

# Safety for Electrical Work 115

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Safety is key when working with electricity. A basic understanding of electricity is important in preventing electric shock and preventing fire hazards due to overheated electrical equipment and wiring.

Three quantities used to measure electricity are voltage (V), current (I), and resistance (R).

Current, sometimes called amperage, is the rate of charge (electron) flows through the electrical wiring. It is measured in amperes (A), or simply amps. Amps of current is what causes electric shock and becomes a fire hazard when the current is more than what the electrical wiring can handle.

Voltage is the force that causes the current flow. It is measured in volts (V). Resistance is the opposition to the current flow. It is measured in ohms ( $\Omega$ ).

The mathematical relationship between voltage, current, and resistance is called Ohm's Law. It states that the voltage is the product of the current and resistance.

$$\text{Voltage} = \text{Current} \times \text{Resistance}$$

$$V = IR$$

Where  $V$  = voltage in volts (V)

$I$  = current or amperage in amps (A)

$R$  = resistance in ohms ( $\Omega$ )

For a given resistance, an increase in voltage results in an increase in current, and a decrease in voltage results in a decrease in current. This means that current and voltage are directly proportional.

For a set voltage, if the resistance increases, the current will decrease and if the resistance decreases, the current will increase. This means that current and resistance are indirectly or inversely proportional.

To apply Ohm's Law correctly, each of the quantities must be measured in the base units of volts, amps, and ohms. If a metric prefix like "milli-" is part of the unit, the unit must first be changed back into the base unit. For example, if a current is measured in milliamps (mA), it must be converted to amps (A) before being substituted into Ohm's Law.

#### EXAMPLE:

A light bulb is plugged into a 120V circuit and draws 910 mA of current. What is the resistance of the light bulb?

#### SOLUTION:

$$\text{Voltage (V)} = 120 \text{ V}$$

$$\text{Current (I)} = 910 \text{ mA} = .91 \text{ A}$$

(Since milli- means 0.001, 910 mA can be converted to amps (A) by multiplying by 0.001.)

Substitute the values into Ohm's Law and solve for the unknown resistance.

$$V = IR$$

$$120 \text{ V} = (.91 \text{ A}) R$$

$$R = \frac{120 \text{ V}}{.91 \text{ A}} \approx 132 \text{ ohms } (\Omega)$$

#### EXERCISES:

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1. A fan motor in a ventilation system runs on 115 V and draws 1.7 A of current. What is the resistance of the fan motor?

2. Two coils are connected to a 120 V source. One coil has a resistance of 95 ohms ( $\Omega$ ) while the second coil has a resistance of 185  $\Omega$ .
  - a. Calculate the current flow through each coil.
  - b. Did the coil with the larger resistance have a larger or smaller current flow through it?
  - c. Based on the answer to part b, are current and resistance directly proportional or inversely proportional?
  
3. An antenna coil runs on 5 V of electricity and has a resistance of 85  $\Omega$ .
  - a. Determine the current flow through the coil in milliamps (mA).
  - b. Based on the current found in part a, what reaction would the human body have to an electric shock from the coil? See the table, "Effects of Electrical Current on the Body," on the next page.

Current	Effects of Electrical Current on the Body Reaction
1 mA	Faint tingle.
5 mA	Slight shock felt but not painful.
6 - 30 mA	Painful shock. Muscles freeze. May not be able to let go.
50 - 150 mA	Extremely painful shock. Breathing stops. Severe muscle contractions. Death is possible.
1 - 4.3 A	Ventricular fibrillation. Muscles contract. Nerve damage occurs. Death is likely.
10 A	Cardiac arrest. Severe burns. Death is probable.

4. A water heater element with a resistance of  $15 \Omega$  is connected to a 230 V source.

a. Determine the current through the element.

b. Will wiring that has a maximum amperage of 25 A help prevent overheating?

c. Is a 15 A breaker for the water heater large enough?



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