

E-11 AC and DC ELECTRICAL SYSTEMS ON BOATS *Based on ABYC's assessment of the existing technology, and the problems associated with achieving the goals of this standard, ABYC recommends compliance with this standard for all systems and associated equipment manufactured and/or installed after July 31, 2009.*

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11.4 DEFINITIONS

11.4.3 Battery cold cranking performance rating 0°F (-17.8°C) - The discharge load in amperes that a battery at 0°F (-17.8°C) can deliver for 30 seconds, and maintain a voltage of 1.2 volts per cell or higher, e.g., 7.2 volts for a 12 volt battery.

11.4.10 Equipment Leakage Circuit Interrupter (ELCI) - A residual current device which detects equipment ground fault leakage current and disconnects all ungrounded (110 V & 240V) and grounded (110 V neutral) current carrying conductors from the supply source at a preset trip threshold.

11.4.15 Ignition protection - The design and construction of a device such that under design operating conditions:

- a. it will not ignite a flammable hydrocarbon mixture surrounding the device when an ignition source causes an internal explosion, or
- b. it is incapable of releasing sufficient electrical or thermal energy to ignite a hydrocarbon mixture, or
- c. the source of ignition is hermetically sealed.

NOTES:

1. A flammable hydrocarbon mixture is a mixture of gasoline and air, CNG and air, or propane (LPG) and air between the lower explosive limit (LEL) and upper explosive limit (UEL).

2. It is not intended to require such devices to be "explosion proof" as that term is defined in the National Electrical Code of the NFPA pertaining to shore systems.

3. It is intended that the protection provided be generally equivalent to that of wiring permitted by this standard wherein a definite short or break would be necessary to produce an open spark.

4. Devices that are "explosion proof" are considered to be ignition protected when installed with the appropriate fittings to maintain their "explosion proof" integrity.

5. It is not intended to require such devices to be "intrinsically safe" per Article 504 of the National Electrical Code of the NFPA.

6. Devices that are "intrinsically safe" are considered to be ignition protected.

7. Test standards to determine ignition protection include SAE J1171, External Ignition Protection of Marine Electrical Devices, and UL 1500, Ignition Protection Test For Marine Products, and the electrical system requirements for boats in Title 33 CFR 183.410(a).

11.4.20 Polarized system AC - A system in which the grounded and ungrounded conductors are connected in the same relation to terminals or leads on devices in the circuit.

11.4.21 Polarized system DC - A system in which the grounded (negative) and ungrounded (positive) conductors are connected in the same relation to terminals or leads on devices in the circuit.

11.4.32 Weatherproof - Constructed or protected so that exposure to the weather will not interfere with successful operation under the test conditions specified in NEMA Standard 250, Type 3 or IEC Standard 60529 Type IP 54.

11.5.2.1 Marking of Controls - All switches and electrical controls shall be marked to indicate their usage.

EXCEPTION: A switch or electrical control whose purpose is obvious and whose mistaken operation will not cause a hazardous condition.

11.5.2.2 Marking of Equipment - Electrical equipment, except a part of an identified assembly, such as an engine, shall be marked or identified by the manufacturer to indicate:

11.5.2.2.7 Phase and frequency, if applicable, and

11.5.2.2.8 "Ignition Protected," if applicable. This shall be identified by a marking such as "SAE J1171 Marine," "UL Marine-Ignition Protected," or "Ignition Protected."

11.5.3.1 Potential electrical sources of ignition located in spaces containing gasoline powered machinery, or gasoline fuel tank(s), or joint fitting(s), or other connection(s) between components of a gasoline system, shall be ignition protected, unless the component is isolated from a gasoline fuel source as described in E-11.5.3.3 (See FIGURE 1, FIGURE 2, FIGURE 3, FIGURE 4, FIGURE 5, FIGURE 6, FIGURE 7, and FIGURE 8)

EXCEPTION:

1. Boats using diesel fuel as the only fuel source.

2. Outboard engines mounted externally or in compartments open to the atmosphere in accordance with the requirements of ABYC H-2, Ventilation of Boats Using Gasoline.

11.5.5.1 The system shall be polarized as defined in E-11.4

11.5.5.2 Grounded Neutral - A grounded neutral system is required. The neutral for AC power sources shall be grounded only at the following points:

11.5.5.2.3 The generator neutral shall be grounded at the generator. (See DIAGRAM 2 or DIAGRAM 4.)

11.5.5.6.1 Transfer of Power - The transfer of power to a circuit from one source to another shall be made by a means that opens all current-carrying conductors, including neutrals, before closing the alternate source circuit, to maintain isolation of power sources.

11.5.5.7 Power Source Disconnecting Means - A means for disconnecting all power sources from the load shall be provided at the same location.

11.6.1.1.1 The battery, or battery bank, shall have at least the cold cranking amperage required by the engine manufacturer.

11.6.3.1.1 Power Inlet - The receptacle, or receptacles, installed to receive a connecting cable to carry AC shore power aboard shall be a male type connector.

11.6.3.1.1.1 Power inlets installed in locations subject to rain, spray, or splash shall be weatherproof whether or not in use.

11.6.3.1.1.2 Power inlets installed in areas subject to flooding or momentary submersion shall be watertight whether or not in use.

11.6.3.1.1.3 Metallic power inlets installed on metallic or carbon fiber reinforced boats using an isolation transformer or a galvanic isolator shall be insulated from metallic structure and components. On non-metallic boats using an isolation transformer or a galvanic isolator the power inlet shall be insulated from metallic components connected to the boat's ground.

11.6.3.1.2 Shore Power Cable – On each boat equipped with an AC shore power system, a shore power cable that contains the conductors for the power circuit and a grounding (green) conductor shall be provided.

11.6.3.1.2.1 Except where the shore power cable is permanently connected to the boat, the boat end of this cable shall be terminated with a locking and grounding female type connector to match the boat power inlet. (See FIGURE 13 and FIGURE 14)

11.6.3.1.2.2 The shore power cable shall be flexible cord with the minimum properties of Type SOW, STW, STOW, SEOW, or STOOW, and shall be suitable for outdoor use. The shore connection end of this cable shall be fitted with a locking and grounding type plug with the required number of poles and shall comply with Article 555 of the National Electrical Code. (See FIGURE 13 and Table VII-A)

EXCEPTION: Pin and sleeve devices in accordance with FIGURE 14.

11.6.3.2 Shore Power Inlet Warning

11.6.3.2.1 Labels and warnings shall comply with ABYC T-5, Safety Signs and Labels.

11.6.3.2.2 Labels shall include the following informational elements:

11.6.3.2.2.1 the signal word for the level of hazard intensity;


11.6.3.2.2.2 nature of the hazard;

11.6.3.2.2.3 consequences that can result if the instructions to avoid the hazard are not followed; and

11.6.3.2.2.4 instructions on how to avoid the hazard.

11.6.3.2.3 A permanently mounted waterproof warning label shall be located at each shore power inlet location on the boat.

NOTE: An example of such a label follows:

 WARNING
Electrical shock and fire hazard. Failure to follow these instructions may result in injury or death.
(1) Turn off the boat's shore power connection switch before connecting or disconnecting the shore power cable.
(2) Connect shore power cable at the boat first.
(3) If polarity-warning indicator is activated, immediately disconnect cable.
(4) Disconnect shore power cable at shore outlet first.
(5) Close shore power inlet cover tightly.
DO NOT ALTER SHORE POWER CABLE CONNECTORS

EXCEPTIONS:

1. Item 3 is not required if a polarity indicator is not installed. (See E-11.6.3.3)

2. Items 2 and 4 are not required for permanently connected shore power cables.

11.6.3.3.1 Reverse polarity indicating devices providing a continuous visible or audible signal shall be installed in 120 V AC shore power systems and must respond to the reversal of the ungrounded (black) and the grounded (white) conductors (See E-11.17.1, DIAGRAM 3), if

11.7.1 Isolation Transformers – If used, an isolation transformer shall be of the encapsulated type and shall meet the requirements of UL 1561, *Dry Type General Purpose and Power Transformers* and the following additional requirements: (See E-11.17, DIAGRAM 6 and DIAGRAM 7.)

