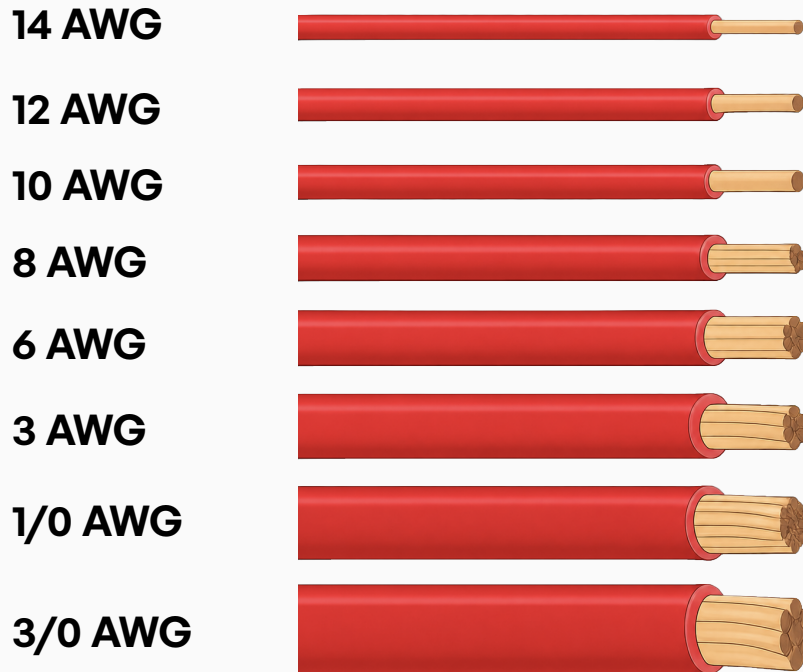


Wire Gauge and Fuse Sizing: How to Protect DC Circuits Correctly



Selecting a fuse is not as simple as matching the fuse rating to the number printed on a piece of equipment. The fuse, wire, load, holder, connectors, ambient temperature, and available fault current all have to work together.

The most important principle is this:

A fuse is primarily installed to protect the wire from carrying damaging current. The equipment may have its own protection requirements, but the fuse cannot exceed the maximum protection permitted for the wiring. If the load requires a larger fuse than the wire can support, increase the wire size instead of oversizing the fuse.

Why Wire Gauge Matters

To keep it as simple as possible: wire has electrical resistance. When current flows through that 'resistance,' the conductor produces heat according to:

$$\text{Power lost as heat} = \text{Current}^2 \times \text{Resistance}$$

Because current is squared, even a moderate increase in current can produce a much larger increase in heating. If the conductor cannot release that heat, its temperature may rise high enough to damage the insulation and possibly catch fire.

American Wire Gauge (AWG) describes the physical size of a conductor. With AWG, a smaller number means a larger conductor:

- 18 AWG is smaller than 12 AWG.
- 4 AWG is larger than 8 AWG.
- After 1 AWG, sizes continue as 1/0, 2/0, 3/0, and 4/0.

A larger conductor generally has lower electrical resistance and greater current-carrying capacity. However, wire gauge alone does not determine ampacity. Other factors can limit how much current a conductor can safely carry, including insulation temperature rating, conductor material, ambient temperature, conductor bundling, enclosure conditions, termination ratings, and allowable voltage drop.

How Fuse Sizing and Wire Gauge Work Together

The wire carries the normal load current. The fuse monitors that current indirectly through the heat produced in its fuse element. When an overcurrent lasts long enough, the element melts and interrupts the circuit. How a Fuse Works explains this process in more detail.

This creates two sizing limits:

1. The fuse must be large enough to carry the normal load and acceptable inrush current.
2. The fuse must be small enough to protect the lowest-rated part of the protected circuit.

That relationship can be expressed as:

Load-based minimum fuse rating $\leq$ Selected fuse rating $\leq$ Max permitted circuit rating

This is all to say that the maximum permitted rating is not determined by the main wire alone. It is the lowest applicable rating among:

- The adjusted ampacity of the conductor
- A smaller pigtail or equipment lead
- The fuse holder or fuse block
- Terminals, connectors, and splices
- The equipment's manufacturer's maximum fuse recommendation
- The limit established by the applicable electrical or marine standard

If no standard fuse size fits between the minimum and maximum limits, the correct solution is usually to increase the wire size, change the holder or connector, or revisit the design.

Select the Wire by Ampacity

Choose a conductor with an allowable ampacity above the circuit's required load and fuse rating after all required correction factors are applied.

The table below shows representative values from an ABYC-derived ampacity chart published by Blue Sea Systems. These values apply to single copper conductors with a 105°C insulation at a 30°C ambient temperature. The engine-space column applies a higher-ambient derating factor.

AWG Size	Approximate Area (mm ²)	Outside Engine Space	Inside Engine Space
18 AWG	0.82	20A	17A
16 AWG	1.31	25A	21A
14 AWG	2.08	35A	30A
12 AWG	3.31	45A	38A
10 AWG	5.26	60A	51A
8 AWG	8.37	80A	68A
6 AWG	13.3	120A	102A
4 AWG	21.2	160A	136A
2 AWG	33.6	210A	179A
1/0 AWG	53.5	285A	242A
2/0 AWG	67.4	330A	281A
4/0 AWG	107.2	445A	378A

Important: This is an ampacity reference, not a universal fuse-size chart. The values assume a particular conductor construction, insulation rating, ambient temperature, and installation method. A 12 AWG conductor appearing as 45A in this table does not mean every 12 AWG circuit should receive a 45A fuse.

Bundling conductors, over-filled conduit, insulation, and nearby heat can reduce ampacity by a considerable factor. Voltage drop must also be checked separately, especially in 12V and 24V systems.

How to Select the Fuse Size

Start with the steady-state/nominal load current and the equipment manufacturer's recommendation. A common starting point is 125% to 135% of normal operating current.

For a 16A continuous load:

- $16A \times 1.25 = 20A$
- $16A \times 1.35 = 21.6A$

Depending on the fuse series and manufacturer instructions, a 20A or 25A fuse may be considered, but it must remain below the circuit's permitted maximum.

The multiplier is only a starting point. Motors, pumps, and capacitive loads may need allowance for startup current or a time-delay fuse.

Check Voltage Drop

Ampacity limits heating; voltage drop determines how much voltage reaches equipment. Voltage drop increases with current, length of the circuit, and conductor resistance. For DC circuits, use the complete round-trip length from the source to the load and back. ABYC-based references commonly use a 3% maximum for critical circuits and up to 10% for certain non-critical loads.

If the voltage drop is too high, increase the wire size. Do not increase the fuse simply because a larger wire was installed. A long 10A circuit may need 10 AWG for voltage drop while still using a 15A fuse.

Additional ABYC Marine Considerations

ABYC-based marine design adds several checks:

- **Placement:** Generally install protection within 7 inches of the source. Conditional extensions to 40 or 72 inches apply only when specified connection and conductor-enclosure criteria are met.
- **Ignition protection:** Devices where fuel vapors may accumulate must meet applicable requirements.
- **Voltage and interrupting rating:** The fuse must have an adequate DC voltage rating, and its interrupting rating must equal or exceed the available fault current at the installation point.

Always verify the current condition of ABYC E-11 and the equipment manufacturer's instructions before finalizing a marine installation.