



ABYC E-11 July 2018

**Electrical Division Standard
Electrical Project Technical Committee**

The ABYC Standards and Technical Information Reports for Small Craft are the product of a consensus of representatives of government, industry and public sectors. It is intended solely as a guide to aid manufacturers and the marine community in the design, construction, equipage and maintenance of small craft.

ABYC reviews each standard at least every five years at which time it may be reaffirmed, revised, or withdrawn. ABYC welcomes any written comments on the Standards and Technical Information Reports.

ABYC E-11

AC AND DC ELECTRICAL SYSTEMS ON BOATS



ELECTRICAL PROJECT TECHNICAL COMMITTEE

Ward Eshleman, Chair
William Brian Criner, Vice Chair

Colin Althen	James Coté	Thomas Marhevko
Andy Brown	Robert Green	Vinod Mehta
Denis Bonneau	Clyde Head	Aaron Meyer
Nigel Calder	Charles Johnson	Paul Michalczyk
William Drake	Wayne Kelsoe	Dave Potter
Po Chang	John Lach	Ray Toth
Jay Check	Stephen Liscinsky	Ray Wong
Pete Chisholm	Robert Macias	

This list represents the membership at the time the Committee was balloted.

NOTE: Membership on a committee shall not in and of itself constitute an endorsement of ABYC or any document developed by the committee on which the member serves.

This standard was developed under procedures accredited as meeting the criteria for American National Standards. The Project Technical Committee that approved the standard was balanced to ensure that individuals from competent and concerned interests have had an opportunity to participate.

This standard, which is the result of extended and careful consideration of available knowledge and experience on the subject, is intended to provide minimum performance requirements.

ABYC's Project Technical Committee meetings are open to the public. All inquiries regarding standards activity, interpretations, or meeting attendance should be directed to the ABYC Technical Department at comments@abycinc.org.

ABYC and its committees do not "approve", "certify", or "endorse" any item, construction, or proprietary device.

REQUEST FOR INTERPRETATIONS

Upon written request the Electrical PTC will render an interpretation of any requirement of the standard. The request for interpretation should be clear and unambiguous. Requests should be presented to the PTC in a manner in which they may be answered in a yes or no fashion.

The committee reserves the right to reconsider any interpretation when or if additional information which might affect it becomes available to the PTC. Persons aggrieved by an interpretation may appeal to the Committee for reinterpretation.