11.8 LOAD CALCULATIONS

11.8.1 FOR DC SYSTEMS

11.8.1.1 The following method shall be used for calculating the total electrical load requirements for determining the minimum size of each panelboard, switchboard, and their main conductors. Additionally this information may be used to size the alternator, or other charging means, and the battery. (See E-11.6.1.1 and ABYC E-10, Storage Batteries)

11.8.1.1.1 In column A of TABLE II, Electrical Load Requirement Worksheet, list the current rating (amps) of the loads that must be available for use on a continuous duty basis for normal operations;

11.8.1.1.2 In column B of TABLE II, list the current rating (amps) of the remaining loads that are intermittent, and total these loads. Take 10% of the total load in column B, or the current draw of the largest item, whichever is greater, and add this value to the total from column A to establish the total electrical load.

NOTE: Calculations are based on the actual operating amperage for each load, and not on the rating of the circuit breaker or fuse protecting that branch circuit.

TABLE II - ELECTRICAL LOAD REQUIREMENT WORKSHEET

A		B	
	AMPERES		AMPERES
Navigation Lights		Cigarette Lighter	
Bilge Blower(s)		Cabin Lighting	
Bilge Pump(s)		Horn	
Wiper(s)		Additional Electronic Equipment	
Largest Radio (Transmit Mode)		Trim Tabs	
Depth Sounder		Power Trim	
Radar		Toilets	
Searchlight		Anchor Windlass	
Instrument(s)		Winches	
Alarm System (standby mode)		Fresh Water Pump(s)	
Refrigerator			
Engine Electronics			
Total Column A		Total Column B	
		10% Column B	
		Largest Item in Column B	

Total Load Required

Total Column A _____

Total Column B _____ (The larger of 10% of Column B or the largest item)

Total Load _____

11.8.2 FOR AC SYSTEMS

11.8.2.1 Power Source Options – The method shown in E-11.8.2.2 shall be used for calculating the total electrical load requirements for determining the size of panelboards and their feeder conductors along with generator, inverter, and shore power capacities. The total power required shall be supplied by one of the following means:

11.8.2.1.1 Single Shore Power Cable - A shore power cable, power inlet, wiring, and components with a minimum capacity to supply the total load as calculated, complying with E-11.6.3.1.

11.8.2.1.2 Multiple Shore Power Cables - Multiple shore power cables, power inlets, wiring, and components shall have a minimum total capacity to supply the total load as calculated complying with E-

11.6.3.1. All sources need not be of equal capacity, but each power inlet shall be clearly marked to indicate voltage, ampacity, phase (if a three phase system is incorporated), and the load or selector switch that it serves.

11.8.2.1.3 On Board AC Generator(s) or Inverter(s) - On board AC generator(s) or inverter(s) to supply the total load as calculated. Total minimum installed Kva (kilovolt amperes) for a single phase system is as follows:

$$\text{kVA} = \frac{\text{Maximum Total Leg Amps. X System Voltage}}{1000}$$

11.8.2.1.4 Combination of Shore Power Cable(s), On-board Generator(s) and Inverter(s) - A combination of power sources, used simultaneously if the boat circuitry is arranged such that the load connected to each source is isolated from the other in accordance with E-11.5.5.6. Shore power cable(s) plus on-board generator(s) and inverter(s) capacity shall be at least as large as the total electrical load requirements calculated as per E-11.8.2.2 for each load group. Generator(s) and inverters(s) installation and switching shall be as required in E-11.6.4.

11.8.2.2 Load Calculations

11.8.2.2.1 The following is the method for load calculation to determine the minimum size of panelboards and their main feeder conductors as well as the size of the power source(s) supplying these devices. (See E-11.8.2.1.)

11.8.2.2.1.1 Lighting Fixtures and Receptacles - Length times width of living space (excludes spaces exclusively for machinery and open deck areas) times 2 watts per square foot (20 watts per square meter).

Formula:

$$\text{Length (feet) x width (feet) x 2} = \text{_____ lighting watts, or}$$

$$\text{Length (meters) x width (meters) x 20} = \text{_____ lighting watts.}$$

11.8.2.2.1.2 Small Appliances - Galley and Dinette Areas - Number of circuits times 1,500 watts for each 20 ampere appliance circuits.

Formula:

$$\text{Number of circuits x 1,500} = \text{_____ small appliance watts.}$$

11.8.2.2.1.3 Total Load

Formula:

$$\text{Lighting watts plus small appliance watts} = \text{_____ total watts.}$$

11.8.2.2.1.4 Load Factor

Formula:

First 2,000 total watts at 100% = _____.

Remaining total watts x 35% = _____.

Total watts divided by system voltage = _____ amperes.

11.8.2.2.2 If a shore power system is to operate on 240 volts, split and balance loads into Leg A and Leg B. If a shore power system is to operate on 120 volts, use Leg A only.

11.8.2.2.3 Add nameplate amperes for motor and heater loads:

LEG A	LEG B	
		Total Amperes
		Exhaust and supply fans
		Air conditioners*, **
		Electric, gas or oil heaters*
		25% of largest motor in above items
		Sub-total

NOTES:

* Omit smaller of these two, except include any motor common to both functions

** If system consists of three or more independent units adjust the total by multiplying by the 75% diversity factor

11.8.2.2.4 Add nameplate amperes at indicated use factor percentage for fixed loads:

LEG A	LEG B	
		Disposal -10%
		Water Heater - 100%
		Wall Mounted Ovens – 75%
		Cooking Units - 75%
		Refrigerator -100%
		Freezer – 100%
		Ice Maker - 50%
		Dishwasher - 25%
		Washing Machine – 25%
		Dryer - 25%
		Trash Compactor – 10%
		Air Compressor - 10%
		Battery Chargers – 100%
		Vacuum System - 10%
		Other Fixed Appliances
		Sub-Total
		**Adjusted Sub-Total

NOTE: **If four or more appliances are installed on a leg, adjust the sub-total of that leg by multiplying by 60% diversity factor.

11.8.2.2.5 Determine Total Loads

LEG A	LEG B	
		Lighting, receptacles, and small appliances (from <u>E-11.8.2.2.1.1</u> , <u>E-11.8.2.2.1.2</u>)
		Motors and heater loads (from <u>E-11.8.2.2.3</u>)
		Fixed appliances (from <u>E-11.8.2.2.4</u>)
		Free standing range (See NOTE 1)
		Calculated total amperes (load)
NOTES:		
<p>1. Add amperes for free standing range as distinguished from separate oven and cooking units. Derive by dividing watts from <u>TABLE III</u> by the supply voltage, e.g., 120 volts or 240 volts.</p> <p>2. If the total for Legs A and B are unequal, use the larger value to determine the total power required</p>		

11.10 **OVERCURRENT PROTECTION**

11.10.1 LOCATION OF OVERCURRENT PROTECTION – DC CIRCUITS

11.10.1.1.1 Overcurrent Protection Device Location - Ungrounded conductors shall be provided with overcurrent protection within a distance of seven inches (175mm) of the point at which the conductor is connected to the source of power measured along the conductor. (See FIGURE 15.)

