

Section 8.0

ELECTRICAL SYSTEMS

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8.1 Application

- 8.1.1 This section applies to all small vessels that have gasoline or diesel engines for propulsion or electrical generating power or LPG (Liquefied Petroleum Gas) or CNG (Compressed Natural Gas) equipment on board.

8.2 Alternative

- 8.2.1 The requirements of *ABYC Standards for Small Craft E-11 AC and DC Electrical Systems on Boats* and *E-10 Storage Batteries* may be met instead of the requirements of sections 8.3 to 8.13.

8.3 General

- 8.3.1 All switches and controls shall be marked to indicate their usage except where there is a switch or electrical control whose function is obvious and where the operation of the device could not, under normal operation, cause a hazardous condition.
- 8.3.2 Single-pole breakers shall be installed in the positive conductor.
- 8.3.3 Switches shall be rated for the voltage and the current rating of the connected load of the circuit.
- 8.3.4 Electrical equipment, such as ignition systems, motors, pumps, fans, and controllers, shall be marked or identified with the following:
- (a) manufacturer;
 - (b) product ID, serial number, type, model;
 - (c) voltage, amperage, wattage;
 - (d) polarity; and
 - (e) ignition protected, if applicable;
- 8.3.5 Circuit Breakers shall:
- (a) have the same DC voltage rating as the system voltage;
 - (b) be of the trip-free, manual reset type;
 - (c) have an interrupting capacity to meet the system requirements; and
 - (d) be in compliance with Underwriters Laboratories UL 1500, *Standard for Ignition-Protection Test for Marine Products*, if located in the space.

- 8.3.6 Fuses shall be:
- (a) of the same nominal voltage as the system voltage;
 - (b) of an interrupting capacity to meet system requirements; and
 - (c) in compliance with Underwriters Laboratories UL 1500, *Standard for Ignition-Protection Test for Marine Products*, where applicable.
- 8.3.7 Every integral overcurrent protect device without manual reset is permitted for use provided the circuit is protected by a fuse or trip-free breaker.
- 8.3.8 All permanently installed electrical equipment and appliances shall be securely mounted to the ship's structure.
- 8.3.9 With the exception of engine mounted equipment, all DC appliances and fixed electrical equipment shall be designed so that all current carrying parts are insulated from exposed electrically conductive parts.
- 8.3.10 The following devices need not comply with paragraph 8.3.9 if one conductor is connected to the exposed electrically conductive parts, provided that the connected conductor is the negative conductor, the polarity of both the negative and positive connections are identified, the device is mounted only on a non-conductive surface, and the device is not bonded:
- (a) communication and audio equipment;
 - (b) electronic equipment;
 - (c) instruments and instrument clusters;
 - (d) cigarette lighters;
 - (e) liquid level gauge transmitters; and
 - (f) navigation lights operating at 12 V or less.
- 8.3.11 Every exposed conductive non-current part of electrical equipment that may normally be in contact with bilge or seawater shall be connected to a DC grounding system, except for small vessels not equipped with a DC grounding system, double insulated devices, and isolated metal parts in non-conductive material.
- 8.3.12 Grounded liquid level gauge transmitters mounted on metallic fuel tanks or tank plates shall have the transmitter negative return conductor connected directly to the engine negative terminal or its bus. This conductor shall serve as the tank bonding or static ground conductor. Where this conductor is employed as the bonding conductor, it shall be not less than 8 AWG, and no other device shall be connected to the conductor.
- 8.3.13 The negative terminal of the battery and the negative side of the DC distribution system shall be connected to the engine negative terminal or its bus. The negative return on vessels with outboard motors shall be connected to the battery negative terminal unless provisions have been specifically provided for the return to be connected to the motor negative terminal by the outboard manufacturer.

- 8.3.14 Where an accessory negative bus is used, the following requirements apply:
- (a) all the connections of the accessories to the bus shall be branch circuits from the same panelboard;
 - (b) the negative bus, the negative return conductors, terminals, and connections shall have an ampacity equal to the panelboard feeder; and
 - (c) the negative return conductors from the panelboard feeding the branch circuits, using the accessory bus, shall be the same size as the positive feeder to the panelboard.
- 8.3.15 Where the DC distribution system is a two-wire system with supply and return, the engine block may be used as the common return for accessories mounted on the engine, except on metallic vessels where the engine is not isolated from the hull.
- 8.3.16 If a small vessel with a grounded DC system has a multiple engine installation with grounded cranking motors that includes an auxiliary generator engine(s), the engines shall be connected to each other by a common conductor that can carry the starting current of each of the grounded cranking motor circuits. Multiple outboard motors shall be connected at the negative battery terminal
- 8.3.17 If a small vessel is equipped with a crossover (parallel) cranking motor system in a multi engine installation, including auxiliary generator(s), the engine shall be connected with a cable large enough to carry the cranking motor circuit; this cable shall be in addition to and independent of any other electrical connections to the engines including those in subsection 8.3.16, except in the case of ungrounded DC systems or outboard motors.
- 8.3.18 If a paralleling switch is installed in crossover circuitry of 8.3.17, it shall be rated to carry the largest cranking motor current. The switch may be of a maintained type or solenoid operated.