E-11 AC AND DC ELECTRICAL SYSTEMS ON BOATS

Table of Contents

11.1	PURPOSE.....	1
11.2	SCOPE.....	1
11.3	REFERENCES.....	1
11.4	DEFINITIONS	3
11.5	GENERAL REQUIREMENTS.....	5
11.6	POWER SOURCES.....	9
	TABLE 1 - Reserve Capacity of Batteries.....	10
11.7	ISOLATION OF GALVANIC CURRENTS.....	13
11.8	LOAD CALCULATIONS.....	14
	TABLE 2 - Electrical Load Requirement Worksheet.....	14
11.9	PANELBOARDS	16
11.10	OVERCURRENT PROTECTION.....	17
11.11	GROUND FAULT PROTECTION - AC.....	21
11.12	SWITCHES	22
11.13	PLUGS AND RECEPTACLES.....	22
11.14	SYSTEM WIRING.....	23
11.15	APPLIANCES AND EQUIPMENT	29
11.16	DC GROUNDING AND BONDING	30
11.17	APPLICATION OF TYPES OF SHORE POWER CIRCUITS.....	31
	DIAGRAM 1 - Single Phase 120 Volt Systems With Shore-Grounded (White) Neutral Conductor and Grounding (Green) Conductor.....	32
	DIAGRAM 2 - Single Phase 120 Volt Systems With Shore-Grounded (White) Neutral Conductor, Grounding (Green) Conductor, and AC Generator Set With Transfer Switch	33
	DIAGRAM 3 - Single Phase 120 Volt Systems With Shore-Grounded (White) Neutral Conductor, Grounding (Green) Conductor, and Polarity Indicator.....	33
	DIAGRAM 4 - Single Phase 120/240 Volt System With Shore Grounded (White) Neutral Conductor and Grounding (Green) Conductor.....	35
	DIAGRAM 5 - Polarization Transformer System With a Single Phase 240 Volt Input and a 120/240 Volt Output, and Generator Illustrating the Use of Main AC Grounding Bus	36
	DIAGRAM 6 - Isolation Transformer System With a Single Phase 120 Volt Input, 120 Volt Output With Boat Grounded Secondary, Transformer Shield Grounded on the Shore, Transformer Metal Case Grounded on the Boat.....	37
	DIAGRAM 7 - Isolation Transformer System With Single Phase 240 Volt Input, 120/240 Volt Output With Boat Grounded Secondary, Transformer Shield Grounded on the Shore, Transformer Metal Case Grounded on the Boat	38
	DIAGRAM 8 - Polarization Transformer System With a Single Phase 120 Volt Input, 120 Volt Output and Shore Grounded Secondary.....	39
	DIAGRAM 9 - Polarization Transformer System With a Single Phase 240 Volt Input, 120/240 Volt Output and Shore Grounded Secondary.....	41
	DIAGRAM 10 - High Frequency/Switch Mode Transformer Wired as an Isolation Transformer With a Single Phase 110 V Input and Output.....	42
	DIAGRAM 11 - High Frequency/Switch Mode Transformer Wired as a Polarization Transformer With an Optional Galvanic Isolator	43
	FIGURE 1 - Isolation of Electrical Components For Ignition Protection	43

FIGURE 2 - Isolation of Electrical Components For Ignition Protection	44
FIGURE 3 - Isolation of Electrical Components For Ignition Protection	44
FIGURE 4 - Isolation of Electrical Components For Ignition Protection	45
FIGURE 5 - Isolation of Electrical Components For Ignition Protection	45
FIGURE 6 - Isolation of Electrical Components For Ignition Protection	46
FIGURE 7 - Isolation Bulkhead Requirements	47
FIGURE 8 - Bulkheads.....	47
FIGURE 9 - Typical Outboard DC System.....	48
FIGURE 10 - Typical Inboard DC System	49
FIGURE 11 - Standard Convenience Receptacle Configuration	50
FIGURE 12 - Typical Shore Power Cable Configurations	50
FIGURE 13 - Typical Shore Power Cable Configurations, Pin And Sleeve	50
FIGURE 14 - Battery Supply Circuits - Location of Overcurrent Devices	51
FIGURE 15 - Some Typical Types of Terminals.....	52
FIGURE 16 - DC Grounding System	52
TABLE 3 - Free Standing Range Ratings	53
TABLE 4A - Minimum Ampere Interrupting Capacity for Overcurrent Protection Devices for Systems Under 60 Volts	53
TABLE 4B - Overcurrent Protection Device Interrupting Capacity for Systems Over 60 Volts	54
TABLE 5 - SAE Conductors.....	54
TABLE 6A - AC & DC Circuits - Allowable Amperage of Single Conductors Not Bundled, Sheathed, or in Conduit.....	55
TABLE 6B - AC & DC Circuits – Allowable Amperage of Conductors When up to Three AC or More Than a Single DC Current-Carrying Conductor(S) Are Bundled, Sheathed, or in Conduit	55
TABLE 6C - AC Circuits Only - Allowable Amperage of Conductors When Four to Six Current- Carrying Conductors Are Bundled.....	56
TABLE 6D - AC Circuits Only - Allowable Amperage of Conductors When Seven to 24 Current- Carrying Conductors Are Bundled.....	56
TABLE 6E - AC Circuits Only - Allowable Amperage of Conductors When 25 or More Current- Carrying Conductors Are Bundled.....	57
TABLE 7A - Flexible Cords Type, Description, Insulation Temperature Rating	57
TABLE 7B - Flexible Cords Location, Oil Resistance, and Usage	58
TABLE 8 - Conductors	58
TABLE 9 - Conductors Sized for 3% Drop in Voltage.....	59
TABLE 10 - Conductors Sizes For 10% Voltage Drop	61
TABLE 11 - Conductor Circular Mil (Cm) Area and Stranding.....	63
TABLE 12 - Conductor Ampacity – Flexible Cords [60°C (140°F) Insulated Rating]	64
TABLE 13 - Wiring Color Code	64
TABLE 14 - Engine and Accessory Wiring Color Code	65
TABLE 15 - Tensile Test Values for Connections	65
APPENDIX	66
AP TABLE 1 - Conductors	66
AP TABLE 2 - Comparison of Conductor Cross-Section.....	67
APPENDIX 3 - Guide for Sizing Copper Busbars	67
ORIGIN AND DEVELOPMENT	68
INDEX	69