EXCEPTIONS:

- 1. Cranking motor conductors.**
- 2. If the conductor is connected directly to the battery terminal and is contained throughout its entire distance in a sheath or enclosure such as a conduit, junction box, control box or enclosed panel, the overcurrent protection shall be placed as close as practicable to the battery, but not to exceed 72 inches (1.83m).**
- 3. If the conductor is connected to a source of power other than a battery terminal and is contained throughout its entire distance in a sheath or enclosure such as a conduit, junction box, control box or enclosed panel, the overcurrent protection shall be placed as close as practicable to the point of connection to the source of power, but not to exceed 40 inches (1.02m).**
- 4. Overcurrent protection is not required in conductors from self-limiting alternators with integral regulators if the conductor is less than 40 inches (1.02m), is connected to a source of power other than the battery, and is contained throughout its entire distance in a sheath or enclosure.**
- 5. Pigtails less than 7 inches (175mm) in length are exempt from overcurrent protection requirements.**

11.10.1.5 Circuit Breakers

11.10.1.5.1 Circuit breakers installed in spaces requiring ignition protection shall comply with SAE J1171, *External Ignition Protection of Marine Devices*, or UL 1500, *Ignition Protection Test for Marine Products*. If internal explosion tests are required, the ignition of the test gas shall be created at four times the current rating of the device being tested.

11.10.1.5.2 Circuit breakers shall

11.10.1.5.3 have a DC voltage rating of not less than the nominal system voltage, and

11.10.1.5.4 be of the trip-free type, and

11.10.1.5.5 be capable of an interrupting capacity according to TABLE IV-A, and remain operable after the fault, and

EXCEPTION: Integral overcurrent protection in electrical devices.

NOTES:

1. A fuse in series with, and ahead of the circuit breaker, may be used to comply with TABLE IV-A.

2. Consult the circuit breaker manufacturer to determine the fuse size and the type of fuse.

11.10.1.5.6 be of the manual reset type except as provided in E-11.10.1.7.

11.10.2 FOR AC SYSTEMS

1.10.2.1 Circuit breakers shall meet the requirements of UL 489, *Molded Case Circuit Protectors For Circuit Breaker Enclosures*, or UL 1077, *Supplementary Protectors For Use In Electrical Equipment*, and

11.10.2.1.1 shall be of the manually reset trip-free type, and-

11.10.2.1.2 shall be capable of an interrupting capacity in accordance with TABLE IV -B.

EXCEPTION: Integral overcurrent protection in electrical devices.

11.10.2.2 Rating of Overcurrent Protection Devices - Overcurrent protection devices shall have a temperature rating and demand load characteristics consistent with the protected circuit and their location in the boat, i.e. machinery space or other space. (See E-11.5.1.)

11.10.2.3 The current rating of the overcurrent protection device shall not exceed the maximum current carrying capacity of the conductor being protected. (See TABLE VI A-E)

EXCEPTION: If there is not a standard current rating of the overcurrent protection device equal to 100 percent of the allowable current for the conductor in TABLE IV-B, the next larger standard current rating may be used, provided it does not exceed 150 percent of the current allowed by TABLE VI or TABLE XII.

11.10.2.4 The AC voltage rating of the overcurrent protection device shall not be less than the nominal voltage of the supply circuit.

11.10.2.7.1 Generator circuit breaker ampere interrupting capacity (rms) shall be selected considering available transient short circuit current (first half cycle).

11.10.2.8.1 Each ungrounded current carrying conductor shall be protected by a circuit breaker or fuse.

11.10.2.8.3 Additional Overcurrent Protection - If the location of the main shore power disconnect circuit breaker is in excess of 10 feet (three meters) from the shore power inlet or the electrical attachment point of a permanently installed shore power cord, additional fuses or circuit breakers shall be provided within 10 feet (three meters) of the inlet or attachment point to the electrical system of the boat. Measurement is made along the conductors.

11.10.2.8.3.1 If fuses are used in addition to the main shore power disconnect circuit breaker, their rating

shall be such that the circuit breakers trip before the fuses open the circuit, in the event of overload. The ampere rating of the additional fuses or circuit breaker shall not be greater than 125% of the rating of the main shore power disconnect circuit breaker. For 120-volt service, both the grounded and ungrounded current carrying conductors shall be provided with this additional overcurrent protection.

11.10.2.8.4 If required, overcurrent protection for power-feeder conductors from AC generators and inverters, shall be within seven inches (180 mm) of the output connections or may be within 40 inches (1.0 meter) of the output connections if the unprotected insulated conductors are contained throughout their entire distance in a sheath or enclosure such as a conduit, junction box or enclosed panel.

11.11.1.1 This device shall meet the requirements of UL 1053 and the requirements of UL 943 with the exception of trip level and trip time. Trip level shall be set at a maximum of 30mA. The trip time shall be set at a maximum of 100ms.

NOTE: Trip levels of less than 30ma and times of less than 100ms may result in nuisance trips in certain environments.

11.14.1.1 Minimum surface marking of the individual conductors and their jackets shall include:

- 11.14.1.1.1 type/style,
- 11.14.1.1.2 voltage,
- 11.14.1.1.3 wire size, and
- 11.14.1.1.4 temperature rating, dry.

EXCEPTION: Flexible cords in Table VII-A and B

11.14.1.2 Conductors shall be at least 16 AWG.

11.14.1.3 In engine spaces the conductor insulation shall be oil resistant and have a temperature rating of at least 167°F (75°C) dry.

11.14.2.1 Conductors and flexible cords shall have a minimum rating of 50 volts.

11.14.2.1.1 The construction of insulated cables and conductors shall conform with the requirements of:

- 11.14.2.1.1.1 UL 1426, *Cables for Boats*, or
- 11.14.2.1.1.2 the insulating material temperature rating requirements of:
- 11.14.2.1.1.3 SAE J378, *Marine Engine Wiring*, and
- 11.14.2.1.1.4 SAE J1127, *Battery Cable*, or SAE J1128, *Low-Tension Primary Cable*.

11.14.2.2 Conductors may be selected from the types listed in TABLE V, Table VII and TABLE VIII. The temperature ratings shown contemplate the routing of wires above bilge water in locations protected from dripping, exposures to weather, spray, and oil.

11.14.2.3 Flexible cords shall conform with the National Electrical Code, and shall be selected from the types listed in TABLE VII.

11.14.2.4 Conductors and flexible cords shall be stranded copper according to TABLE XI.

11.14.2.5 Conductors used for panelboard or switchboard main feeders shall have ampacities as determined in E-11.8.1.1. Conductors used for branch circuits or in electrical systems that do not use a panelboard or switchboard shall have their ampacities determined by their loads (See TABLE II)

11.14.2.6 Voltage Drop - Conductors used for panelboard or switchboard main feeders, bilge blowers, electronic equipment, navigation lights, and other circuits where voltage drop must be kept to a minimum, shall be sized for a voltage drop not to exceed three percent. Conductors used for lighting, other than navigation lights, and other circuits where voltage drop is not critical, shall be sized for a voltage drop not to exceed 10 percent.

11.14.2.7 Conductor Size - To determine conductor size and insulation temperature rating, use the ampacity as specified in E-11.14.2.5 in conjunction with TABLE VI. Then use TABLE IX or TABLE X to check the conductor size for compliance with the maximum allowable voltage drop specified in E-11.14.2.6. In the event of a conflict between the ampacity table and the voltage drop tables, the larger conductor size shall be used.

