From: Blue Sea Systems Marine Electrical Products

ABYC Excerpts.....

The following is a synopsis of the most important information contained in the American Boat and Yacht Council Standards and Recommended Practices. It does not contain all the information contained in the standards and should not be relied on for definitive compliance with the Standards and Recommended Practices.

ABYC Excerpts
Application Briefs
Circuit Protection
Data
Glossary
Instructions
Technical Briefs

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The American Boat and Yacht Council standards and recommended practices are guides to achieving a specific level of design or performance, and are not intended to preclude attainment of desired results by other means.

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 boats, associated equipment, and systems manufactured after July 31, 2002.

E-8.2 SCOPE

These standards and recommended practices apply to boat alternating current (AC) electrical systems operating at frequencies of 50 or 60 hertz and less than 300 volts including shore powered systems up to the point of connection to the shore outlet and including the shore power cable.

E-8.5 REQUIREMENTS - IN GENERAL

E-8.5.1 The system shall be polarized as defined in ABYC E-8.4.

E-8.5.2 A grounded neutral system is required. The neutral for AC power sources shall be grounded only at the following points:

E-8.5.2.1 The shore power neutral is grounded through the shore power cable and shall not be grounded on board the boat.

E-8.5.2.2 The secondary neutral of an isolation transformer or polarization transformer shall be grounded at the secondary of an isolation or polarization transformer. See Diagram 5, Diagram 6, Diagram 7, Diagram 8, Diagram 9, Diagram 10, Diagram 11, Diagram 12, and Diagram 13. See Exception.

E-8.5.2.3 The generator neutral shall be grounded at the generator. See Diagram 2 or Diagram 4.

E-8.5.2.4 The inverter output neutral shall be grounded at the inverter. The inverter output neutral shall be disconnected from ground when the inverter is operating in the charger or the feed-through mode(s). See ABYC A-25, Power Inverters.

EXCEPTION: Exception to E-8.5.2.2, E-8.5.2.3 and E-8.5.2.4: For systems using an isolation transformer or polarization transformer, both the generator or inverter neutral and the transformer secondary neutrals may be grounded at the AC main grounding bus instead of at the generator, inverter, or transformer secondaries. See Diagram 5.

E-8.5.3 The main AC system grounding bus shall be connected to

E-8.5.3.1 the engine negative terminal or the DC main negative bus on grounded DC systems, or

E-8.5.3.2 the boat's DC grounding bus in installations using ungrounded DC electrical systems. See ABYC E-9, DC Electrical Systems On Boats.

E-8.5.4 There shall be no switch or overcurrent protection device in the AC grounding (green) conductor.

E-8.5.5 When more than one shore power inlet is used, the shore power neutrals shall not be connected together on board the boat.

E-8.5.6 Individual circuits shall not be capable of being energized by more than one source of electrical power at a time. Each shore power inlet, generator, or inverter is a separate source of electrical power.

E-8.5.6.1 The transfer from one power source circuit to another shall be made by a means that opens all current-carrying conductors, including neutrals, before closing the alternate source circuit, and prevents arc-over between sources.

E-8.5.6.1.1 A means for disconnecting all power sources from the load shall be provided at the same location.

EXCEPTION: Exception to E-8.5.6 and its subsections: The grounded neutral from a polarization transformer, isolation transformer, generator or inverter may be permanently connected to the same main AC grounding bus (see E-8.23, Diagram 5) and is not required to be switched.

E-8.5.7 Energized parts of electrical equipment shall be guarded against accidental contact by the use of enclosures or other protective means that shall not be used for non-electrical

equipment.
E-8.5.7.1 Access to energized parts of the electrical system shall require the use of hand tools.

E-8.6 MARKING

E-8.6.1 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.

E-8.6.2 Marking Of Equipment - All electrical equipment shall be marked to indicate

E-8.6.2.1 manufacturer's identification,

E-8.6.2.2 product identification or model number,

E-8.6.2.3 AC electrical rating in volts and amperes or volts and watts,

E-8.6.2.4 phase and frequency, if applicable, and

E-8.6.2.5 "Ignition Protected," if applicable. This shall be identified by a marking such as "SAE J1171 Marine," "UL Marine-Ignition Protected," or "Ignition Protected."

E-8.7 SYSTEM VOLTAGE

E-8.7.1 Nominal system voltages for AC electrical systems shall be selected from the following:

E-8.7.1.1 120 volts AC, single phase;

E-8.7.1.2 240 volts AC, single phase;

E-8.7.1.3 120/240 volts AC, single phase;

E-8.7.1.4 120/240 volts AC, delta three phase; or

E-8.7.1.5 120/208 volts AC, Wye three phase.

E-8.8 AMBIENT TEMPERATURE

E-8.8.1 The ambient temperature of machinery spaces is considered to be 50°C (122°F) and of all other spaces is considered to be 30°C (86°F). The ambient temperature for rating of shore power cables shall be 30°C (86°F).

E-8.9 IGNITION PROTECTION

E-8.9.1 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 ABYC E-8.9.3. See Figure 1, Figure 2, Figure 3, Figure 4, Figure 5, Figure 6, Figure 7, and Figure 8.

EXCEPTION: Boats using diesel fuel as the only fuel source.

E-8.9.2 If LPG or CNG is provided on the boat, all electrical potential sources of ignition located in compartments containing LPG/CNG appliances, cylinders, fittings, valves or regulators shall be ignition protected.

EXCEPTION: For boats with LPG/CNG systems installed in accordance with ABYC A-1, Marine Liquefied Petroleum Gas (LPG) Systems, or ABYC A-22, Marine Compressed Natural Gas (CNG) Systems, and stoves

that comply with ABYC A-3, Galley Stoves, electrical devices in the following compartments are excepted:

1. Accommodation spaces
2. Open compartments having at least 15 square inches (968 mm2) of open area per cubic foot (0.03 m3) of net compartment volume exposed to the atmosphere outside of the craft.

E-8.9.3 An electrical component is isolated from a gasoline fuel source if

E-8.9.3.1 a bulkhead that meets the requirements of ABYC E-8.9.4 (Figure 7 and Figure 8) is between the electrical components and the gasoline fuel source; or

E-8.9.3.2 the electrical component is

E-8.9.3.2.1 lower than the gasoline fuel source and a means is provided to prevent gasoline fuel and gasoline fuel vapors that may leak from the gasoline fuel sources from becoming exposed to the electrical component, or

E-8.9.3.2.2 is higher than the gasoline fuel source and a deck or other enclosure is between it and the gasoline fuel source, or

E-8.9.3.2.3 the distance between the electrical component and the gasoline fuel source is at least two feet, and the space is open to the atmosphere. See Figure 6.

E-8.9.4 Each bulkhead required by ABYC E-8.9.3.1 shall

E-8.9.4.1 separate the electrical component from the fuel source, and extend both vertically and horizontally the distance of the open space between the gasoline fuel source and the ignition source, and

E-8.9.4.2 resist a water level that is 12 inches (305 mm) high or one-third of the maximum height of the bulkhead, whichever is less, without seepage of more than one-quarter fluid ounce (7.5 cc) of fresh water per hour; and

E-8.9.4.3 shall have no opening higher than 12 inches (305 mm) or one-third the maximum height of the bulkhead, whichever is less, unless the opening is used for the passage of conductors, piping, ventilation ducts, mechanical equipment, and similar items, or doors, hatches and access panels, and the maximum annular space around each item or door, hatch, or access panel must not be more than 6 mm (one-quarter inch).

E-8.9.5 To minimize the potential for migration of carbon monoxide from machinery compartments containing gasoline engines to adjacent accommodation compartments, bulkhead and deck penetrations shall be in accordance with the requirements of ABYC H-2, Ventilation of Boats Using Gasoline.

NOTE: For additional information see ABYC T-22, Educational Information About Carbon Monoxide, and ABYC TH-23, Design, Construction, and Testing of Boats in Consideration of Carbon Monoxide.

E-8.10 SHORE POWER POLARITY DEVICES

E-8.10.1 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-8.23.1, Diagram 3,) if
E-8.10.1.1 the polarity of the system must be maintained for the proper operation of the electrical devices in the system, or
E-8.10.1.2 a branch circuit is provided with overcurrent protection in only the ungrounded current-carrying conductors per ABYC E-8.11.6.1 NOTE.

NOTES: 1. Reverse polarity indicating devices respond to the reversal of an ungrounded conductor and the grounded (white) conductor only when there is continuity of the grounding (green) conductor to shore.

2. Reverse polarity indicating devices might not respond to reversals of an ungrounded conductor and the grounding (green) conductor, the grounded (white) conductor and the grounding (green) conductor, or three phase conductors.

E-8.10.2 Reverse polarity indicating devices are not required in systems employing polarization or isolation transformers that establish the polarity on the boat.

E-8.10.3 The total impedance of polarity indicating and protection devices connected between normal current carrying conductors (grounded [white] conductor and ungrounded [black] conductor) and the grounding conductor shall not be less than 25,000 ohms at 120 volts, 60 hertz at all times.

E-8.11 OVERCURRENT PROTECTION

E-8.11.1 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 ABYC E-8.8.

E-8.11.2 The current rating of the overcurrent protection device shall not exceed the maximum current carrying capacity of the conductor being protected. See Table II and Table V.

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 V, the next larger standard current rating may be used, provided it does not exceed 150 percent of the current allowed by Table II or Table V.

E-8.11.3 The AC voltage rating of the overcurrent protection device shall not be less than the nominal voltage of the supply circuit.

E-8.11.4 Each transformer shall be provided with overcurrent protection for the primary circuit that also provides protection for the secondary winding(s).

E-8.11.4.1 This overcurrent feeder protection device shall open all primary feeder conductors simultaneously, and
E-8.11.4.1.1 it shall be rated at not more than 125% of the rated primary current of the transformer.

EXCEPTION: Feeder conductors for 120/240 volt primary circuits require protection only in the ungrounded conductors.

E-8.11.5 If the transformer secondary is wired to provide 120/240 volt (three wire) output on the secondary, the transformer shall

also be protected on the secondary side by a circuit breaker that simultaneously will open all the ungrounded conductors. This overcurrent protection shall be rated at not more than 125 percent of the rated secondary current of the transformer.

E-8.11.6 Branch Circuits - Each ungrounded conductor of a branch circuit shall be provided with overcurrent protection at the point of connection to the panelboard bus. Each circuit breaker or fuse used for this purpose shall be rated not to exceed the current rating of the smallest conductor between the fuse or circuit breaker and the load.

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 V, the next larger standard current rating may be used, provided it does not exceed 150 percent of the current allowed by Table II or Table V.

E-8.11.6.1 For boats wired with 120 volt, single phase systems, branch circuit breakers shall simultaneously open both current carrying conductors. Fuses shall not be used. See E-8.23.1, Diagram 1 and Diagram 2.

EXCEPTION: Branch circuit breakers may open only the ungrounded current carrying conductor if the AC system on the boat is equipped with a polarity indicator, or transformer.

