Flow: This theory states that electrons flow from positive to negative. Benjamin Franklin theorized this when very little was known about electricity. It states that an invisible fluid known as electricity tended to flow through a wire from the positive to the negative. Ben's theory became the convention (hence the term "conventional current") in electrical theory, mathematics, textbooks and electrical equipment for the next hundred years.

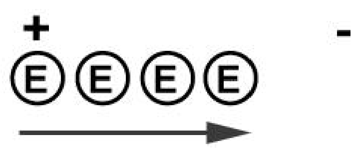

FIGURE 2: CONVENTIONAL FLOW

Electron Flow: This theory states that electrons flow from negative to positive. When more was known about the behavior of electrons, **scientists discovered that electrons actually flow from negative to positive.** Since electrons are negatively charged, it follows that they are attracted by positively charged bodies and repelled by negatively charged bodies.

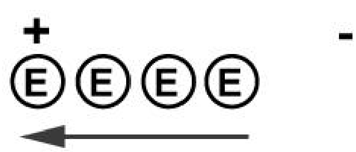

FIGURE 3: ELECTRON FLOW

Current (continued)

Despite the fact that it has been positively determined that electron flow is the correct theory, the conventional flow theory still dominates the industry. Either theory can be used as long as the orientations are correct. Conventional flow will be used from this point on in these training modules unless otherwise stated.

Voltage

Voltage is the force that is applied to a conductor to free electrons, which causes electrical current to flow. It is measured in _volts_ or "V". Current will flow in a conductor as long as voltage, the electrical pressure, is applied to the conductor. Voltage is expressed in a number of ways:

Quantity	Symbol	Decimal
1 millivolt	1 mV	1/1000 volt
1 volt	1 V	1 volt
1 kilovolt	1 kV	1000 volts

There are two methods that voltage forces current to flow:

- _Direct Current_
- _Alternating Current_

Direct current: With this method, the voltage forces the electrons to flow continuously in one direction through a closed circuit. This type of voltage is called Direct Current (DC) voltage. Batteries and DC generators produce DC voltage.

Alternating current: With this method, voltage forces electrons to flow first in one direction, then in the opposite direction, alternating very quickly. This type of voltage is called Alternating Current (AC) voltage. A generator is used to produce AC voltage. The voltage generated by utility companies for our home, factories and offices is AC voltage.

Voltage (continued)