11.14.2.7.1 To use TABLE IX and TABLE X, measure the length of the conductor from the positive power source connection to the electrical device and back to the negative power source connection. Use the conductor length, the system voltage, and the ampacity as specified in E-11.14.2.5, in conjunction with the appropriate volt drop table, i.e., three percent or 10 percent – TABLE IX or TABLE X, to determine conductor size.

NOTES:

1. The power source connection may be the battery, or a panelboard or switchboard, if used.

2. If the ampacity as specified in E-11.14.2.5 exceeds the ampacities in TABLE IX and TABLE X, the conductor size necessary to keep voltage drop below the maximum permitted level may be calculated by means of the following formula:

$$CM = \frac{K \times I \times L}{E}$$

Where:

CM = Circular mil area of conductor.
K = 10.75 (constant representing the resistivity of copper)
I = Load current in amperes
L = Length of conductor from the positive power source connection to the electrical device and back to the negative power source connection, measured in feet.
E = Maximum allowable voltage drop at load in volts (e.g., for a three percent voltage drop at nominal 12V, $E = 0.03 \times 12 = 0.36$; for a 10 percent voltage drop at nominal 12V, $E = 1.2$).

3. Use TABLE XI or TABLE XII to convert circular mils (cm) to conductor gauge. If the cm area falls between two gauge sizes, the larger conductor shall be used.

11.14.3.1 Conductors shall have a minimum rating of 600 volts.

11.14.3.2 Flexible cords shall have a minimum rating of 300 volts.

11.14.3.3 The temperature rating of conductors and flexible cords shall be at least 140°F (60°C) dry.

11.14.3.4 All conductors and flexible cords shall meet the flame retardant and moisture resistant requirements of UL 83, *Thermoplastic-Insulated Wires and Cables*.

11.14.3.5 All conductors and flexible cords shall meet the requirements of the applicable standards of Underwriters Laboratories Inc.

11.14.3.6 Conductors and flexible cords shall be stranded copper according to TABLE XI.

NOTE: Some currently available wire types that meet all of the above requirements are listed in Table VIII.

11.14.3.7 Conductors and flexible cords shall be of size according to TABLE VI and TABLE XII

11.14.3.7.1 Where single conductors or multi-conductor cables are bundled for a distance greater than 24 inches (610 mm), the allowable ampacity of each conductor shall be reduced as shown in TABLE VI and TABLE XII.

NOTE: When determining the allowable amperage of bundled conductors using TABLE VI and TABLE XIII, the AC grounding conductor and a neutral conductor that carries only the unbalanced current from other conductors are not considered to be current carrying conductors.

11.14.3.7.2 The AC grounding conductor shall be permitted to be one size smaller than the current carrying conductors on circuits rated greater than 30 amperes.

11.17.4 Isolation Transformer System with a Single Phase 120-Volt Input, 120-Volt Output with Boat Grounded Secondary. Transformer Shield Grounded On the Shore. Transformer Metal Case Grounded on the Boat. (See DIAGRAM 6.)

11.17.4.1 The shore grounded (white) and ungrounded shore current carrying conductors are connected from the shore power inlet to the primary winding of the isolation transformer through an overcurrent protection device that simultaneously opens both current carrying shore conductors. Fuses shall not be used instead of the simultaneous trip devices. (See E-11.10.2.8.2.)

11.17.4.1.1 The shore grounding (green) conductor is connected, without interposing switches or overcurrent protection devices (See E-11.5.5.5), from the shore power inlet to the isolation transformer shield.

11.17.4.2 The shell of a metallic shore power inlet shall be electrically insulated from the boat.

11.17.4.3 The secondary of the isolation transformer is grounded (polarized) on the boat. (See E-11.5.5.2.2 and (E-11.5.5.2.3 EXCEPTION.)

11.17.4.4 The boat grounding (green) conductor is connected, without interposing switches or overcurrent protection devices (See E-11.5.5.5), from

11.17.4.4.1 the transformer grounded secondary terminal,

11.17.4.4.2 the transformer metal case, and

11.17.4.4.3 to all non-current-carrying parts of the boat's AC electrical system, including

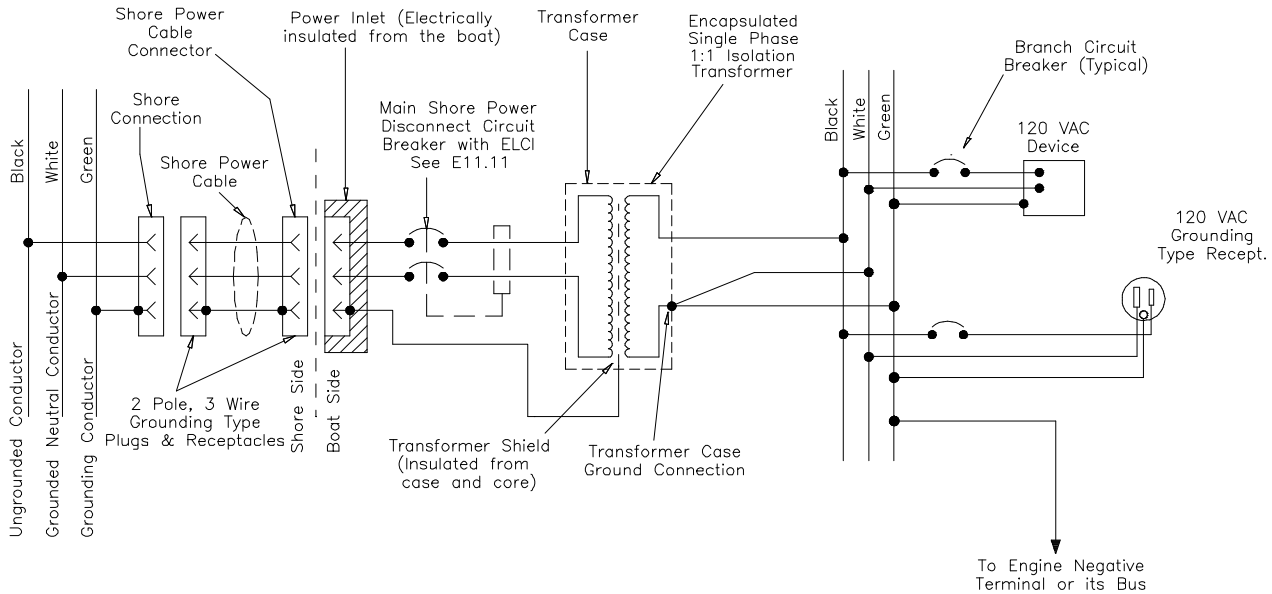
11.17.4.4.4 the engine negative terminal or its bus.

11.17.4.5 If the boat's AC electrical system includes branch circuit breakers, the branch circuit breakers shall simultaneously open both current carrying conductors unless a polarity indicating device is provided. (See E-11.10.2.6.1 EXCEPTION.)

11.17.4.6 Polarization of conductors must be observed in all circuits.

DIAGRAM 6 – (See E-11.17.4.)

Isolation Transformer System with a Single Phase 120-Volt Input, 120-Volt Output with Boat Grounded Secondary. Transformer Shield Grounded On the Shore. Transformer Metal Case Grounded on the Boat.
Note: This diagram does not illustrate a complete system. Refer to appropriate text.



11.17.5 Isolation Transformer System with Single Phase 240 Volt Input, 120/240-Volt Output with Boat Grounded Secondary. Transformer Shield Grounded on the Shore. Transformer Metal Case Grounded on the Boat. (See [DIAGRAM 7.](#))

11.17.5.1 Each ungrounded shore current carrying conductor is connected from the shore power inlet to the primary winding of the isolation transformer through an overcurrent protection device that simultaneously opens both current carrying shore conductors. Fuses shall not be used instead of simultaneous trip devices. (See [E-11.10.2.8.2.](#))

11.17.5.2 The shore grounded (white) terminal of the shore power inlet is not connected on the boat.

11.17.5.3 The shore grounding (green) conductor is connected, without interposing switches or overcurrent protection devices (See [E-5.5.5](#)), from the shore power inlet to the transformer shield.

