Shock

Muscular Spasm Caused by Charge Flow

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Derivation: From Old French choquier, *collide with, akin to Middle Dutch* schocken *to jolt.*

Electrical current is the flow of charges. We try to keep this flow within wires and appliances. But sometimes we become part of the circuit ourselves, and get a nasty reminder of electricity's danger.

The movement of electrical energy has two basic components—voltage and amperage. Remember the simple formula for power—volts times amps equals watts. Voltage can be thought of as the "push," the electrical pressure. Amperage is the flow rate of charges.

For voltage to push charges, there needs to be a circuit—a complete electrical loop with a wire from the energy source to the load and one returning to the source. The wires in the circuit provide a closed path that is full of moveable charges.

But sometimes things don't go as planned. Wires fray, appliances malfunction, or conditions change. The charges can then try to use the ground as a pathway back to the source. And, if you're in the wrong place at the wrong time, you can become part of that path. For instance, what if the insulation rubs off an ungrounded outdoor wire, and you happen to touch it while standing on the ground? Your body offers a new path, so the charges will travel through you to ground. You'll feel a tingle, a shock, or worse.

You've handled 1.5-volt flashlight batteries, and even 9-volt batteries from radios and such, and haven't been shocked. You may have even touched the posts of your car's starting battery with no ill effects. So what's the big deal? It may seem like these low-voltage sources pose no threat, and that only high-voltage devices are dangerous. But that's a dangerous oversimplification that could come back to bite you.

Under most conditions (but not all!) voltages below 40 V are not hazardous. But it's actually not the voltage alone but the amperage through your body that is lethal, and it doesn't take much. From 100 to 200 milliamps (mA, or $^{1}/_{1000}$ A) is enough to kill you. This is the current in a 15-watt, 120 VAC lightbulb. (See the table for levels of shock for different amperages.) The particular pathway that charges follow through your body makes a difference too. If you touch a hot wire with your right hand and are standing on the ground with your right foot, the charges may not flow through vital organs, which could save your life.

The voltage does play a role in shock, and that's because of the basic principle stated in Ohm's law—amperage equals voltage divided by resistance. Your skin protects you electrically because it has a fairly high resistance to the flow of electrical charges when it's dry—in the range of 100,000 ohms. This explains why we can handle low voltage electrical sources without being shocked. It takes a bit of push to get through your skin, which is not very conductive, into your tissues and organs, which are very conductive. Open wounds are much more vulnerable to shock than your skin.

Stand in a puddle, or worse yet, in salt water, and the conductivity of your skin goes way up. Resistance can drop to 1,000 ohms or less. You can experiment with an ohmmeter, with one probe contacting each hand, and see the difference when you lick your fingers before touching the probes. (This is not dangerous; the voltage is very low.)

Besides not standing in puddles while holding bare wires, how can you avoid shocking experiences? Properly grounding appliances and equipment is the first step. This allows fault currents to bleed off to ground, providing a more inviting path than your body or tripping the circuit breaker. Another precaution is using ground fault circuit interrupters (GFCIs). These devices monitor the charge flow on both legs of a circuit, and if it's uneven (indicating a flow to ground), they disconnect the circuit. Although they are not foolproof, they are another line of defense.

Possible Health Effects of 60 Hz AC

Amperage	Effect
1 mA	Barely perceptible
16 mA	Max an average man* can grasp & "let go"
20 mA	Paralysis of respiratory muscles
100 mA	Ventricular fibrillation threshold
2 A	Cardiac standstill & internal organ damage
15–20 A	Common fuse or breaker opens circuit

*Differences in muscle and fat content affect the severity of shock.
From the National Institute for Occupational Safety & Health

The first line of defense against shock is human intelligence. Turn off switches or breakers before you start working on your electrical system. Test the circuit with a voltmeter to make sure it's dead. Avoid making yourself the pathway for errant charges. A shock will make your muscles contract, so don't grip any exposed metal with your hand—a shock may prevent you from letting go. Instead, use the back of your hand to touch potentially live wires and objects. In the event of a shock, this will enable you to pull away safely. If you have to troubleshoot a live circuit, always keep "one hand in a pocket" to make sure you do not provide a short across the circuit being tested. Then your only electrical excitement will be the thrill of making your own electricity from renewable sources.

Access

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