ANSI/NFPA 302 An American National Standard August 5, 1994

NFPA 302 Fire Protection Standard for Pleasure and Commercial Motor Craft 1994 Edition

National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101

NOTICE

All questions or other communications relating to this document should be sent only to NFPA headquarters, addressed to the attention of the Committee responsible for the document.

For information on the procedures for requesting Technical Committees to issue Formal Interpretations, proposing Tentative Interim Amendments, proposing amendments for Committee consideration, and appeals on matters relating to the content of the document, write to the Secretary, Standards Council, National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

A statement, written or oral, that is not processed in accordance with Section 16 of the Regulations Governing Committee Projects shall not be considered the official position of NFPA or any of its Committees and shall not be considered to be, nor be relied upon as, a Formal Interpretation.

Users of this document should consult applicable federal, state and local laws and regulations. NFPA does not, by the publication of this document, intend to urge action that is not in compliance with applicable laws, and this document may not be construed as doing so.

Policy Adopted by NFPA Board of Directors on December 3, 1982

The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

Licensing Provision—This document is copyrighted by the National Fire Protection Association (NFPA).

---

1. Adoption by Reference—Public authorities and others are urged to reference this document in laws, ordinances, regulations, administrative orders, or similar instruments. Any deletions, additions, and changes desired by the adopting authority must be noted separately. Those using this method are requested to notify the NFPA (Attention: Secretary, Standards Council) in writing of such use. The term "adoption by reference" means the citing of title and publishing information only.

2. Adoption by Transcription—A. Public authorities with lawmaking or rule-making powers only upon written notice to the NFPA (Attention: Secretary, Standards Council), will be granted a royalty-free license to print and republish this document in whole or in part, with changes and additions, if any, noted separately, in laws, ordinances, regulations, administrative orders, or similar instruments having the force of law, provided that: (I) due notice of NFPA's copyright is contained in each law and in each copy thereof; and (2) that such printing and republication is limited to numbers sufficient to satisfy the jurisdiction's lawmaking or rule-making process. **B.** Once this NFPA Code or Standard has been adopted into law, all printings of this document by public authorities with lawmaking or rule-making powers or any other persons desiring to reproduce this document or its contents as adopted by the jurisdiction in whole or in part, in any form, upon written request to NFPA (Attention: Secretary, Standards Council), will be granted a nonexclusive license to print, republish, and vend this document in whole or in part, with changes and additions, if any, noted separately, provided that due notice of NFPA's copyright is contained in each copy. Such license shall be granted only upon agreement to pay NFPA a royalty. This royalty is required to provide funds for the research and development necessary to continue the work of NFPA and its volunteers in continually updating and revising NFPA standards. Under certain circumstances, public authorities with lawmaking or rule-making powers may apply for and may receive a special royalty where the public interest will be served thereby.

3. Scope of License Grant—The terms and conditions set forth above do not extend to the index to this document.

(For further explanation, see the Policy Concerning the Adoption, Printing, and Publication of NFPA Documents, which is available upon request from the NFPA.)

Statement on NFPA Procedures

This material has been developed under the published procedures of the National Fire Protection Association, which are designed to assure the appointment of technically competent Committees having balanced representation. While these procedures assure the highest degree of care, neither the National Fire Protection Association, its members, nor those participating in its activities accept any liability resulting from compliance or noncompliance with the provisions given herein, for any restrictions imposed on materials or processes, or for the completeness of the text.

NFPA has no power or authority to police or enforce compliance with the contents of this document, and any certification of products stating compliance with requirements of this document is made at the peril of the certifier.

99 98 97 96 95 94 5 4 3 2 1 SC-AM-94

CHARLES S. MORGAN LIBRARY
NATIONAL FIRE PROTECTION ASSOCIATION
1 BATTERYMARCH PARK
QUINCY, MA 02269-9101

Copyright © 1994 NFPA, All Rights Reserved

NFPA 302

Fire Protection Standard for

Pleasure and Commercial Motor Craft

1994 Edition

This edition of NFPA 302, *Fire Protection Standard for Pleasure and Commercial Motor Craft*, was prepared by the Technical Committee on Motor Craft and acted on by the National Fire Protection Association, Inc. at its Annual Meeting held May 16–18, 1994, in San Francisco, CA. It was issued by the Standards Council on July 14, 1994, with an effective date of August 5, 1994, and supersedes all previous editions.

The 1994 edition of this document has been approved by the American National Standards Institute.

Origin and Development of NFPA 302

This *Fire Protection Standard for Motor Craft* represents the cumulative result of over 69 years of attention to fire safety of power boats by the NFPA. The first edition of this standard was adopted by the Association in 1937. Successive editions adopted are as follows: 1939, 1948, 1950, 1951, 1952, 1953, 1954, 1955, 1957, 1960, 1964, 1966, 1968, 1972, 1980, 1984, and 1989.

Prior to 1937, the information was contained in Appendix D of NFPA 301, *Fire Prevention Regulations for the Construction and Maintenance of Vessels*.

For the 1994 edition, NFPA 302 was completely revised to improve its usability and adoptability, to make it compatible with industry practice and other industry standards, as well as to create a new chapter on lightning protection systems for boats. The Committee on Motor Craft also amended the existing provisions in Chapter 6 on gas-fueled equipment as well as added provisions for new fuels being used for cooking appliances on boats.

Technical Committee on Motor Craft

Bolling F. Douglas, *Chair*
Marine Assoc., Inc., GA

David Beach, Nat'l Marine Mfrs. Assn., IL
Ernest F. Braatz, Boat Owners Assn. of the U.S., VA
Russell Chiasson, Trident Marine Consultants, Inc., Canada
Desmond Connolly, Nat'l Assn. of Marine Surveyors Inc., MA
Bruce F. Dining, Marine Energy Systems, Inc., NH
Rep. Nat'l Propane Gas Assn.
David J. Duea, Fire Etc., CA
Rep. Nat'l Assn. of Fire Equipment Distributors Inc.
Charles B. Ford, Queenstown, MD
Rep. U.S. Coast Guard Auxiliary
E. Charles Game, Hatteras Yachts, NC
Lysle B. Gray, American Boat and Yacht Council, MD
Rep. American Boat & Yacht Council Inc.
Paul O. Huston, Amerex Corp., AL
Rep. Fire Equipment Mfrs., Assn. Inc.
Ralph E. Lambrecht, Independent Marine Engineer, IL
Robert Loeser, Underwriters Laboratories Inc., FL
Kim I. MacCartney, CIGNA Loss Control Services Inc., VA
Donald B. Pray, Donald B Pray Marine Surveyor, MA
Timothy G. Stillman, Ft. Lauderdale, FL
Rep. NFPA Fire Service Section

Alternates

Howard Carmichael Boyd, Amerex Corp., AL
(Alt. to P. O. Huston)
Thomas M. Hale, American Boat & Yacht Council, MD
(Alt. to L. B. Gray)
Jeffrey Hall, Underwriters Laboratories Inc., NC
(Alt. to R. Loeser)
Richard P. Schwartz, Boat Owners Assn. of the U.S., VA
(Alt. to E. F. Braatz)

Martha H. Curtis, NFPA Staff Liaison

This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

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

Committee Scope: This Committee shall have primary responsibility for documents on fire prevention and protection of motor craft and the encouragement of their use by designers, builders and owners.

Contents

NFPA 302

Fire Protection Standard for

Pleasure and Commercial Motor Craft

1994 Edition

NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates explanatory material on that paragraph in Appendix A.

Information on referenced publications can be found in Chapter 11 and Appendix D.

Chapter 1 General

1-1 Scope.

1-1.1 This standard provides minimum requirements for the prevention of fire and explosion and for life safety in case of fire. This standard also provides minimum requirements for:

(a) The elimination of possible sources of vapor ignition;

(b) Ventilation of accommodation spaces, fuel tanks, and machinery;

(c) The use of combustible materials; and

(d) Fire extinguishing equipment and fire exits.

1-1.2 This standard shall apply to boats of less than 300 gross tons (305 metric tons) used for pleasure and commercial purposes.

1-1.3 No requirement of this standard shall be construed as reducing applicable federal regulations.

1-2 Purpose.

1-2.1 The purpose of this standard is to minimize the loss of life and property due to fires and explosions aboard pleasure and commercial motor craft. The intent of this standard is to make motor craft as free from the hazards of fire as practicable.

1-2.2 The requirements of this standard shall be considered necessary to provide a reasonable level of protection from loss of life and property from fire and explosion. These requirements reflect the conditions and the state of the art at the time the standard was issued.

1-2.3 Applicability. Unless otherwise noted, it is not intended that the provisions of this standard be applied to facilities, equipment, structures, or installations existing or approved for construction or installation prior to the effective date of the standard, except in those cases where it is determined by the authority having jurisdiction that the existing situation involves a distinct hazard to life or adjacent property.

1-3 Equivalency. Nothing in this standard shall be intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety in place of those required by the standard, provided technical documentation is submitted to the authority having jurisdiction to demonstrate equivalency.

1-4 Units.* Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI). The liter unit, which falls outside of but is recognized by SI, is used commonly in international fire protection. These units are listed in Table 1-4 with their conversion factors.

Table 1-4

Name of Unit	Unit Symbol	Conversion Factor
Millimeter	mm	1 in. = 25.4 mm
Meter	m	1 in. = 0.0254 m
Square centimeter	cm^2	1 $in.^2$ = 6.452 cm^2
Square meter	m^2	1 ft^2 = 0.093 m^2
Cubic centimeter	cm^3	1 $in.^3$ = 16.39 cm^3
Cubic meter	m^3	1 ft^3 = 0.0283 m^3
Grams	g	1 oz = 28.35 g
Liter	L	1 gal = 3.785 L
Kilopascal	kPa gauge	1 psi = 6.90 kPa gauge
Bar	Bar	14.50 psi = 1 Bar
$Meters^3$ per minute	m^3/min	1cfm = 0.0283 m^3/min

1-4.1 If a value for a required measurement in this standard is followed by an equivalent value in metric units, the first stated value shall be regarded as the requirement. The equivalent value that follows is approximate.

Exception: For motor craft under the jurisdiction of Canadian authorities, the metric unit value shall be the requirement.

1-4.2 SI units have been converted by multiplying the quantity by the conversion factor and then rounding the result to the appropriate number of significant digits.

1-5 Definitions. For the purpose of this standard, the following terms are defined as follows:

AC Grounded Conductor. A current-carrying conductor intentionally maintained at ground potential that is connected to the side of the source.

AC Grounding Conductor (Green). A normally noncurrent-carrying conductor that connects the exposed metallic noncurrent-carrying parts of electrical equipment to the AC system and engine negative terminal or its bus for the purpose of minimizing shock hazard to personnel.

Accessible. Capable of being reached for inspection, maintenance, or removal without disturbing the permanent hull structure.

Accommodation Space. Space designed for living purposes.

Approved.* Acceptable to the authority having jurisdiction.

Authority Having Jurisdiction.* The organization, office, or individual responsible for approving equipment, an installation, or a procedure.

Battery Cold Cranking Rating. The discharge load in amperes that a battery at 0°F (–17.8°C) can deliver for 30 sec while maintaining a voltage of 1.2 volts per cell or higher.

Battery Reserve Capacity. The number of minutes for which a new, fully charged battery at 80°F (26.7°C) can be discharged at 25 amperes while maintaining a voltage of 1.75 volts per cell or higher (10.5 volts for a 12-volt battery or 5.25 volts for a 6-volt battery).

Bonding Conductor. A normally noncurrent-carrying conductor that is not intended to carry leakage current from either the AC or the DC system. Bonding conductors connect underwater metallic objects as part of any cathodic protection system and serve as lightning grounding conductors. If used, they shall be colored green or shall be of bare copper.

Butane. See LPG (Liquefied Petroleum Gas).

CNG (Compressed Natural Gas).* A natural lighter-than-air gas that consists principally of methane in gaseous form plus naturally occurring mixtures of hydrocarbon gases.

DC Grounded Conductor. A current-carrying conductor connected to the side of the source that is intentionally maintained at boat ground potential.

DC Grounding Conductor. A normally noncurrent-carrying conductor used to connect metallic noncurrent-carrying parts of a direct current device to the engine negative terminal or its bus for the purpose of minimizing stray current corrosion.