11.17.5.4 The shell of a metallic shore power inlet shall be electrically insulated from the boat.

11.17.5.5 The secondary of the isolation transformer is grounded (polarized) on the boat. (See [E-11.5.5.2.2](#) and [E-11.5.5.2.3](#) **EXCEPTION.**)

11.17.5.6 The boat grounding (green) conductor is connected, without interposing switches or overcurrent protection devices (See [E-11.5.5.5](#)), from

11.17.5.6.1 the transformer grounded secondary terminal,

11.17.5.6.2 the transformer metal case, and

11.17.5.6.3 to all non-current carrying parts of the boat's AC electrical system, including

11.17.5.6.4 the engine negative terminal or its bus.

11.17.5.7 If the boat's AC electrical system includes branch circuit breakers, the branch circuit breakers shall simultaneously open both current carrying conductors unless a polarity indicating device is provided. (See [E-11.10.2.6.1](#) **EXCEPTION.**)

11.17.5.8 240-volt branch circuit breakers shall simultaneously open all current-carrying conductors. (See E-11.10.2.6.2)

11.17.5.9 Polarization of conductors must be observed in all circuits.

DIAGRAM 7 – (See E-11.17.5.)

Isolation Transformer System with Single Phase 240 Volt Input, 120/240-Volt Output with Boat Grounded Secondary. Transformer Shield Grounded on the Shore. Transformer Metal Case Grounded on the Boat.

Note: This diagram does not illustrate a complete system. Refer to appropriate text.

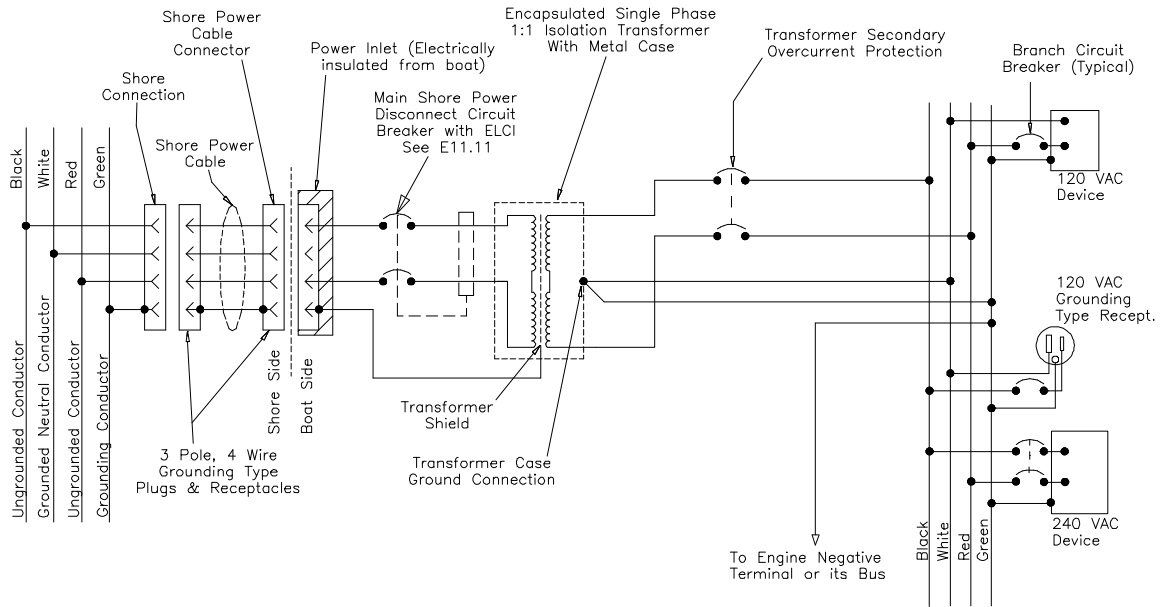
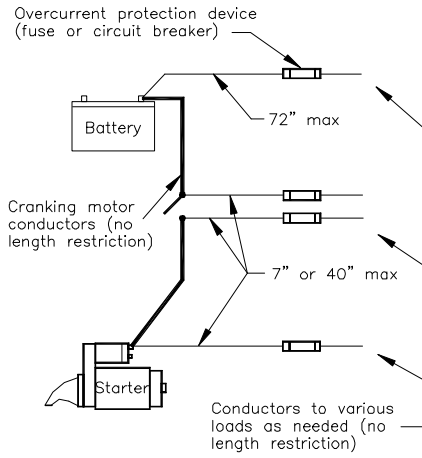


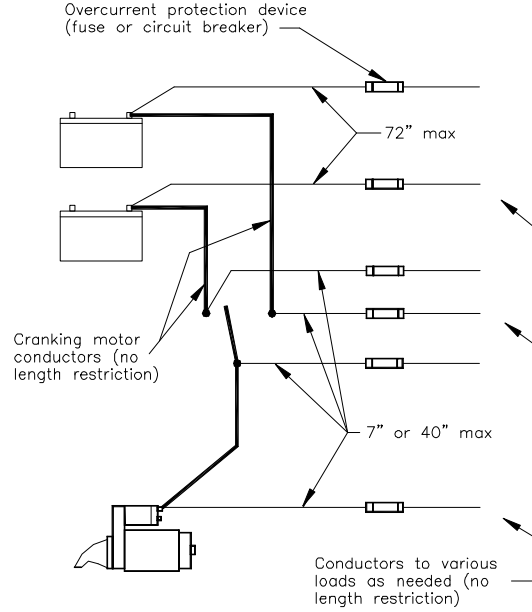
FIGURE 15 – BATTERY SUPPLY CIRCUITS – LOCATION OF OVERCURRENT DEVICES

NOTE: Up to 40 inches (1.02m) is allowed if the conductor throughout this distance is contained in a sheath or enclosure, such as a junction box, control box, or enclosed panel.

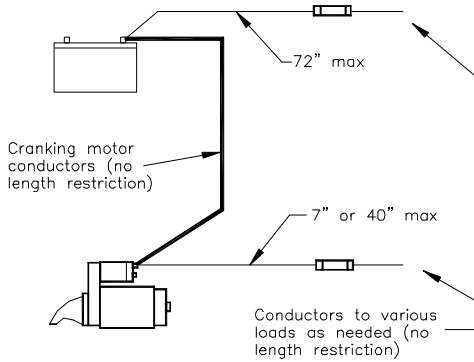
SINGLE BATTERY
(See E-11.10)



DUAL BATTERY
(See E-11.10)



NO BATTERY SWITCH
(See E-11.10)



NO STARTER CIRCUIT
(See E-11.10)

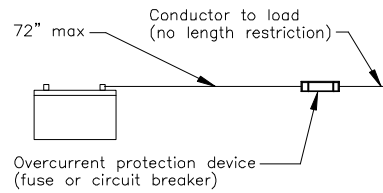


TABLE III – FREE STANDING RANGE RATINGS

NAMEPLATE RATING (WATTS)	USE (WATTS)
10,000 or less	80% of rating
10,001 – 12,500	8,000
12,501 – 13,500	8,400
13,501 – 14,500	8,800
14,501 – 15,500	9,200
15,501 – 16,500	9,600
16,501 – 17,500	10,000

NOTE: Ratings are for free standing ranges as distinguished from separate oven and cooking units.

