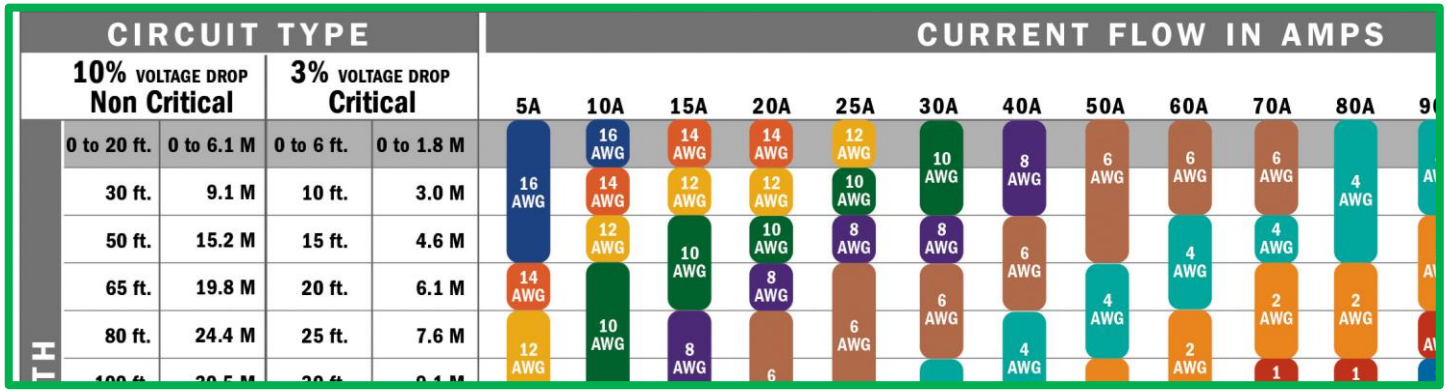
# How to Size and Fuse Wire for 12VDC Systems

TJG 1/12/2023



| CIRCUIT TYPE | | | | CURRENT FLOW IN AMPS | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10% VOLTAGE DROP Non Critical | | 3% VOLTAGE DROP Critical | | 5A | 10A | 15A | 20A | 25A | 30A | 40A | 50A | 60A | 70A | 80A |
| 0 to 20 ft. | 0 to 6.1 M | 0 to 6 ft. | 0 to 1.8 M | 16 AWG | 16 AWG | 14 AWG | 14 AWG | 12 AWG | 10 AWG | 8 AWG | 6 AWG | 6 AWG | 6 AWG | 4 AWG |
| 30 ft. | 9.1 M | 10 ft. | 3.0 M | 14 AWG | 14 AWG | 12 AWG | 12 AWG | 10 AWG | 8 AWG | 6 AWG | 4 AWG | 4 AWG | 4 AWG | |
| 50 ft. | 15.2 M | 15 ft. | 4.6 M | 12 AWG | 12 AWG | 10 AWG | 10 AWG | 8 AWG | 6 AWG | 4 AWG | 2 AWG | 2 AWG | 2 AWG | |
| 65 ft. | 19.8 M | 20 ft. | 6.1 M | 10 AWG | 10 AWG | 8 AWG | 8 AWG | 6 AWG | 4 AWG | 2 AWG | 1 | 1 | | |
| 80 ft. | 24.4 M | 25 ft. | 7.6 M | 8 AWG | 8 AWG | 6 AWG | 6 AWG | 4 AWG | 2 AWG | 1 | | | | |

see BlueSea/etc for full table, or use a voltage drop calculator

*this table is 12VDC specific*

*this table uses "round trip" distances*

## Step #1 – Select Wire Size from VOLTAGE DROP TABLE

- Determine expected max amp draw based on device(s)
- Determine voltage drop criticality based on device type(s)
- **Select wire size** to satisfy the amps & volts at distance requirements
- **This selection is driven by performance requirements involving amps & volts at a distance, where voltage drop over distance can degrade system performance and often harm devices**

## Step #2 Default – Select Fuse Size based on ALLOWABLE AMPERAGE TABLE

- Determine wire/insulation temperature rating
- Determine mounting location and exposure to other heat sources, *and other derating factors*
- **Select fuse size** to blow at or below the allowable wire amperage
- **This selection is driven solely by wire/insulation temperature safety**
- The goal is to protect the wire from overload
- *for panel/sub-panel setups, consult NEC/ABYC/etc for more advanced rules*
- *wire sized per the 3% & 10% rules will typically operate below the allowed amperage (good!)*