E-8.11.6.2 If branch circuits contain two or more ungrounded current carrying conductors protected by fuses, means shall be provided to disconnect all energized legs of the circuit simultaneously or remove all fuses from the circuit simultaneously.

E-8.11.6.3 If a branch circuit contains two or more ungrounded current carrying conductors protected by a circuit breaker, the circuit breakers shall be of the simultaneous trip type.

E-8.11.7 AC Motors - Each motor installation, and each motor of a motor operated device, shall be individually protected by an overcurrent or thermal protection device.

EXCEPTION: Motors that will not overheat under locked rotor conditions.

E-8.11.8 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, or UL 1133, Boat Circuit Breakers, and

E-8.11.8.2 shall be of the manually reset trip-free type, and

E-8.11.8.3 shall be capable of an interrupting capacity in accordance with Table I.

EXCEPTION: Integral overcurrent protection in electrical devices.

E-8.11.8.3.1 Generator circuit breaker ampere interrupting capacity (rms) shall be selected considering available transient short circuit current (first half cycle).

E-8.11.9 Location Of Overcurrent Protection

E-8.11.9.1 General Requirements

E-8.11.9.1.1 Each ungrounded current carrying conductor shall be protected by a circuit breaker or fuse.

E-8.11.9.1.2 A circuit breaker or fuse shall be placed at the source of power for each circuit or conductor except that

E-8.11.9.1.2.1 if it is physically impractical to place the circuit breaker or fuse at the source of power, it can be placed within seven inches (178 mm) of the source of power for each circuit or conductor, measured along the conductor.

E-8.11.9.1.2.2 If it is physically impractical to place the circuit breaker or fuse at or within seven inches of the source of power, it can be placed within 40 inches (102 cm) of the source of power for each circuit or conductor, measured along the conductor, if the conductor is contained throughout its entire distance between the source of power and the required circuit breaker or fuse in a sheath or enclosure such as a junction box, control box, or enclosed panel.

EXCEPTION: Exception to E-8.11.9.1.2. Overcurrent protection as required in sections E-8.11.9.3 and E-8.11.9.4.

E-8.11.9.2 Simultaneous trip circuit breakers shall be provided in power feeder conductors as follows:

E-8.11.9.2.1 120 volt AC, single phase - ungrounded and grounded conductors (white),

E-8.11.9.2.2 240 volt AC, single phase - both ungrounded conductors,

E-8.11.9.2.3 120/240 volt AC, single phase - both ungrounded conductors,

E-8.11.9.2.4 120/240 volt AC, delta three phase - all ungrounded conductors,

E-8.11.9.2.5 120/208 volt AC, Wye three phase - all ungrounded conductors.

E-8.11.9.3 If the location of the main shore power disconnect circuit breaker is in excess of three meters (10 feet) 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.

E-8.11.9.3.1 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.

E-8.11.9.4 If required, overcurrent protection for power-feeder conductors from AC generators and inverters, shall be within 7 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.

E-8.12 GROUND FAULT PROTECTION

E-8.12.1 If installed, a ground fault protector (GFP) shall only be used to protect equipment.

NOTE: A ground fault circuit interrupter (GFCI) may be used on single phase AC circuits to provide additional protection for personnel and equipment.

E-8.12.2 GFCI and GFP breakers shall meet the requirements of Underwriters Laboratories standard UL 943, Ground Fault Circuit Interrupters, and the requirements of UL 489, Molded Case Circuit Protectors for Circuit Breaker Enclosures.

E-8.12.3 GFCI and GFP breakers may be installed as panelboard feeder breakers to protect all associated circuits or in individual branch circuits.

E-8.12.4 Single-pole GFCI and GFP breakers shall only be used if:

E-8.12.4.1 the single phase 120 volt system has a polarity indicator, or

E-8.12.4.2 the system uses either a polarization transformer, or

E-8.12.4.3 the system is 120/240 volts.

E-8.12.5 GFCI receptacle devices shall meet the requirements of Underwriters Laboratories' standard UL 943, Ground Fault Circuit Interrupters, and the requirements of UL 498, Electrical Attachment Plugs and Receptacles.

E-8.12.6 GFCI receptacle devices may be installed as part of a convenience outlet installation either in single outlet applications or in multiple feed through installations. See ABYC E-8.17.8.

NOTE: Isolation transformer primary main breakers - GFP breakers may be installed as the main breaker on the primary side of isolation transformers. See E-8.23, Diagram 8 and Diagram 11. This GFP breaker will provide ground fault protection only for the primary winding of the transformer. Protection for circuits supplied by the secondary winding of the transformer may be provided in accordance with ABYC E-8.11.4, E-8.11.5, E-8.11.6.3, and E-8.12.4.

E-8.13 APPLIANCES AND EQUIPMENT

E-8.13.1 Fixed AC electrical equipment used on boats shall be designed so that the current carrying parts of the device are effectively insulated from all exposed electrically conductive parts.

E-8.13.2 All exposed, electrically conductive, non-current carrying parts of fixed AC electrical equipment and appliances intended to be grounded shall be connected to the grounding conductor.

NOTE: If an appliance, e.g., electric range, electric dryer, has a neutral to ground bonding strap, it must be removed in order to comply with ABYC E-8.5.2.

E-8.13.3 Integral overcurrent protection may be provided.

E-8.14 SYSTEM WIRING

E-8.14.10 The AC grounding conductor shall be permitted to be one size smaller than the current carrying conductors on circuits rated greater than 30 amperes.

E-8.14.11 Conductors shall be at least 16 AWG.

EXCEPTIONS:

1. 18 AWG conductors may be used if included with other conductors in a sheath, and do not extend more than 30 inches (760 mm) outside the sheath.
2. 18 AWG conductors may be used as internal wiring on panelboards.
3. Conductors that are totally inside an equipment housing.
4. Pigtails less than 7 inches (178 mm) used as wiring on panelboards.

E-8.14.12 Conductors shall be identified to indicate circuit polarity as follows:

ungrounded conductor black, or brown
grounded neutral conductor white, or light blue
grounding conductor green, green w/yellow stripe
additional ungrounded conductors red, orange, blue,
additional colors for ungrounded conductors (black) black w/red stripe,
black w/ blue stripe,
black w/orange stripe

E-8.15 INSTALLATION

E-8.15.1 All connections normally carrying current shall be made in enclosures to protect against shock hazards.

E-8.15.2 Nonmetallic outlet boxes, flush device boxes and covers shall meet the requirements of UL 514C, Nonmetallic Outlet Boxes, Flush Device Boxes And Covers.

E-8.15.3 Junction boxes, cabinets, and other enclosures in which electrical connections are made shall be weatherproof, or installed in a protected location, to minimize the entrance or accumulation of moisture or water within the boxes, cabinets, or enclosures.

E-8.15.4 In wet locations, metallic boxes, cabinets, or enclosures shall be mounted to minimize the entrapment of moisture between the box, cabinet, or enclosure, and the adjacent structure. If air spacing is used to accomplish this, the minimum shall be 1/4 inch (7.0 mm).

E-8.15.5 Unused openings in boxes, cabinets, and weatherproof enclosures shall be closed.

E-8.15.6 All conductors shall be supported and/or clamped to relieve strain on connections.

E-8.15.7 When AC and DC conductors are run together, the AC conductors shall be sheathed, bundled, or otherwise kept separate from the DC conductors.

E-8.15.8 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 connections shall be watertight.

E-8.15.9 Conductors shall be routed as far away as practicable from exhaust pipes and other heat sources. Unless an equivalent thermal barrier is provided, a clearance of at least 2 inches (51

mm) between conductors and water cooled exhaust components, and a clearance of at least 9 inches (230 mm) between conductors and dry exhaust components, shall be maintained. Conductors shall not be routed directly above a dry exhaust.

E-8.15.10 Conductors that may be exposed to physical damage shall be protected by self draining; loom, conduit, tape, raceways, or other equivalent protection. Conductors passing through bulkheads or structural members shall be protected to minimize insulation damage such as chafing. Conductors shall also be routed clear of sources of chafing such as steering cable and linkages, engine shafts, and control connections.

E-8.15.10.1 Loom used to cover conductors shall be self extinguishing, classified V-2 or better, in accordance with UL 94, Tests For Flammability Of Plastic Materials.

E-8.15.11 Conductors shall be supported throughout their length, or shall be secured at least every 18 inches (460 mm) by one of the following methods:

E-8.15.11.1 Nonmetallic clamps of a size to hold the conductors firmly in place. Nonmetallic straps or clamps shall not be used over engine(s), moving shafts, other machinery, or passageways if failure would result in a hazardous condition.

E-8.15.11.1.1 The material shall be resistant to oil, gasoline, and water, and shall not break or crack under flexing within a temperature range of -30°F (-34°C) to 250°F (121°C).

E-8.15.11.2 Metal straps or clamps with smooth, rounded edges, to hold the conductors firmly in place without damage to the conductors or insulation. That section of the conductor or cable directly under the strap or clamp shall be protected by means of loom, tape, or other suitable wrapping to prevent injury to the conductor.

E-8.15.11.3 Metal clamps lined with insulating material resistant to the effects of oil, gasoline, and water.

E-8.15.12 All electrical appliances and equipment designed for permanent installation shall be securely mounted to the boat's structure.

E-8.15.13 Wiring connections shall be designed and installed to make mechanical and electrical joints without damage to the conductors.

E-8.15.14 Metals used for the terminal studs, nuts, and washers shall be corrosion resistant and galvanically compatible with the conductor and terminal lug. Aluminum and unplated steel shall not be used for studs, nuts, and washers.

E-8.15.15 Each conductor-splice joining conductor to conductor, conductor to connectors, and conductor to terminals must be able to withstand a tensile force equal to at least the value shown in Table IV for the smallest conductor size used in the splice for a one minute duration, and not break.

E-8.15.16 Terminal connectors shall be the ring or captive spade types. See Figure 9.

EXCEPTION: Friction type connectors may be used on components if

1. the circuit is rated not more than 20 amperes or the

manufacturer's rating for a terminal designed to meet the requirements of UL 310, Electrical Quick-Connect Terminals, or UL 1059, Terminal Blocks, and

2. the voltage drop from terminal to terminal does not exceed 50 millivolts for a 20 amp current flow, and

3. the connection does not separate if subjected for one minute to a six pound (27 Newton) tensile force along the axial direction of the connector, on the first withdrawal.

E-8.15.17 Connections may be made using a set screw pressure type conductor connector, providing a means is used to prevent the set-screw from bearing directly on the conductor strands.

E-8.15.18 Twist on connectors, i.e., wire nuts, shall not be used.

E-8.15.19 Solder shall not be the sole means of mechanical connection in any circuit. If soldered, the connection shall be so located or supported as to minimize flexing of the conductor where the solder changes the flexible conductor into a solid conductor.

E-8.15.20 Solderless crimp on connectors shall be attached with the type of crimping tools designed for the connector used, and that will produce a connection meeting the requirements of ABYC E-8.15.15.

E-8.15.21 No more than four conductors shall be secured to any one terminal stud. If additional connections are necessary, two or more terminal studs shall be connected together by means of jumpers or copper straps.