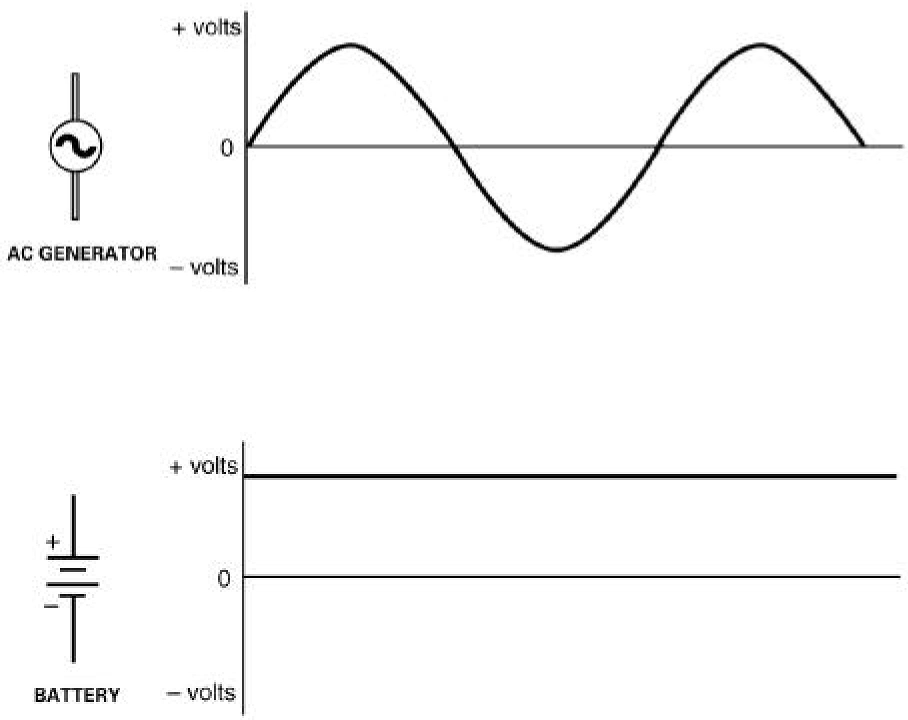

FIGURE 4: AC AND DC CURRENT

Resistance

This is the third characteristic of electricity. The restriction to the flow of electrons through a conductor is called resistance and it is measured in *ohms* and abbreviated "Ω", the Greek symbol Omega. Resistance is expressed in a number of ways:

Quantity	**Symbol**	**Decimal**
1 ohm	1Ω	1 ohm
1 kilohm	1kΩ	1000 ohms
1 megohm	1MΩ	1,000,000 ohms

Resistance (continued)

In general, there are four factors that affect the amount of resistance in a conductor:

- Material
- Length
- Cross-Sectional Area
- Temperature

Material: We know that the amount of electron flow depends upon how readily particular atoms give up their electrons and accept new electrons. Materials that permit this are called conductors. Copper, silver and aluminum are considered good conductors.

Materials that don't readily give up electrons, which restricts the flow, are called *insulators*. Rubber, glass and porcelain are considered good insulators.

Conductors and insulators perform a very important team function. An electrical cord to a lamp, for example, has a copper wire conductor on the inside with a rubber-coating insulator around the outside. Free electrons flow along the copper wire to light the lamp while the rubber coating keeps the free electrons inside to prevent shock and other problems.

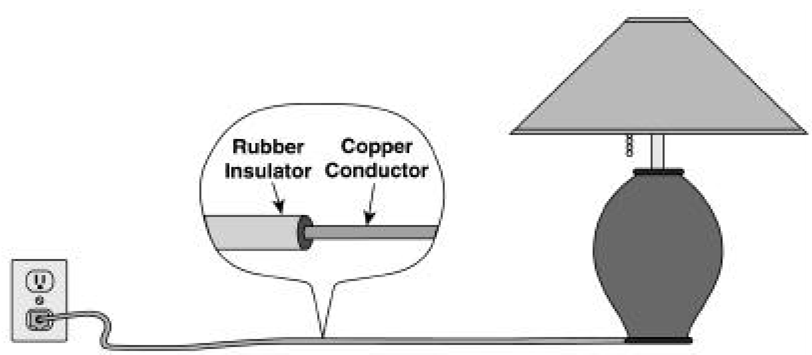

FIGURE 5: CONDUCTORS AND INSULATORS

Length: The longer the conductor, the more resistance in the conductor. **Resistance is increased or decreased in proportion to the conductor's length**. For example, a 2-foot long conductor would have twice the resistance of a one-foot long conductor.

Resistance (continued)

Cross-Sectional Area: As the cross-sectional area of a conductor increases, the resistance decreases, and vice versa. For example, if the **area of a conductor is doubled, the resistance is cut in half**.

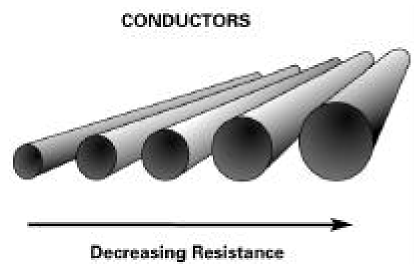

FIGURE 6: CONDUCTOR CROSS-SECTIONAL AREA

Temperature: Usually when the **temperature of a conductor increases, the resistance increases**. The temperature factor is not as predictable as the other factors, but it must be considered when dealing with electricity.