## Step #2 Better – Select Fuse Size BETWEEN Expected Load and Allowable Amperage

- **For dedicated wires to known device load(s)**
  - (a) **Select fuse size** as specified by the device manufacturer. Most are close to the (b) rule
  - (b) **Select fuse size** based on ~125% of the expected load
  - (c) **Select fuse size** to be halfway or more between the expected load and the allowable amperage if experiencing nuisance blows, especially with motors and inverters
- **This "better" step adds in the device manufacturer's fusing requirements**
- The goal is to protect the wire and the device from overload (e.g., clogged water pump)
- Thermal fusing at the power source and smaller device fusing at the device is also acceptable
- *125% (b) is based on the widespread "practice" of only running systems at 80% of rated capacity, and on the 80% NEC OCPD sizing rules for continuous loads on service > feeder > branch circuits*

## References *(tables abstracted on this slide for copyright reasons)*

- BlueSea - best to-the-point resource
  - **One page PDF - https://d2pyqm2yd3fw2i.cloudfront.net/files/resources/reference/20010.pdf**
  - "Choose wire", voltage drop table - https://www.bluesea.com/resources/1437 (shown here)
  - "Choose fuse", max fuse size selection table - https://www.bluesea.com/resources/1441
- ABYC – excellent boat standard partially leveraged by the RV industry
  - ABYC E-09, all tables - https://law.resource.org/pub/us/cfr/ibr/001/abyc.E-09.1990.pdf (shown here)
  - ABYC E-11, all tables - http://www.elettronavigare.it/files/E-11%20norme%20americane.pdf
- ANSI RVIA LV (US) and CSA Z240 (Canada) – RV standards loosely used by the RV industry
  - RVIA LV (paywalled) - https://www.rvia.org/.../association-and-ansi-standards
  - CSA Z240 (paywalled) - https://www.scc.ca/en/standardsdb/standards/7244
  - http://rv-project.com/resources/publications.php
- NEC - Standards that underlie the ABYC and RVIA Standards
  - NEC (NFPA 70) Table 310-15 for ampacity - https://www.lapptannehill.com/.../ampacity-chart
  - NEC (NFPA 70) full (paywalled) - https://www.nfpa.org/.../detail?code=70
- Other
  - Federal CFR 183.425, thermal - https://www.law.cornell.edu/cfr/text/33/183.425
  - Anchor wire specs - https://us.binnacle.com/pdf/AncorWireTechnicalDataCatalog.pdf
  - https://diysolarforum.com ... mobile-vehicle-rv-electrical.5587
  - https://www.forestriverforums.com/forums/f2/are-there-codes-for-rv-construction-165877.html
  - https://www.rvtravel.com/rv-electricity-part1-abcs-campground-power

see ABYC or NEC 310-15 for full table

**TABLE 1**
**ALLOWABLE AMPERAGE OF CONDUCTORS FOR UNDER 50 VOLTS**

| CONDUCTOR SIZE ENGLISH(METRIC) SEE TABLE IV | Temperature Rating of Conductor Insulation | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 60° C (140° F) | | 75° C (167° F) | | 80° C (176° F) | | 90° C (194° F) | | 105° C (221° F) | | 1 (2 |
| | OUTSIDE ENGINE SPACES | INSIDE ENGINE SPACES | OUTSIDE ENGINE SPACES | INSIDE ENGINE SPACES | OUTSIDE ENGINE SPACES | INSIDE ENGINE SPACES | OUTSIDE ENGINE SPACES | INSIDE ENGINE SPACES | OUTSIDE ENGINE SPACES | INSIDE ENGINE SPACES | OUTSIDE ENGINE SPACES |
| 18 (0.8) | 10 | 5.8 | 10 | 7.5 | 15 | 11.7 | 20 | 16.4 | 20 | 17.0 | 25 |
| 16 (1) | 15 | 8.7 | 15 | 11.3 | 20 | 15.6 | 25 | 20.5 | 25 | 21.3 | 30 |
| 14 (2) | 20 | 11.6 | 20 | 15.0 | 25 | 19.5 | 30 | 24.6 | 35 | 29.8 | 40 |
| 12 (3) | 25 | 14.5 | 25 | 18.8 | 35 | 27.3 | 40 | 32.8 | 45 | 38.3 | 50 |
| 10 (5) | 40 | 23.2 | 40 | 30.0 | 50 | 39.0 | 55 | 45.1 | 60 | 51.0 | 70 |
| 8 (8) | 55 | 31.9 | 65 | 48.8 | 70 | 54.6 | 70 | 57.4 | 80 | 68.0 | 90 |
| 6 (13) | 80 | 46.4 | 95 | 71.3 | 100 | 78.0 | 100 | 82.0 | 120 | 102.0 | 125 |
| 4 (19) | 105 | 60.9 | 125 | 93.8 | 130 | 101.4 | 135 | 110.7 | 160 | 136.0 | 170 |

# How Many Amps Can a 10AWG Wire Really Handle ?

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**The up shot is** – as distance and amperage-load increase on a wire, **the first concern encountered is "voltage drop"** and failing to deliver enough volts for a device to operate properly, and then as the amperage-load further increases independent of distance, **the second concern encountered is "thermal overload"** of the wire and the risk of fire

## Voltage Drop Table & Limits

for a given amp load, how long can 10AWG wire be before suffering a 3% or 10% voltage drop?