Double Insulation System. An insulation system comprised of insulation and supplementary insulation, with each insulation physically separated and so arranged to prevent its simultaneous subjection to the same level of deteriorating influences (temperature, contaminants, and the like) as the other.

Engine Exhaust System. The means by which products of combustion are conducted from the engine exhaust manifold to an outboard terminus. This system includes related accessories that can be metallic or nonmetallic, such as pipes, mufflers, silencers, turbochargers, spark arresters, and all necessary connecting and supporting fittings. Wet exhaust systems are provided with water injection into the exhaust gas stream; dry exhaust systems do not have this provision.

Engine Negative Terminal. The point on the engine at which the negative battery cable is connected.

Galvanic Isolator. A device installed in series with the AC grounding (green) conductor of the shore power cable to block, in effect, the low voltage DC galvanic current flow, yet permit the passage of AC current normally associated with the AC grounding (green) conductor.

Galvanically Compatible.* Metals that are related closely to each other in the galvanic series.

Gross Ton. Identical to document tonnage; generally related to the total internal volume of the vessel. Gross tonnage is a measurement of volume, not displacement.

Ground. The electrical potential of the earth's surface. The boat's ground is established by a conducting connection (intentional or accidental) with the earth, including any conductive part of the wetted surface of a hull.

Grounded Conductor. A current-carrying conductor intentionally maintained at ground potential that is connected to the side of the source.

Ground-Fault Circuit-Interrupter (GFCI). A device intended for protection of personnel that functions to de-energize a circuit or portion thereof within an established period of time when a current-to-ground exceeds some predetermined value that is less than that required to operate the overcurrent protective device of that supply circuit.

Ground-Fault Protector (GFP). A device intended to protect equipment by interrupting the electric current to the load when a fault current-to-ground exceeds some predetermined value that is less than that required to operate the overcurrent protection device of that supply circuit.

Grounding Conductor. A normally noncurrent-carrying conductor provided to connect the exposed metallic enclosures of electrical equipment to ground for the purpose of minimizing shock hazard to personnel.

Ignition Protection.* The design and construction of a device such that under the designed operating conditions:

(a) The device does not initiate ignition when surrounded by a flammable hydrocarbon mixture if an ignition source causes an internal explosion; or

(b) The device is incapable of releasing sufficient electrical or thermal energy to ignite a hydrocarbon mixture; or

(c) The source of ignition is hermetically sealed.

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

LPG (Liquefied Petroleum Gas).* The terms "liquefied petroleum gas," "LP-Gas," and "LPG" are synonymous and include any product composed predominantly of any of the following gaseous hydrocarbons: propane, propylene, butane, isobutane, butylenes, or a mixture thereof.

Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation that maintains periodic inspection of production of labeled equipment or materials and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Listed.* Equipment or materials included in a list published by an organization acceptable to the authority having jurisdiction and concerned with product evaluation that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

Machinery Space. Any space containing an internal combustion engine.

Open to the Atmosphere. A space or compartment that has at least 15 $in.^2/ft^3$ (97.5 cm^2/m^3) of net open area directly exposed to the atmosphere of net compartment volume.

Overcurrent Protection Device. A device, such as a fuse or circuit breaker, designed to interrupt the circuit when the current flow exceeds a predetermined value.

Panelboard. An assembly of devices for the purpose of controlling or distributing, or both, power on a boat. It can include devices such as circuit breakers, fuses, switches, instruments, and indicators. Panelboards are intended to be installed in enclosures and are accessible from the front or rear.

Permanently Installed. Fastened in place and not intended for ready removal except for service, repair, or replacement.

Pigtail. An external conductor that originates within an electrical component or appliance installed by the manufacturer.

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

Polarized System (AC). A system in which the grounded (white) and ungrounded conductors are connected identically in relation to all terminals or fixture leads on all devices in the circuit, including the shore power connections.

NOTE: This standard assumes the shore power source is wired in accordance with NFPA 70, *National Electrical Code®, Article 555.*

Propane. See LPG (Liquefied Petroleum Gas).

Readily Accessible. Capable of being reached quickly and safely for effective use under emergency conditions without the aid of tools.

Self-Limiting. A machine with a maximum output restricted to a specified value by its magnetic characteristics.

Shall. Indicates a mandatory requirement.

Sheath. A material, such as overlapping electrical tape, molded rubber, molded plastic, or flexible tubing, used as a continuous protective covering around one or more insulated conductors.

Shore Power Inlet. A reverse service-type fitting designed for mounting on a boat that requires a female connector on the shore power cable in order to make the electrical connection.

Should. Indicates a recommendation or that which is advised but not required.

Transformer, Isolation. A transformer installed in the shore power supply circuit of a boat to isolate electrically all AC system conductors, including the AC grounding conductor (green) on the boat, from the AC system conductors of the shore power supply.

Transformer, Polarization. A transformer ("dry-type" lightning transformer) installed in the shore power supply circuit on the boat to isolate electrically the normally current-carrying AC system conductors, but not the AC grounding conductor (green), from the normally current-carrying conductors of the shore power supply.

Trip-Free Circuit Breaker. A thermal or magnetically operated, or both, overcurrent protection device designed so that the resetting means cannot be pressed in manually to override the current-interrupting mechanism.

Watertight. So constructed that water does not enter the enclosure under test conditions specified in NEMA 250, *Enclosures for Electrical Equipment (1000 V Maximum).*

Weatherproof. Constructed or protected so that exposure to the weather does not interfere with successful operation.

NOTE: For the purpose of this standard, where applied to marine use, weatherproof implies resistance to rain, spray, and splash.

Ventilation. The changing of air within a compartment by natural or mechanical means. Ventilation can be achieved by introduction of fresh air to dilute contaminated air or by local exhaust of contaminated air.

Chapter 2 Hull

2-1 General Arrangement.

2-1.1 The hull shall be arranged so that all compartments are accessible and all escape hatches are unobstructed and readily accessible. Means of egress from accommodation spaces shall be provided without necessitating passage through the engine room.

2-1.1.1 Every boat having enclosed accommodation spaces shall have a readily accessible and unobstructed means of egress.

2-1.1.2 Every boat having enclosed accommodation spaces shall have a second accessible means of egress if it is possible for one exit to be blocked by a fire in a galley or machinery area.

2-1.1.3 The means of egress in 2-1.1.1 and 2-1.1.2 shall provide for minimum clear opening dimensions of 14 1/2 in. × 18 1/2 in. (36.8 cm × 47 cm) (rectangular); or 18 in. diameter (45.7 cm) (circular); or 270 in.^{2} (1741 cm^2) with a minimum dimension of 14 1/2 in. (36.8 cm) (oval).

2-1.1.4 Any hatch that is required for egress shall have a means of being operated from the inside and a means of being operated from the outside when not secured from the inside. All hinged hatches shall have a means or method to support the hatch in an open position.

2-1.2* Bulkheads or enclosures shall be installed between machinery spaces and accommodation spaces. These bulkheads or enclosures shall be continuous, except for necessary penetrations, to minimize the escape of fire extinguishing agents discharged into the machinery space.

2-1.3 Bilges of spaces containing fuel line fittings shall be separated from bilges of accommodation spaces and other enclosed spaces containing sources of ignition by bulkheads that shall not permit more than 0.25 fl oz (7.4 m) of leakage per hour when the liquid in the bilge is at a height of 12 in. (30 cm) or 1/3 the maximum height of the bulkhead, whichever is less. Above heights of 12 in. (30 cm) or 1/3 the maximum height, the bulkhead shall be permitted to have openings for the passage of conductors, piping, ventilation ducts, mechanical equipment, doors, hatches, and access panels, provided the maximum annular space around each item is not greater than 1/4 in. (6.4 mm).

Exception: Boats using diesel fuel only.

2-1.4 Machinery spaces shall be readily accessible.

2-1.5 Materials used for thermal and acoustical insulation in any compartment or enclosure containing an internal combustion engine or heater shall have a flame spread index of 75 or less. Material shall be labeled or listed as having been tested to meet the requirements of NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials.*

2-1.6 Materials used for thermal and acoustical insulation shall not disintegrate in the presence of hydrocarbon vapor.

2-1.7 Materials used for thermal and acoustical insulation shall be designed and installed such that hydrocarbon vapors cannot accumulate within the material and thereby reduce its flame spread rate.

2-2 Spaces Open to the Atmosphere.

2-2.1 Compartments or spaces connecting with engine or portable fuel tank spaces that are open to the atmosphere shall require ventilation if the connecting space has an open area of less than 15 $in.^2/ft^3$ (2.8 cm^2/m^3) of its net volume. The open area shall be open either to the atmosphere or to another open space, provided that, for the combined net volumes of the connecting spaces, there is a total area open to the atmosphere of at least 15 $in.^2/ft^3$ (2.8 cm^2/m^3).

2-2.2 Long, narrow spaces formed by side panels or accommodation floors shall have openings at both ends or along the sides if they are to be considered open to the atmosphere.

2-3 Connecting Compartments or Spaces by a Natural Ventilation System.

2-3.1 A natural ventilation system shall be provided for each compartment in a boat that:

(a) Contains a permanently installed gasoline engine;

(b) Has openings between the compartment and a compartment that requires ventilation, where the aggregate of those openings exceeds 2 percent of the area between the compartments, except as provided in 2-3.1(e)(2);

(c) Contains a permanently installed fuel tank and an electrical component that is not provided with ignition protection;

(d) Contains a fuel tank that vents into that compartment; or

(e) Contains a nonmetallic fuel tank that:

1. Has an aggregate permeability rate exceeding 1.2 g (0.04 oz) of fuel loss in 24 hours per cubic foot of net compartment volume; or

2. Is located where the net compartment volume is less than 1 ft^3. The nonmetallic fuel tank shall have a permeability rate not exceeding 1.2 g (0.04 oz) of fuel loss in 24 hours. Reference fuel "C" at 104°F ± 36°F (40°C ± 2°C) from ASTM D471, *Standard Test Method for Rubber Property, Effect of Liquids,* shall be used in determining the permeability rate.

Exception: Compartments open to the atmosphere.

2-3.2 Each required supply opening shall be located on the exterior surface of the boat.

Exception: An accommodation compartment located above a compartment requiring ventilation that is separated from the compartment requiring ventilation by a deck or other structure shall not be required to meet the provisions of 2-3.1(e)(2).

2-3.3 An accommodation compartment located above a compartment requiring ventilation that is separated from the compartment requiring ventilation by a deck or other enclosure shall not be considered a connecting compartment.

2-4* Natural Ventilation.

2-4.1 Each compartment not open to the atmosphere shall be provided with a natural ventilation system where such a compartment:

(a) Contains a permanently installed gasoline engine.

(b)* Contains a portable fuel tank that vents into the compartment. Space under a motor well in outboard boats that is large enough to accommodate a 6-gal (23-L) portable fuel tank but is not intended for such usage shall be labeled to prohibit its use for fuel storage.

(c) Contains fuel tanks and contains components without ignition protection.

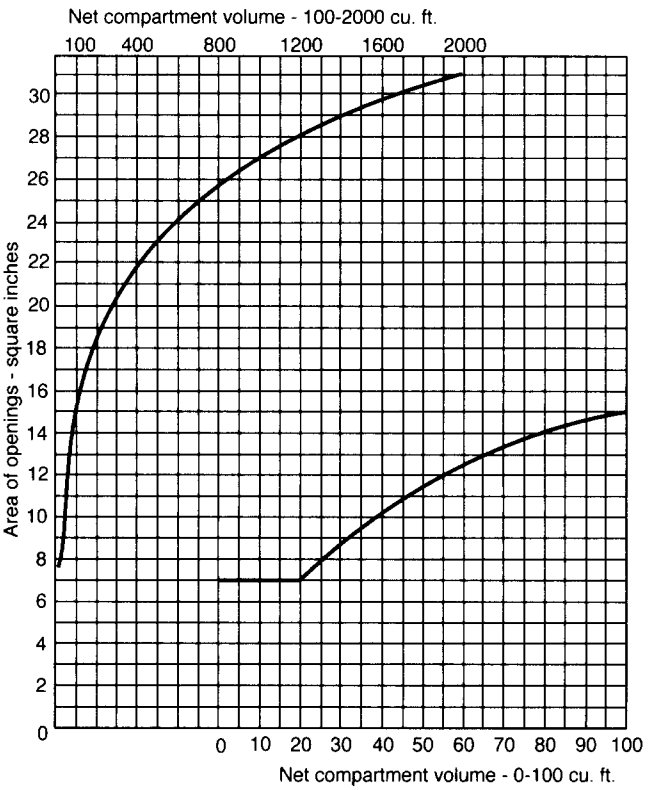
2-4.2 Each natural ventilation system shall be constructed with at least one intake and one exhaust opening that shall be located on the boats exterior surface.