TABLE IV - A – CIRCUIT BREAKER MINIMUM AMPERE INTERRUPTING CAPACITY FOR SYSTEMS UNDER 50 VOLTS

		Ampere Interrupting Capacity (AIC) (amperage available at circuit breaker terminals)	
		Total Connected Battery (Cold Cranking Amperes)	
			Main Circuit Breaker (Amperes) *See Note
			Branch Circuit Breaker (Amperes) *See Note
12 Volts and 24 Volts	650 or less	1500	750
	651-1100	3000	1500
32 Volts	over 1100	5000	2500
	1250 or less	3000	1500
	over 1250	5000	2500

***NOTE:** The main circuit breaker(s) shall be considered to be the first breaker(s) in a circuit connected in series with the battery. All subsequent breakers, including sub-main breakers, connected in series with a main circuit breaker shall be considered to be “branch circuit breakers.” (See FIGURE 16.)

TABLE IV - B – CIRCUIT BREAKER INTERRUPTING CAPACITY FOR SYSTEM OVER 50 VOLT

SHORE POWER SOURCE	MAIN SHORE POWER DISCONNECT CIRCUIT BREAKER	BRANCH BREAKER
120V – 30A	3000	3000
120V – 50A	3000	3000
120/240V – 50A	5000	3000
240V – 50A	5000	3000
120/208V – 3 phase/WYE – 30A	5000	3000
120/240V – 100A	5000	3000
120/208V – 3 phase/WYE – 100A	5000	3000

NOTES:

1. The main circuit breaker shall be considered to be the first circuit breaker connected to a source of AC power. All subsequent breakers, including sub-main breakers connected in series with a main circuit breaker, shall be considered to be branch circuit breakers.

2. A fuse in series with, and ahead of, a circuit breaker may be required by the circuit breaker manufacturer to achieve the interrupting capacity in TABLE IV - A and TABLE IV – B.

TABLE V – SAE CONDUCTORS

SAE CONDUCTORS		
TYPE	DESCRIPTION	AVAILABLE INSULATION TEMPERATURE RATING PER SAE J378
GPT	Thermoplastic Insulation, Braidless	60° C (140° F), 90° C (194° F), 105° C (221° F)
HDT	Thermoplastic Insulation, Braidless	60° C (140° F), 90° C (194° F), 105° C (221° F)
SGT	Thermoplastic Insulation, Braidless	60° C (140° F), 90° C (194° F), 105° C (221° F)
STS	Thermosetting Synthetic Rubber Insulation, Braidless	85° C (185° F), 90° C (194° F)
HTS	Thermosetting Synthetic Rubber Insulation, Braidless	85° C (185° F), 90° C (194° F)
SXL	Thermosetting Cross Linked Polyethylene Insulation, Braidless	125° C (257° F)

TABLE VI – A - AC & DC CIRCUITS– ALLOWABLE AMPERAGE OF SINGLE CONDUCTORS NOT BUNDLED, SHEATHED, OR IN CONDUIT

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)		125°C (257°F)		200°C (392°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	OUTSIDE ENGINE SPACES	INSIDE ENGINE SPACES	OUTSIDE OR INSIDE ENGINE SPACES
18	10	NOT PERMITTED	10	7.5	15	11.7	20	16.4	20	17.0	25	22.3	25
16	15		15	11.3	20	15.6	25	20.5	25	21.3	30	26.7	35
14	20		20	15.0	25	19.5	30	24.6	35	29.8	40	35.6	45
12	25		25	18.8	35	27.3	40	32.8	45	38.3	50	44.5	55
10	40		40	30.0	50	39.0	55	45.1	60	51.0	70	62.3	70
8	55		65	48.8	70	54.6	70	57.4	80	68.0	90	80.1	100
6	80		95	71.3	100	78.0	100	82.0	120	102.0	125	111.3	135
4	105		125	93.8	130	101.4	135	110.7	160	136.0	170	151.3	180
3	120		145	108.8	150	117.0	155	127.1	180	153.0	195	173.6	210
2	140		170	127.5	175	136.5	180	147.6	210	178.5	225	200.3	240
1	165		195	146.3	210	163.8	210	172.2	245	208.3	265	235.9	280
0	195		230	172.5	245	191.1	245	200.9	285	242.3	305	271.5	325
00	225		265	198.8	285	222.3	285	233.7	330	280.5	355	316.0	370
000	260		310	232.5	330	257.4	330	270.6	385	327.3	410	364.9	430
0000	300		360	270.0	385	300.3	385	315.7	445	378.3	475	422.8	510

NOTE: For DC, cross reference with voltage drop tables and formula in E-Error! Reference source not found., Note 2.

TABLE VI – B - AC & DC CIRCUITS – ALLOWABLE AMPERAGE OF CONDUCTORS WHEN UP TO THREE CURRENT CARRYING CONDUCTORS ARE BUNDLED, SHEATHED OR IN CONDUIT

		TEMPERATURE RATING OF CONDUCTOR INSULATION											
SIZE CONDUCTOR (AWG)	60°C (140°F)		75°C (167°F)		80°C (176°F)		90°C (194°F)		105°C (221°F)		125°C (257°F)		200°C (392°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	OUTSIDE ENGINE SPACES	INSIDE ENGINE SPACES	OUTSIDE OR INSIDE ENGINE SPACES
18	7.0	NOT PERMITTED	7.0	5.3	10.5	8.2	14.0	11.5	14.0	11.9	17.5	15.6	17.5
16	10.5		10.5	7.9	14.0	10.9	17.5	14.4	17.5	14.9	21.0	18.7	24.5
14	14.0		14.0	10.5	17.5	13.7	21.0	17.2	24.5	20.8	28.0	24.9	31.5
12	17.5		17.5	13.1	24.5	19.1	28.0	23.0	31.5	26.8	35.0	31.2	38.5
10	28.0		28.0	21.0	35.0	27.3	38.5	31.6	42.0	35.7	49.0	43.6	49.0
8	38.5		45.5	34.1	49.0	38.2	49.0	40.2	56.0	47.6	63.0	56.1	70.0
6	56.0		66.5	49.9	70.0	54.6	70.0	57.4	84.0	71.4	87.5	77.9	94.5
4	73.5		87.5	65.6	91.0	71.0	94.5	77.5	112.0	95.2	119.0	105.9	126.0
3	84.0		101.5	76.1	105.0	81.9	108.5	89.0	126.0	107.1	136.5	121.5	147.0
2	98.0		119.0	89.3	122.5	95.6	126.0	103.3	147.0	125.0	157.5	140.2	168.0
1	115.5		136.5	102.4	147.0	114.7	147.0	120.5	171.5	145.8	185.5	165.1	196.0
0	136.5		161.0	120.8	171.5	133.8	171.5	140.6	199.5	169.6	213.5	190.0	227.5
00	157.5		185.5	139.1	199.5	155.6	199.5	163.6	231.0	196.4	248.5	221.2	259.0
000	182.0		217.0	162.8	231.0	180.2	231.0	189.4	269.5	229.1	287.0	255.4	301.0
0000	210.0		252.0	189.0	269.5	210.2	269.5	221.0	311.5	264.8	332.5	295.9	357.0