E-8.15.22 Ring and captive spade type terminal connectors shall be the same nominal size as the stud.

E-8.15.23 Conductors terminating at panelboards in junction boxes or fixtures shall be arranged to provide a length of conductor to relieve tension, to allow for repairs and to permit multiple conductors to be fanned at terminal studs.

E-8.15.24 The shanks of terminals shall be protected against accidental shorting by the use of insulation barriers or sleeves, except for those used in grounding systems.

E-8.16 SWITCHES

E-8.16.1 Switches used in branch circuits shall simultaneously open all ungrounded conductor(s) of the branch circuit.

E-8.16.2 Switches shall have voltage ratings not less than the system voltage, current ratings not less than the connected load, and shall be rated for the type of load, i.e., inductive or resistive.

E-8.17 RECEPTACLES

E-8.17.1 Receptacles shall be installed in boxes that meet the requirements of UL 514A, Metallic Outlet Boxes, or 514C, Nonmetallic Outlet Boxes, Flush Device Boxes And Covers.

E-8.17.2 Receptacles shall be of the grounding type with a terminal provided for the grounding (green) conductor as shown in Figure 10 and Figure 11.

E-8.17.3 Receptacles and matching plugs used on AC systems shall not be interchangeable with receptacles and matching plugs used on

DC systems.

E-8.17.4 Power wiring for receptacles shall be connected so that the grounded (white) conductor attaches to the terminal identified by the word "white" or a light color (normally white or silver). The ungrounded conductor(s) shall be attached to the terminal(s) identified by a dark color (normally brass or copper) and, optionally, the letters X, Y, and Z or L1, L2, and L3.

E-8.17.5 A branch circuit supplying a combination of receptacle loads and permanently connected loads shall not supply fixed loads in excess of the following:

E-8.17.5.1 600 watts for a 15 ampere circuit;

E-8.17.5.2 1000 watts for a 20 ampere circuit.

NOTE: Refer to E-8.18.5 for load calculations.

E-8.17.6 Receptacles shall be installed in locations not normally subject to rain, spray, or flooding, but, if receptacles are used in such areas, the following shall apply:

E-8.17.6.1 Receptacles installed in locations subject to rain, spray, or splash shall be weatherproof as may be provided by a spring loaded, self closing cover.

E-8.17.6.2 Receptacles installed in areas subject to flooding or momentary submersion shall be of a watertight design as may be provided by a threaded, gasketed cover.

E-8.17.7 Receptacles provided for the galley shall be located so appliance cords can be plugged in without crossing a traffic area, galley stove, or sink.

E-8.17.8 If installed in a head, galley, machinery space, or on a weather deck, the receptacle shall be protected by a Type A (nominal 5 milliamperes) Ground Fault Circuit Interrupter (GFCI). See ABYC E-8.12.

NOTE: GFCI receptacle devices are not necessarily ignition protected per ABYC E-8.9.1.

E-8.19 PANELBOARDS

E-8.19.1 A panelboard shall be installed in a readily accessible location, in accordance with E-8.15.1 and E-8.5.7, and shall be weatherproof or be protected from weather and splash.

E-8.19.2 Panelboard Marking

E-8.19.2.1 The face of panelboards shall be permanently marked with the system voltage and either "VAC" or system frequency. EXAMPLE: "120 VAC," or "120V-60 hertz."

E-8.19.2.2 If the frequency is other than 60 hertz, the frequency shall be indicated.

E-8.19.2.3 For three phase systems the system voltage, phase, and number of conductors shall be indicated.

E-8.19.3 A system voltmeter shall be installed on the main panelboard if the system is permanently connected to

E-8.19.3.1 motor circuits, or

E-8.19.3.2 a generator, or

E-8.19.3.3 an inverter. If the inverter does not have a true sinusoidal output, the voltmeter shall be a true RMS type. See

ABYC A-25, Inverters.
EXCEPTION: The inverter voltmeter may be installed in proximity to the panelboard.
E-8.19.4 Boats equipped with both AC and DC electrical systems shall have their distribution on separate panelboards, or in the case of systems with combined AC and DC panelboards, the panel shall be designed so that when the panel is open there is no access to energized AC parts without the use of tools.

E-8.20 AC GENERATOR

E-8.20.1 AC generators shall be connected to the electrical distribution system as required in ABYC E-8.5.5. See E-8.23.1, Diagram 2.
E-8.20.2 The power feeder conductor from the AC generator shall be sized to at least accommodate the generator's maximum rated output and shall be protected at the generator with overcurrent protection devices in accordance with ABYC E-8.11.1, E-8.11.2 and E-8.11.3. The rating of these overcurrent protection devices shall not exceed 120 percent of the generator rated output.
EXCEPTION: Self limiting generators, whose maximum overload current does not exceed 120 percent of its rated current output, do not require additional external overcurrent protection.

TABLE I - CIRCUIT BREAKER INTERRUPTING CAPACITY (AMPERES)

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 I.

E-8.23 APPLICATION OF TYPES OF SHORE POWER CIRCUITS

E-8.23.1 Single Phase 120 Volt Systems With Shore-Grounded (White) Neutral Conductor And Grounding (Green) Conductor. See Diagram 1, Diagram 2, and Diagram 3.

E-8.23.1.1 The shore grounded (white) and ungrounded shore current carrying conductors are connected from the shore power inlet to the boat's AC electrical system through an overcurrent protection device that simultaneously opens both current carrying conductors. Fuses shall not be used instead of simultaneous trip devices. See E-8.11.9.2.

E-8.23.1.2 Neither the shore grounded (white) neutral conductor nor the ungrounded current carrying conductors shall be grounded on the boat. See E-8.5.2.1.

E-8.23.1.3 When more than one shore power inlet is used, the shore power neutrals shall not be connected together on the boat. See E-8.5.5.

E-8.23.1.4 The shore-grounding (green) conductor is connected, without interposing switches or overcurrent protection devices (See E-8.5.4.), from the shore power inlet to

E-8.23.1.4.1 an optional galvanic isolator, and then to

E-8.23.1.4.2 all non-current carrying parts of the boat's AC electrical system, including

E-8.23.1.4.3 the engine negative terminal or its bus.

E-8.23.1.5 If an optional galvanic isolator is used, the shell of a metallic shore power inlet shall be electrically insulated from the boat.

E-8.23.1.6 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-8.11.6.1 Exception.

E-8.23.1.7 Polarization of conductors must be observed in all circuits.

E-9 DIRECT CURRENT (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 boats, associated equipment, and systems manufactured after July 31, 1999.

NOTE: The United States Coast Guard has promulgated mandatory requirements for electrical systems in Title 33, CFR 183 Subpart I, Section 183. Refer to the CFR for complete, current federal requirements.

E-9.2 SCOPE

These standards and recommended practices apply to direct current (DC) electrical systems on boats that operate at potentials of 50 volts or less.

EXCEPTION: Any wire that is part of an outboard engine assembly and does not extend inside the boat.

E-9.5 REQUIREMENTS - IN GENERAL

E-9.5.1 Two-Wire System - All direct current electrical distribution systems shall be of the two-wire type. See Figures 1A and 1B, and Figures 2A and 2B.

EXCEPTION: Engine mounted equipment.

E-9.5.2 DC Grounding Systems and Bonding - A metallic hull, or the bonding and DC grounding systems, shall not be used as a return conductor. See Figures 1A and 1B, and Figures 2A and 2B, and E-9.21, DC Grounding and Bonding.

E-9.5.3 Grounded Systems - If one side of a two-wire direct current system is connected to ground, it shall be the negative side and polarized as defined in E-9.4.

E-9.5.4 Multiple Engine Installation - If a boat has more than one engine with a grounded cranking motor, which includes auxiliary generator engine(s), the engines shall be connected to each other by a common conductor that can carry the cranking motor current of each of the grounded cranking motor circuits. Outboard engines shall be connected at the battery negative terminals.

E-9.5.5 Crossover (Parallel) Cranking Motor Circuits - In multiple inboard engine installations, which includes auxiliary generator(s) with cross-over (parallel) cranking motor systems, the engines shall be connected together with a cable large enough to carry the cranking motor current. This cable and its terminations shall be in addition to, and independent of, any other electrical connections to the engines including those required in E-9.5.4.

EXCEPTIONS: 1. Installations using ungrounded DC electrical systems.

2. Outboard engines.

E-9.5.6 If a paralleling switch is installed, it shall be capable of carrying the largest cranking motor current.

NOTE: A paralleling switch may be either of the maintained contact or momentary contact type.

E-9.5.7 DC System Negative Connections

E-9.5.7.1 If an alternating current (AC) system is installed, the main AC system grounding bus shall be connected to

E-9.5.7.1.1 the engine negative terminal or the DC main negative bus on grounded DC systems, or

E-9.5.7.1.2 the boat's DC grounding bus in installations using ungrounded DC electrical systems. See ABYC E-8, AC Electrical Systems on Boats.

E-9.5.7.2 The negative terminal of the battery, and the negative side of the DC system, shall be connected to the engine negative terminal or its bus. On boats with outboard motors, the load return lines shall be connected to the battery negative terminal or its bus, unless specific provision is made by the outboard motor manufacturer for connection to the engine negative terminal.

E-9.5.7.3 If an accessory negative bus with provision for additional circuits is used for the connection of accessories, the ampacity of this bus, and the conductor connected to the engine

negative terminal or the DC main negative bus, shall be at least equal to the ampacity of the feeder(s) to the panelboard(s) supplying the connected accessories. See Figures 1A and 1B, and Figures 2A and 2B.

E-9.5.7.4 If the negative side of the DC system is to be connected to ground, the connection shall be made only from the engine negative terminal, or its bus, to the DC grounding bus. This connection shall be used only as a means of maintaining the negative side of the circuit at ground potential and is not to carry current under normal operating conditions.

E-9.5.7.5 Continuously energized parts, such as positive battery terminals and both ends of all wire connected thereto, shall be physically protected with boots, or other form of protection, that cover all energized surfaces to prevent accidental short circuits.

EXCEPTION: Circuits that have overcurrent protection at the source of power in accordance with E-9.12.

E-9.6 MARKING

E-9.6.1 Marking - 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.

E-9.6.2 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:

E-9.6.2.1 manufacturer;

E-9.6.2.2 product identification;

E-9.6.2.3 DC electrical rating in volts;

NOTE: Rated amperage or wattage of electrical equipment may be marked on the device. See E-9.6.3.

E-9.6.2.4 the terminal polarity or identification, if necessary to operation;

E-9.6.2.5 "ignition protected," if applicable. This shall be identified by a marking such as "SAE J1171-Marine," "UL Marine Ignition Protected," or "Ignition Protected."

E-9.6.3 Rated amperage or wattage of electrical equipment shall be available. See the note in E-9.6.2.3.

E-9.7 AMBIENT TEMPERATURE

E-9.7.1 The ambient temperature of machinery spaces is considered to be 50°C (122°F), and of all other spaces is considered to be 30°C (86°F).

E-9.8 IGNITION SOURCE

E-9.8.1 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-9.8.3. See Figure 3 through 10.

