

Electric Shock Advisory

Objectives: After absorbing the material, students will be able to:

- a) Describe factors affecting electrical shock
- b) Differentiate between internal and external resistance
- c) Describe the effect of various levels of shock
- d) Describe precautions in emergency situations

Current Not Voltage

The determining factor in electric shock is the *current* passing through various parts of the body. The voltage that causes the current to flow depends on the resistance of the contact and the resistance of the body. It is important to note that there are 2 distinctly different resistances involved.

External or Skin Resistance

The skin resistance is quite variable and depends in part on the dryness, pressure and area of contact. It is a useful exercise to measure your own skin resistance using a multimeter or Digital Volt Meter (DVM). Set the meter to measure resistance in the 100 K ohm range and grasp the leads. Record your resistance. Then push harder on the leads using as much contact area as possible and again record the resistance. Now wash your hands, leave them moist and repeat the test. Your skin resistance will be considerably lower.

Typical values: Dry Skin = 100 K ohms to 600 K ohms
 Wet Skin = 1 K ohm

Now it should be more obvious why the voltage can be very different for lethal situations. A current of 100 mA will cause death. If you have very dry skin, the voltage required will be:

Ohm's law states **Voltage = Current (Intensity) times Resistance** or **V=IR**

$$V_{\text{death}} = IR = (.1)(600,000) = 60,000 \text{ volts } \mathbf{** \text{ do not try this } **}$$

If your skin is wet such as sweating on a humid day:

$$V_{\text{death}} = IR = (.1)(1000) = 100 \text{ volts}$$

You should not conclude that below 100 volts is safe or that above 100 volts is lethal! One situation concerns very high voltages that are current limited. Irrespective of the voltage or your skin resistance, if the current is limited to safe levels, you are safe too. It is always good practice to assume that the currents are not limited to safe levels and act accordingly.

Internal Resistance

Although the external skin resistance can be high, your internal resistance is most definitely low. Once the skin has been punctured, the internal body resistance is low.

Typical values: Hand to foot 400 to 600 ohms , Ear to ear 100 ohms

Should you ever have the misfortune to impale yourself on a 24 volt lighting system...

Ohm's Law: $V = IR$, $I = V/R = 24/100 = .240$ Amperes = 240 mA

A current of 240 milliamps is a lethal current.

Level of Shock

0 - 1 mA	Not perceptible
1 - 8 mA	Mild sensation
8 - 15 mA	Painful shock but person still has control of muscles and can let go of source of shock
15 - 20 mA	Painful shock. Unable to let go
20 - 50 mA	Severe shock. Severe muscular contractions Breathing difficult
50 -100 mA	Extreme shock. Extreme breathing difficulties
100 -200 mA	Death by Ventricular Fibrillation.
over 200 mA	Severe burns. Breathing stops. Chest muscles clamp and stop the heart but no ventricular fibrillation. Victim may survive if given immediate resuscitation

Path Through the Body

Currents which pass through the heart or respiratory centers are especially dangerous because of the muscle paralysis or ventricular fibrillation. If you are leaning your elbow on ground and touch a high voltage connection with the same hand, the current will pass from finger to elbow and give you a painful but not lethal shock. If the current path is to another hand or a foot, the situation is much more serious because of the path that the current takes through the body.

Emergency Situations

If someone is in an electric shock situation **DO NOT TOUCH THEM**

- a) Remove the source of power (switch or circuit breaker) if possible
- b) If not possible, drag the victim with a rope, clean dry clothes, or other nonconducting material until they are no longer in contact.
- c) Apply artificial respiration immediately. Have someone else call for help.

Lab Conditions

Most voltages encountered in experiments in circuits are under 24 volts. Be aware that putting 2 supplies in series can raise this to 50 volts. This can be particularly dangerous if you charge a very large capacitor which is then discharged through your body. Always assume that very large capacitors are charged unless proven otherwise.

Metal jewelry is a very good conductor. If you have a power supply that can deliver high current, your class ring would be happy to provide the conduction path. Here the danger is heat rather than shock. The ring will conduct as much current as the supply will deliver. If you short out a car battery with your ring, the ring will literally vaporize. Imagine what that would feel like on your ring finger. Vaporizing metal wouldn't be fun in the eyes either.

In summary, always observe the following precautions. Remove all rings, bracelets, necklaces, etc. before working on live electronic circuits. Keep your hands dry at all times. Wear full coverage bandages on all open wounds. Respect all circuits, especially those that have high voltage, or high current capability. Exercise extreme caution whenever 120VAC is exposed.