8.4 Ignition Protection

- 8.4.1 Every electrical component shall be ignition protected in accordance with Society of Automotive Engineers Standard SAE J1171, *External Ignition Protection of Marine Electrical Devices* or Underwriters Laboratories UL 1500, *Ignition Protection Test for Marine Products* unless the component is isolated from the fuel source, such as engines, stoves, valves, connections, or other fittings on vent lines, fill lines, distribution lines, or fuel tanks.
- 8.4.1.1 Exceptions to 8.4.1 are the following:
- (a) any small vessel using diesel fuel as the only fuel source; and
 - (b) electrical devices in accommodation spaces or open compartments, or both, having at least 97 cm² of open area per cubic metre of net compartment volume exposed to the atmosphere outside of the small vessel.

- 8.4.1.2 Electrical devices in compartments containing LPG or CNG appliances, cylinders fittings, valves, or regulators shall be ignition protected (refer to paragraph 8.4.1.1 for exceptions).
- 8.4.2 Isolation of an electrical component from a fuel source shall be provided by:
- (a) a bulkhead that meets the requirements of paragraph 8.4.3 and that is located between the electrical component and the fuel source;
 - (b) the installation of the electrical component with provision of a means to prevent fuel and fuel vapours from becoming exposed to the electrical component; or
 - (c) a space that is open to the atmosphere and that provides at least 600 mm (24 in) between the fuel source and the electrical component.
- 8.4.3 A bulkhead, as detailed in paragraph 8.4.2 shall:
- (a) extend both vertically and horizontally at least the distance of the open space between the fuel source and the ignition source;
 - (b) resist a water level that is 305 mm (12 in) high or one-third the maximum height of the bulkhead, whichever is less, without seepage of more than 7.5 mL of fresh water per hour; and
 - (c) have no opening located higher than 305 mm (12 in) or one-third the maximum height of the bulkhead, whichever is less, unless:
 - (i) the opening is used for the passage of conductors, piping, ventilation ducts, mechanical equipment, or doors, hatches, and access panels, and
 - (ii) the maximum annular space around each item or door, hatch, or access panel is not larger than 6 mm ($\frac{1}{4}$ in).
- 8.4.4 Fuel tank, fuel filter, or fuel line fittings shall not be installed over a source of ignition. All personal watercraft are exempt from this requirement.

8.5 Grounding

- 8.5.1 Where a small vessel has more than one gasoline engine, the grounded cranking motor circuits shall meet the requirements of 8.3.16.
- 8.5.2 The engine block may be used as the common return for accessories mounted on the engine, except on metallic small vessels, where the engine is not isolated from the hull.
- 8.5.3 A metallic hull or the grounding conductor shall not be used as the return conductor.
- 8.5.3.1 If one side of the DC system is grounded, it shall be of negative polarity.

- 8.5.3.2 In steel and aluminum small vessels, non-conducting exposed metal parts of electrical equipment that requires grounding shall be effectively grounded to the hull.
- 8.5.4 On small wood, fiber-reinforced plastic and composite vessels, a continuous ground conductor shall be installed to facilitate the grounding of non-conducting exposed metal parts of electrical, electronic, and communication equipment that requires grounding. The ground conductor shall terminate at a point on the main engine or at a copper plate of area not less than 0.2 m² fixed to the keel below the light waterline so as to be fully immersed under all conditions of heel or trim.
- 8.5.5 Every grounding conductor shall be of copper or other corrosion-resistant material and shall be securely installed and protected, where necessary, against damage and electrolytic corrosion.
- 8.5.6 Every grounding connection to the small vessel's structure, or on wood, fiber-reinforced plastic, and composite small vessels, to the continuous ground conductor, shall be made in an accessible position and shall be secured by a screw or connector of brass or other corrosion-resistant material used solely for that purpose.

8.6 Batteries

8.6.1 General

- 8.6.1.1 Batteries shall be installed in a dry, ventilated location above bilge water level, accessible for inspection and maintenance.
- 8.6.1.2 Batteries shall not be tapped for voltages other than the total voltage of the cells comprising the battery.
- 8.6.1.3 Batteries, as installed in every small vessel, shall be capable of inclinations of up to 40 degrees without leakage of electrolyte. A means shall be provided for containment of any spilled electrolyte.
- 8.6.1.4 Batteries shall be protected against mechanical damage by either location or an enclosure, and electrically protected by a non-conductive cover to protect metal objects coming in direct contact with the ungrounded terminals of the battery.
- 8.6.1.5 Every battery shall be secured so as not move more than 25 mm (1 in) when a pulling force of twice the battery weight is applied through the centre of gravity in each of the following five directions for one minute:
- (a) vertically;
 - (b) horizontally, fore and aft; and
 - (c) horizontally port and starboard.
- 8.6.1.6 Every metallic fuel line and fuel system component located within 305 mm (12 in) above the level of the top of an installed battery shall be shielded with dielectric material.

- 8.6.1.7 Means for adequate ventilation shall be provided to prevent the accumulation of hydrogen from the battery during charging or discharging cycles. Vented batteries shall not be installed in accommodation spaces.
- 8.6.1.8 The positive terminal of a battery shall be identified on the terminal or on the battery case near the terminal, with one of the following symbols:
- (a) "POS";
 - (b) "P"; or
 - (c) "+".
- 8.6.1.9 No battery terminal connector shall depend upon spring tension for its connection to the terminal.

