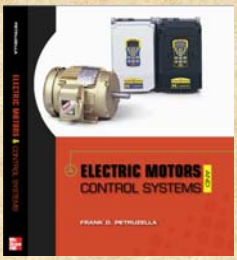


Chapter 1

Safety in the Workplace

PART 1 Protecting against Electrical Shock

ELECTRIC SHOCK

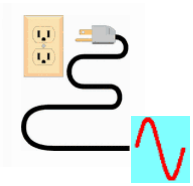
The main factor for determining the severity of an electric shock is the amount of electric current which passes through the body. This current is dependent upon the voltage and the resistance of the path it follows through the body.

$$I = \frac{E}{R}$$

Electrical *resistance (R)* is the opposition to the flow of current in a circuit and is measured in ohms (Ω).

Dry skin is a good insulator; moisture lowers the resistance of skin, which explains why shock intensity is greater when the hands are wet.

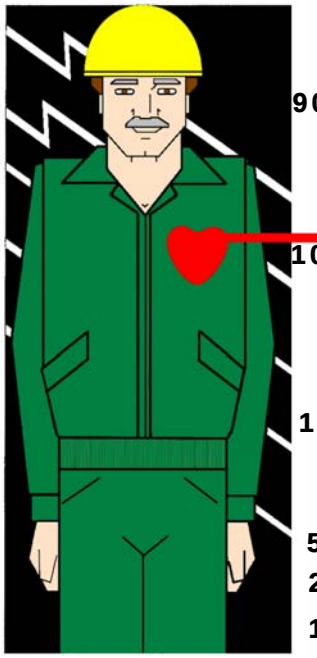
Voltage (E) **is the pressure that causes the flow of electric current in a circuit and is measured in volts (V).**



The amount of voltage that is dangerous to life varies with each individual because of differences in body resistance and heart conditions. Generally, voltage levels above *30 volts* are considered dangerous.

Electric current (I) **is the rate of flow of electrons in a circuit and is measured in amperes (A).**

Generally, any current flow above 0.005 A or 5 mA is considered dangerous.



1 Ampere
(1,000 mA)

900

100 — Heart stops pumping

10 — Cannot let go

5 — Trip setting for GFCI

2 — Mild shock

1 — Threshold of sensation

mA

Example: If you came into direct contact with 120-volts and your body resistance was 100,000 ohms, then the current, which would flow, would be:

$$I = \frac{120V}{100,000\Omega} = 0.0012\,A = 1.2\,mA$$

This is just about at the threshold of perception, so would produce only a tingle.

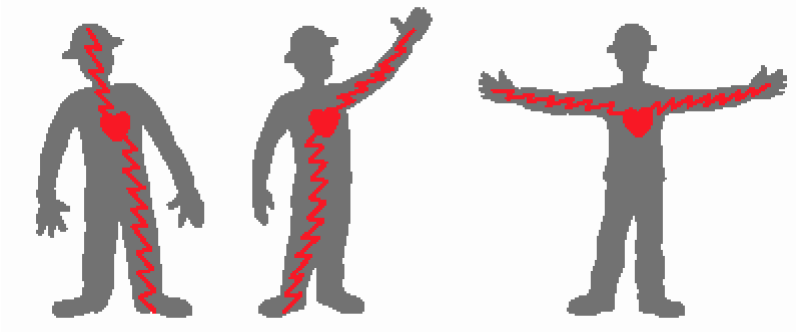
If you are sweaty and barefoot, then your resistance to ground might be as low as 1000 ohms. Then the current would be:

$$I = \frac{120V}{1,000\Omega} = 0.12\,A = 120\ mA$$

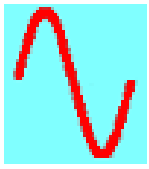
This is a lethal shock capable of resulting in death!

The *pathway* through the body is another factor influencing the effect of an electric shock.

Head to foot | Hand to foot | Hand to hand



A current from hand to foot, which passes through the heart and part of the central nervous system, is far more dangerous than a shock between two points on the same arm



AC (alternating current) is *three to five times* more dangerous than DC (direct current) of the same voltage and current value. AC causes muscle spasm, often *'freezing' the hand to the circuit.* The fist clenches around the current source resulting in prolonged exposure with severe burns.