TABLE VI – C - AC CIRCUITS – ALLOWABLE AMPERAGE OF CONDUCTORS WHEN FOUR TO SIX CURRENT CARRYING CONDUCTORS ARE BUNDLED

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)		125°C (257°F)		200°C (392°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	OUTSIDE ENGINE SPACES	INSIDE ENGINE SPACES	OUTSIDE OR INSIDE ENGINE SPACES
18	6.0	NOT PERMITTED	6.0	4.5	9.0	7.0	12.0	9.8	12.0	10.2	15.0	13.4	15.0
16	9.0		9.0	6.8	12.0	9.4	15.0	12.3	15.0	12.8	18.0	16.0	21.0
14	12.0		12.0	9.0	15.0	11.7	18.0	14.8	21.0	17.9	24.0	21.4	27.0
12	15.0		15.0	11.3	21.0	16.4	24.0	19.7	27.0	23.0	30.0	26.7	33.0
10	24.0		24.0	18.0	30.0	23.4	33.0	27.1	36.0	30.6	42.0	37.4	42.0
8	33.0		39.0	29.3	42.0	32.8	42.0	34.4	48.0	40.8	54.0	48.1	60.0
6	48.0		57.0	42.8	60.0	46.8	60.0	49.2	72.0	61.2	75.0	66.8	81.0
4	63.0		75.0	56.3	78.0	60.8	81.0	66.4	96.0	81.6	102.0	90.8	108.0
3	72.0		87.0	65.3	90.0	70.2	93.0	76.3	108.0	91.8	117.0	104.1	126.0
2	84.0		102.0	76.5	105.0	81.9	108.0	88.6	126.0	107.1	135.0	120.2	144.0
1	99.0		117.0	87.8	126.0	98.3	126.0	103.3	147.0	125.0	159.0	141.5	168.0
0	117.0		138.0	103.5	147.0	114.7	147.0	120.5	171.0	145.4	183.0	162.9	195.0
00	135.0		159.0	119.3	171.0	133.4	171.0	140.2	198.0	168.3	213.0	189.6	222.0
000	156.0		186.0	139.5	198.0	154.4	198.0	162.4	231.0	196.4	246.0	218.9	258.0
0000	180.0		216.0	162.0	231.0	180.2	231.0	189.4	267.0	227.0	285.0	253.7	306.0

TABLE VI – D - AC CIRCUITS – ALLOWABLE AMPERAGE OF CONDUCTORS WHEN 7 TO 24 CURRENT CARRYING CONDUCTORS ARE BUNDLED

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)		125°C (257°F)		200°C (392°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	OUTSIDE ENGINE SPACES	INSIDE ENGINE SPACES	OUTSIDE OR INSIDE ENGINE SPACES
18	5.0	NOT PERMITTED	5.0	3.8	7.5	5.9	10.0	8.2	10.0	8.5	12.5	11.1	12.5
16	7.5		7.5	5.6	10.0	7.8	12.5	10.3	12.5	10.6	15.0	13.4	17.5
14	10.0		10.0	7.5	12.5	9.8	15.0	12.3	17.5	14.9	20.0	17.8	22.5
12	12.5		12.5	9.4	17.5	13.7	20.0	16.4	22.5	19.1	25.0	22.3	27.5
10	20.0		20.0	15.0	25.0	19.5	27.5	22.6	30.0	25.5	35.0	31.2	35.0
8	27.5		32.5	24.4	35.0	27.3	35.0	28.7	40.0	34.0	45.0	40.1	50.0
6	40.0		47.5	35.6	50.0	39.0	50.0	41.0	60.0	51.0	62.5	55.6	67.5
4	52.5		62.5	46.9	65.0	50.7	67.5	55.4	80.0	68.0	85.0	75.7	90.0
3	60.0		72.5	54.4	75.0	58.5	77.5	63.6	90.0	76.5	97.5	86.8	105.0
2	70.0		85.0	63.8	87.5	68.3	90.0	73.8	105.0	89.3	112.5	100.1	120.0
1	82.5		97.5	73.1	105.0	81.9	105.0	86.1	122.5	104.1	132.5	117.9	140.0
0	97.5		115.0	86.3	122.5	95.6	122.5	100.5	142.5	121.1	152.5	135.7	162.5
00	112.5		132.5	99.4	142.5	111.2	142.5	116.9	165.0	140.3	177.5	158.0	185.0
000	130.0		155.0	116.3	165.0	128.7	165.0	135.3	192.5	163.6	205.0	182.5	215.0
0000	150.0	180.0	135.0	192.5	150.2	192.5	157.9	222.5	189.1	237.5	211.4	255.0	

TABLE VI – E - AC CIRCUITS - ALLOWABLE AMPERAGE OF CONDUCTORS WHEN 25 OR MORE CURRENT CARRYING CONDUCTORS ARE BUNDLED

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)		125°C (257°F)		200°C (392°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	OUTSIDE ENGINE SPACES	INSIDE ENGINE SPACES	OUTSIDE OR INSIDE ENGINE SPACES
18	4.0	NOT PERMITTED	4.0	3.0	6.0	4.7	8.0	6.6	8.0	6.8	10.0	8.9	10.0
16	6.0		6.0	4.5	8.0	6.2	10.0	8.2	10.0	8.5	12.0	10.7	14.0
14	8.0		8.0	6.0	10.0	7.8	12.0	9.8	14.0	11.9	16.0	14.2	18.0
12	10.0		10.0	7.5	14.0	10.9	16.0	13.1	18.0	15.3	20.0	17.8	22.0
10	16.0		16.0	12.0	20.0	15.6	22.0	18.0	24.0	20.4	28.0	24.9	28.0
8	22.0		26.0	19.5	28.0	21.8	28.0	23.0	32.0	27.2	36.0	32.0	40.0
6	32.0		38.0	28.5	40.0	31.2	40.0	32.8	48.0	40.8	50.0	44.5	54.0
4	42.0		50.0	37.5	52.0	40.6	54.0	44.3	64.0	54.4	68.0	60.5	72.0
3	48.0		58.0	43.5	60.0	46.8	62.0	50.8	72.0	61.2	78.0	69.4	84.0
2	56.0		68.0	51.0	70.0	54.6	72.0	59.0	84.0	71.4	90.0	80.1	96.0
1	66.0		78.0	58.5	84.0	65.5	84.0	68.9	98.0	83.3	106.0	94.3	112.0
0	78.0		92.0	69.0	98.0	76.4	98.0	80.4	114.0	96.9	122.0	108.6	130.0
00	90.0		106.0	79.5	114.0	88.9	114.0	93.5	132.0	112.2	142.0	126.4	148.0
000	104.0		124.0	93.0	132.0	103.0	132.0	108.2	154.0	130.9	164.0	146.0	172.0
0000	120.0	144.0	108.0	154.0	120.1	154.0	126.3	178.0	151.3	190.0	169.1	204.0	

TABLE VII - FLEXIBLE CORDS

Table VII-A

FLEXIBLE CORDS		
TYPE	DESCRIPTION	AVAILABLE INSULATION TEMPERATURE RATING
SO, SOW	Hard Service Cord, Oil Resistant Compound	60°C (140° F), 75°C (167°F) & higher
ST, STW	Hard Service Cord, Thermoplastic	60°C (140° F), 75°C (167°F) & higher
STO, STOW, SEO, SEOW	Hard Service Cord, Oil Resistant Thermoplastic	60°C (140° F), 75°C (167°F) & higher
SJO, SJOW	Junior Hard Service Cord, Oil Resistant Compound	60°C (140°F), 75°C (167°F) & higher
SJT, SJTW	Junior Hard Service Cord, Thermoplastic	60°C (140°F), 75°C (167°F) & higher
SJTO, SJTOW	Junior Hard Service Cord, Oil Resistant Thermoplastic	60°C (140°F), 75°C (167°F) & higher

TABLE IX – CONDUCTORS SIZED FOR 3 PERCENT DROP IN VOLTAGE

NOTE: *In the event of a conflict between the voltage drop table and the ampacity table, use the larger wire size.*