8.6.2 Battery Disconnect Switch

- 8.6.2.1 A battery disconnect switch shall be installed in the positive conductor from each battery or group of batteries, with a cold cranking average rating greater than 800 amperes, except for small vessels less than 8.0 m (26 ft 3 in) in length.
- 8.6.2.1.1 The following devices may be connected to the battery side of the battery switch described in paragraph 8.6.2.1; however, each device shall be provided with circuit protection in accordance with section 8.9:
- (a) electronic equipment with continuously powered memory;
 - (b) safety equipment such as bilge pumps, alarms, CO detectors, and bilge blowers;
 - (c) battery charging equipment.
- 8.6.2.2 Battery switches shall be placed in a readily accessible location as close as practicable to the battery, or batteries.
- 8.6.2.3 Battery disconnect switches shall be capable of carrying the maximum current of the distribution system including the intermittent load of the starter motor circuit.
- 8.6.2.4 Remote controlled battery disconnect switches, if used, shall also permit safe manual operation at the switch.

8.7 Conductors

8.7.1 General – Systems Less Than 50 Volts

- 8.7.1.1 This subsection does not apply to:
- (a) communications systems;
 - (b) electronic navigation equipment;

- (c) resistance conductors that control circuit amperage;
- (d) high-voltage ignition systems, conductors, and terminations;
- (e) pigtails of less than 200 mm (8 in) of exposed length;
- (f) cranking motor conductors.

8.7.1.2 Every permanently installed cable and conductor shall:

- (a) have a minimum nominal voltage rating of 50 V; and
- (b) have stranded copper conductors with an insulation rated for a minimum temperature of 60°C; and
- (c) be of single or multi-conductor construction; and
- (d) be flame retardant, impervious to water absorption, and of an oil resistant type when installed in engine room spaces; and
- (e) be of a type as described in 8.7.1.3.

8.7.1.3 For the purpose of 8.7.1.2(e), the types are those that are:

- (a) listed in Table 8–1; or
- (b) listed for marine use by an independent testing laboratory that provides listing, labelling, and follow-up service; or
- (c) constructed in accordance with the latest editions of one of the following:
 - (i) CSA C22.2 No. 245, *Marine Shipboard Cable*; or
 - (ii) UL 1309, *Marine Shipboard Cable*; or
 - (iii) IEEE STD 45, *Recommended Practice for Electrical Installations on Shipboard*; or
 - (iv) IEEE STD 1580 *Recommended Practice for Marine Cable for Use on Shipboard and Fixed or Floating Platforms*; or
 - (v) requirements of Underwriters Laboratories UL 1426, *Electrical Cables for Boats*.

8.7.1.4 Conductors and flexible cords shall have the following surface markings:

- (a) type/style;
- (b) voltage rating;
- (c) wire size; and
- (d) temperature rating.

Table 8-1 Wire Types

Types	Description	Available Insulation	Types of Conductors
TW	Moisture Resistant, Flame Tested Thermoplastic	60°C	Single Conductors
TWU	Heat and Moisture Resistant Flame Tested Thermoplastic	60°C	Single Conductors
TWN	Heat and Moisture Resistant Flame Tested Thermoplastic	75°C	Single Conductors
TW 75	Heat and Moisture Resistant Flame Tested Thermoplastic	75°C	Single Conductors
TWU 75	Heat and Moisture Resistant Flame Tested Thermoplastic	75°C	Single Conductors
T 90 Nylon	Heat and Moisture Resistant Flame Tested Thermoplastic	90°C	Single Conductors or Multi-Conductors
RW 90	Heat and Moisture Resistant Thermoset	90°C	Multi-Conductors

8.7.1.5 Where flexible cords or power cables are used for portable equipment, they shall be of a type SO, ST, SJO, SJT, SJOW, or SJTW, as listed in the *CSA Canadian Electrical Code*, Part 1, or be of a similar cable that has been constructed to a recognized national standard.

8.7.1.6 Except for intermittent surges, no conductor shall carry a current greater than that specified in Table 8-2 for the conductor's gauge and temperature rating.

8.7.1.7 In circuits where voltage drop must be kept to a minimum, the following maximum voltage drops are permitted:

- (a) panelboard main feeders: 3%;
- (b) navigation light circuits: 3%;
- (c) electronic equipment circuits: 3%;
- (d) bilge blower and pump: 3%; and
- (e) all remaining circuits 10%.

(For the calculation of the above voltage drops, refer to Tables 8-3 and 8-4)

8.7.1.8 Conductors shall be not less than 16 AWG (1 mm), other than those conductors contained in manufacturer's equipment and communication circuits of less than 1 amp.

8.7.2 Wire Colour Coding

8.7.2.1 The colour coding shown in Table 8-5 identifies colours for DC general wiring purposes on vessels together with one selection of colours used for engine accessories. Other means of cable identification may be employed provided a wiring diagram of the electrical system indicating the method of identification is provided particular to the vessel electrical installation.