***DC* (direct current) tends to cause a convulsive contraction of the muscles, often forcing the victim *away* from further current exposure.**

The most common electric related injury is a burn. ***Electrical burns*** are a result of electric current flowing through the tissues or bones. The burn itself may be only on the skin surface or deeper layers of the skin may be affected.

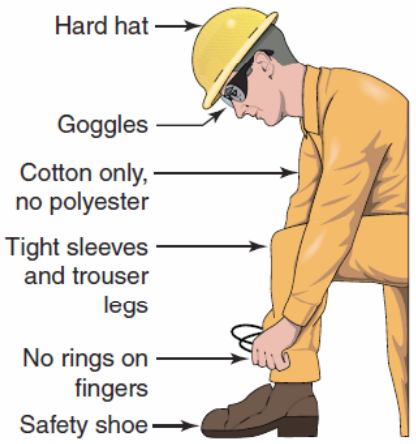
Arc burns are a result of an extremely high temperature caused by an electric arc in close proximity to the body.

Thermal contact burns that are a result of the skin coming in contact with hot surfaces.

Personal Protection Equipment

A safe operation depends largely upon all personnel being informed and aware of potential hazards. Safety signs and tags indicate areas or tasks that can pose a hazard to personnel and/or equipment.

Appropriate Attire



Rubber gloves are used to prevent the skin from coming into contact with energized circuits. A separate outer leather cover is used to protect the rubber glove from punctures and other damage.

High Voltage Protection Apparel – Special protective equipment available for high voltage applications include high-voltage sleeves, high-voltage boots, nonconductive protective helmets, nonconductive eyewear and face protection, switchboard blankets, and flash suits.

Hot Sticks **– Hot sticks are insulated tools designed for the manual operation of high voltage disconnecting switches, high voltage fuse removal and insertion, as well as the connection and removal of temporary grounds on high voltage circuits.**

Shorting Probes **– Shorting probes are used on de-energized circuits to discharge any charged capacitors or built-up static charges that may be present when power to the circuit is disconnected.**

Face Shields **– Listed face shields should be worn during all switching operations where there is a possibility of injury to the eyes or face from electrical arcs or flashes, or from flying or falling objects that may result from an electrical explosion.**

Safety Essentials

- Never take a shock *on purpose*.
- Keep material or equipment at least *10 feet* away from high-voltage overhead power lines.
- Do not *close* any switch unless you are familiar with the circuit that it controls and know the reason for its being *open*.
- When working on any circuit, take steps to ensure that the controlling switch is not operated in your absence. Switches should be *padlocked open*, and *warning notices* should be displayed.

- Avoid working on *"live"* circuits as much as possible.
- When installing new machinery, ensure that all *metal* framework is efficiently and permanently *grounded*.
- Always treat circuits as *"live"* until you have *proven* them to be *"dead."* It is a good practice to take a meter reading before starting work on a dead circuit.
- Avoid touching any *grounded* objects while working on electrical equipment.

- Don't *reach into energized equipment* while it is being operated. This is particularly important in high-voltage circuits.

- Remember that even with a 120-V control system, you may well have a *higher voltage in the panel*. Always work so that you are clear of any of the higher voltages.

- Use good electrical practices even in *temporary wiring* for testing. At times you may need to make alternate connections, but make them *secure enough* so that they are not in themselves an electrical hazard.

- When working on live equipment containing voltages over approximately 30 V, work with *only one hand*. Keeping one hand out of the way greatly reduces the possibility of passing a current through the chest.

- *Discharge capacitors* before handling them. Capacitors connected in live motor control circuits can store a lethal charge for a considerable time after the voltage to the circuits has been switched off.

Confined Spaces

All hazards found in a regular workspace can also be found in a confined space. However, they can be even more hazardous in a confined space than in a regular worksite.

A *"permit-required confined space"* is a confined space that has specific health and safety hazards associated with it. Permit-required confined spaces require assessment of procedures in compliance with Occupational Safety and Health Administration (OSHA) standard prior to entry.