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.

E-9.8.2 If LPG or CNG is provided on the boat, all electrical sources of ignition located in a compartment containing LPG or CNG appliances, cylinders, fittings, valves, or regulators shall be ignition protected.

EXCEPTION: For boats with LPG or CNG systems installed in accordance with the requirements of ABYC A-1, Marine Liquefied Petroleum Gas (LPG) Systems, or ABYC A-22, Marine Compressed Natural Gas (CNG) Systems, and stoves complying with ABYC A-3, Galley Stoves, electrical devices in the following compartments are excepted:

1. Accommodation spaces.
2. Open compartments having at least 15 square inches (970cm2) of open area per cubic foot (0.28cm3) of net compartment volume exposed to the atmosphere outside of the craft.

E-9.8.3 An electrical component is isolated from a gasoline fuel source if

E-9.8.3.1 a bulkhead that meets the requirements of E-9.8.4 (see Figure 9 and Figure 10) is between the electrical component and the gasoline fuel source, or

E-9.8.3.2 the electrical component is

E-9.8.3.2.1 lower than the gasoline fuel source, and a means is provided to prevent gasoline fuel and gasoline fuel vapors that may leak from the gasoline fuel sources from becoming exposed to the electrical component; or

E-9.8.3.2.2 higher than the gasoline fuel source, and a deck or other enclosure is between it and the gasoline fuel source; or

E-9.8.3.2.3 the distance between the electrical component and the fuel source is at least two feet (610mm), and the space is open to the atmosphere. See Figure 8.

E-9.8.4 Each bulkhead required by E-9.8.3.1 (see Figure 9 and Figure 10) shall

E-9.8.4.1 separate the electrical component from the fuel source, and extend, both vertically and horizontally, the distance of the open space between the gasoline fuel source and the ignition source, and

E-9.8.4.2 resist a water level that is 12 inches (305mm) high, or one-third of the maximum height of the bulkhead, whichever is less, without seepage of more than one-quarter fluid ounce (7.4cc) of fresh water per hour, and

E-9.8.4.3 have no opening higher than 12 inches (305mm), or one-third the maximum height of the bulkhead, whichever is less, unless the opening is used for the passage of conductors, piping, ventilation ducts, mechanical equipment, and similar items, or doors, hatches, and access panels; and the maximum annular space around each item or door, hatch or access panel shall not be more than one-quarter inch (6mm).

E-9.8.5 To minimize the potential for migration of carbon monoxide

from machinery compartments containing gasoline engines to adjacent accommodation compartments, bulkhead and deck penetrations shall be in accordance with the requirements of ABYC H-2, Ventilation of Boats Using Gasoline.
NOTE: For additional information see ABYC T-22, Educational Information About Carbon Monoxide; and ABYC TH-23, Design, Construction, and Testing of Boats in Consideration of Carbon Monoxide.

E-9.10 BATTERY CAPACITY
E-9.10.1 The battery, or battery bank, shall have at least the cold cranking amperage required by the engine manufacturer.
E-9.10.2 The battery, or battery bank, shall have a rated reserve capacity so that,
E-9.10.2.1 for boats with one battery charging source the battery shall be capable of supplying the total load of Column A in Table I for a minimum of 1 1/2 hours; or
E-9.10.2.2 for boats with multiple simultaneous battery charging sources, the capacity of all charging sources, except the largest charging source shall be subtracted from the total load of Column A. The battery shall be capable of supplying the resulting differences for a minimum of 1 1/2 hours.
E-9.10.2.3 Use Table II for reserve capacity values, or the following formula derived from Peukert's equation to calculate the required reserve capacity:
$T = 0.0292 \times I\ 1.225 \times 60$
T = battery reserve capacity in minutes
I = total current of column A in amperes per E-9.9.1

E-9.11 DC POWER SOURCES
E-9.11.1 Overcurrent Protection Device Location - Ungrounded conductors shall be provided with overcurrent protection within a distance of 7 inches (175mm) of the point at which the conductor is connected to the source of power measured along the conductor. See Figure 11.
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).
NOTE: See Section E-9.17, Installation.
E-9.11.2 Battery Charging Sources
E-9.11.2.1 Each ungrounded conductor connected to a battery

charger, alternator, or other charging source, shall be provided with overcurrent protection within a distance of 7 inches (175mm) of the point of connection to the DC electrical system or to the battery.

EXCEPTIONS: 1. 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).

2. 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). 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.

E-9.11.2.2 In addition to the provisions of E-9.11.2.1, the ungrounded conductor shall be provided with overcurrent protection within the charging source, or within 7 inches (175mm) of the charging source, based on the maximum output of the device.

EXCEPTION: Self-limiting devices.

E-9.11.3 Battery Switch

E-9.11.3.1 A battery switch shall be installed in the positive conductor(s) from each battery or battery bank with a CCA rating greater than 800 amperes.

EXCEPTIONS: 1. Trolling motor conductors connected to dedicated trolling motor batteries provided with overcurrent protection at the battery and a manual means of electrical disconnect separate from the trolling motor controls.

2. Conductors supplying the following may be connected to the battery side of the switch (see Figure 12):

a. Electronic equipment with continuously powered memory;

b. Safety equipment such as bilge pumps, alarms, CO detectors and bilge blowers;

c. Battery charging equipment.

E-9.11.3.2 A battery switch shall be mounted in a readily accessible location as close as practicable to the battery.

E-9.11.3.3 Battery Switch Ratings - The intermittent rating of a battery switch shall not be less than the maximum cranking current of the largest engine cranking motor that it serves. The minimum continuous rating of a battery switch shall be the total of the ampacities of the main overcurrent protection devices connected to the battery switch, or the ampacity of the feeder cable to the switch, whichever is less.

E-9.12 OVERCURRENT PROTECTION

E-9.12.1 Motors or Motor Operated Equipment - Motors and motor

operated equipment, except for engine cranking motors, shall be protected internally at the equipment, or by branch circuit overcurrent protection devices suitable for motor current. The protection provided shall preclude a fire hazard if the circuit, as installed, is energized for seven hours under any conditions of overload, including locked rotor.

NOTES: 1. It may be necessary to use thermally responsive protection devices on the equipment or system if the motor is not capable of operating continuously at maximum possible loading.

2. It may be necessary to test as installed in order to assure compliance with the locked rotor requirement. Voltage drop, due to wire size, and delay characteristics of the overcurrent protection device may have to be adjusted to protect the motor.

E-9.12.2 Non-motor Loads - The rating of overcurrent protection devices used to protect a load other than a DC motor shall not exceed 150 percent of the ampacity of its supply conductor. See Table IV.

E-9.12.3 Branch Circuits

E-9.12.3.1 Each ungrounded conductor of a branch circuit shall be provided with overcurrent protection at the point of connection to the main switchboard unless the main circuit breaker or fuse provides such protection.

E-9.12.3.2 Each fuse or trip-free circuit breaker shall be rated in accordance with E-9.12.1 and E-9.12.2 and shall not exceed 150 percent of the conductor ampacity in Table IV. See Figure 12.

E-9.12.4 Panelboards and Switchboards - A trip-free circuit breaker or a fuse shall be installed at the source of power for panelboards and switchboards, and shall not exceed 100 percent of the load capacity of that panel, or 100 percent of the current carrying capacity of the feeders.

EXCEPTION: The trip free circuit breaker or fuse at the source of power may be rated at up to 150 percent of the conductor ampacity if there is a sub-main circuit breaker or fuse in the panelboard or switchboard that is rated at no more than 100 percent of the load capacity, or the feeder ampacity, whichever is less. See Figure 13.

E-9.12.5 Circuit Breakers

E-9.12.5.1 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 4 times the current rating of the device being tested.

E-9.12.5.2 Circuit breakers shall

E-9.12.5.2.1 have a DC voltage rating of not less than the nominal system voltage, and

E-9.12.5.2.2 be of the trip-free type, and

E-9.12.5.2.3 be capable of an interrupting capacity according to Table III, and remain operable after the fault,

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 III.
2. Consult the circuit breaker manufacturer to determine the fuse size and the type of fuse.
E-9.12.5.2.4 be of the manual reset type except as provided in E-9.12.7.
E-9.12.6 Fuses
E-9.12.6.1 Fuses shall have a voltage rating of not less than the nominal system voltage.
E-9.12.6.2 Fuses installed in spaces requiring ignition protection shall comply with SAE J1171, External Ignition Protection for 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 rating of the fuse.
E-9.12.7 Integral Overcurrent Protection Devices - Integral overcurrent protection devices without a manual reset may be used as an integral part of an electrical device provided the rest of the circuit is protected by a trip-free circuit protection device(s) or a fuse(s).
E-9.12.8 Pigtails - Pigtails less than 7 inches (175mm) in length are exempt from overcurrent protection requirements.
E-9.13 SWITCHES
E-9.13.1 If single pole switches are used in branch circuits they shall be installed in the positive conductor of the circuit.
EXCEPTIONS: 1. Engine mounted pressure, vacuum, and temperature operated switches.
2. Switches such as those used for control of alarm systems.
E-9.13.2 Switches shall have voltage ratings not less than the system voltage, current ratings not less than the connected load, and shall be rated for the type of load, i.e., inductive or resistive.
EXCEPTION: Battery switches. See E-9.11.3.3.
E-9.14 APPLIANCES AND EQUIPMENT
E-9.14.1 Appliances and fixed DC electrical equipment shall be designed so that the current carrying parts of the device are insulated from all exposed electrically conductive parts.
EXCEPTIONS: 1. 12 volt equipment not located in machinery spaces, not in contact with bilge, and not in contact with a fuel line.
2. Communications and audio equipment
3. Electric navigation equipment
4. Instruments and instrument clusters
5. Liquid level gauge transmitters. For installation of fuel tank transmitters on conductive surfaces. See E-9.14.4.
6. Navigation lights operating at nominal 12 volts. See ABYC A-16, Electric Navigation Lights.
7. Auxiliary generator sets
8. Engine mounted equipment. See E-9.5.1.
E-9.14.2 Devices subject to exceptions 1 through 8 in E-9.14.1 shall be installed with the case negative, and the positive connection shall be identified.
E-9.14.3 All exposed electrically conductive non-current carrying

parts of fixed DC electrical equipment, and appliances that may normally be in contact with bilge water or seawater, shall be connected to the DC grounding system.

EXCEPTIONS: 1. Boats not equipped with a DC grounding system.
2. Equipment with an effective double insulation system.
3. Metal parts isolated in non-conductive material
4. Electric trolling motors

E-9.14.4 Grounded Liquid Level Gauge Transmitters (senders) - Grounded liquid level gauge transmitters mounted on fuel tanks or tank plates shall have the transmitter negative return conductor connected directly to the DC main negative bus, the engine negative terminal, or for outboard boats the battery negative terminal or its bus. No other device shall be connected to this conductor. This conductor shall also serve as the static ground and/or the bonding conductor for the tank and fill. If a fuel tank is included in the lightning protection system the conductor between the fuel tank and the DC main negative bus shall meet the requirements of ABYC E-4, Lightning Protection.