2-4.3* Each compartment requiring natural ventilation shall be equipped with an exhaust duct(s) originating in the lower one-third of the compartment, with the duct opening permanently fixed above the normal accumulation of bilge water. If the compartment is an engine compartment, the exhaust duct(s) shall be located as near below the engine(s) as practicable.

2-4.4 Each exhaust duct shall be fitted with a cowl or its equivalent at the discharge opening, that shall face aft.

2-4.5 Air intake openings inside a compartment shall be separated from exhaust duct openings inside the compartment by at least 24 in. (0.60 cm) or the longest compartment dimension.

2-4.6 The minimum aggregate internal cross-sectional area of intake ducts or openings shall be as shown in Figure 2-4.6.



Note: The values in Figure 2-4.6 are based on the following equation:

$$A = 5 \log_e \left(\frac{V}{5}\right)$$

where: A = the minimum aggregate internal cross-sectional area of the openings or ducts in square inches.

V = the net compartment volume in cubic feet, including the net volume of other compartments sharing the same ventilation system.

$\log_e \left(\frac{V}{5}\right)$ = the natural logarithm of the quantity $\left(\frac{V}{5}\right)$ See Figure 2-4.6.

Figure 2-4.6 Area of openings.

2-4.7 The minimum aggregate internal cross-sectional area of exhaust ducts or openings shall be calculated in the same manner as for intakes. (*See 2-4.6.*)

2-4.8 Duct size shall be based on nominal diameters and shall be at least 3 in. (7.5 cm) in diameter. Openings shall be of at least equivalent cross-sectional area. See Table 2-4.8 for standard duct sizes.

Table 2-4.8 Standard Duct Sizes

7.07 in.^{2} (46.0 cm^2)	(3 in. dia) (7.5 cm)
9.62 in.^{2} (62.5 cm^2)	(3½ in. dia) (8.8 cm)
12.57 in.^{2} (81.7 cm^2)	(4 in. dia) (10 cm)
19.63 in.^{2} (12.6 cm^2)	(5 in. dia) (12.5 cm)

2-4.9 The minimum cross-sectional area of terminal fittings for flexible ventilation ducts shall not be less than 80 percent of the required internal cross-sectional area of the flexible ventilation duct.

2-5 Powered Ventilation System.

2-5.1 Each compartment, not open to the atmosphere, that has a permanently installed gasoline engine with a cranking motor shall be ventilated by an exhaust blower.

2-5.2 Blowers.

2-5.2.1 Blowers shall be rated for continuous operation at 120 percent of nominal voltage.

2-5.2.2* Blowers shall meet the external ignition protection requirements of UL 1128, *Standard for Safety Marine Blowers*, or UL 1500, *Standard for Safety Ignition-Protection Test for Marine Products*.

2-5.2.3 Blowers shall be rated for airflow in cubic feet per minute, at nominal voltage, in accordance with Figure 12 of AMCA/ANSI 210, *Laboratory Methods of Testing Fans for Rating*, or UL 1128, *Standard for Safety Marine Blowers*. (*See Figure 2-5.2.3.*)

2-5.3 Installation of Powered Ventilation.

2-5.3.1 Blower(s) capacity shall be selected in accordance with the blower capacity curve in Figure 2-5.2.3. More than one blower shall be permitted.

2-5.3.2 As installed, the blower system(s) shall exhaust air from the boat at a rate in accordance with the system performance curve in Figure 2-5.2.3 when the engine is not operating and the blower is operating at the electrical systems nominal voltage.

2-5.3.3 Blowers shall be mounted above the normal level of accumulated bilge water.

Exception: Submersible blower motors.

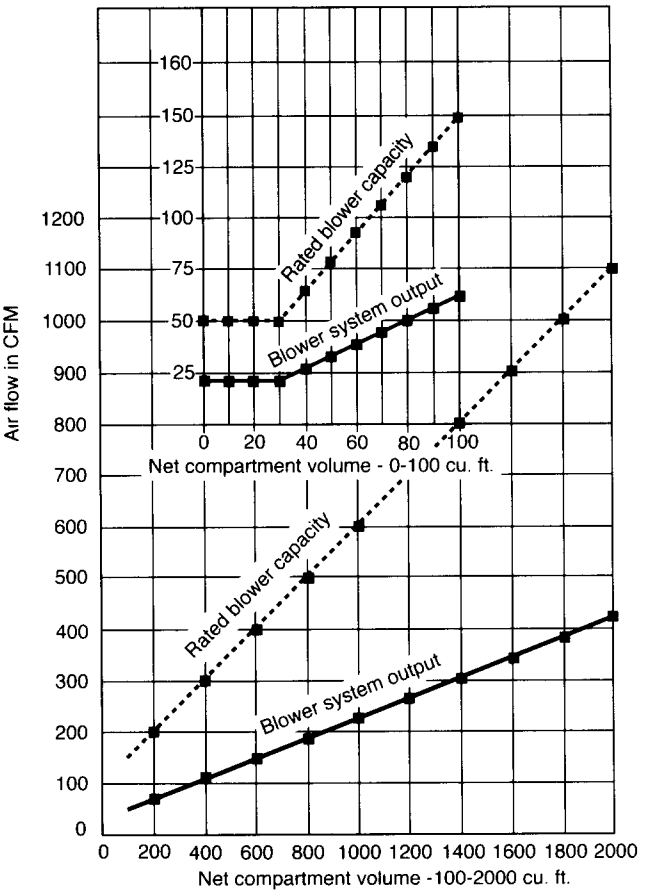
2-5.3.4 Blowers shall be installed with ducts having intake openings that are:

(a) Permanently secured;

(b) Located in the lower one-third of the compartment;

(c) Located above the normal level of accumulated bilge water; and

(d) Located as near below the engine(s) that they serve as practicable.



Note: The blower capacity curve is included for informational purposes and represents the average relationship of capacity to performance.

Figure 2-5.2.3 Minimum blower capacity and system performance.

2-5.3.5 Electrical wiring shall be installed in accordance with Chapter 7 or Chapter 8.

2-5.3.6 Each boat that requires a powered ventilation system shall display a warning label that provides the information that follows, located in plain view of the operator, and located as close as practicable to each ignition switch (including auxiliary equipment).

The powered ventilation label shall read as follows:

WARNING
Gasoline Vapors Can Explode

Before Starting Engine:
1. Check Engine Compartment for Gasoline or Vapors
2. Operate Blower for 4 Minutes

2-6 Arrangements of Openings.

2-6.1 Ventilation openings shall be located to prevent the entrance of water in amounts that could impair the stability or handling of the vessel or that could cause machinery malfunction under conditions of maximum heel or trim, reverse operation, eccentric loading or wave action, and all operating conditions.

2-6.2 External openings of intakes and exhausts shall be located to minimize re-entry of exhausted fumes.

2-6.3 External openings of intakes and exhausts shall be located and oriented to prevent entry of fuel vapors. In no instance shall the intakes and exhausts be closer than 15 in. (38 cm) horizontally from the gasoline fill and vent fittings.

2-6.4 Ventilation openings shall be unobstructed by side curtains, cockpit enclosures, dodgers, and other weather enclosures.

Chapter 3 Engines

3-1 Exposed Engine Surface Temperatures. Exposed engine surfaces shall not exceed 225°C (437°F) under normal operating conditions. An audible or visual device shall be installed to warn of excessive engine temperature.

Exception: Short branch connections between liquid-cooled exhaust manifolds and cylinder head exhaust ports, or hot spots on intake manifolds.

3-1.1 Gasoline engine fuel pumps of the diaphragm type shall be designed so that fuel shall not be released to the engine space if primary diaphragm failure occurs. Means shall be provided to determine that diaphragm failure has occurred without dismantling the fuel pump.

3-1.2* Marine Carburetors.

3-1.2.1 Marine carburetors shall not leak more than 5 cm^3 (0.17 fl oz) of fuel in 30 seconds when the float valve is open, the carburetor is at half throttle, and the engine is cranked without having been started or when the fuel pump is delivering the maximum pressure specified by its manufacturer.

3-1.2.2 Each updraft and horizontal draft carburetor shall have a device that collects and holds fuel that flows out of the carburetor venturi section toward the air intake, prevents collected fuel from being carried out of the carburetor assembly by the shock wave of a backfire or by reverse airflow, and returns collected fuel to the engine induction system after the engine starts.

3-1.2.3* Spark ignition engine air intakes shall be fitted with a means of backfire flame control approved by the U.S. Coast Guard or meeting the requirements of UL 1111, *Standard for Safety Marine Carburetor Flame Arresters.*

3-1.3 Electrical components for engines shall comply with Chapters 7 and 8, as applicable.

3-1.4 Air-Cooled Engines.

3-1.4.1 Permanently installed air-cooled engines with self-contained fuel systems shall be located only on open decks or on cabin tops. Any housing over such units shall be open whenever the engine is operating.

3-1.4.2 If air-cooled engines are enclosed, the following shall apply:

(a) Factory installed engine air-cooling shrouding shall be constructed and mounted to trap all engine-cooling air and lead it to a point from which it can be discharged outside the hull or engine box by means of ducting.

(b) Ducts for engine-cooling air shall have a flame spread index of 75 or less. Material shall labeled or listed as having been tested to meet the requirements of NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials.*

(c) Engine-cooling air shall not be used as a direct source of cabin heating.

3-1.5 Portable gasoline engines with integral fuel tanks or portable gasoline fuel tanks shall be stowed securely in an open or ventilated space in accordance with Sections 2-2 and 7-8 so that fuel or vapors cannot reach interior spaces.

3-1.6 Nonpropulsion engines intended for automatic operation shall be equipped with an automatic shutdown device actuated by low oil pressure, excessive engine overheat, and excess heat from exhaust pipe or exhaust gas ducting.

3-1.7* High tension cable assemblies shall conform to SAE J2031, *Standard for High Tension Ignition Cable.*

3-1.8 Ignition distributors shall conform to UL 1500, *Standard for Safety Ignition-Protection Test for Marine Products.*

NOTE: For information on ignition distributors, see SAE J1294, *Recommended Practice for Ignition Distributors—Marine.*

Chapter 4 Engine Exhaust Systems

4-1 General Requirements.

4-1.1 Exhaust systems shall:

(a) Be gastight to hull interiors;

(b) Have all connections accessible;

(c) Be supported to minimize failure from vibration, shock, expansion, and contraction;

(d) Have no threaded fittings into nonmetallic exhaust system components; and

(e) Have no discharge from other devices into the exhaust.

Exception: Engine-cooling water.

4-1.2 Wherever personnel or combustibles can come in contact with hot surfaces, effective protection shall be provided by water-jacketing, lagging, shielding, guards, or engine enclosures.

4-1.3 Hangers, brackets, or other means used to support metallic exhaust systems shall be noncombustible:

(a) Within 6 ft (1.8 m) of the engine connection(s) for wet exhaust systems.

(b) For the full length of dry exhaust systems.

4-1.4 A means to indicate loss of exhaust-cooling water shall be provided so that it is effective at all helm positions.

Exception: Outboard engines.

4-1.4.1 Auxiliary engines shall be permitted to use an automatic shutdown device in place of an audible or visual device for response to high exhaust temperature.

4-1.5 A separate exhaust system shall be provided for each engine.

4-2 Materials.

4-2.1 Materials used in engine exhaust systems shall be resistant to fuels, water, corrosion, and the products of combustion.

4-2.2 Copper shall not be used in contact with dry diesel exhaust gases or within six pipe diameters downstream from the point of water entry in water-cooled exhaust systems.

4-2.3 As installed, nonmetallic exhaust system components shall retain watertight integrity for two minutes after a total loss of cooling water, with the engine operating at full power.