Table 8-2 Allowable Amperage of Conductors

Conductor Size		Temperature rating of conductor insulation						
(Circular Mils)	(AWG)	60°C	75°C	80°C	90°C	105°C	125°C	200°C
1 620	18	10	10	15	20	20	25	25
2 580	16	15	15	20	25	25	30	35
4 110	14	20	20	25	30	35	40	45
6 530	12	25	25	35	40	45	50	55
10 400	10	40	40	50	55	60	70	70
16 500	8	55	65	70	70	80	90	100
26 300	6	80	95	100	100	120	125	135
41 700	4	105	125	130	135	160	170	180
52 600	3	120	145	140	155	180	195	210
66 400	2	140	170	175	180	210	225	240
83 700	1	165	195	210	210	245	265	280
106 000	0	195	230	245	245	285	305	325
133 000	00 (2/0)	225	265	285	285	330	355	370
168 000	000 (3/0)	260	310	330	330	385	410	430
212 000	0000 (4/0)	300	360	385	385	445	475	510

Correction Factors**Note 1 Correction for Temperature of Conductor**

Temperature Rating	60°C	75°C	80°C	90°C	105°C	125°C	200°C
Correction Factor	0.58	0.75	0.78	0.82	0.85	0.89	1.00

Note 2 Correction for Number of Conductors

Number of current carrying conductors	Correction Factor
3	0.70
4 to 6	0.60
7 to 24	0.50
25 or more	0.40

8.7.2.2 If coloured tape is employed for colour coding, it shall be not less than 5 mm ($3/16$ in) wide and shall make at least two (2) complete turns around the conductor in a visible location adjacent to the terminal.

8.7.3 Secondary Circuits of Ignition Systems

8.7.3.1 Every conductor in a secondary circuit of an ignition system shall conform to Society of Automotive Engineers Standard SAE Standard J2031.

8.7.3.2 The connection of every ignition conductor to a spark plug, coil, or distributor shall have a tight fitting cap, boot, or nipple.

8.7.4 Conductors – Support and Protection

8.7.4.1 This subsection does not apply to communication systems, electronic navigation equipment, or high-voltage secondary conductors and termination in ignition systems.

8.7.4.2 Except for the first 1000 mm (3 ft 3 in) of a conductor leading from a battery terminal, every conductor or group of conductors shall be supported by clamps or straps at intervals not greater than 500 mm (1 ft 8 in) unless the conductor or group of conductors is enclosed in a rigid duct or conduit.

8.7.4.3 Non-metallic straps or clamps shall be resistant to oil, gasoline, and water, and shall not break under flexing at a temperature range of -34°C to 121°C and where exposed to sunlight shall not be sensitive to ultraviolet radiation.

8.7.4.4 Where metal clamps are lined with an insulating material, the material shall be resistant to oil, gasoline, and water, and be compatible with the insulation or sheath.

8.7.4.5 Clamps, straps, ducts, or conduits shall be designed to prevent chafing or damage to the conductor insulation.

8.7.4.6 Provision shall be made to prevent stress being placed on any conductor that connects two components that can move in relation to each other.

8.7.4.7 Every conductor or group of conductors that passes through a bulkhead, structural member, junction box, or other rigid surface shall be protected from abrasion.

8.7.4.8 Every conductor shall be protected from damage due to exposure to heat sources capable of damaging the insulation.

8.7.4.9 Current carrying conductors shall be routed as high as practicable above the bilge water level and other areas where water may accumulate. If conductors must be routed in the bilge or other areas where water may accumulate, the wiring and connections shall be watertight.

8.7.4.10 AC and DC conductors or multiconductors shall be separately sheathed in conduit or cable or trunking or bundled, or otherwise kept separate from each other.