E-9.15 SYSTEM WIRING

E-9.15.8 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 3 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.

E-9.16 WIRING IDENTIFICATION

E-9.16.1 Each electrical conductor that is part of the boat's electrical system shall have a means to identify its function in the system.

EXCEPTION: Pigtails less than 7 inches (175mm) in length.

E-9.16.2 Insulated grounding conductors shall be identified by the color green or green with yellow stripe(s).

E-9.16.3 The color code shown in Table XI identifies colors for DC conductors used for general wiring purposes on boats.

E-9.16.4 The color code shown in Table XII identifies one selection of colors for use as an engine accessory wiring color code. Other means of identification may be used providing a wiring diagram of the system indicating the method of identification is provided with each boat.

E-9.16.4.1 Color coding may be accomplished by colored sleeving or color application to wiring at termination points.

E-9.16.4.2 If tape is used to mark a wire, the tape shall be at least 3/16 inch (5mm) in width, and shall have sufficient length to make at least two complete turns around the conductor to be marked. The tape shall be applied to be visible near each terminal.

E-9.17 INSTALLATION

E-9.17.1 Wiring shall be installed in a manner that will avoid magnetic loops in the area of the compass and magnetically sensitive devices. Direct current wires that may create magnetic

fields in this area shall run in twisted pairs.
E-9.17.2 Junction boxes, cabinets, and other enclosures in which electrical connections are made, shall be weatherproof or installed in a protected location to minimize the entrance or accumulation of moisture or water within the boxes, cabinets, or enclosures.
E-9.17.3 In wet locations, metallic junction boxes, cabinets, or enclosures shall be mounted to minimize the entrapment of moisture between the box, cabinet, or enclosure and the adjacent structure. If air spacing is used to accomplish this, the minimum spacing shall be 1/4 inch (7mm).
E-9.17.4 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.
E-9.17.5 Conductors shall be routed as far away as practicable from exhaust pipes and other heat sources. Unless an equivalent thermal barrier is provided, a clearance of at least 2 inches (51mm) between conductors and water cooled exhaust components, and a clearance of at least 9 inches (230mm) between conductors and dry exhaust components, shall be maintained. Conductors shall not be routed directly above a dry exhaust.
EXCEPTIONS: 1. Wiring on engines.
2. Exhaust temperature sensor wiring.
E-9.17.6 Battery cables without overcurrent protection shall comply with the following:
E-9.17.6.1 Battery cables shall be routed above normal bilge water levels throughout their length;
E-9.17.6.2 Battery cables shall be routed to avoid contact with metallic fuel system components;
E-9.17.6.3 The ungrounded battery cable shall be routed to avoid contact with any part of the engine or drive train.
E-9.17.7 Conductors that may be exposed to physical damage shall be protected by self-draining loom, conduit, tape, raceways, or other equivalent protection. Conductors passing through bulkheads or structural members shall be protected to minimize insulation damage such as chafing. Conductors shall also be routed clear of sources of chafing such as steering cable and linkages, engine shafts, and throttle connections.
E-9.17.8 DC conductors shall be sheathed, bundled, or otherwise kept separate from AC conductors.
E-9.17.9 Conductors shall be at least 16 AWG.
EXCEPTIONS: 1. 18 AWG conductors may be used if included with other conductors in a sheath, and do not extend more than 30 inches (760mm) outside the sheath.
2. Conductors having a current flow of less than one amp in communication systems, electronic navigation equipment and electronic circuits.
3. Conductors that are totally inside an equipment housing.
E-9.17.10 Conductors shall be supported throughout their length or

shall be secured at least every 18 inches (455mm) by one of the following methods:
E-9.17.10.1 By means of non-metallic clamps sized to hold the conductors firmly in place. Non-metallic straps or clamps shall not be used over engine(s), moving shafts, other machinery or passageways, if failure would result in a hazardous condition. The material shall be resistant to oil, gasoline, and water and shall not break or crack within a temperature range of -34°C (-30°F) to 121°C (250°F);
E-9.17.10.2 By means of metal straps or clamps with smooth, rounded edges to hold the conductors firmly in place without damage to the conductors or insulation. That section of the conductor or cable directly under the strap or clamp shall be protected by means of loom, tape or other suitable wrapping to prevent injury to the conductor;
E-9.17.10.3 By means of metal clamps lined with an insulating material resistant to the effects of oil, gasoline, and water.
EXCEPTIONS: Exception to E-9.17.10:
1. Battery cables within 36 inches (910mm) of a battery terminal.
2. Cables attached to outboard motors.
E-9.17.11 All electrical appliances and equipment designed for permanent installation shall be securely mounted to the boat's structure.
E-9.17.12 Wiring Connections
E-9.17.12.1 All connections shall be in locations protected from the weather, or in weatherproof enclosures, or shall be watertight. If connections are exposed to immersion they shall be watertight.
E-9.17.12.2 Wiring connections shall be designed and installed to make mechanical and electrical joints without damage to the conductors.
E-9.17.12.3 Metals used for terminal studs, nuts, and washers shall be corrosion resistant and galvanically compatible with the conductor and terminal lug. Aluminum and unplated steel shall not be used for studs, nuts, and washers.
E-9.17.12.4 Each conductor splice joining conductor to conductor, conductor to connectors, and conductor to terminals shall be able to withstand a tensile force equal to at least the value shown in Table XIII for the smallest conductor size used in the splice for a one minute duration and not break.
E-9.17.12.5 Terminal connectors shall be the ring or captive spade types. See Figure 14.
EXCEPTION: Friction type connectors may be used if
a. the voltage drop from terminal to terminal does not exceed 50 millivolts for a 20 amp current flow, and
b. the connection does not separate if subjected to a six pound (2.75kg) tensile force along the axial direction of the connector for one minute.
E-9.17.12.6 Connections may be made using a set screw pressure type conductor connector providing a means is used to prevent the set screw from bearing directly on the conductor strands.

E-9.17.12.7 Twist-on connectors, i.e., wire nuts, shall not be used.
E-9.17.12.8 Solder shall not be the sole means of mechanical connection in any circuit. If soldered, the connection shall be so located or supported as to minimize flexing of the conductor where the solder changes the flexible conductor into a solid conductor.
EXCEPTION: Battery lugs with a solder contact length of not less than 1.5 times the diameter of the conductor.
NOTE: When a stranded conductor is soldered, the soldered portion of the conductor becomes a solid strand conductor and flexing can cause the conductor to break at the end of the solder joint unless adequate additional support is provided.
E-9.17.12.9 Crimp-on connectors shall be attached with crimping tools designed for the connector used, and to produce a connection that meets the requirements of E-9.17.12.4.
E-9.17.12.10 No more than four conductors shall be secured to any one terminal stud. If additional connections are necessary, two or more terminal studs shall be connected together by means of jumpers or copper straps.
E-9.17.12.11 Ring and captive spade type terminal connectors shall be the same nominal size as the stud.
E-9.17.12.12 Conductors terminating at switchboards, in junction boxes, or fixtures shall be arranged to provide a length of conductor to relieve tension, to allow for repairs, and to permit multiple conductors to be fanned at terminal studs.
E-9.17.12.13 The shanks of terminals shall be protected against accidental shorting by the use of insulation barriers or sleeves.
EXCEPTION: The shanks of terminals used in grounding systems.
E-9.18 RECEPTACLES
E-9.18.1 Receptacles installed in locations subject to rain, spray, or splash shall be weatherproof when not in use.
NOTE: Weatherproofing may be provided by means such as spring-loaded, self-closing, or snap-type receptacle covers.
E-9.18.2 Receptacles installed in areas subject to flooding or momentary submersion shall be of a watertight design, the integrity of which is not affected when the receptacle is in use.
E-9.18.3 Receptacles and matching plugs used on DC systems shall not be interchangeable with receptacles and matching plugs used elsewhere on the boat for AC systems.
E-9.19 PLUG CONNECTIONS
E-9.19.1 Multi-wire plugs and receptacles used in conjunction with harness type wiring systems shall comply with the following:
E-9.19.1.1 Plugs and receptacles shall incorporate means, such as cable clamps, molded connectors, insulation grips, extended terminal barrels, etc., for supporting all wires to limit flexing at the connection, and
E-9.19.1.2 plugs and receptacles exposed to weather shall be weatherproof, or if subject to immersion, shall be watertight.
E-9.19.2 Each terminal in a multi-wire plug and receptacle shall be protected from accidental short-circuiting to adjacent terminals.

E-9.19.3 Plug connectors shall have a minimum disengagement force of 6 pounds (2.75kg) along the axial direction of the connector for one minute.
E-9.19.4 The plug connector's capacity shall be selected to meet or exceed the ampacity and temperature rating of the connecting conductors in addition to its wire size capability.
E-9.20 MAIN SWITCHBOARD OR PANELBOARD
E-9.20.1 A main switchboard or panelboard shall be installed in a readily accessible location, and shall be weatherproof or protected from the weather and splash.
E-9.20.2 Switchboards and panelboards used on boats with more than one system voltage shall have a permanent marking showing the system voltage and its type (DC).
E-9.20.3 Switchboards and panelboards shall be designed so that there are no exposed energized AC parts accessible to the operator when the DC panel is open.
E-9.21 DC GROUNDING AND BONDING
E-9.21.1 DC Grounding - If a DC grounding system is installed, the DC grounding conductor shall be used to connect metallic non-current carrying parts of those direct current devices identified in E-9.14.3 to the engine negative terminal or its bus for the purpose of minimizing stray current corrosion. See Figure 15.
NOTE: This system is the DC grounding system formerly published as ABYC E-1, Bonding of Direct Current Systems.
E-9.21.2 DC Grounding Conductor
E-9.21.2.1 A DC grounding conductor shall not be smaller than one size under that required for current carrying conductors supplying the device and not less than 16 AWG. See Figure 15 and Figure 16.
E-9.21.2.2 Routing - The DC grounding conductor shall be routed from the device to the engine negative terminal or the DC main negative bus by one of the following means:
E-9.21.2.2.1 The DC grounding conductor shall be routed together with the current carrying conductors as a third wire;
E-9.21.2.2.2 The DC grounding conductor shall be routed as a separate conductor.
E-9.21.2.3 The DC grounding conductor shall be connected to a DC grounding bus in accordance with E-9.21.5.
E-9.21.2.4 Connections - DC grounding conductor connections shall be made in accordance with E-9.17.12.
E-9.21.5 DC Grounding Bus
E-9.21.5.1 The DC grounding bus shall be connected directly to the engine negative terminal or the DC main negative bus.
E-9.21.5.2 The DC grounding bus serving more than one electrical device shall comply with E-9.21.2 for the largest device, and shall be manufactured and installed in accordance with the following:
E-9.21.5.2.1 If the DC grounding bus is fabricated from copper or bronze strip, it shall have a thickness not less than 1/32 inch (0.8mm) and a width of not less than 1/2 inch (13mm); and
E-9.21.5.2.1.1 shall be drilled and tapped providing its thickness

ensures no less than three full threads of engagement for the terminal screws; or
E-9.21.5.2.1.2 shall be through-drilled, and the connections made with machine screws and locknuts.
NOTE: Copper pipe may be used providing its wall thickness is sufficient for the pipe to be drilled and tapped as required above.
E-9.21.5.2.2 Copper braid shall not be used.
E-9.21.6 Combined DC Grounding and Bonding Systems - The DC grounding conductors may be combined with the following systems providing all the requirements with respect to conductor size are met for each system. See Figure 15, Figure 16 and Figure 17.
E-9.21.6.1 Lightning Protection - See ABYC E-4, Lightning Protection.
E-9.21.6.2 Cathodic Bonding - See ABYC E-2, Cathodic Protection.
E-9.21.6.3 Static Electricity Grounding - See E-9.14.4, ABYC H-24, Gasoline Fuel Systems, and ABYC H-33, Diesel Fuel Systems.
E-9.21.7 Radio Ground Plate - If the radio ground plate is connected to the engine negative terminal, the connecting conductor shall meet the requirements of ABYC E-4, Lightning Protection, since a radio ground plate may also function as a lightning ground plate.
E-9.21.8 Coaxial Cables and Conduit - The metallic braid of coaxial cables and metal conduit used for radio interference, or any form of radio shielding or armoring, shall be connected to earth ground with an insulated stranded copper conductor.
TABLE III - CIRCUIT BREAKER MINIMUM AMPERE INTERRUPTING CAPACITY