4-3 Hose Connections. Hose connections shall be double-clamped.

Exception: Single-clamped hoses designed for specific use as part of an engine assembly.

4-4 Temperature Protection. The turbine side of nonwater-jacketed turbochargers and unjacketed, single-wall, dry exhaust components shall be installed so that the temperature of adjacent combustible surfaces shall not exceed 250°F (121°C).

4-5 Labeling. All nonmetallic exhaust components shall be labeled or marked "marine exhaust."

NOTE: For information on nonmetallic exhaust components, see UL 1129, *Standard for Safety Wet Exhaust Components for Marine Engines.*

Exception: Components designed for use as a part of a specific engine assembly.

Chapter 5 Fuel Systems

5-1 Scope.

5-1.1 The requirements of this chapter shall apply to the design, construction, choice of materials, and installation of permanently installed fuel systems (except compressed gas) that run from the fuel fill opening to the connections at each engine or at auxiliary equipment.

5-1.2 The requirements of this chapter shall apply to all tanks that are permanently installed. Any tanks with a capacity of more than 7 gal (27 L) shall be permanently installed.

5-2 General Requirements.

5-2.1 Fuel systems shall be liquid- and vapor-tight with respect to hull interiors. Individual system components and the system as a whole shall be designed and installed to withstand the stresses of and exposure to marine service such as pressure, vibration, shock, movement, grease, lubricating oil, bilge solvents, high aromatic fuels, and corrosive environments.

5-2.2 All individual components of the fuel system, as installed in the boat, shall be capable of withstanding a 2½-minute exposure to free-burning fuel without a failure that results in leakage of liquid or vapor.

Exception No. 1: Fuel distribution lines on boats shall not be required to comply with 5-2.4 if a break at any point in the line will cause a discharge of not more than 5.0 fl oz (150 ml) of fuel within 2½ minutes. (See 5-6.2.2.)

Exception No. 2: Self-draining fuel tank vent hose located outside the engine compartment shall not be required to comply with 5-2.4.

5-2.3 To ground static electricity, the resistance between ground and each metallic or metallic-plated component of the fuel fill system and fuel tank that is in contact with fuel shall be less than 1 ohm.

5-2.4 Pressurized fuel tanks shall not be used.

5-3 Fuel Tank Materials.

5-3.1 Fuel tanks shall not be integral with the hull structure.

Exception: Tanks for diesel fuel in boats with metal hulls.

5-3.2 Materials for fuel tanks shall be corrosion-resistant. Materials meeting the specifications of 5-3.2.1 through 5-3.2.5 and of Table 5-3.2 shall be considered as satisfying this corrosion resistance requirement. Any departure from these specifications shall be identified and marked specifically.

Table 5-3.2 Minimum Plate Thickness for Fuel Tank Corrosion Resistance

Material	Specification	Minimum Nominal Sheet Thickness	Gauge
Nickel-copper	ASTM B127 Class A	0.031 in.	22
Copper-nickel steel	ASTM B122 M	0.045 in.	17
Aluminized steel	ASTM A90 M	0.0747 in.	14
Aluminum	ASTM A463	0.0478 in.	18
	Alloy 5052	0.090 in.	
	Alloy 5083		
	Alloy 5086		
Stainless steel	316L	0.031	22

For SI units: 1 in. = 2.5 cm
NOTE: Gauges provided in Table 5-3.2 are U.S. Standard for nickel-copper, AWG for copper-nickel, and Manufacturer's Standard for steel.

5-3.2.1 Steel tanks used for fuel shall:

(a) Be galvanized inside and outside by the hot-dip process;

Exception: Diesel fuel tanks shall not be galvanized on the inside.

(b) Be constructed of aluminized steel;

(c) Not be constructed of terneplate steel.

5-3.2.2 Aluminized steel tanks with a wall thickness of less than 0.0785 in. (2 mm) shall be installed only above the cockpit floor or above deck if not clearly defined cockpit exists.

5-3.2.3 Stainless steel tanks shall be cylindrical with domed heads and shall have a capacity of less than 20 gal (76 L).

5-3.2.4 Seams of tanks constructed of nickel-copper shall be made by using oxyacetylene, shielded arc, atomic hydrogen, electric resistance seam welding, brazed joints, and riveted and brazed joints.

5-3.2.5 Seams of 22-gauge nickel-copper shall be formed by electric resistance seam welds. Fuel tanks formed of 22-gauge nickel-copper shall not be used for tanks exceeding 30 gal (114 L) capacity.

5-3.3 Nonmetallic materials meeting the applicable requirements of Chapter 5 shall be permitted to be used for tanks, provided the aggregate permeability rate of such tank does not exceed 1.2 g/ft^3 (0.04 oz/m^3) in 24 hours (1.2 g/m^3) in 24 hours of fuel loss of net compartment volume, or, if the compartment volume is less than 1 ft^3 (0.03 m^3), the permeability rate does not exceed 1.2 g (0.04 oz) of fuel loss in 24 hours. (*See 5-5.4.*)

5-4 Fuel Tank Design and Construction.

5-4.1 Fuel tanks shall conform to the following:

(a) They shall not have openings in bottom, sides, or ends.

(b) Openings for fill, vent, and feed pipes and level gauges (if installed) shall be at or above the topmost surface of tanks.

(c) Clean-out plates shall not be installed.

(d) Plates used for fittings shall be secured in such a manner that they cannot be used for clean-out purposes.

Exception: Diesel fuel tanks shall not be required to comply with 5-4.1.

5-4.2 Tanks shall be constructed so that, when installed, exterior surfaces shall not trap water.

5-4.3 Threaded fittings shall conform to Table 5-4.3.

Table 5-4.3 Minimum Thread Engagement

Thread Engagement	Minimum Length of I. P. S.
1/4 in.	3/8 in.
3/8 in.	3/8 in.
1/2 in.	1/2 in.
3/4 in.	9/16 in.
1 in.	5/8 in.
1 1/4 in.	5/8 in.
1 1/2 in.	5/8 in.
2 in.	11/16 in.

For SI units: 1 in. = 2.5 cm

5-4.4 Fuel tanks with a capacity of 25 gal (95 L) or greater shall not leak when subjected to the pressure impulse test requirement of Title 33, *Code of Federal Regulations*, Subpart 183.586.

5-4.5 Fuel tanks with a capacity of less than 25 gal (95 L) shall not leak when subjected to the shock test requirement of Title 33, *Code of Federal Regulations*, Subpart 183.584.

5-4.6 Fuel tanks with a capacity of 200 gal (760 L) or more shall not leak when subjected to the slosh test requirement of Title 33, *Code of Federal Regulations*, Subpart 183.588.

5-4.7 All metal tanks and the metal fitting plates of nonmetallic fuel tanks shall be provided with a bonding terminal suitable for the attachment of a No. 8 AWG bonding conductor.

5-4.8 Indentations for labeling or other identification shall not weaken the fuel tank.

5-4.9 All fuel tanks shall bear a legible, permanent label located so that it is visible for inspection after installation. The label shall provide the following information:

(a) Manufacturer's name or logo and address

(b) Month (or lot or serial number) and year of manufacture

(c) Capacity in U.S. gallons (capacity also shall be permitted to be expressed in liters)

(d) Construction material and thickness

(e) Fuel for which tank is intended

(f) Maximum test pressure

(g) Model number, if applicable

(h) A statement that reads "This tank has been tested under Title 33, *Code of Federal Regulations*, Subpart 183.510(a)"

Exception: Diesel fuel tanks.

(i) A statement that reads "Must be installed aft of the half-length of the boat," if the tank has been tested under Title 33, *Code of Federal Regulations*, Subpart 183.584, at less than 25 G vertical accelerations.

5-4.10 All fuel tanks shall be tested by the manufacturer for fuel tightness at 3.0 psig (21 kPa gauge) or 1.5 times the maximum head to which they can be subjected during service, whichever is greater.

5-4.11 Because the tank can flex in service, the design of the pick-up tube shall preclude damage to the tank bottom.

5-4.12 The use of gauge glasses shall be restricted to day or service tanks of diesel fuel systems.

5-5 Fuel Tank Installation.

5-5.1 Fuel tanks and their fittings shall be accessible.

5-5.2 Metallic fuel tanks shall be positioned above normal accumulations of bilge water and supported in a manner that shall ensure complete drainage of water from all exterior tank surfaces, as installed.

Exception: Diesel fuel tanks that are integral with the hull.

5-5.3 Fuel tanks shall be installed and secured to prevent permanent deformation and to provide immobilization to the extent practicable.

5-5.4 Nonmetallic fuel tanks that expand dimensionally after exposure to fuel shall:

(a) Be installed in accordance with the fuel tank manufacturer's instructions, which shall indicate clearly in diagram form the clearances required; and

(b) Be provided with a warning label that includes the following information:

WARNING: To prevent hull and tank damage due to expansion of the tank while in service, installation shall be in accordance with the manufacturer's instructions.

5-5.5 In order to permit free circulation of air, contact between metallic fuel tanks and other structures shall be limited to necessary structural supports.

5-5.6 All abrasive or absorbent surfaces of tank supports and braces shall be insulated effectively from contact with tank surfaces by a nonabrasive and nonabsorbent material.

5-5.7 Aluminized steel tanks of thicknesses less than 0.0785 in. (2 mm) shall be installed above the cockpit deck, or above deck if there is no clearly defined cockpit.

5-5.8 Nonferrous and nonmetallic fuel tanks shall be permitted to be foamed in place if they comply with the requirements of Title 33, *Code of Federal Regulations*, Subpart 183.516. (*See 5-5.4.*)

5-5.9 Fuel tanks shall not be installed above the engine or other sources of ignition.

5-6 Fuel Lines and Related Accessories.

5-6.1 For the purposes of this section, fuel lines shall mean all pipes, tubing, or hoses that conduct fuel from the deck fill plate to the engine connection. Related accessories shall include any attachments to fuel lines such as valves, filters, strainers, pumps, and connecting fittings.

5-6.2 General Requirements.

5-6.2.1 Rigid metallic fuel lines shall be made of seamless, annealed copper, nickel-copper, or copper-nickel having a minimum nominal wall thickness of 0.032 in. (0.8 mm).

5-6.2.2 Flexible nonmetallic fuel hose shall be U.S.C.G. Type A-1 hose where 2½ minutes minimum fire resistance is required or shall be U.S.C.G. Type B-1 hose where 2½ minutes minimum fire resistance is not required. (*See 5-2.2.*)

5-6.2.3 Fuel lines, connections, and accessories shall be accessible.

5-6.2.4 Plastic pipe and fittings shall not be used in fuel distribution lines, vent lines, and fill lines. (*See 5-2.2.*)

Exception No. 1: Components of deck fill fittings, vent fillings, carburetor fittings, fuel pump fittings, and fuel filter fittings.

Exception No. 2: Engineering grade plastics such as glass-reinforced nylons.

5-6.2.5 Fuel lines shall be secured against movement or vibration by the use of noncombustible clips or straps without rough surfaces or sharp edges. Clips and straps shall have fire resistance equivalent to the requirement of the line they support.

5-6.2.6 Where making up threaded pipe connections, a gasoline-resistant sealing compound or tape shall be used.

5-6.2.7 Where making flared tubing connections, tubing shall be cut squarely and flared by tools designed for the purpose. Tubing shall be deburred, and copper tubing shall be annealed prior to being flared.

5-6.2.8 Outlets for drawing fuel from the system are prohibited.

Exception: Filter bowl plugs provided for the purpose of servicing only.

5-6.2.9 Manually operated multiposition valves shall be required to indicate only their open and closed positions. Manually operated stop valves shall be designed with positive stops in the open and closed positions.

5-6.3 Installation of Fill and Vent Pipes.

5-6.3.1 Fuel tank fill and vent pipes shall be located to prevent the escape of liquid and vapor overflow to the inside of the hull and to provide protection from the flow of vapors escaping into the hull.

5-6.3.2 No liquid fuel shall enter the boat from the fill due to an overflow rate of 5 gpm (19 Lpm) for 5 seconds when the boat is in its static floating position.

5-6.3.3 The vent pipe shall terminate as remotely as practicable from any hull opening and shall be installed to minimize the intake of water without resisting the release of vapor. Overflow from the vent at a rate of 2 gpm (7.7 Lpm) shall not enter the boat.