Table 8-3 Conductor Sizes for 3% Drop in Voltage

Length of Conductor from Source of Current to Device and Back to Source - Feet																			
Metres	3	4.5	6	8	9	12	15	12	20	25	27	30	33	36	40	43	45	48	52
Feet	10	15	20	25	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170
12 Volts - 3% Drop Wire Sizes (gage) - Based on Minimum CM Area																			
Total Amps.*																			
3	18	16	14	12	12	10	10	10	8	8	6	6	6	6	6	6	6	6	6
10	14	12	10	10	10	8	6	6	6	4	4	4	4	4	2	2	2	2	2
15	12	10	10	8	8	6	6	6	4	2	2	2	2	2	2	1	1	1	1
20	10	10	8	6	6	6	4	4	2	2	2	2	1	1	1	0	0	0	2/0
25	10	8	6	6	6	4	4	2	2	1	1	1	0	0	0	2/0	2/0	2/0	3/0
30	10	8	6	4	4	4	2	2	1	0	0	0	0	2/0	2/0	3/0	3/0	3/0	3/0
40	8	6	6	4	4	2	2	1	0	2/0	2/0	2/0	2/0	3/0	3/0	4/0	4/0	4/0	4/0
50	6	6	4	2	2	2	1	0	2/0	3/0	3/0	3/0	3/0	4/0	4/0	-	-	-	-
60	6	4	4	2	2	1	0	2/0	3/0	4/0	4/0	4/0	4/0	-	-	-	-	-	-
70	6	4	2	1	1	0	2/0	3/0	3/0	4/0	4/0	-	-	-	-	-	-	-	-
80	6	4	2	1	0	0	3/0	3/0	4/0	-	-	-	-	-	-	-	-	-	-
90	4	2	2	0	2/0	2/0	3/0	4/0	4/0	-	-	-	-	-	-	-	-	-	-
100	4	2	2	0	2/0	2/0	3/0	4/0	-	-	-	-	-	-	-	-	-	-	-
24 Volts - 3% Drop Wire Sizes (gage) - Based on Minimum CM Area																			
Total Amps.*																			
5	18	18	18	16	16	14	12	12	12	10	10	10	10	10	8	8	8	8	8
10	18	16	14	12	12	10	10	10	8	8	8	6	6	6	6	6	6	6	6
15	16	14	12	12	10	10	8	8	6	6	6	6	6	4	4	4	4	4	2
20	14	12	10	10	10	8	6	6	6	6	4	4	4	4	2	2	2	2	2
25	12	12	10	10	8	6	6	6	4	4	4	4	2	2	2	2	2	2	1
30	12	10	10	8	8	6	6	4	4	4	2	2	2	2	2	1	1	1	1
40	10	10	8	6	6	6	4	4	2	2	2	2	1	1	1	0	0	0	2/0
50	10	8	6	6	6	4	4	2	2	2	1	1	0	0	0	2/0	2/0	2/0	3/0
60	10	8	6	6	4	4	2	2	1	1	0	0	0	2/0	2/0	3/0	3/0	3/0	4/0
70	8	6	6	4	4	2	2	1	1	0	0	2/0	2/0	3/0	3/0	3/0	3/0	4/0	4/0
80	8	6	6	4	4	2	2	1	0	0	2/0	2/0	3/0	3/0	3/0	4/0	4/0	4/0	-
90	8	6	4	4	2	2	1	0	0	2/0	2/0	3/0	3/0	4/0	4/0	4/0	4/0	4/0	-
100	6	6	4	4	2	2	1	0	2/0	2/0	3/0	3/0	4/0	4/0	4/0	-	-	-	-
32 Volts - 3% Drop Wire Sizes (gage) - Based on Minimum CM Area																			
Total Amps.*																			
3	18	18	18	18	16	16	14	14	12	12	12	12	10	10	10	10	10	10	8
10	18	16	16	14	14	12	12	10	10	10	8	8	8	8	8	6	6	6	6
15	16	16	14	12	12	10	10	8	8	8	6	6	6	6	6	6	6	4	4
20	16	14	12	12	10	10	8	8	6	6	6	6	6	4	4	4	4	4	2
25	14	14	12	10	10	8	8	6	6	6	6	4	4	4	4	2	2	2	2
30	14	12	10	10	8	8	6	6	6	4	4	4	4	2	2	2	1	1	1
40	12	12	10	8	8	6	6	4	4	4	2	2	2	2	2	1	1	1	1
50	12	10	8	8	6	6	4	4	2	2	2	2	2	1	1	0	0	0	0
60	10	10	8	6	6	4	4	2	2	2	2	1	1	0	0	0	2/0	2/0	2/0
70	10	10	6	6	6	4	2	2	2	1	1	0	0	0	2/0	2/0	2/0	3/0	3/0
80	10	8	6	6	4	4	2	2	1	1	0	0	0	2/0	2/0	3/0	3/0	3/0	3/0
90	8	8	6	6	4	2	2	2	1	0	0	2/0	2/0	2/0	3/0	3/0	3/0	4/0	4/0
100	8	6	6	4	4	2	2	1	0	0	2/0	2/0	2/0	3/0	3/0	3/0	4/0	4/0	4/0

*Total current on circuit in amperage.