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

*NOTE: The main circuit breaker(s) is 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 12.
TABLE XI - WIRING COLOR CODE

Color	Use
Green, or green w/yellow stripe(s)	DC grounding conductors

Black, or yellow DC negative conductors
Red DC positive conductors

TABLE XII - 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
Generator armature to regulator
Alternator charge light

Pumps 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
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)
(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.

E-10 12/96 STORAGE BATTERIES
E-10.5.7.1 A battery bank consisting of storage batteries connected in series shall be connected for voltage other than its total voltage only when a device specifically designed to equalize the charge between the batteries is utilized.
EXCEPTION: This requirement does not apply to parallel battery banks momentarily connected in series for engine starting.
E-10.6 BATTERY CAPACITY
E-10.6.1 Cranking batteries shall have at least the cold cranking performance rating (CCA @ O°F) or marine cranking performance rating (MCA @ 32°F) amperage required by the engine manufacturer.
E-10.6.2 Accessory batteries and cranking batteries used as accessory batteries shall have a rated reserve capacity in minutes determined by the calculations in ABYC E-9, DC Electrical Systems Under 50 Volts.
E-10.7 INSTALLATION
E-10.7.1 If the mounting surfaces of components of the boat in the immediate vicinity of the battery are of a material attacked by the electrolyte, a mounting means shall be provided that is made of material that is not damaged by electrolyte.
E-10.7.2 Provision shall be made to contain leakage and spillage of electrolyte.
E-10.7.3 Fasteners for the attachment of battery boxes or trays shall be isolated from areas intended to collect spilled electrolyte.
E-10.7.4 Each installed battery shall not move more than one inch (25mm) in any direction when a pulling force of 90 pounds (41kg) or twice the battery weight, whichever is less, is applied through the center of gravity of the battery as follows;
E-10.7.4.1 vertically for a duration of one minute, and
E-10.7.4.2 horizontally and parallel to the boat's centerline, for a duration of one minute fore and one minute aft, and
E-10.7.4.3 horizontally and perpendicular to the boat's centerline for a duration of one minute to starboard and one minute to port.
E-10.7.5 No battery shall be installed directly above or below a fuel tank, fuel filter, or fitting in a fuel line.
NOTE: This does not prohibit a battery from being installed directly above or below an uninterrupted fuel line. However, if a metallic fuel line is within the 12 inch (305mm) envelope of the surface of the battery, it shall be shielded dielectrically as required in E-10.7.8.
E-10.7.6 Batteries shall not be installed directly below battery chargers or inverters.

E-10.7.7 To prevent accidental contact of the ungrounded battery connection to ground, each battery shall be protected so that metallic objects cannot come into contact with the ungrounded battery terminal and uninsulated cell straps. This may be accomplished by means such as;

E-10.7.7.1 covering the ungrounded battery terminal with a boot or non-conductive shield, or

E-10.7.7.2 installing the battery in a covered battery box, or

E-10.7.7.3 installing the battery in a compartment specially designed only for the battery(s).

E-10.7.8 Top Terminal Battery - Each metallic fuel line and fuel system component within 12 inches (305mm) of a battery terminal, and above the horizontal plane of the battery top surface, as installed, shall be shielded with dielectric material to protect against accidental short-circuiting. See Figure 1.

E-10.7.9 Side Terminal Battery - Each metallic fuel line and fuel system component within 12 inches (305mm) of the terminal side of a side terminal battery shall be shielded with a dielectric material to protect against accidental short circuiting. If the battery has side terminals, the horizontal plane shall be considered to begin below the side terminals. See Figure 1.

NOTES: 1. Terminal insulation or battery covers do not comply with this requirement since, during installation or removal of a battery, these protective devices are usually removed in order to connect the cables.

2. Any non-conductive material may be used for shielding as long as it is durable enough to withstand accidental contact by a tool or the battery terminals during servicing, installation or removal.

E-10.7.10 A vent system or other means shall be provided to permit the discharge from the boat of hydrogen gas released by the battery. See ABYC H-2, Ventilation Of Boats Using Gasoline.

E-10.7.11 Battery boxes, whose cover forms a pocket over the battery, shall be vented at the uppermost portion of the cover.

NOTE TO E-10.7.10 and E-10.7.11: These requirements also apply to installations of all batteries whether they employ removable vent caps, non-removable caps, are "sealed" or "maintenance free" batteries, or have pressure regulated valve vent systems with immobilized electrolyte (gel batteries).

E-10.7.12 Batteries shall be charged by means of an automatically controlled device, that is capable of supplying the current and voltage appropriate to the type of battery being charged. See ABYC A-20, Battery Chargers, and ABYC A-25, Power Inverters.

E-10.8 WIRING

E-10.8.1 Battery wiring shall conform to the Installation section of ABYC E-9, DC Electrical Systems Under 50 Volts.

E-10.8.2 Connectors to battery terminals shall be made with fitted connectors providing secure mechanical and electrical connections as required in the Wiring Connections' section of ABYC E-9, DC Electrical Systems Under 50 Volts. Spring clips or temporary clamps shall not be used.

NOTE: A soldered connection that joins a battery terminal connector to a conductor may be used as the sole means of mechanical connection if the length of the soldered joint is at least 1.5 times the diameter of the stranded portion of the battery conductor. See Figure 2.
E-10.8.3 Battery conductors must be sized to satisfy the load calculations as outlined in the section referencing Load Calculations, ABYC E-9, DC Electrical Systems Under 50 Volts.

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 boats, associated equipment, and systems manufactured after July 31, 2001.

A-20.2 SCOPE
These standards and recommended practices apply to all permanently installed 120 or 240 volt AC powered marine non-rotating battery chargers which supply current at a potential of 50 volts DC or less.
NOTE: This standard does not apply to devices that are intended to supply DC loads without a battery.
A-20.5 REQUIREMENTS - IN GENERAL
A-20.5.1 Battery chargers shall be of the automatically controlled type.
A-20.5.2 All battery chargers shall meet the applicable requirements of UL 1236, Battery Chargers for Charging Engine-Starter Batteries, and the requirements of Supplement SA - Marine Battery Chargers.
A-20.5.2.1 A battery charger shall be provided with an ammeter or an alternative indicator for measuring the output current.
A-20.5.3 All battery chargers shall be designed to withstand an ambient temperature of 70°C (158°F) and operate at the ambient temperature of 50°C (122°F).
A-20.5.4 Isolation of high and low voltage circuits
A-20.5.4.1 High voltage, i.e., 120 volt or 240 volt, and low voltage, i.e., output voltages, shall be electrically isolated from each other by one or more of the following methods:
A-20.5.4.1.1 a metallic shield;
A-20.5.4.1.2 insulation and gap.
EXCEPTION: Chargers having an integral GFCI in the AC input circuit.
NOTE: For inverter/chargers see ABYC A-25, Power Inverters.
A-20.5.4.2 If a metallic shield is used to meet the requirements of A-20.5.4.1 the shield shall be located between the high voltage and low voltage circuit, and shall be connected to the boat's AC grounding (green wire) system.
A-20.5.4.3 If insulation and gap is used to meet the requirements of A-20.5.4.1 the insulation and gap between the high voltage and low voltage circuit shall withstand a high potential test of 1500 volts, 60 Hz, for one minute.
A-20.5.5 Each battery charger shall be supplied with an

installation and operation manual.
A-20.5.6 Each ungrounded DC output conductor shall be provided with overcurrent protection, based on the maximum output of the charger, within the charger, or
A-20.5.6.1 the charger manufacturer shall provide instructions to install the overcurrent protection device within 7" of the charger.
EXCEPTION: Self limiting battery chargers.
A-20.5.7 AC Overcurrent Protection - All battery chargers shall incorporate an integral manually resetable circuit breaker or replaceable fuse in the primary circuit to the isolation transformer which will pass the overload test in UL 1236.
EXCEPTION: Self limiting battery chargers.
A-20.5.8 Grommets, bushings, or other means shall be provided to prevent chafing of wires passing through the battery charger case.
A-20.5.9 The battery charger's negative terminal and DC grounded (negative) output conductor shall not be connected to the battery charger case or chassis at the battery charger itself. See ABYC E-9, Direct Current (DC) Electrical Systems On Boats.
A-20.5.10 Safety signs and labels shall comply with ABYC T-5, Safety Signs and Labels, and shall contain at least the following informational elements:
A-20.5.10.1 The signal word for the hazard intensity level; and
A-20.5.10.2 the nature of the hazard; and
A-20.5.10.3 the consequences that can result if the instructions to avoid the hazard are not followed; and
A-20.5.10.4 instructions on how to avoid the hazard.
A-20.6 INSTALLATION AND LOCATION
A-20.6.1 The battery charger shall be installed in accordance with the charger manufacturer's instructions.
A-20.6.2 Battery chargers shall be selected and set, or adjusted, to charge the battery at the current and voltage appropriate for the size and type of battery or battery bank(s).
NOTE: For load calculations and reserve capacity see ABYC E-9, Direct Current (DC) Electrical Systems On Boats.
A-20.6.3 Each ungrounded DC conductor shall be provided with overcurrent protection at the point of connection to the DC electrical system or to the battery, per ABYC E-9, Direct Current (DC) Electrical Systems On Boats.
A-20.6.4 The installation and overcurrent protection of vessel wiring associated with battery chargers shall comply with ABYC standards ABYC E-8, Alternating Current (AC) Electrical Systems On Boats, and ABYC E-9, Direct Current (DC) Electrical Systems On Boats.
A-20.6.5 Battery chargers shall be installed in a ventilated, dry, accessible location away from heat sources such as dry engine exhaust and other heat producing devices where the ambient temperature may exceed 50°C (122°F).
A-20.6.6 To avoid corrosive fumes, battery chargers shall not be installed directly over batteries.
A-20.6.7 Battery charger controls and meters shall be readily