5-6.3.4 The minimum inside diameter of the fill pipe system shall be 1¼ in. (3.2 cm) [a minimum hose diameter of 1½ in. (3.8 cm)].

5-6.3.5 The fill pipe shall run as directly as possible, preferably in a straight line, from the deck plate or other closable plate to the tank top spud.

5-6.3.6 The fuel fill shall be identified by a permanent marking indicating the type of fuel.

5-6.3.7 If a nonmetallic hose is used in the fill pipe system, it shall be secured tightly with a minimum of two corrosion-resistant metal clamps of ½ in. (12.7 mm) minimum width at each end of the hose. Clamps depending solely on spring tension shall not be used.

5-6.3.8* Bonding wire ends shall not be clamped between the fill pipes and the flexible tubing.

5-6.3.9 There shall be no blow-back of fuel through the fill fitting while filling at a rate of 9 gpm (35 Lpm) and to a level of ¼ to ¾ of the capacity indicated by the tank label.

5-6.3.10 The vent pipe connection shall be at the highest point of the tank, when installed in the boat, under conditions of normal trim.

5-6.3.11 The minimum inside diameter of any component of the vent line system shall be not less than 7/16 in. (11 mm).

5-6.3.12 The fittings at the hull vent line opening shall be corrosion-resistant. Each fuel tank vent system shall have a flame arrester that can be cleaned, unless the vent system itself is a flame arrester.

Exception: If metallic vent lines are used and serve as effective flame arresters, the hull vent fitting shall not be required to be a flame arrester.

5-6.4* Installation of Fuel Feed Lines and Accessories.

5-6.4.1* Electric fuel supply pumps shall operate only when the engine is operating, when the cranking motor is energized, or when they are operated by a momentary switch for priming and shall be located either on or within 12 in. (30 cm) of the engine. Hose installed on the pressure side of the fuel pump shall be U.S.C.G. Type A-1.

Exception: Priming pumps in outboard motor fuel systems.

5-6.4.2 Fuel lines shall be run with as few connections as practicable.

5-6.4.3 Anti-siphon protection shall be provided in fuel systems that are exempted from the requirements of 5-2.2 or where the fuel level in the tank is higher than the carburetor inlet fitting. Anti-siphon protection shall be provided by one of the following methods:

(a) All parts of the fuel distribution lines shall be kept above the tank top when the boat is in its static floating position.

(b) An anti-siphon valve shall be installed at or above the tank withdrawal fitting.

(c) An electrically operated valve shall be installed, at or above the tank withdrawal fitting, that opens only when the engine is energized and that provides for manual override.

5-6.4.4 A readily accessible manual shutoff valve shall be installed on all fuel tanks directly at the tank connection, except on those fuel systems provided with anti-siphon protection. If the fuel tank(s) is located in machinery space(s), a remotely operated means of closing the valve(s) without opening machinery spaces shall be provided.

5-6.4.5 That part of the fuel feed line secured to the hull members shall be separated from that part secured to the engine by a flexible section meeting the requirements of 5-6.2.2.

5-6.4.6 The fixed fuel line shall be fastened to structures within 4 in. (10 cm) of the connection to the flexible section to secure against vibration and movement.

Chapter 6* Cooking, Heating, and Auxiliary Appliances

6-1 General.

6-1.1 Printed instructions for proper installation, operation (including refueling, where applicable), and maintenance shall be provided with each appliance. The instructions shall include information on the hazards associated with appliance air consumption and installer information regarding the proper display of a warning label.

6-1.2 Appliances using gasoline in liquid or solid form for priming or fuel shall be prohibited.

6-1.3* The design and installation of appliances shall consider the air consumption of the appliances and the venting of exhaust products.

6-1.4 An appliance shall be mounted in accordance with the manufacturer's instructions and shall be fastened securely when in use or stored.

6-1.5 A burner system shall be capable of operation without creating a fire hazard during periods of boat pitch and roll at angles up to 30 degrees from horizontal in any direction sustained for 15 seconds and shall be capable of continuous operation at angles of heel up to 30 degrees.

6-1.6 A durable and permanently legible sign mounted to be readily visible and detailing the proper operation and any unique hazards of the appliance shall be provided.

6-1.7 Operating controls shall be located to be easily accessible and to reduce the likelihood of injury from burners or elements while in use.

6-1.8 Appliances with automatic igniter glow plugs or continuously lighted pilot lights for burner ignition shall be prohibited.

Exception No. 1: Automatic igniter glow plugs in appliances using sealed combustion chambers.

Exception No. 2: An oven control flame that operates only when the stove is in use.

6-1.9 Appliances shall be marked or identified permanently with the following information in a location visible after installation:

Manufacturer's name or trademark
Model number
Serial number, if applicable
Fuel/energy used
Maximum power consumption in kW when operating at capacity.

6-2 Cooking Appliances Installation.

6-2.1 Exposed materials and finishes above, below, and surrounding heat-generating surfaces of appliances shall have a flame spread index of not more than 75 as determined in accordance with NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials.*

6-2.2 Fabrics located above and within 39 in. (1 m) of a galley stove top, used for decorative or other purposes, shall be flame resistant in accordance with NFPA 701, *Standard Methods of Fire Tests for Flame-Resistant Textiles and Films.*

6-2.3 With the appliance installed, the temperature of vertical combustible surfaces below and surrounding heat-generating surfaces shall not rise more than 150°F (65°C) above the compartment's ambient temperature when tested using the temperature test of UL 858, *Standard for Safety Household Electric Ranges*, Section 53.

6-3 Coal, Charcoal, and Wood Burning Appliances.

6-3.1 Solid-fuel burning appliances shall not be installed in gasoline powered boats.

6-3.2 Coal, charcoal, and wood burning stoves shall be either mounted on a noncombustible base (preferably hollow tile) or mounted on legs providing a clearance of at least 5 in. (13 cm) between the stove bottom and the deck, and the deck shall be insulated with a noncombustible material or sheathing. The sides and backs of uninsulated stoves shall have a minimum clearance of 9 in. (23 cm) from the exposed materials and finishes, which shall meet the requirements of 6-2.1 or shall be separated by fire-resistant thermal insulation. The sides and backs of insulated stoves shall have a minimum clearance as specified by the manufacturer.

6-3.3 Single-wall smoke pipes and stacks shall have a minimum clearance of 9 in. (23 cm) from combustible materials, including painted surfaces, or shall be separated by fire-resistant thermal insulation. Listed and labeled double- or triple-wall smoke stacks shall be installed with a minimum clearance specified by the manufacturer.

Exception: At decks equipped with water irons.

6-3.4 Permanently installed solid-fuel burning appliances shall be equipped with a double- or triple-wall smoke pipe or stack that shall terminate above deck, with smoke heads designed to minimize water entry, spark emission, and backdraft.

Exception No. 1: Solidified alcohol galley stoves.

Exception No. 2: Exterior mounted grills.

6-3.4.1 Double- or triple-wall smoke stacks meeting the requirements of UL 103, *Standard for Safety Chimneys, Factory-Built, Residential Type, and Building Heating Appliances*, shall be installed in accordance with the specifications of the manufacturer.

6-3.5 To prevent spontaneous combustion, charcoal shall be kept dry and stored in a closed, dry, metal container.

6-4 Liquid Fuel Appliances [Does not include LPG (Liquefied Petroleum Gas)].

6-4.1 Both pressure and gravity-fed burners shall be permitted.

6-4.2 Fuel supply tanks shall be constructed of corrosion-resistant metal or of metal having a corrosion-resistant finish or coating.

6-4.2.1 Pressurized liquid fuel tanks that are integral with an appliance shall withstand an internal pressure of four times the relief valve setting or 200 psig (1400 kPa gauge), whichever is greater. The tanks shall be shielded or insulated so that, under continuous operation at maximum heat, the pressure in the tank shall not exceed 50 percent of the relief valve setting. The complete system shall be tested up to the pressure of the relief valve setting.

6-4.2.2 Pressure tanks for remote installation shall be able to withstand a test pressure of at least 100 psig (700 kPa gauge) or twice the appliance relief valve setting, whichever is greater. The tanks shall be secured rigidly in an accessible location, allowing convenient filling and pump operation.

6-4.2.3 Gravity tanks installed in the compartment with the appliance shall be located or shielded so that, when installed and under continuous operation at maximum heat output, the fuel temperature shall not rise more than 25°F (–4°C) above the compartment temperature.

6-4.2.4 No gravity tank shall have a capacity exceeding 2.1 gal (8 L). Tanks of larger capacity shall meet the requirements of Section 5-3 and shall be capable of withstanding a pressure of 3 psig (21 kPa gauge).

6-4.2.5 Nonintegral gravity tanks shall have provisions for filling and venting at a distance of at least 39 in. (1 m) from open flame unless separated by a vapor-tight partition or bulkhead.

6-4.2.6 A readily accessible shutoff valve, not integral with the appliance, shall be located near liquid fuel gravity tanks and at or on all remote pressure fuel supply tanks. The valve shall close against fuel flow and shall indicate clearly the closed and open positions.

6-4.2.7 Liquid fuel supply lines from remote tanks shall be installed as a continuous run from the shutoff valve at the tank to the appliance or to the flexible section located immediately before a gimbaled stove.

6-4.2.7.1 Flexible liquid fuel supply hose sections shall be compatible with the fuel used.

6-4.2.8* The fill openings for remote fuel tanks shall be identified to indicate the type of fuel to be used with the system. The word "fuel" shall not be used alone.

6-4.2.9 In diesel fuel or other liquid-fuel burning appliances having remote gravity tanks, provisions shall be made to relieve any excess pressure in the fuel line between the tank shutoff valve and the burner valve.

6-4.2.10 Liquid-fuel priming pans or troughs shall be secured to the burner or generator so that their mutual function is maintained.

6-4.2.11 A liquidtight, nonflammable drip pan at least ¾ in. (19 mm) deep shall be provided below all burners and shall be readily accessible for cleaning.

6-4.2.12 Appliances with integral tanks supplying fuel by gravity or pressure shall display a permanently affixed, legible warning sign that provides the following minimum information and instruction:

DANGER
Fire and explosion hazard; severe burns.
Before filling, turn off burners.

6-4.2.13 Pressurized fuel tanks shall be equipped with relief valves.

6-4.2.14 Unpressurized stoves with fuel held in absorbent matter that are designed with a fuel container that is removed for filling shall display a permanently affixed, legible sign that provides the following minimum information and instructions:

DANGER
Fire and explosion hazard; severe burns.
Before filling, turn off all stove burners.
Remove fuel container from stove.
Fill fuel container away from stove.
Follow filling instructions provided.

6-4.3 If solidified alcohol is used as stove fuel, the container shall be secured on a fixed base to prevent sliding or overturning due to a sudden roll of the vessel.

6-4.4 Stacks and stoves shall comply with the applicable requirements of Section 6-3.

6-4.5 Sealed combustion chamber heaters that burn fuel oil shall be permitted to be used, provided they are designed to provide complete separation of the combustion system from the atmosphere in the boat. A combustion air inlet and flue gas outlet shall be provided as integral parts of the appliance.

6-4.6 Stove operating controls shall be located to be easily accessible and to minimize possible injury from burners or elements while in use. The operation of controls shall not require reaching over or across burners or heated elements.

6-4.7 Means shall be provided on stove top cooking surfaces to prevent both deep and shallow cooking utensils from sliding across or off the stove.

6-4.8 Oven doors shall be provided with a means to prevent their unintentional opening due to the force of sliding food and utensils.

6-4.9 A permanent, legible warning sign shall be affixed in a conspicuous manner on or adjacent to fuel-burning stoves or ranges and shall provide the following information and instructions:

WARNING
Open-flame cooking appliances consume oxygen, which can cause asphyxiation or death in enclosed areas.
Maintain open ventilation.
Do not use appliances for comfort heating.

6-5* Liquefied Petroleum Gas (LPG) and Compressed Natural Gas (CNG) Systems for Permanently Installed Appliances.

6-5.1 The installation for use and storage of stoves with attached (integral) LPG containers of more than 8 oz (230 g) capacity weight of gas shall be prohibited in accommodation spaces in the boat interior.

6-5.2 LPG and CNG appliances shall be permanently installed.