BlueSea table, round trip distances

| CIRCUIT TYPE | | | | CURREN | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 10% VOLTAGE DROP Non Critical | | 3% VOLTAGE DROP Critical | | 5A | 10A | 15A | 20A | 25A | 30A | 40A |
| 0 to 20 ft. | 0 to 6.1 M | 0 to 6 ft. | 0 to 1.8 M | 16 AWG | 16 AWG | 14 AWG | 14 AWG | 12 AWG | 10 AWG | 8 AWG |
| 30 ft. | 9.1 M | 10 ft. | 3.0 M | | 14 AWG | 12 AWG | 12 AWG | 10 AWG | 8 AWG | 6 AWG |
| 50 ft. | 15.2 M | 15 ft. | 4.6 M | | 12 AWG | 10 AWG | 10 AWG | 8 AWG | 6 AWG | |
| 65 ft. | 19.8 M | 20 ft. | 6.1 M | 14 AWG | | | 8 AWG | | | 4 AWG |
| 80 ft. | 24.4 M | 25 ft. | 7.6 M | 12 AWG | 10 AWG | 8 AWG | 6 AWG | 6 AWG | 4 AWG | |
| 100 ft. | 30.5 M | 30 ft. | 9.1 M | | 8 | | | | | |

NGTH

## Thermal Safety Table & Limits

for a given insulation rating and mounting location, how many amps can 10AWG wire carry safely?

ABYC table / Also See NEC

| CONDUCTOR SIZE (AWG) | TEMPERATURE RATING OF CONDUCTOR INSULATION | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 60°C (140°F) | | 75°C (167°F) | | 80°C (176°F) | | 90°C (194°F) | | 105°C (221°F) | | |
| | OUTSIDE ENGINE SPACES | INSIDE ENGINE SPACES | OUTSIDE ENGINE SPACES | INSIDE ENGINE SPACES | OUTSIDE ENGINE SPACES | INSIDE ENGINE SPACES | OUTSIDE ENGINE SPACES | INSIDE ENGINE SPACES | OUTSIDE ENGINE SPACES | INSIDE ENGINE SPACES | OUTS ENGI SPAC |
| 18 | 10 | 5.8 | 10 | 7.5 | 15 | 11.7 | 20 | 16.4 | 20 | 17.0 | 25 |
| 16 | 15 | 8.7 | 15 | 11.3 | 20 | 15.6 | 25 | 20.5 | 25 | 21.3 | 30 |
| 14 | 20 | 11.6 | 20 | 15.0 | 25 | 19.5 | 30 | 24.6 | 35 | 29.8 | 40 |
| 12 | 25 | 14.5 | 25 | 18.8 | 35 | 27.3 | 40 | 32.8 | 45 | 38.3 | 50 |
| 10 | 40 | 23.2 | 40 | 30.0 | 50 | 39.0 | 55 | 45.1 | 60 | 51.0 | 70 |
| 8 | 55 | 31.9 | 65 | 48.8 | 70 | 54.6 | 70 | 57.4 | 80 | 68.0 | 90 |

0 Amps | 5A | 10A | 15A | 20A | 25A | 30A | 35A | 40A | 45A | 50A | 55A | 60A | …

10 AWG 105°C / 221°F Acme Wire Company

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10 AWG 105°C / 221°F Acme Wire Company

Given a modest 10A load and trying to comply with the modest 10% rule, 10AWG wire can be up to 100ft round-trip aka 50ft POS + 50ft NEG

Given a beefy 30A load and trying to comply with the more demanding 3% rule, 10AWG wire can only be up to 10ft long round-trip aka 5ft POS + 5ft NEG

10AWG wire with wimpy 75C rated insulation can safely handle 40A +/- deratings like bundling

10AWG wire with common 105C rated insulation can safely handle 60A +/- deratings like bundling

**The practical limit of 10AWG is 30A based on voltage drop concerns, even though 105C-rated 10AWG can safely handle 60A**

NFPA 1192 (RVs), NFPA 70 (NEC) and ANSI RVIA (RVs) impose other limits and wire deratings based on wire bundling, device types, load duty-cycles, desired headroom, etc

NEC also has OCPD deratings; 80% for continuous duty loads

**While 60A on unbundled 105C-rated 10AWG is "safe", 60A at 30ft (for example) will resulting in a crippling ~20% voltage drop**