Table 8-4 Conductor Sizes for 10% Drop in Voltage

Length of Conductor from Source of Current to Device and Back to Source - Feet																			
Metres	3	4.5	6	8	9	12	15	18	20	25	27	30	33	36	40	43	45	48	52
Feet	10	15	20	25	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170
Total Amps.* 12 Volts - 10% Drop Wire Sizes (gage) - Based on Minimum CM Area																			
5	18	18	18	18	18	16	16	14	14	14	12	12	12	12	12	10	10	10	10
10	18	18	16	16	14	14	12	12	10	10	10	10	8	8	8	8	8	8	6
15	18	16	14	14	12	12	10	10	8	8	8	8	8	6	6	6	6	6	6
20	16	14	14	12	12	10	10	8	8	8	6	6	6	6	6	6	4	4	4
25	16	14	12	12	10	10	8	8	6	6	6	6	6	4	4	4	4	4	2
30	14	12	12	10	10	8	8	6	6	6	6	4	4	4	4	2	2	2	2
40	14	12	10	10	8	8	6	6	6	4	4	4	2	2	2	2	2	2	2
50	12	10	10	8	8	6	6	4	4	4	2	2	2	2	2	1	1	1	1
60	12	10	8	8	6	6	4	4	2	2	2	2	2	1	1	1	0	0	0
70	10	8	8	6	6	6	4	2	2	2	2	1	1	1	0	0	0	2/0	2/0
80	10	8	8	6	6	4	4	2	2	2	1	1	0	0	0	2/0	2/0	2/0	2/0
90	10	8	6	6	6	4	2	2	2	1	1	0	0	0	2/0	2/0	2/0	3/0	3/0
100	10	8	6	6	4	4	2	2	1	1	0	0	0	2/0	2/0	2/0	3/0	3/0	3/0
Total Amps.* 24 Volts - 10% Drop Wire Sizes (gage) - Based on Minimum CM Area																			
5	18	18	18	18	18	18	18	18	16	16	16	16	14	14	14	14	14	14	12
10	18	18	18	18	18	16	16	14	14	14	12	12	12	12	12	10	10	10	10
15	18	18	18	16	16	14	14	12	12	12	10	10	10	10	10	8	8	8	8
20	18	18	16	16	14	14	12	12	10	10	10	10	8	8	8	8	8	8	6
25	18	16	16	14	14	12	12	10	10	10	8	8	8	8	8	6	6	6	6
30	18	16	14	14	12	12	10	10	8	8	8	8	8	6	6	6	6	6	6
40	16	14	14	12	12	10	10	8	8	8	6	6	6	6	6	6	4	4	4
50	16	14	12	12	10	10	8	8	6	6	6	6	6	4	4	4	4	4	2
60	14	12	12	10	10	8	8	6	6	6	6	4	4	4	4	2	2	2	2
70	14	12	10	10	8	8	6	6	6	6	4	4	4	2	2	2	2	2	2
80	14	12	10	10	8	8	6	6	6	4	4	4	2	2	2	2	2	2	2
90	12	10	10	8	8	6	6	6	4	4	4	2	2	2	2	2	2	1	1
100	12	10	10	8	8	6	6	4	4	4	2	2	2	2	2	1	1	1	1
Total Amps.* 32 Volts - 10% Drop Wire Sizes (gage) - Based on Minimum CM Area																			
5	18	18	18	18	18	18	18	18	18	18	18	16	16	16	16	14	14	14	14
10	18	18	18	18	18	18	16	16	14	14	14	14	12	12	12	12	12	12	12
15	18	18	18	18	18	16	14	14	14	12	12	12	12	10	10	10	10	10	10
20	18	18	18	16	16	14	14	12	12	12	10	10	10	10	10	8	8	8	8
25	18	18	16	16	14	14	12	12	10	10	10	10	10	8	8	8	8	8	8
30	18	18	16	14	14	12	12	10	10	10	10	8	8	8	8	8	6	6	6
40	18	16	14	14	12	12	10	10	8	8	8	8	8	6	6	6	6	6	6
50	16	14	14	12	12	10	10	8	8	8	6	6	6	6	6	6	6	4	4
60	16	14	12	12	10	10	8	8	8	6	6	6	6	6	6	4	4	4	4
70	14	14	12	10	10	8	8	8	6	6	6	6	6	4	4	4	4	2	2
80	14	12	12	10	10	8	8	6	6	6	6	4	4	4	4	2	2	2	2
90	14	12	10	10	8	8	6	6	6	4	4	4	4	2	2	2	2	2	2
100	14	12	10	10	8	8	6	6	6	4	4	4	4	2	2	2	2	2	2

*Total current on circuit in amperage.

Table 8-5 General Wiring Colour Code

Colour	Use	
Green or green w/yellow stripe(s)	DC Grounding Conductors	
Black or Yellow	DC Negative Conductors	
Red	DC Positive Conductors	
Engine and Accessory Wiring Colour Code		
Colour	Item	Use
Yellow w/red strip (YR)	Starting circuit	Starting switch to solenoid
Brown/yellow stripe (BY) or Yellow (Y) – see note	Bilge blowers	Fuse or switch to blowers
Dark Gray (Gy)	Navigation lights	Fuse or switch to lights
	Tachometer	Tachometer sender to gauge
Brown (Br)	Generator armature	Generator armature to regulator
	Alternator charge light	Generator
		Terminal/Alternator
		Auxiliary terminal to light to regulator
	Pumps	Fuse or switch to pumps
Orange (O)	Accessory feed	Ammeter to alternator or generator output and accessory fuses or switches
		Distribution panel to accessory switch
Purple (Pu)	Ignition	Ignition switch to coil and electrical instruments
	Instrument feed	Distribution panel to electric instruments
Dark blue	Cabin and instrument lights	Fuse or switch to lights
Light blue (Lt Bl)	Oil pressure	Oil pressure sender to gauge
Tan	Water temperature	Water temperature sender to gauge
Pink (Pk)	Fuel gauge	Fuel gauge sender to gauge
Green/stripe (G/x)	Tilt down and/or trim in	Tilt and/or trim circuits
Except G/Y		
Blue/stripe (Bl/x)	Tilt up and/or trim out	Tilt and/or trim circuits

Note on Table 8-5

1. If yellow is used for DC negative, the bilge blower must be brown with yellow stripe.

- 8.7.4.11 Each conductor that is part of the electrical system, except for conductors integral with engines as supplied by their manufacturers, shall be clearly differentiated between AC and DC and identified as to its function in the system.
- 8.7.4.12 DC equipotential bonding conductors shall be identified by green or green with yellow stripe insulation, which shall not be used to indicate current carrying conductors, or may be uninsulated.
- 8.7.4.13 In situations where boxes must be located in wet locations, space surrounding the boxes or enclosures of at least 6 mm ($1/4$ in) shall be provided to prevent the accumulation of water.