Exception: Those appliances employing integral butane cylinders containing no more than 8 oz (230 g) of fuel complying with 6-5.11.7.

6-5.3 All components of LPG systems subject to cylinder pressure shall have a rated working pressure of at least 250 psig (1725 kPa gauge); components of CNG systems subject to cylinder pressure shall have a working pressure of at least 133 percent of the maximum fill pressure of the cylinder.

6-5.4 Ignition Protection of Electrical Devices. On boats equipped with LPG or CNG systems, potential sources of ignition of an electrical nature that can function or cycle on and off automatically without the presence of a person, located below the main deck, shall be provided with ignition protection in accordance with UL 1500, *Standard for Safety Ignition-Protection Test for Marine Products*, if located in compartments containing LPG or CNG appliances, cylinders, fittings, valves, or regulators.

NOTE: For information on external ignition protection of marine electrical devices, see SAE J1171, *Recommended Practice for External Ignition Protection of Marine Electrical Devices.*

Exception No. 1: Accommodation spaces.

Exception No. 2: Open compartments having at least 15 in.^{2} (97 cm^2) of open area per cubic foot of net compartment volume exposed to the open atmosphere outside the craft.

6-5.5 Only systems using cylinders of the vapor withdrawal type shall be permitted. Cylinders designed or installed to admit LPG into any other part of the system shall be prohibited.

6-5.6 With each LPG or CNG system installed on a boat, at least two signs required by 6-1.1 and 6-1.6 shall be provided.

These signs shall include:

(a) The signal word "WARNING."

(b) The introductory statement "To Avoid Fire and Explosion."

6-5.6.1 These signs also shall provide information in accordance with the following sample wording and shall include:

(a) An applicable statement: "This system is designed for use with (insert "LPG" or "CNG") only. Do not connect (insert "CNG" or "LPG") to this system."

Exception: This statement shall not be required on the sign at the container.

(b) The following instructions:

1. Close container valves when boat is unattended and in case of leak or fire.

2. Close all appliance valves before opening container valves.

3. Always apply the source of ignition to burner before opening burner valve.

4. Test system for leakage whenever system is used, when system is serviced, or when container is changed as follows:

With the appliance valves closed and all other valves open, note pressure on the gauge. Close container valve. The pressure shall remain constant for at least 5 minutes. If pressure drops, locate leakage by application of soapy water solution at all connections. Repeat test for each container in multicontainer systems. NEVER USE FLAME TO CHECK FOR LEAKS. NEVER USE SOAP CONTAINING AMMONIA.

NOTE: If a leak detection device is installed, these instructions shall be permitted to be modified as appropriate.

5. Mark container locker for storage of (insert "LPG" or "CNG") containers only.

6. Keep valves closed and plugged on empty or unconnected containers.

Exception: This statement shall not be required on the sign at the appliance.

6-5.6.2 On boats that have gasoline engines, the sign also shall include at least the following information and instruction:

WARNING
Avoid fire or explosion.
Open-flame appliances can ignite gasoline vapor, causing fire or explosion.
Turn off all open flame appliances while fueling.

6-5.6.3 The required warning signs shall be installed in plainly visible locations on the outside of each container enclosure and adjacent to each consuming appliance.

6-5.7 Containers.

6-5.7.1 Containers shall be constructed, tested, marked, maintained, requalified for continued service, and refilled in accordance with:

(a) The regulations of the U.S. Department of Transportation for containers in LPG or CNG service; or

(b) Equivalent specifications or regulations determined by the authority having jurisdiction.

6-5.7.2 Containers shall be withdrawn from service when they leak, when corrosion, denting, bulging, or other evidence of rough usage exists to the extent that the container has been weakened, or when exposed to fire.

6-5.8 Container Valves and Safety Relief Devices.

6-5.8.1 Each container shall have a manually operated shutoff valve installed directly into the container outlet opening that can be operated without the use of tools.

Exception: Nonrefillable containers.

6-5.8.2 In addition to the valve required by 6-5.8.1, a readily accessible manual or electrically operated (solenoid) shutoff valve shall be located in the low- or high-pressure line at the fuel supply. The valve or its control shall be operable from within the vicinity of the appliance(s). If the

cylinder valve is readily accessible from within the vicinity of the appliance, the shutoff valve on the supply line shall not be required. The location of the shutoff valve or control shall not require reaching across flame or heat-generating surfaces for operation.

6-5.8.3 All containers shall be provided with safety relief devices as required by U.S. Department of Transportation regulations or equivalent regulations.

6-5.8.4 LPG container valves and safety relief devices shall have direct connection with the vapor space of the cylinder.

6-5.8.5 In addition to the valve required at the cylinder, a multiple cylinder system shall be provided with a manual positive shutoff valve or automatic check valve at the cylinder manifold such that each cylinder shall be isolated from the pressure feedback from other cylinders.

6-5.8.6 All relief valves shall discharge to the open atmosphere at a point at least 2 ft (0.6 m) from any opening to a cabin or hull interior or from an engine exhaust terminus.

6-5.8.7 Valve outlets on containers shall be equipped with a plug or cap for thread protection and to keep out foreign material. This plug or cap shall be in place whenever the container is not connected for use, and the valve shall be kept tightly closed.

6-5.9 Reducing Regulators.

6-5.9.1 Each system shall be provided with a pressure-regulating device, specifically designed for the type of gas being used and so adjusted as to deliver gas to the distribution piping at a pressure not to exceed 14 in. (36 cm) water column, approximately 0.735 psig (5.0 kPa gauge) for LPG systems, or 6 in. (15 cm) water column, approximately 0.22 psig (1.5 kPa gauge) for CNG systems.

6-5.9.2 A low-pressure relief valve shall be integral with each regulator. It shall discharge at between 1.7 and 3 times the delivery pressure of the regulator.

6-5.9.3 The relief valve vent outlet shall be located and designed to prevent water from entering the discharge system.

6-5.9.4* Each reducing regulator shall be fitted with a pressure gauge on the high-pressure side. A leak detector shall be permitted to be used in addition to the gauge.

6-5.9.5 Each CNG system shall be supplied with a high-flow check valve located on the container pressure side of the regulating device. The high-flow check valve shall actuate and control gas flow through the vent or vent systems to the atmosphere in the event of regulator malfunction and shall maintain this gas flow within designed pressure limits of the vent system. Relief high-flow restrictor vent outlets shall conform to the requirements of 6-5.8.6.

6-5.9.6 CNG pressure regulators shall be connected directly to the cylinder shutoff valve, using one CGA series 350 connection.

6-5.10 Piping, Hose, and Fittings — LPG and CNG Distribution Systems.

6-5.10.1 Piping. Low-pressure distribution piping between the regulator and appliances shall be galvanically compatible for a marine environment and shall be as specified below:

(a) In LPG systems, piping shall be either copper tubing of standard Type K or Type L, or equivalent, with a minimum wall thickness of at least 0.032 in. (0.8 mm) nominal.

(b) In CNG systems, piping shall be of internally tinned copper tubing of standard Type K or Type L, or equivalent, with a minimum wall thickness of at least 0.032 in. (0.8 mm) nominal.

6-5.10.2 Flexible Hose.

6-5.10.2.1 Hose Specifications.

(a) LPG flexible distribution hose shall meet the requirements of UL 21, *Standard for Safety LP-Gas Hose.*

(b) CNG flexible hose shall meet the requirements of NFPA 52, *Standard for Compressed Natural Gas (CNG) Vehicular Fuel Systems.*

6-5.10.2.2 In both LPG and CNG systems, flexible hose shall be labeled for the fuel being used.

6-5.10.3 Connecting fittings shall be accessible. Metallic connections, if soldered, shall be soldered or brazed with a material having a melting point exceeding 840°F (450°C).

6-5.10.4 Distribution lines shall be protected from physical damage and shall be accessible for inspection.

6-5.10.4.1 Lines shall be secured against vibration.

6-5.10.4.2 Lines shall be protected from abrasion wherever they pass through decks or bulkheads.

6-5.10.4.3 Each appliance shall be served by a separate low-pressure regulated supply line, which shall originate inside the locker or protective enclosure.

6-5.10.4.4 Flexible supply hose shall have permanently attached end fittings, such as a swaged sleeve or a sleeve and threaded insert.

6-5.10.5 Metal tube or piping shall be connected by means of flare fittings or other fittings designed for resistance to loosening due to vibration or movement. Metal-to-metal compression sleeve-type fittings shall not be used.

6-5.10.6 Flexible hose sections connecting appliances to their supply shall be nonmetallic. Flexible metallic connectors shall not be used.

6-5.10.7 A flexible hose section shall be installed to allow the free swing of gimbaled stoves without stress to end fittings at expected extremes of travel.

6-5.10.8 Fuel supply lines shall be continuous lengths of tubing, piping, or hose from the regulating device, solenoid valve or leak detector (if installed), or manifold to the appliance.

Exception: Flexible hose installed to connect tube or piping to a device.

6-5.10.9 Metallic fuel supply lines shall not be used for electrical grounding or bonding.

6-5.11 Appliances.

6-5.11.1 Appliances with automatic igniters for burner ignition are prohibited.

Exception: Appliances with sealed combustion chambers.

6-5.11.2 All gas-fueled appliances shall incorporate a flame failure device on each burner or oven control flame to prevent gas flow if flame is not present.

Exception: Stoves with integral gas cylinders not exceeding 8 oz (230 g) capacity.

6-5.11.3 Cabin space heaters, water heaters, gas-fueled refrigerators, and air conditioners shall be of the sealed combustion chamber type, designed to provide complete separation of the combustion system from the atmosphere in the boat. A combustion air inlet and flue gas outlet shall be provided as integral parts of the appliance.

6-5.11.4 Burner controls shall be equipped or designed to provide a push-turn or other two-phase operation when moved from the "off" position to the "on" position.

6-5.11.5 Cooking appliances shall meet the combustion requirements of ANSI Z21.57, *Recreational Vehicle Cooking Gas Appliances*.

6-5.11.6 A permanent, legible sign shall be affixed in a conspicuous location on or adjacent to appliances not having sealed combustion chambers that shall include the following information and instruction:

WARNING
Open-flame appliances consume oxygen.
Lack of oxygen can cause asphyxiation or death.
Maintain open ventilation when appliance is in use.

6-5.11.7 Means shall be provided on stove top cooking surfaces to prevent both deep and shallow cooking utensils from sliding across or off the stove at boat pitch or roll up to 30 degrees horizontal in any direction.

6-5.11.8 Cooking Equipment with Integral Fuel Cylinders.

6-5.11.8.1 Printed instructions for proper installation, operation, fuel storage, refueling, and maintenance shall be provided with each stove.

6-5.11.8.2 Fuel cylinders with 8 oz (230 g) maximum capacity shall be DOT approved 2P/2Q cylinders with rim vent release.

6-5.11.8.3 Where used in the boat interior, stoves shall be secured in a designated location with a positive means of mechanical retention. The installation shall meet the requirements of Section 6-2.

6-5.11.8.4 A means shall be provided for storing all unattached fuel cylinders in a protected, self-draining location on the exterior of the boat where vapors can flow overboard only.

6-5.11.8.5 The appliance shall have a label to indicate the location of the device relative to all combustible surfaces, meeting the requirements of Section 6-2. The label shall identify the type of fuel to be used with the appliance.

6-5.12 Location and Installation.

6-5.12.1 Containers, regulating devices, and safety equipment shall be:

(a) Rigidly secured;

(b) Readily accessible for operation of valves and testing for leakage; and

(c) Protected by a dedicated locker.

Exception: Containers located on open decks such that escaping vapor cannot accumulate in a cockpit or enclosed spaces, provided regulators, tank valves, and fittings are protected against mechanical damage by a vented housing, shield, or guard.

6-5.12.1.1 A protective dedicated locker shall be:

(a) Located above the waterline;

(b) Vapor-tight to the hull interior;

(c) Provided with a means to latch its cover;

(d) Vented to the atmosphere; and

(e) Located so that, with its cover open or closed, escaping vapor cannot reach the bilges, machinery spaces, accommodations, or other enclosed spaces.