E-11 AC & DC ELECTRICAL SYSTEMS ON BOATS

Based on ABYC's assessment of the existing technology, and the problems associated with achieving the goals of this standard, ABYC recommends compliance with this standard for all systems and associated equipment manufactured and/or installed after July 31, 2019.

11.1 PURPOSE

This standard is a guide for the design, construction, and installation of alternating current (AC) electrical systems and direct current (DC) electrical systems on boats.

NOTES:

1. The United States Coast Guard has promulgated mandatory requirements for electrical systems in Title 33, CFR 183 Subpart I. Refer to the CFR for current federal requirements.
2. See [E-30, Electric Propulsion Systems](#), for voltages over 300 VAC and 60 VDC for the purposes of electric/hybrid propulsion.
3. Three phase power systems pose different risks from those encountered with single phase systems and should only be installed and maintained in accordance with specifications detailed in any of the various recognized standards development organizations including IEEE, ABS, Det Norske Veritas, etc.

11.2 SCOPE

This standard applies to:

11.2.1 alternating current (AC) electrical systems on boats operating at frequencies of 50 or 60 hertz and less than 300 volts, including shore power systems up to the point of connection to the shore outlet and including the shore power cable and,

11.2.2 direct current (DC) electrical systems on boats operating at 60 volts nominal or less.

EXCEPTIONS:

1. Any conductor that is part of an outboard engine assembly and does not extend beyond the outboard engine manufacturer's supplied cowling.
2. Engine manufacturer supplied engine management systems and their associated conductors.

11.3 REFERENCES

The following references form a part of this standard. Unless otherwise noted, the latest version of the referenced standards shall apply.

11.3.1 ABYC - American Boat & Yacht Council, Inc, 613 Third Street, Suite 10, Annapolis, MD 21403. Phone: (410) 990-4460. Fax: (410) 990-4466. Website: www.abycinc.org

[ABYC A-1, Marine Liquefied Petroleum Gas \(LPG\) Systems](#)

[ABYC A-3, Galley Stoves](#)

[ABYC A-16, Electric Navigation Lights](#)

[ABYC A-22, Marine Compressed Natural Gas \(CNG\) Systems](#)

[ABYC A-28, Galvanic Isolators](#)

[ABYC A-31, Battery Chargers and Inverters](#)

[ABYC A-32, Power Conversion Equipment and Systems](#)

[ABYC C-1500, Ignition Protection for Marine Products](#)

[ABYC E-2, Cathodic Protection](#)

[ABYC E-10, Storage Batteries](#)

[ABYC E-30, Electric Propulsion Systems](#)

[ABYC H-2, Ventilation of Boats Using Gasoline](#)

[ABYC H-24, Gasoline Fuel Systems](#)

[ABYC H-33, Diesel Fuel Systems](#)

[ABYC T-5, Safety Signs and Labels](#)

[ABYC TE-4, Lightning Protection](#)

[ABYC TH-22, Educational Information About Carbon Monoxide](#)

[ABYC TH-23, Design, Construction, and Testing of Boats in Consideration of Carbon Monoxide](#)