8.7.5 Conductors – Termination

- 8.7.5.1 This subsection does not apply to communications systems and electronic navigation equipment.
- 8.7.5.2 Every connection to a screw terminal or stud that is outside a junction box or enclosure shall be connected by a closed-ring connector, eyelet connector, captive spade connector, mechanical locking connector, or spring locking connector.
- 8.7.5.3 Every stripped connector that is connected to a compression screw terminal that is outside a junction box or other enclosure shall be mechanically secured to avoid stress on the connection.
- 8.7.5.4 Every single friction connection, spring type connector, and multi-connector plug that is outside a junction box or enclosure shall be capable of withstanding a force of 27 N for one minute, applied along the axial direction of the conductor.
- 8.7.5.5 Subject to paragraph 8.7.5.6, a soldered connection that is outside a junction box or enclosure shall not be the sole means of connection between two or more conductors, or between a conductor and connector. If the connection is soldered, the connection shall be located or supported to limit the flexing of the conductor where the solder has changed the stranded flexible conductor to a solid conductor.
- 8.7.5.6 A conductor may be soldered to a connector that joins the conductor to a battery terminal or stud, provided that the length of the soldered joint is at least 1.5 times the diameter of the stranded portion of the battery conductor.
- 8.7.5.7 Every ungrounded terminal or stud that is continuously energized:
- (a) shall comply with paragraphs 8.7.3.1 and 8.7.3.2; or
 - (b) shall have a boot, nipple, cap, cover, or shield that prevents accidental short-circuiting at the terminal or stud.

- 8.7.5.8 Every termination that is composed of an ungrounded current carrying conductor, terminal fitting, and connector shall be protected from accidental short-circuiting with:
- (a) another termination from another circuit that is composed of an ungrounded current carrying conductor, terminal fitting, and connector; or
 - (b) any metal that is grounded.
- 8.7.5.9 No conductor shall be joined to another conductor by a twist-on wire nut, or wire screw.
- 8.7.5.10 Blade type friction connectors may be used provided:
- (a) the voltage drop from terminal to terminal does not exceed 50 mV for a 20-amp current flow; and
 - (b) the connection does not separate if subjected to a 27 N tensile force along the axial direction of the connector for one minute.
- 8.7.5.11 Terminal connectors of the ring or captive spade types shall be the same nominal size as the stud.
- 8.7.5.12 All connections shall be in locations protected from the weather or in weather tight enclosures.
- 8.7.5.12.1 Connections exposed to immersion shall be in watertight enclosures.
- 8.7.5.13 Metals used for terminal studs, nuts, or washers shall be corrosion resistant and galvanically compatible with the conductor and terminal. Aluminum and unplated steel shall not be used for studs, nuts, or washers in electrical circuits.
- 8.7.5.14 Mechanical and electrical joints shall be designed and installed to avoid damage to the conductors.
- 8.7.5.15 Setscrew connectors may be used provided the setscrew does not bear directly on the conductor strands.
- 8.7.5.16 Connectors of the crimp-on type shall be attached only by tools designed for the connector being used.
- 8.7.5.17 There shall not be more than four conductors connected to any one-stud terminal.
- 8.7.5.18 Where a conductor terminates at a switchboard, in a fixture, or in a junction box, a length of the conductor shall remain to provide strain relief at the terminal and allow for any future repairs.
- 8.7.5.19 Shanks of terminals shall be protected against accidental shorting except those employed for grounding lugs.
- 8.7.5.20 Harness-type wiring using multi-wire plugs and receptacles shall have cable clamps, molded connectors, insulation grips, or extended terminals to limit flexing at the connection point; the connectors where exposed to weather shall be weatherproof or watertight; each terminal shall be protected from accidental short-circuiting and the capacity shall meet or exceed the ampacity and temperature rating of the connecting conductors.

8.8 Receptacles

- 8.8.1 Receptacles and matching plugs used on DC systems shall not be interchangeable with those used on AC systems on the small vessel.
- 8.8.2 Receptacles installed in locations subject to rain, spray, or splash shall be protected by a cover with an effective weatherproof seal.
- 8.8.3 Receptacles, including connecting plugs, installed in areas subject to flooding or immersion shall be protected by an effective cover with a watertight seal.

8.9 Overcurrent Protection

8.9.1 General

- 8.9.1.1 This section does not apply to resistance conductors that control circuit amperage, conductors in secondary circuits of ignition systems, pigtails of less than 200 mm (8 in) of exposed length, and power supply conductors in cranking motor circuits.
- 8.9.1.2 Every ungrounded, current carrying conductor shall be protected by a manually reset, trip-free circuit breaker or fuse that shall be:
- (a) at the source of power for each conductor; or
 - (b) at the point where a conductor size is reduced to a smaller gauge; or
 - (c) at the origin of the circuit, if the circuit breaker or fuse has a current rating that prevents overloading of the smallest conductor in the circuit.
- 8.9.1.2.1 Overcurrent protection for each ungrounded conductor of a branch circuit shall be at the point of connection to panelboard or switchboard.
- 8.9.1.3 Except as provided in paragraph 8.9.1.4, the current rating of each circuit breaker or fuse shall not exceed the current rating of the smallest conductor in the circuit.
- 8.9.1.4 If the value specified in paragraph 8.9.1.3 does not correspond to a standard circuit breaker or fuse rating, the next larger rated circuit breaker or fuse may be used, provided it does not exceed 150% of the allowed current capacity of the conductor.
- 8.9.1.5 The voltage rating of each circuit breaker or fuse shall not be less than the nominal voltage of the circuit that it protects.