6-5.12.1.2 Venting of LPG container lockers shall be from the bottom by means of a vent pipe of at least 1/2 in. (13 mm) internal diameter that shall lead outboard, without pockets that can trap water, passing through the hull above the waterline at a point lower than the locker bottom, that is at least 2 ft (0.6 m) distant from, and not directly above, any hull opening, including the engine exhaust.

6-5.12.1.3 Compartments and lockers in which CNG cylinders are stored shall have a ventilation opening located above the level of the cylinder of at least 1/2 in. (13 mm) internal diameter.

6-5.12.2 Installation of gas equipment in lockers or housing shall be such that, when the means of access to the lockers or housing is open, the container valves can be conveniently and quickly operated and the system pressure gauge dials are fully visible.

6-5.12.3 Lockers or housings shall not be used for storage of any other equipment, nor shall quick access to the gas system be obstructed in any way.

6-5.12.4 Provisions for storage of unconnected reserve containers, filled or empty, shall be the same as those for containers in use.

6-5.12.5 After installation, distribution tubing shall be tested prior to its connection to the regulator and appliance using an air pressure of not less than 5 psig (34.5 kPa gauge) above ambient. The container valve shall be checked for leakage at its outlet and at its connection to the container by application of liquid detergent or soapy water solution prior to connection of the system. After these tests and when appliances and high-pressure equipment have been connected, the entire system shall be subjected to the following test:

(a) With appliance valves closed, solenoid valve or master shutoff valve at the appliance open, and one container valve open, note the pressure on the gauge.

(b) Close the container valve.

(c) The pressure shall remain constant for at least 5 minutes.

(d) If the pressure drops, locate the leakage by application of soapy water solution at all connections.

(e) Never use flame to check for leaks.

NOTE: Avoid soaps containing ammonia, which cause season cracking at some metal fittings.

6-5.12.6 CNG cylinders and regulating equipment shall be readily accessible and secured against movement.

Exception No. 1: CNG systems where a single container of a capacity not greater than 100 ft³ (2.8 m³) at 14.5 psi (1 bar) and 70°F (21°C) is connected to the system. CNG containers of a capacity greater than 100 ft³ (2.8 m³) shall be installed in accordance with the same requirements as LPG containers.

Exception No. 2: Lockers required to be vented as in 6-5.12.1.3.

6-5.12.7 CNG cylinders shall not be installed in compartments containing an internal combustion engine.

6-5.12.8 CNG cylinder storage compartments shall not have openings that communicate with the engine space above the level of the pressure regulator.

6-6 Heating Equipment.

6-6.1 Service Water Heating Units and Cabin Heaters.

6-6.1.1 Vent stacks shall lead to the atmosphere and shall be equipped with an effective device for preventing flame extinguishment or flareback from backdraft and entrance of rain or spray.

6-6.1.2 Dampers shall not be installed in vent stacks.

6-7 Auxiliary Appliances.

6-7.1 Lamps.

6-7.1.1 Gasoline shall not be used for fuel.

6-7.1.2 Oil lamps shall have metal bodies and shall be hung in gimbals.

6-7.1.3 Oil lamps shall not be located directly over galley stoves or heating units.

6-7.1.4 Metal shields shall be secured above chimneys.

6-8 Electric Stoves.

6-8.1 Electric stoves shall meet the requirements of UL 858, *Standard for Safety Household Electric Ranges.*

6-8.2 Electric stoves equipped with a lid or cover shall incorporate an automatic power disconnect switch that turns off all surface burners when the lid or cover is lowered over the heating elements.

6-8.3 Electric stoves shall have a light indicating when one or more heating elements are energized.

6-9 Installation of Electric Stoves. Electric stoves shall be installed in accordance with the manufacturer's instructions.

Chapter 7 Electrical Systems Under 50 Volts

7-1 General. The standards and practices of this chapter establish requirements for the design and installation of direct current (DC) electrical systems on boats that operate at potentials of 50 volts or less.

Exception: Any wire permanently attached to an outboard engine and extending not more than 72 in. (183 cm) from the outboard engine.

7-2 Requirements — General.

7-2.1 Two-Wire System. All DC electrical distribution systems shall be of the two-wire type and shall use insulated conductors. The feed and return wires shall run together where the wiring is routed near compasses or other magnetically sensitive equipment. See Diagrams 7-2.1(a) and 7-2.1(b).

Exception: See Section 7-11.

7-2.2 Return Circuit. A metal hull, bonding conductor, or grounding conductor shall not be used as a return circuit.

Exception: See Section 7-11.

7-2.3 Grounded Systems. If one side of a two-wire DC system is connected to ground, it shall be the negative side, and the system shall be polarized.

7-2.4 Multiple Engine Installation. If a boat has more than one inboard propulsion or auxiliary engine, grounded cranking motor circuits shall be connected to each other by a common conductor that can carry the starting current of each of the grounded cranking motor circuits. Outboard engines shall be connected at the battery negatives.

7-2.5 Crossover (Parallel) Cranking Motor Circuits. In multiple inboard engine installations (including auxiliary generators) with crossover (parallel) cranking motors systems, the engines shall be connected together with a cable large enough to carry the cranking motor current of the largest cranking motor. This cable and its terminations shall be in addition to and independent of any other electrical connections to the engines, including those required by 7-2.4.

Exception No. 1: Installations using ungrounded DC electrical systems.

Exception No. 2: Outboard engines.

7-3 Batteries.

7-3.1 Batteries shall be accessible for inspection and maintenance.

7-3.2 Batteries shall not be tapped for voltages other than the total voltage of all the cells comprising the battery.

7-3.3 A vent system or other means shall be provided to allow the discharge from the boat of hydrogen gas released by the battery. Battery boxes with a cover that forms a pocket over the battery shall be vented.

NOTE: These provisions also apply to installations of sealed batteries.

7-3.4 Batteries shall be secured to provide immobilization to the extent practicable.

NOTE: For information on securing batteries, see Title 33, *Code of Federal Regulations*, Part 183.

7-3.5 Batteries shall be located in a liquid-tight tray or battery box of adequate capacity to retain normal spillage or boilover of electrolytes. The tray shall be constructed of or lined with materials resistant to deterioration by the electrolytes.

7-3.6 A nonconductive, perforated cover or other means shall be provided to prevent accidental shorting of the ungrounded battery terminals and cell connectors.

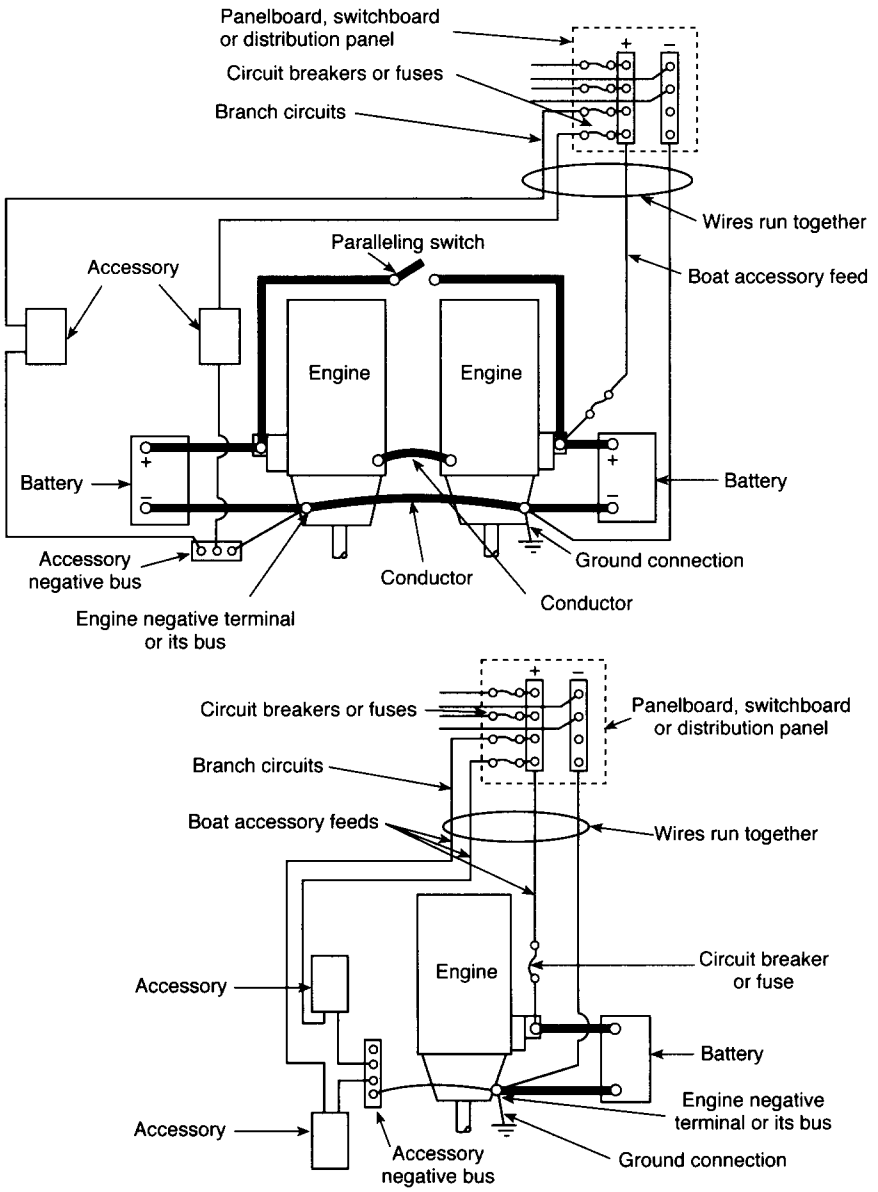


Diagram 7-2.1(a) Typical inboard DC grounding systems.

7-3.7 Batteries with metal cell containers shall be assembled in nonconductive trays having insulated cell supports. Provision shall be made to prevent other conductive materials that could cause a short circuit from contacting cell containers.

7-3.8 Each metallic fuel line and fuel system component located within 12 in. (30 cm) and above the horizontal plane of the battery top surface, as installed, shall be shielded with dielectric material.

NOTE: For information on shielding with dielectric material, see Title 33, *Code of Federal Regulations*, Part 183.

7-3.9 The positive terminal of each battery shall be identified by the letters "POS" or "P" or by the symbol "+," marked on the terminal or on the battery case near the terminal.

7-3.10 Battery terminal connections shall not depend on spring tension.

7-4 Power Distribution System Negative Connections.

7-4.1 The negative terminal of the battery and the negative side of the electrical power distribution system shall be connected to the engine negative terminal or its bus.

Exception: Outboard boats shall be permitted to use the battery negative terminal.

7-4.2 Separate Negative Bus. A separate negative bus shall be permitted to be created off the engine, or, in the case of outboard boats, off the battery, provided:

(a) All accessories connected to the bus are branch circuits from the same panelboard.