Length of Conductor from Source of Current to Device and Back to Source - Feet																			
TOTAL CURRENT ON CIRCUIT IN AMPS	10	15	20	25	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170
	<u>12 Volts - 3% Drop Wire Sizes (gauge)</u>										<u>Based on Minimum CM Area</u>								
5	18	16	14	12	12	10	10	10	8	8	8	6	6	6	6	6	6	6	6
10	14	12	10	10	10	8	6	6	6	6	4	4	4	4	2	2	2	2	2
15	12	10	10	8	8	6	6	6	4	4	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	2	1	1	0	0	0	2/0	2/0	2/0	3/0
30	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
40	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	4/0
50	6	6	4	4	2	2	1	0	2/0	2/0	3/0	3/0	4/0	4/0	4/0				
60	6	4	4	2	2	1	0	2/0	3/0	3/0	4/0	4/0	4/0						
70	6	4	2	2	1	0	2/0	3/0	3/0	4/0	4/0								
80	6	4	2	2	1	0	3/0	3/0	4/0	4/0									
90	4	2	2	1	0	2/0	3/0	4/0	4/0										
100	4	2	2	1	0	2/0	3/0	4/0											
<u>24 Volts - 3% Drop Wire Sizes (gauge)</u>										<u>Based on Minimum CM Area</u>									
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	4	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	3/0
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	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				

Length of Conductor from Source of Current to Device and Back to Source - Feet

TOTAL CURRENT ON CIRCUIT IN AMPS	10	15	20	25	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170
	32 Volts - 3% Drop Wire Sizes (gauge)										Based on Minimum CM Area								
5	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	14	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	12	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	10	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	8	8	6	6	4	4	2	2	2	2	1	1	0	0	0	2/0	2/0	2/0
70	10	8	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	6	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

TABLE X - CONDUCTORS SIZES FOR 10 PERCENT VOLTAGE DROP

NOTE: In the event of a conflict between the voltage drop table and the ampacity table, use the larger wire size.

Length of Conductor from Source of Current to Device and Back to Source - Feet

TOTAL CURRENT ON CIRCUIT IN AMPS	10	15	20	25	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170
	12 Volts - 10% Drop Wire Sizes (gauge)										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	4	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 CURRENT ON CIRCUIT IN AMPS	24 Volts - 10% Drop Wire Sizes (gauge)										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
0	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	8	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	4	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	1	1	1	
100	12	10	10	8	8	6	6	4	4	4	2	2	2	2	2	1	1	1	1	

Length of Conductor from Source of Current to Device and Back to Source - Feet

TOTAL CURRENT ON CIRCUIT IN AMPS	10	15	20	25	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170
	32 Volts - 10% Drop Wire Sizes (gauge)										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	14	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	10	8	6	6	6	6	4	4	4	4	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

TABLE XI - CONDUCTOR CIRCULAR MIL (CM) AREA AND STRANDING

CONDUCTOR GAUGE	NOMINAL ACCEPTABLE CM AREA AWG	NOMINAL ACCEPTABLE CM AREA SAE	NOMINAL NUMBER OF STRANDS		
			TYPE 1*	TYPE 2**	TYPE 3***
18	1,620	1,537	-	16	-
16	2,580	2,336	-	19	26
14	4,110	3,702	-	19	41
12	6,530	5,833	-	19	65
10	10,380	9,343	-	19	105
8	16,510	14,810	-	19	168
6	26,240	24,538	-	37	266
4	41,740	37,360	-	49	420
2	66,360	62,450	-	127	665
1	83,690	77,790	-	127	836
0	105,600	98,980	-	127	1064
00	133,100	125,100	-	127	1323
000	167,800	158,600	-	259	1666
0000	211,600	205,500	-	418	2107

***Type 1 - Solid conductor and stranding less than that indicated under Type 2 shall not be used.**

****Type 2 - Conductors with at least Type 2 stranding shall be used for general purpose boat wiring.**

*****Type 3 - Conductors with Type 3 stranding shall be used for any wiring where frequent flexing is involved in normal use.**

NOTE:

1. Metric wire sizes may be used if of equivalent circular mil area. If the circular mil area of the metric conductor is less than that listed, the wire ampacity shall be corrected based on the ratio of the circular mil areas. For comparison of conductor cross sections (AWG and ISO) see AP TABLE 2.

2. The circular mil area given is equal to the mathematical square of the diameter of the AWG standard solid copper conductor measured in one thousandths of an inch.

$$\text{The area in square inches} = \frac{\pi(\text{circular mils})}{4(1,000,000)}$$

The circular mil area of the stranded conductors may differ from the tabulated values and is the sum of the circular mil areas of the wires (strands) in the conductor.

TABLE XIV – ENGINE AND ACCESSORY WIRING COLOR CODE

COLOR	ITEM	USE
Yellow w/Red Stripe (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 Tachometer	Fuse or switch to lights Tachometer sender to gauge
Brown (Br)	Generator Armature Alternator Charge Light Pumps	Generator armature to regulator Generator Terminal/alternator Auxiliary terminal to light to regulator 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 Instrument Feed	Ignition switch to coil and electrical instruments. Distribution panel to electric instruments
Dark Blue (Dk Bl)	Cabin and Instrument Lights	Fuse or switch to lights
Light Blue (Lt Bl)	Oil Pressure	Oil pressure sender to gauge
Tan (Tn)	Water Temperature	Water temperature sender to gauge
Pink (Pk)	Fuel Gauge	Fuel gauge sender to gauge
Green/Stripe (G/x) (Except G/Y)	Tilt down and/or Trim in	Tilt and/or trim circuits
Blue/Stripe (Bl/x)	Tilt up and/or Trim out	Tilt and/or trim circuits

NOTE: If yellow is used for DC negative, blower must be brown with yellow stripe.

AP TABLE 1 – CONDUCTORS

AWG	INSULATION TYPE	NOMINAL WALL THICKNESS (MILS)	MAXIMUM OPERATING TEMP. DRY (°C)	MAXIMUM OPERATING TEMP. WET (°C)	BREAK DOWN VOLTAGE (V)	OIL RESISTANT TEMP. (°C)	COMMENTS
14-10	THW	45	75	75	600		Thermoplastic
8-2	THW	60					
1-4/0	THW	80					
14-10	TW	30	75	60	600		Thermoplastic
8	TW	45					
14-12	THWN	19	105	75	600	60	PVC/Nylon
10	THWN	20					
14-12	XHHW	30	90	75	600		X-linked
10							
8-2		45					
1-4/0		55					
18-10	MTW	45	90	60	600		Heavy Wall PVC
8	MTW	45					
6	MTW	60					
18-8	TW	30	90	60	600		Light Wall PVC
18-10	AWM Style #1230 PVC	30	105	60	600	60	
18-8	AWM Style #1231 PVC	45	105	60	600	60	
8-2	AWM Style #1232 PVC	60	105	60	600	60	
1-4/0	AWM Style #1232 PVC	80	105	60	600	60	
18-10	AWM Style #1275 PVC	60	105	60	600	60	
18-10	AWM Style #1345 PVC	30	105	75	600	60	
8-2	AWM Style #1346 PVC	60	105	75	600	60	
18-10	UL 1426 Boat Cable	30	105	75	600	60	
8	Boat Cable	45	105	75	600	60	
6-2	Boat Cable	60	105	75	600	60	
1-4/0	Boat Cable	80	105	75	600	60	

NOTES:

1. AWM must be accompanied by a style number.

2. Some of the listed types are not commonly available in standard construction for sizes smaller than 8 AWG. However, these types are acceptable if obtainable.

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