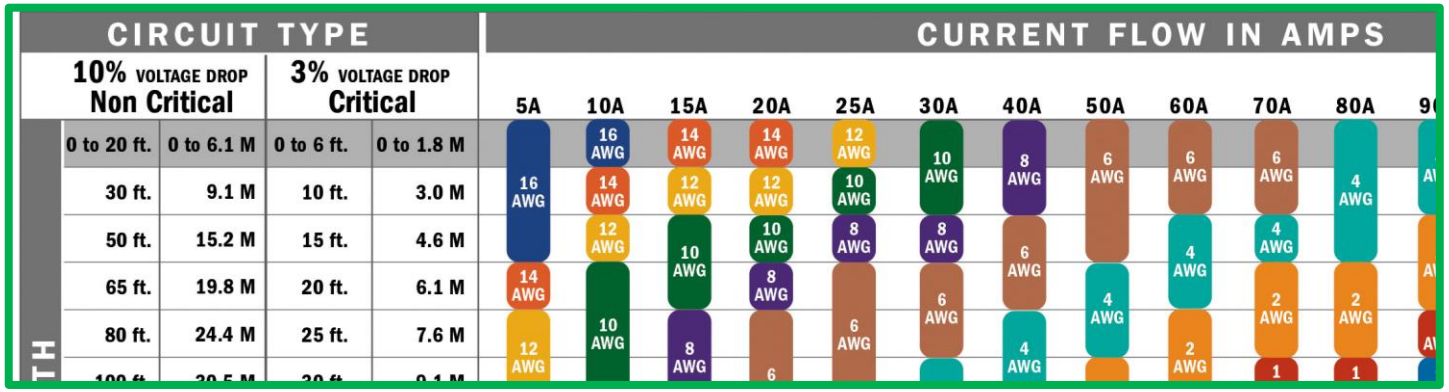
How to Size and Fuse Wire for 12VDC Systems



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	90
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	A
30 ft.	9.1 M	10 ft.	3.0 M		14 AWG	12 AWG	12 AWG	10 AWG	8 AWG	6 AWG		4 AWG	4 AWG		
50 ft.	15.2 M	15 ft.	4.6 M		12 AWG	10 AWG	10 AWG	8 AWG	6 AWG		4 AWG		2 AWG	2 AWG	A
65 ft.	19.8 M	20 ft.	6.1 M	14 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	12 AWG			6								A
TH															

see BlueSea/etc for full table

this table is 12VDC specific

this table uses "round trip" distances

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

- BlueSea - best to-the-point resource IMHO
  - "Choose wire", voltage drop table (shown) - https://www.bluesea.com/resources/1437
  - "Choose fuse", max fuse selection table - https://www.bluesea.com/resources/1441
- ABYC - boat standard partially leveraged by RV industry
  - ABYC E-09, all tables - https://law.resource.org/pub/us/cfr/ibr/001/abyc.E-09.1990.pdf (shown)
  - ABYC E-11, all tables - http://www.elettronavigare.it/files/E-11%20norme%20americane.pdf
  - ABYC discussion with Battle Born - https://www.youtube.com/watch?v=21Ql6n7nndQ
  - ABYC basic wiring concepts - https://www.youtube.com/watch?v=OdvAz7oNr5o
  - ABYC wiring auditor perspectives - https://www.youtube.com/watch?v=I_FnykN3uAM
- ANSI/RVIA LV and CSA Z240.6.2 - RV standards loosely used by RV industry
  - https://www.rvia.org/standards-regulations/standards-compliance/association-and-ansi-standards
  - http://rv-project.com/resources/publications.php
  - NEC covers 120/208/240VAC in RVs, the standards above cover "low voltage <24VDC"
- Other
  - Federal CFR 183.425, thermal - https://www.law.cornell.edu/cfr/text/33/183.425
  - Ancor wire specs (example) - https://www.ancorproducts.com/en/~/media/inriver/411902-49961.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

Step #1 – Select Wire Size from VOLTAGE DROP TABLE

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

Step #2 Default – Select Fuse Size from ALLOWABLE AMPERAGE TABLE

- Determine wire/insulation temperature rating
- Determine mounting location and exposure to other heat sources
- **Select fuse size** to blow at (or below) the allowable wire amperage
- **This selection is driven by wire/insulation temperature safety**
- The goal is to protect the wire from overload
- *fyi - wire sized per the 3% & 10% rules will operate below the amperage/thermal limits*

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

- For dedicated wires to known appliance(s)/device(s)
  - (a) **Select fuse size** per the appliance/device manual. 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 thermal limit if experiencing nuisance blows
- The goal is to protect the wire and the appliance(s)/device(s) from overload
- Thermal fusing at the power source and smaller device fusing at the device is also acceptable
- Inverters and motors can be tricky to size due to high momentary startup currents, see (c)
- Clogged melted bilge/water pumps are the ABYC poster child for failing to fuse "in between"

see ABYC/etc for full table

TABLE I

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
2 (33)	140	81.2	170	127.5	175	136.5	180	147.6	210	178.5	225

How Many Amps Can a 10AWG Wire Really Handle ?

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 an appliance or device to operate properly, and then as the amperage further increases independent of distance, **the second concern encountered is thermal overload** of the wire and the risk of fire

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	14 AWG	12 AWG	12 AWG	10 AWG	8 AWG	6 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
65 ft.	19.8 M	20 ft.	6.1 M	10 AWG	10 AWG	8 AWG	8 AWG	6 AWG	4 AWG	
80 ft.	24.4 M	25 ft.	7.6 M	8 AWG	8 AWG	6 AWG	6 AWG	4 AWG		
100 ft.	30.5 M	30 ft.	9.1 M	6 AWG	6 AWG	4 AWG	4 AWG			

ABYC table

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

Voltage Drop Table & Limits

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

Thermal Safety Table & Limits

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

3% drop at 30ft roundtrip at 10A ★
10% drop at 100ft ★

3% drop at 15ft ★
10% drop at 50ft ★

3% drop at 10ft ★
10% drop at 30ft ★

★ *60C insulation* *(outside of engine space)*

★ *80C insulation*

★ ***105C insulation handles 60A*** *(105C is a common temp rating)*

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

- **#2 – BETTER YET, for <u>dedicated</u> wires to <u>known</u> appliance(s)/device(s), select a fuse size in between the expected load and the thermal limit to protect the wire and the appliance(s)/device(s)**
- ABYC, BlueSea and Victron all provide guidance on picking fuse sizes in between the expected load and the thermal limit
- Thermal fusing at the power source and smaller device fusing at the device is also acceptable

- **#1 – BY DEFAULT, select a fuse size that protects the wire from thermal overload**

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

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