These are the Basics of Electrical Safety
by Rob Siegel (30 May 2017)

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Last week, we learned enough about how electricity works in the automotive environment (meaning a battery supplying 12 volt direct current (DC) with the negative battery terminal attached to the body of the car which then acts as ground) to understand why a short circuit is so dangerous and can engulf your car in flames in under a minute. This week, we're going to use that as the lead-in to have a quick talk about electrical safety.

Everyone skips over the safety section. It's boring, and it's usually written to satisfy a lawyer ("say this so you're covered if you're sued"). This isn't one of those. It's short and exactly what you need to know and nothing more.

In order for electricity to present a shock hazard, both the voltage and the current have to be above a certain threshold. The Occupational Safety and Health Administration (OSHA) has published tables showing the level at which current is first dangerous, and then fatal. However, these tables are misunderstood because they apply to household electrical systems, which have 120 volts of alternating current (AC), not the 12 volts of DC flowing through a car.

12 volts DC is not a shock hazard. And that's not just my opinion; that's part of OSHA regulation. According to OSHA, "live parts of electric equipment operating at 50 volts or more shall be guarded against accidental contact." Thus, anything under 50 volts, including the 12 volt systems in cars, don't even need to be enclosed. You can't touch the wires in your 120V AC household electrical system without getting a nasty, dangerous shock, but you can touch bare wires carrying 12V DC in your car, even lay your hands across the positive and negative 12V battery terminals, without risk of electrocution. The resistance of your body is too high for any dangerous amount of current to flow (though I wouldn't go out of your way to do it like I did).

12V DC isn't a shock hazard.

That having been said, keep five things in mind:

1. ***The voltage levels in electric or hybrid vehicles can kill you!*** The above comments apply to the 12 volt systems in conventional vehicles. In contrast, the battery voltages in electric and hybrid vehicles can range from 144 to 650 volts. Combined with the amount of current flowing, these are lethal voltage levels. ***Do not perform any electrical work on an electric or hybrid vehicle without researching, understanding, and adopting the required level of electrical protection.***

2. ***12V systems don't need to be enclosed, but they still need to be secured***. You can't have exposed wires or terminals carrying 12V flopping around where they might touch the body of the car and cause a short to ground, which then creates an immediate fire hazard.

3. ***12V isn't a shock hazard, but it IS a burn hazard***. Even without a short circuit, if you make or break an electrical connection that has a lot of current going through it, the point at which the connection is made can get very hot very quickly and can burn your fingers. It is much safer to turn off the power, make the connection, and then turn the power back on.

4. ***The high-voltage portion of the ignition system IS a shock hazard***. The wire from the coil to the distributor, and the wires from the distributor to the spark plugs, don't run at 12 volts, but at tens of thousands of volts. On a vintage car with its stock ignition coil, points, and condenser, it's enough to give you a good but probably harmless jolt, but on a car with a high-energy ignition system, the voltage level is high enough that it can potentially interfere with your heart rhythm. So don't handle the coil or plug wires without wearing rubber gloves.

5. ***Wear gloves when handling the battery***. Even though there's no shock hazard, and even though most car batteries these days are sealed, it is possible for a battery to leak acid. Thus, even though I'm touching the battery terminals with bare hands to demonstrate that there is no shock hazard, gloves should be worn when directly handling the battery.

From a safety standpoint, the other thing you need to understand is that wires need to be sized properly (to be the correct diameter) in order to carry the current. A starter motor will pull hundreds of amps of current while the starter is cranking. Thus, the wire to the starter needs to be thick enough to carry all that current. This is why the battery cable to the starter motor is typically the thickness of a finger, whereas wires carrying less current can be much thinner. If you tried to wire a starter motor with thin speaker wire, it would melt in the same way that if you tried to pump water from an open fire hydrant through a soda straw, the straw would blow apart.

Wire thickness is generally specified using numbers from the American Wire Gauge (AWG). Even if the car is European or Asian, AWG wiring is usually employed for any aftermarket installations. The AWG numbering runs backward—that is, smaller numbers refer to larger diameter wire, and vice versa. The finger-thick battery cable running to the starter motor is usually 2 gauge. The thick wire running from the alternator to the battery or fuse box is often 8 gauge. Wire employed for other moderately high-current devices such as headlights and fan motors are 10 to 12 gauge;

and 14 to 16 gauge wire is used extensively for current loads created by brake, tail, directional, and parking lights. Thin 18 to 20 gauge wire is appropriate for low-load applications such as sensors, control signals, or low-power speakers.

You can find tables and calculators online (or in my electrical book) showing you how to calculate the wire gauge you need on the basis of the number of amps a device draws, the length of the wire, and the maximum permissible voltage drop, but, again, from a safety standpoint, the take-away message is that you can't select the 20 gauge wire that came with those Jensen triaxial speakers you bought in 1978 and use it to install driving lights that are bright enough to stun a moose a mile away. It's just not safe. The wire isn't thick enough—it doesn't have a low enough resistance—to carry the current without its resistance generating heat. The heat can melt the insulation off the wire and allow the wire to short to ground, creating an immediate fire hazard. For additional highway lighting or a radiator cooling fan, err on the side of using 10 to 12 gauge wire.

Wire sizes from a 2 gauge battery cable (right) to 20 gauge speaker wire (left). Each has its place.

Now that we've covered the basic safety issues, we'll cover the five types of circuit failures next week.

But you paid attention, right? My lawyer will be happy. (Note to self: Hire a lawyer.)

Rob Siegel has been writing the column *The Hack Mechanic™* for BMW CCA *Roundel* Magazine for 30 years. His new book, *Ran When Parked: How I Road-Tripped a Decade-Dead BMW 2002tii a Thousand Miles Back Home, and How You Can, Too*, is available here on Amazon. In addition, he is the author of *Memoirs of a Hack Mechanic* and *The Hack Mechanic™ Guide to European Automotive Electrical Systems*. Both are available from Bentley Publishers and Amazon. Or you can order personally inscribed copies through Rob's website: www.robsiegel.com.