



TECH NOTE: WIRE DIAMETER AND GAUGE NUMBERS

Wire diameters are often expressed in terms of gauge numbers. In the **American Wire Gauge (AWG)** standard, the larger the number, the thinner the wire. So a #2 AWG wire has a much larger diameter than a #30 AWG wire. The wiring used to carry power to outlets and light fixtures in most households or through a heavy-duty extension cord is usually about #14 AWG.

Table 8.4 lists some common wire gauges and some of their properties and uses. It also allows you to use Ohm's Law to calculate how much voltage drop you can expect per foot per amp of current. (A sample calculation is given in *Section 7.4.1. Voltage Drop*.)

Table 8.4: Some Standard AWG Wire Sizes and Properties

AWG	Diameter of metal core (approximate inches)	Resistance (ohms per foot of length)	Maximum current* (Amperes)	Example of a typical use for this gauge wire
#2	0.258	0.00015	180	main power line into an apartment building
#14	0.064	0.001	55	typical electrical wiring inside house walls or inside a heavy-duty extension cord.
#22	0.025	0.017	7	hookup wire commonly used for hand-wired circuits
#24	0.020	0.026	3.5	one of the small wires within a phone jack or Ethernet cable
#30	0.010	0.103	0.9	very slender wires used in wire-wrapped circuits.

* Note: Maximum current values are very situation-specific and should be viewed only as rough guidelines.

7.2. Fuses

It would be nice if everything always went according to plan, but life just doesn't work that way. And it's fair to say that Murphy's Law ("Anything that can go wrong, will go wrong") appears to have a particular fondness for electric circuits. Fortunately **fuses** can help keep a small electrical problem from becoming a bigger headache. Fuses are conceptually simple devices designed to protect circuits and people from some of the hazards associated with short circuits, including fires and electrocution. They are common in battery-powered devices and AC appliances and should be included in every ROV or AUV project.

Many circuit issues are just nuisance problems where the ROV or other gadget just doesn't work the way it's supposed to. But some of the problems are more serious and can present significant threats to the safety of people and property. One of the most common and potentially serious problems is a short circuit. A short can occur whenever a loose wire, dropped tool, flood of seawater, or other circumstance provides electricity with a shortcut around all or part of the regular load. Since the load normally limits the amount of current allowed to flow from the battery or other source, a short can cause a huge surge in current. This surge can quickly heat wires or other components red-hot and start a fire. A short



Image courtesy of Teledyne Impulse

Figure 8.37: Various Electrical Connectors for Underwater Use



Figure 8.38: Fuses

The image on the left shows two common types of fuses—a cylindrical “cartridge” type and a flattened “blade” or “spade” type. Both types come in a wide range of different voltage and current ratings, and both types are appropriate for ROV or AUV use.

The middle image shows a cartridge fuse in one of many available types of sockets used to connect a fuse electrically with the circuit it is protecting.

The silhouetted image on the right shows a cartridge fuse that has “blown” in response to excessive current. You can see the gap where the thin section of metal wire inside the glass cylinder melted in two.

can also bring higher voltage parts of a circuit into direct electrical contact with parts that are normally at lower voltages, so in high-voltage circuits, a short can present a dangerous electrocution hazard.

7.2.1. How Fuses Work

A conventional fuse is, essentially, just a thin section of wire that’s designed to be the “weakest link” in a circuit, but not so weak that it fails under normal operating conditions. A fuse is normally placed between the positive terminal of the battery and the rest of the circuit, so that all current leaving the battery must pass through the fuse. If a short develops, the excessive current flowing through the circuit will melt the fuse wire in two, cutting off current to the rest of the circuit before anything else in the circuit has enough time to overheat. When a fuse melts like this, it is said to have “blown.” A blown fuse acts like a switch in the open (OFF) position; it cuts off power to the rest of the circuit, preventing further damage and reducing the likelihood of electric shock. Usually the fuse’s thin section of wire is encased in a protective glass or plastic covering, so that the fuse wire itself won’t damage anything when it gets hot and melts in two (Figure 8.38).

To be effective, the fuse must be able to withstand normal voltage and current levels in the circuit without failure, but fail more quickly than any other part of the circuit as soon a current overload condition occurs. Since the voltage and current requirements of different circuits are different, fuses come in a wide variety of voltage and current ratings.

One problem with a conventional fuse is that it’s not reusable. Once it blows, it’s dead and must be replaced, like a burned-out light bulb. Fortunately, fuses are meant to be replaced fairly easily; they usually plug or screw into fuse sockets. However, before a fuse is replaced, the cause of the excess current must be diagnosed and repaired, or the

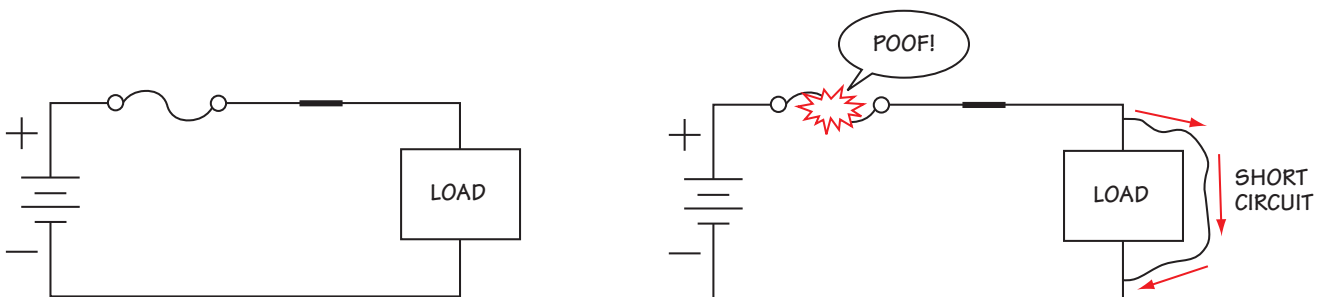


Figure 8.39: A Fuse-Protected Circuit

The stretched-out sideways “S” with the two small circles at either end is a common schematic symbol (in the U.S.) for a fuse. In this circuit, the fuse has been placed between the positive terminal of the battery and the power switch, so that all current leaving the battery must flow through the fuse. This is a good location for a fuse.

An unintended short circuit (red arrows) allows current to bypass the current limits normally imposed by the load, thereby increasing current levels and blowing the fuse. When the fuse blows (Poof!), it opens the circuit, stopping the excessive and unauthorized current flow and thereby reducing the risk of fire or other damage.