accessible.
A-20.6.8 Battery chargers shall be located so that hinged covers and access plates can be opened.
A-20.6.9 Battery chargers shall be securely fastened to bulkheads or other vessel structure.
A-20.6.10 When mounted, the base of the unit shall be at least two feet above normal bilge water or protected so it is not subject to bilge water splash.
A-20.6.11 The installer shall provide physical protection from falling objects or drippage unless such provision is integral to the battery charger.
A-20.6.12 A readily accessible manual disconnect must be provided in the AC branch supply of the battery charger.
A-20.6.13 If a remote ammeter is provided with a shunt in a positive conductor, the conductors to the meter shall have overcurrent protection at the shunt based on the size of the conductors supplying the remote ammeter.
A-20.6.14 Battery chargers installed in spaces requiring ignition protection shall meet the ignition protection requirements of SAE J1171 or UL 1500.
NOTE: For information on locations requiring ignition protected equipment see: 33 CFR 183.410; ABYC A-1, Marine Liquefied Petroleum Gas (LPG) Systems; ABYC A-22, Marine Compressed Natural Gas (CNG) Systems; ABYC E-9, Direct Current (DC) Electrical Systems on Boats; and ABYC H-24, Gasoline Fuel Systems,.
A-20.6.15 The metallic case or chassis shall be connected to the AC and DC grounding systems. See A-20.7.3 and A-20.7.4.2.
A-20.7 WIRING CONNECTIONS
A-20.7.1 Strain relief shall be provided for all wiring passing through the battery charger case to relieve strain on terminals, splices or internal wiring. Unless a strain relief method is integral with the case for wiring passing through, a means to achieve strain relief shall be installed within six inches of the case.
A-20.7.2 All AC connections shall conform to ABYC E-8, Alternating Current (AC) Electrical Systems on Boats.
A-20.7.2.1 Provision shall be made to permit the ready connection of three or more AC conductors to the battery charger.
A-20.7.2.2 AC conductor connection points shall be labeled as follows:
A-20.7.2.2.1 L, N, G (120 V AC single phase input), or
A-20.7.2.2.2 L1, L2, G (240 V AC single phase input), or
A-20.7.2.2.3 L1, L2, L3, G (208 or 240 V AC three phase input).
A-20.7.3 The AC grounding conductor (green) shall be connected to the battery charger in a manner so that the AC ground connection will not be disconnected in servicing. This conductor shall be in addition to and independent of the DC grounding conductor required in section A-20.7.4.2. See Figure 1.
A-20.7.4 Provision shall be made within the battery charger to permit the ready connection of the DC output conductors.
A-20.7.4.1 DC output conductor terminals shall be labeled as

follows:
A-20.7.4.1.1 DC+, or POS, or +
A-20.7.4.1.2 DC-, or NEG, or -.
A-20.7.4.2 The DC grounding conductor (see Figure 1) shall,
A-20.7.4.2.1 be connected from the metallic case or chassis of the battery charger to the engine negative terminal or its bus, and
EXCEPTION: On outboard powered boats this conductor may be connected to the battery negative terminal or its bus.
A-20.7.4.2.2 not be smaller than one size under that required for the DC current carrying conductors, and not less than 16 AWG.
EXCEPTION: The DC grounding conductor may be one size smaller than the minimum size conductor required for the DC current carrying conductors (See ABYC E-9, Table IV, Allowable Amperage of Conductors For Systems Under 50 Volts) providing the overcurrent protection device in the DC positive conductor is rated no greater than 135% of the ampacity of the DC grounding conductor and the conductor is no smaller than 16 AWG.
A-20.7.4.2.3 the DC negative conductor between the engine negative terminal, or its bus, and the battery negative terminal shall be of an ampacity at least equal to that of the battery charger DC positive conductor.
A-20.8 MARKING
A-20.8.1 All battery chargers shall be suitably identified by a legible permanent marking on the cabinet where readily visible. This shall include, as a minimum, the following information:
A-20.8.1.1 Manufacturer's name and address;
A-20.8.1.2 Input voltage, amperage and frequency;
A-20.8.1.3 Model number;
A-20.8.1.4 Serial number or date of manufacture;
A-20.8.1.5 Nominal output voltage and current;
A-20.8.1.6 DC output voltage at float or shut-off;
A-20.8.1.7 Continuous output current at 12 volts DC (24 or 32) at specified input voltage at 25°C (77°F);
A-20.8.1.8 Battery type.
A-20.9 LABELS AND WARNINGS
A-20.9.1 Devices that are ignition protected per UL 1500 or SAE J1171 shall be labeled to indicate their status as ignition protected.

A-25.5 REQUIREMENTS - IN GENERAL
A-25.5.1 If the inverter also serves as a battery charger, it shall also meet the requirements of ABYC A-20, Battery Charging Devices.
NOTE: An inverter incorporating a battery charging circuit that meets UL 458, Power Converters/Inverters and Power Converter/Inverter Systems for Land Vehicles and Marine Crafts, and Supplement SA, Marine Power Converters/Inverters and Power Converter/Inverter Systems, need not meet UL 1236 as referenced in ABYC A-20, Battery Charging Devices.
A-25.5.2 Output voltage and frequency shall be in accordance with ABYC E-8, Alternating Current (AC) Electrical Systems On Boats.

EXCEPTION: Inverters dedicated to supply power to only a specific piece of equipment.
A-25.5.3 All marine power inverters shall meet the applicable requirements of UL 458, Power Converters/Inverters and Power Converter/Inverter Systems for Land Vehicles and Marine Crafts, and Supplement SA, Marine Power Converters/Inverters and Power Converter/Inverter Systems.
A-25.5.4 Power inverters shall be automatically controlled to provide frequency and voltage regulation compatible with section 27 of UL 1248, Engine-Generator Assemblies for Use in Recreational Vehicles.
A-25.5.5 Power inverters shall provide isolation of the AC output from the DC supply circuit.
A-25.5.6 Integral inverter receptacle shall be protected by an integral GFCI device in accordance with ABYC E-8, Alternating Current (AC) Electrical Systems On Boats. The receptacle is to be used only with cord connected loads.
A-25.5.7 A visible means (e.g., voltmeter or lamp) of determining that the inverter is "on line" and/or in "stand-by" mode shall be provided at the main electrical distribution panel.
A-25.5.8 A warning label shall be provided at the main electrical panel to indicate that the electrical system includes an inverter. See A-25.10.1.
A-25.5.9 Grommets, bushings, or other means shall be provided to prevent chafing of wires passing through the inverter case.
A-25.5.10 Safety signs and labels shall comply with ABYC T-5, Safety Signs and Labels, and shall contain at least the following informational elements:
A-25.5.10.1 The signal word for the hazard intensity level; and
A-25.5.10.2 the nature of the hazard; and
A-25.5.10.3 the consequences that can result if the instructions to avoid the hazard are not followed; and
A-25.5.10.4 instructions on how to avoid the hazard.
A-25.6 INSTALLATION AND LOCATION
A-25.6.1 The installation and protection of electrical wiring associated with inverters shall comply with ABYC standards ABYC E-8, Alternating Current (AC) Electrical Systems on Boats, and ABYC E-9, Direct Current (DC) Electrical Systems On Boats.
A-25.6.2 Inverters shall be installed:
A-25.6.2.1 in a ventilated, dry, accessible location; and
A-25.6.2.2 where the ambient temperature will not exceed 122°F (50°C); and
A-25.6.2.3 away from heat sources, such as dry engine exhaust and other heat producing devices.
A-25.6.3 Inverters shall not be installed directly over batteries.
A-25.6.4 Inverter controls shall be readily accessible.
A-25.6.5 Inverters shall be located so that hinged covers and access plates can be opened.
A-25.6.6 Inverters shall be securely fastened to bulkheads or other vessel structural parts.
A-25.6.7 When mounted, the base of the inverter shall be at least

two feet above normal bilge water, or protected so it is not subject to bilge splash.

A-25.6.8 The installer shall provide physical protection from falling objects or drippage unless such provision is integral to the inverter.

A-25.6.9 Overcurrent protection in the DC input circuit shall comply with the requirements of ABYC E-9. This protection is intended to protect the wiring in the DC circuit.

NOTE: See ABYC E-9 for battery switch requirements.

A-25.6.10 If ground fault circuit interruption is provided in the output of the inverter, the ground fault interrupter shall not be located in a compartment requiring ignition protection, unless it is ignition protected as provided in SAE J-1171 or UL 1500.

A-25.6.11 An inverter that does not have an integral ground fault protection device and is installed so that GFCI protection is required by ABYC E-8, shall have the required GFCI device(s) specified by the inverter manufacturer as to GFCI manufacturer and model number.

NOTE: Harmonic distortion of the AC output waveform from some inverters may affect the operation of some GFCI devices.

A-25.6.12 Power inverters installed in spaces requiring ignition protection shall meet the ignition protection requirements of SAE J1171 or UL 1500. See A-25.10.2 for labeling requirements.

NOTE: For information on spaces requiring ignition protected equipment see 33 CFR 183.410; ABYC A-1, Marine Liquefied Petroleum Gas (LPG) Systems; ABYC A-22, Marine Compressed Natural Gas (CNG) Systems; ABYC E-8, Alternating Current (AC) Electrical Systems On Boats; ABYC E-9, Direct Current (DC) Electrical Systems On Boats; and ABYC H-24, Gasoline Fuel Systems.

A-25.6.13 A means to achieve strain relief shall be installed within six inches of the case unless a strain relief method is integral with the case for wiring passing through.

A-25.7 AC WIRING CONNECTIONS

A-25.7.1 ABYC E-8, Alternating Current (AC) Electrical Systems On Boats, requires a grounded neutral system. The neutral for AC power sources shall be grounded only at the following points:

A-25.7.1.1 The shore power neutral is grounded through the shore power cable and shall not be grounded on board the boat.

A-25.7.1.2 The inverter output neutral shall be grounded at the inverter.

A-25.7.1.2.1 The inverter/charger output neutral shall be grounded at the inverter/charger.

EXCEPTION: Exception to A-25.7.1.2.1: When the inverter/charger is in the charge or transfer mode.

EXCEPTION: Exception to A-25.7.1.2 and A-25.7.1.2.1: On systems using an isolation transformer or a polarization transformer, the inverter or inverter/charger neutral, and the transformer secondary neutral, may be grounded at the main AC grounding bus instead of at the inverter or inverter/charger.

A-25.7.1.3 AC Connections - Provision shall be made within the inverter to permit the ready connection of three or more

conductors, terminated with crimp connectors or other connectors that conform to ABYC E-8, Alternating Current (AC) Electrical Systems on Boats. These terminals or conductors shall be labeled as follows:

A-25.7.1.3.1 L, N, G (120 V AC single phase output), or

A-25.7.1.3.2 L1, L2, G (240 V AC single phase output), or

A-25.7.1.3.3 L1, L2, L3, G (208 or 240 V AC three phase output).