8.9.2 Special Applications

- 8.9.2.1 Every ungrounded supply conductor from a storage battery shall have a manually reset, trip-free circuit breaker or fuse, unless the supply conductor is in the main power feed circuit from the battery to an engine cranking motor.
- 8.9.2.2 The circuit breaker or fuse, as specified in paragraph 8.9.2.1 shall be within 1800 mm (5 ft 11 in) of the battery, as measured along the conductor, unless the circuit has a switch that disconnects the battery.

8.10 Panelboards

- 8.10.1 The front side of panelboards (i.e., switch and breaker operating face) shall be readily accessible, and the rear side (i.e., terminal and connection side) shall be accessible.
- 8.10.2 Panel boards shall be designed, constructed, and installed so that there are no exposed live parts accessible to the operator in the normal operating position.
- 8.10.3 Panel boards shall be weatherproof or protected from weather and splash.
- 8.10.4 Vessels equipped with both AC and DC electrical systems shall have their distribution from separate panel boards. If both systems share a common enclosure, it must have a partition or have other positive means provided to clearly separate the AC and DC sections from each other. Wiring diagrams to identify circuits, components, and conductors shall be included.
- 8.10.4.1 The switchboard or panel board shall be provided with clear permanent markings of the nominal voltage and types and provide circuit identification.

8.11 Non-Pleasure Craft Electrical Arrangements

8.11.1 Application

- 8.11.1.1 This section applies in respect of non-pleasure craft only.

8.11.2 Emergency Lighting for Non-Pleasure Craft Only

- 8.11.2.1 A system of emergency lighting shall be provided, to allow the passengers and crew to exit from any area of the vessel. The lighting units shall be of a self-contained type, rechargeable from the vessel's electrical distribution system, and fitted with a charge indicator. As an alternative to an emergency hard-wired lighting system, rechargeable or non-rechargeable portable hand lanterns of not less than the 6-V battery type may be provided. For those vessels with non-rechargeable lanterns, a spare battery shall be carried and batteries shall be replaced with new batteries annually.

8.11.3 Cables and Connectors

- 8.11.3.1 All cables shall have stranded copper conductors and a protective covering of either watertight metallic sheath or impervious non-metallic sheath that is compatible with the insulation and shall be rated for at least 75°C service. The cables shall be installed and terminated in accordance with subsections 8.7.4 and 8.7.5.
- 8.11.3.2 All connections shall be made in terminal or junction boxes providing mechanical and environmental protection.

8.12 Electrical Systems of 50 Volts or More – Pleasure Craft Only

8.12.1 Application

- 8.12.1.1 This subsection applies to pleasure craft only.
- 8.12.1.2 This subsection does not apply to:
- (a) communication systems;
 - (b) electronic navigation equipment;
 - (c) resistance conductors that control circuit amperage;
 - (d) conductors in secondary circuits of ignition systems; and
 - (e) pigtails of less than 200 mm (8 in) of exposed length.

8.12.2 General

- 8.12.2.1 Every permanently installed conductor in a circuit which has a nominal voltage of 50 V or more shall be not less than the nominal voltage of the system and shall:
- (a) (i) be covered with insulation classified as moisture resistant and flame retardant in accordance with the latest edition of the *Canadian Electrical Code*, Part I, or conform to the mechanical water absorption and flame retardant standards of Underwriters Laboratories UL 83, *Thermoplastic-Insulated Wires and Cables*, and
 - (ii) be of an oil resistant type when installed in engine spaces and bilge water areas; or
 - (b) conform to TP127 *Ship Electrical Standard*; or
 - (c) conform to the most recent edition of IEEE Standard 45, IEEE 1580; or
 - (d) be listed for marine use by an independent testing laboratory that provides listing, labeling, and follow-up service.

- 8.12.2.2 Where the nominal circuit voltage of each of three or more current carrying conductors in a duct, bundle, or cable is 50 V or more, the amperages of each of those conductors shall not exceed that listed in Table 8-2 multiplied by the correction factor in Note 2 of Table 8-2 for the applicable number of conductors.
- 8.12.2.3 The installation of the electrical equipment in systems of 50 V or over shall conform to Transport Canada *Marine Electrical Standards*, TP127, Part 1 or ABYC *Standard for Small Vessels* Chapter 8.

8.13 Conductors in Circuits of 50 Volts or More – Non-Pleasure Craft

- 8.13.1 Permanently installed electrical systems of 50 V or over shall conform to Transport Canada *Marine Electrical Standards*, TP127, Part 1, or ABYC *Standards for Small Craft*, Chapter 8.
- 8.13.2 All connections shall be made in terminal or junction boxes, which shall provide mechanical and environmental protection.