EXCEPTION: Receptacle wiring device connected outputs.

A-25.7.2 If an inverter, and any other source(s) of AC can supply a branch circuit or receptacle, then the transfer from one power source circuit to another shall be made by a means that opens one source circuit before closing the alternate source circuit, preventing arc-over or feedback between sources. (See Figure 1, Figure 2, and Figure 3.)

A-25.7.2.1 A grounded neutral system is required and shall be achieved at the inverter output, when it is serving as the source of AC power.

A-25.7.2.2 The transfer switch(ing) (e.g. switch gear) shall be protected against overcurrent.

A-25.7.2.3 The current rating of the transfer switch (e.g. switch gear) shall be at least equivalent to the ampacity of the branch circuit feeding the transfer switch.

A-25.7.2.4 Inverter integral switching shall switch all ungrounded conductors, and the grounded (neutral) conductor, from ground.

A-25.7.3 Grounding

A-25.7.3.1 The AC grounding conductor (green) shall be connected to the inverter in a manner so that the AC ground connection will not be disconnected in servicing. This conductor shall be in addition to and independent of the DC grounding conductor required in section A-25.8.2. See Figure 1, Figure 2, and Figure 3.

A-25.8 DC WIRING CONNECTIONS

A-25.8.1 DC Input Connections - Terminals, terminations, crimp connectors or conductors shall comply with ABYC E-9, Direct Current (DC) Electrical Systems On Boats. These terminals or conductors shall be labeled as follows:

A-25.8.1.1 DC+, or POS, or +

A-25.8.1.2 DC-, or NEG, or -

A-25.8.1.3 DC grounding to engine negative terminal or bus.

A-25.8.2 The DC grounding conductor (see Figure 1, Figure 2, and Figure 3) shall,

A-25.8.2.1 be connected from the case of the inverter to the engine negative terminal or its bus, and

EXCEPTION: Outboard powered boats may be connected to the battery negative terminal or its bus.

A-25.8.2.2 shall be of an ampacity equal to that of the DC positive conductor feeding the inverter.

EXCEPTION: The DC grounding conductor may be one size smaller than the minimum size conductor required for the DC current carrying conductors (See ABYC E-9, Table IV, Allowable Amperage of Conductors For Systems Under 50 Volts) providing the overcurrent protection device in the DC positive conductor is rated no greater

than 135% of the ampacity of the DC grounding conductor and the conductor is no smaller than 16 AWG.
A-25.8.3 The inverter's, or inverter/charger's, negative terminal and DC grounded (negative) conductor shall not be connected to the inverter case or chassis at the inverter or inverter/charger itself. See Figure 1, Figure 2, and Figure 3. See ABYC E-9, Direct Current (DC) Electrical Systems On Boats.
A-25.8.4 The DC negative conductor between the engine negative terminal, or its bus, and the battery negative terminal shall be of an ampacity at least equal to that of the inverter DC positive conductor.
A-25.9 MARKING
A-25.9.1 All inverters shall have a readily visible, legible, and permanent marking on the inverter cabinet. As a minimum, the marking shall include the following data;
A-25.9.1.1 manufacturer's name and address, and
A-25.9.1.2 input voltage and current, and
A-25.9.1.3 model number, and
A-25.9.1.4 serial number or date of manufacture and
A-25.9.1.5 nominal output voltage, and frequency, and
A-25.9.1.6 continuous current at rated voltage, and
A-25.9.1.7 surge capability and duration.
A-25.10 LABELS AND WARNINGS
A-25.10.1 The inverter manufacturer shall provide a warning label that complies with A-25.5.10, to be installed at the boat's main electrical panel, indicating that there is an inverter installed.
A-25.10.2 Inverters that are ignition protected in accordance with SAE J1171 or UL 1500, shall be so labeled.

A-25.10.3 Inverters that are not ignition protected in accordance with SAE J1171 or UL 1500, shall be labeled in accordance with A-25.5.10.

A-25.10.4 Hinged covers and access plates on the inverter that permit access to high voltage connections shall be labeled in accordance with A-25.5.10.
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A-25.10.5 Hinged covers and access plates on the inverter that permit access to low voltage connections shall be labeled in accordance with A-25.5.10.

A-27.5 DESIGN AND CONSTRUCTION - IN GENERAL
A-27.6 Ignition Protection
A-27.6.1 All generator sets shall be ignition protected in accordance with the requirements of ABYC E-8, Alternating Current (AC) Electrical Systems on Boats, and ABYC E-9, DC Electrical Systems On Boats.
EXCEPTION: Boats using diesel fuel as the only fuel source.
A-27.6.2 If any electrical component is required to be ignition protected, the generator set, and the sound shield or enclosure,

shall be visibly marked with a safety label in accordance with the requirements of A-27.18.2. See A-27.18.2.2 for an example of the label.

A-27.6.3 High tension cable assemblies shall conform to SAE J1191, High Tension Ignition Cable Assemblies - Marine.

A-27.6.4 Ignition distributors shall conform to SAE J1294, Ignition Distributors - Marine, or UL 1120, Marine Engine Ignition Systems and Components.

A-27.6.5 Shorting switches for magneto ignition systems shall be located outside spaces requiring ignition protection, or

A-27.6.5.1 shall be ignition protected in accordance with the requirements of ABYC E-9, DC Electrical Systems On Boats.

A-27.7 ENCLOSURES

A-27.7.6 Terminal enclosures for AC output power shall meet the following requirements:

A-27.7.6.1 Output wiring connections shall be made in an enclosure so that these connections can be readily inspected after the generator is installed as intended; and

A-27.7.6.2 An enclosure intended for the connection of a supply conduit, etc., shall be so attached to the generator set so that the enclosure is prevented from turning; and.

A-27.7.6.3 Generator set output wiring connections shall be provided with strain relief; and

A-27.7.6.4 If an enclosure is to enclose wire-to-wire connections, it shall have a minimum dimension of the cover opening, and a minimum usable volume in accordance with Table I; and,

A-27.7.6.5 If an enclosure surrounds rigidly mounted terminals, it shall be sized to provide spacings in accordance with Table III, and usable volume in accordance with Table II; and

A-27.7.6.6 Metal enclosures to which a wiring system is to be connected shall be not less than 0.032 inch (0.8mm) thick if painted steel (No. 20 MSG), not less than 0.034 inch (0.9mm) thick if galvanized steel (No. 20 GSG), and not less than 0.045 inch (1.1mm) (No. 16 AWG) thick if nonferrous.

EXCEPTION: Non-metallic boxes shall meet the requirements of UL 514C, Non-metallic Outlet Boxes, Flush-device Boxes, and Covers.

A-27.8 SOUND SHIELDS

A-27.8.4 Batteries shall not be installed within a sound shield.

A-27.9 WIRING TERMINALS AND LEADS - AC (50 TO 300 v)

A-27.9.1 A generator set shall be provided with output wiring terminals for the connection of conductors having an ampacity in accordance with the requirements of ABYC E-8, Alternating Current (AC) Electrical Systems on Boats.

A-27.9.2 A terminal intended solely for connection of an AC equipment grounding conductor shall be capable of securing a conductor of the size for the particular application, in accordance with the requirements of ABYC E-8, Alternating Current (AC) Electrical Systems on Boats.

A-27.9.3 Each lead provided for wiring to the generator set, or for interconnection between parts of the generator, shall be provided with a means to prevent stress from being transmitted to

internal connections when subjected to an axial pull of 20 pounds (9kg), applied for 1 minute, without any displacement.
NOTE: This test may be waived if the leads are not intended to be exposed in the final application, and are handled only when the generator set is being factory wired.
A-27.9.4 Wiring color shall comply with the requirements of ABYC E-8, Alternating Current (AC) Electrical Systems on Boats, or
A-27.9.4.1 wires shall be identified by permanent marking, so that proper output connections can be made by use of the generator set installation instructions, and a wiring diagram contained therein.
A-27.9.5 A current carrying part shall be of silver, copper, or a copper alloy.
A-27.10 WIRING TERMINALS AND LEADS - DIRECT CURRENT
A-27.10.1 All generator sets and control wiring shall meet the requirements of ABYC E-9, DC Electrical Systems On Boats.
A-27.10.2 In addition to normal negative ground, a second crossover stud shall be provided to the cranking motor of the generator set.
A-27.11 INTERNAL GENERATOR SET WIRING
A-27.11.1 Unless it is an uninsulated energized part, insulated internal wiring, including an equipment grounding conductor, shall meet the requirements of ABYC E-8, Alternating Current (AC) Electrical Systems on Boats.
A-27.11.2 Wiring shall be protected from sharp edges, including screw threads, burrs, fins, moving parts, hot generator set parts, exhaust systems, fuel systems, and other features that might damage the insulation of a conductor. Acceptable protection may include clamps, grommets, loom, sleeves, added insulation, and routing.
A-27.11.3 Wiring and cables shall not be exposed to drippage of fuel, oil, or grease, and shall not be supported on oil or grease-retaining surfaces unless insulation or other protection, approved for the application, is provided.
A-27.12 SEPARATION OF CIRCUITS
A-27.12.8 Bonding and Grounding. All exposed non-current carrying metal parts that could become energized due to a fault shall have metal-to-metal contact, or otherwise be electrically connected or bonded together, to provide a common ground connection.
A-27.12.8.1 The generator set shall be provided with a designated bonding terminal. This terminal shall not be on a part of the machine disassembled during operation or routine maintenance.
A-27.12.8.2 The bonding terminal shall be of adequate size for a flexible grounding conductor, and
A-27.12.8.2.1 the terminal shall accommodate at least No. 8 AWG wire or its equivalent.
NOTE: A battery negative connection may serve to meet this requirement.
A-27.13 TESTS REQUIRED
A-27.13.3 Variation in Rated Voltage and Frequency. In order to protect appliance motors attached to the output of generator sets, the generator set shall maintain the following characteristics

during any steady state conditions from no load to full rated load;

A-27.13.3.1 plus or minus 10 percent of rated voltage, at rated frequency, and

A-27.13.3.2 plus or minus 5 percent of rated frequency, at rated voltage, and

A-27.13.3.3 a combined variation in voltage and frequency of plus or minus 10 percent (sum of absolute values) of the rated values where voltage and frequency variations are of opposite signs, provided the frequency variation does not exceed plus or minus 5 percent of rated frequency. See Appendix C.

A-27.13.4 Overload or Short Circuit Protection

A-27.13.4.1 The generator and feeder conductors to the junction box for connection to the load shall be protected by an appropriately rated overcurrent protective device, not to exceed 120% of rated current in accordance with the requirements of ABYC E-8, Alternating Current (AC) Electrical Systems on Boats.

EXCEPTION: This overcurrent protection need not be provided for generator sets having a collapsible field or other built-in overcurrent protection, if feeder conductors are sized for the maximum sustained current available.

A-27.16 GENERATOR SET MARKING

A-27.16.1 All fuses, switches, meters, circuit breakers, lights, etc. must be identified as to their function.