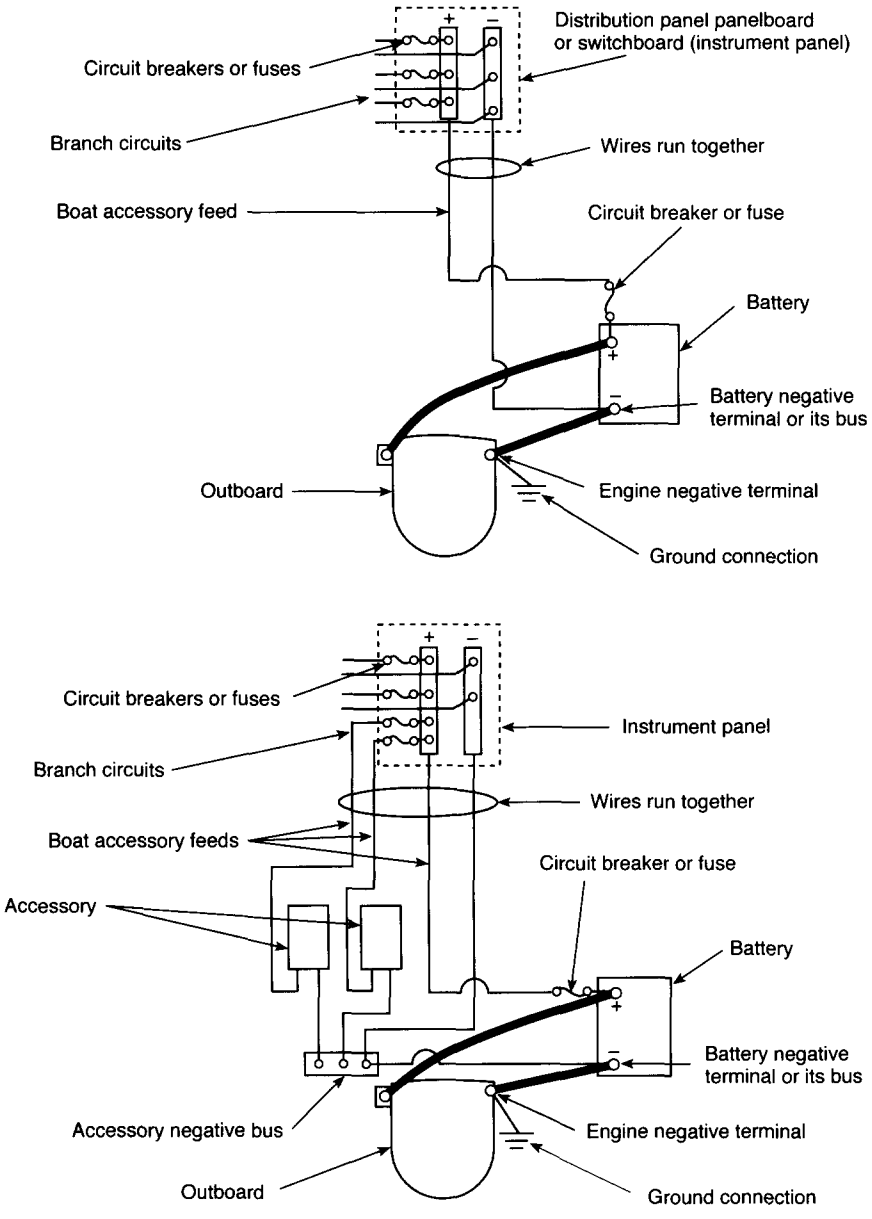


Diagram 7-2.1(b) Typical outboard DC grounding systems.

(b) The negative bus, the negative bus return conductors, and their terminals and connections shall have an ampacity equal to the panelboard feeder.

(c) The negative return conductor from the panelboard feeding the branch circuits that use the separate negative bus shall be equal in size to the positive feeder to the panelboard.

7-5 Continuously Energized Parts. Continuously energized parts, such as the positive battery terminal and both ends of all wires connected thereto, shall be protected by boots, sleeving, or other insulation to prevent an accidental short circuit.

Exception: Circuits provided with overcurrent protection in accordance with 7-9.6.

7-6 Marking.

7-6.1 Marking. Switches and electrical controls shall be marked to indicate their use.

Exception: A switch or electrical control whose purpose is obvious and whose erroneous operation cannot cause a hazardous condition shall not be required to be marked.

7-6.2 Marking of Equipment. Electrical equipment such as an engine shall be marked or identified to indicate:

(a) The manufacturer.

(b) The identifying number.

(c) The DC electrical rating in volts. The rated current of electrical equipment shall be available and shall be permitted to be marked on the device.

(d) The terminal polarity or identification, if necessary to operation.

(e) The ignition protection, if applicable.

Exception: If part of an identified assembly.

7-7 Ambient Temperature. The ambient temperature of machinery spaces shall be considered to be 122°F (50°C), and the ambient temperature of all other spaces shall be considered to be 86°F (30°C).

7-8 Ignition Sources.

7-8.1 Potential sources of ignition located in gasoline-powered machinery and fuel tank spaces, and in spaces containing joints, fittings, or other connections between components of the gasoline fuel system, shall be ignition-protected, unless the electrical component is isolated from a gasoline fuel source as shown in Figures 7-8.1(a) through (g).

Exception: Boats using diesel fuel as the only fuel.

7-8.2 An electrical component shall be considered to be isolated from a gasoline fuel source, provided:

(a) The distance between the electrical component and the fuel source is at least 2 ft (0.6 m) and the space is open to the atmosphere.

(b) The electrical component is located:

1. Below the gasoline fuel source and a means is provided to prevent gasoline fuel and gasoline fuel vapors that can leak from the gasoline fuel sources from exposure to the electrical component; or

2. Above the gasoline fuel source and a deck or other enclosure is located between the ignition source and the gasoline fuel source; or

(c) A bulkhead is provided between the fuel source and ignition source that:

1. Separates the electrical component from the fuel source and extends the length of both the vertical and horizontal distances of the open space between the gasoline fuel source and the ignition source; and

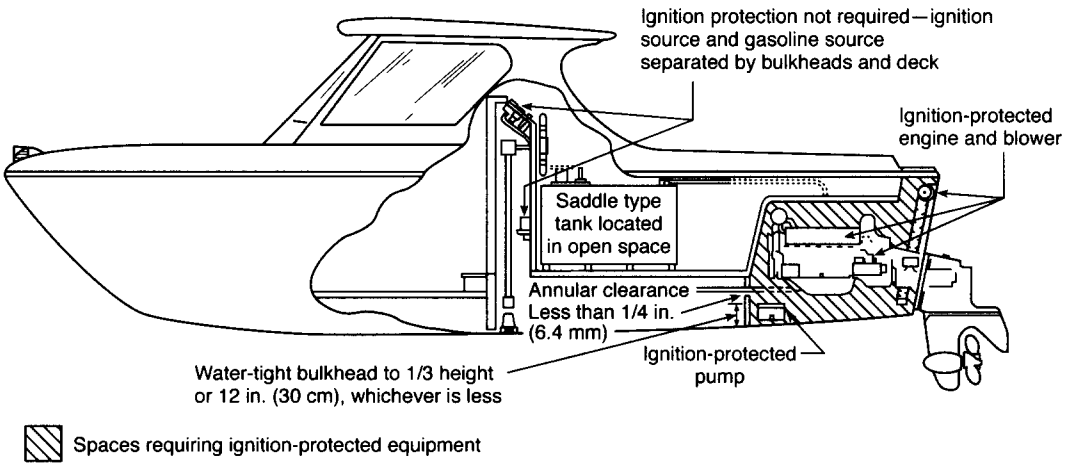
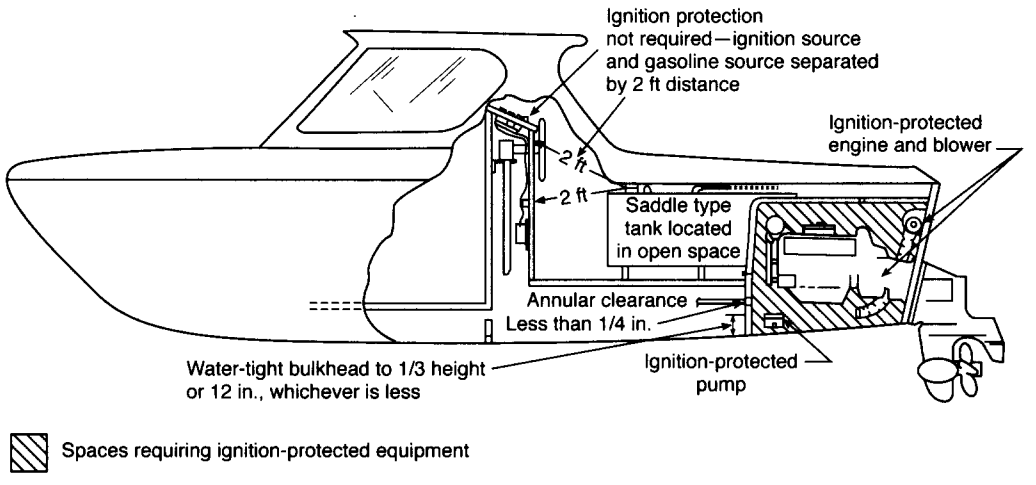


Figure 7-8.1(a) Location of ignition-protected equipment on gasoline-powered inboard engine boats with bulkhead and deck separations.



SI units: 2 ft (0.6 m), 12 in. (30 cm), 1/4 in. (6.4 mm).

Figure 7-8.1(b) Location of ignition-protected equipment on gasoline-powered inboard engine boats with ignition source and gasoline source separated by 2 ft (0.6 m) distance.

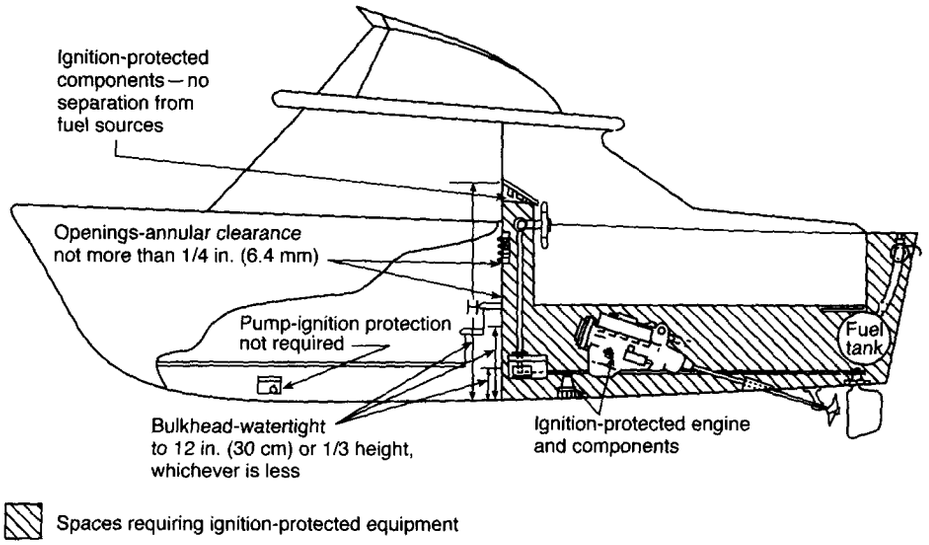


Figure 7-8.1(c) Ignition protection in space containing gasoline engine and fuel line fittings.

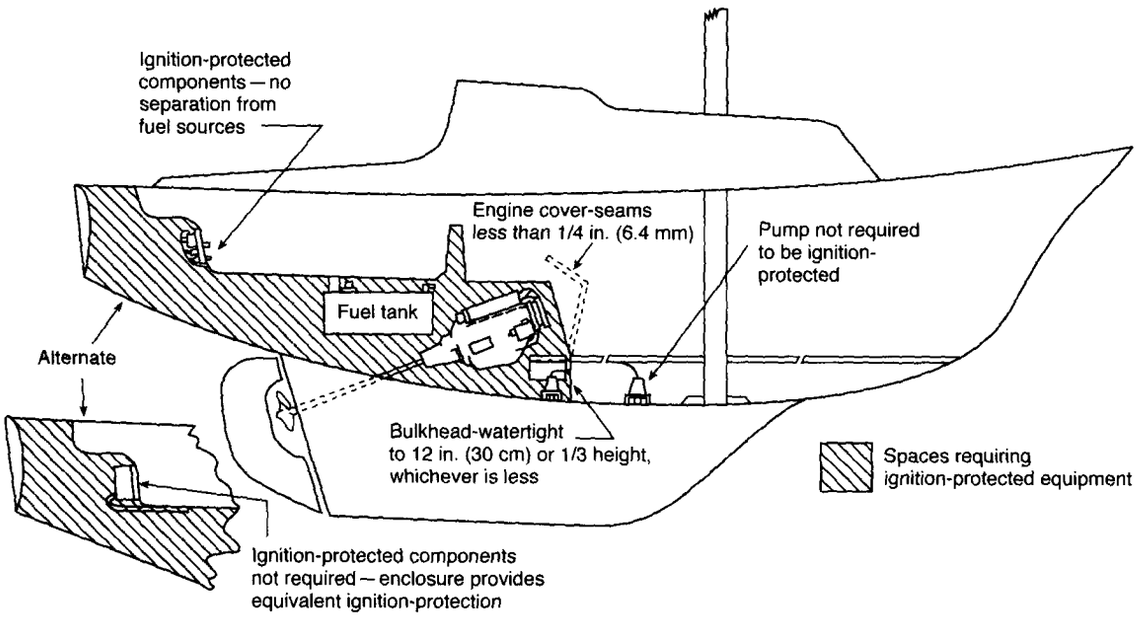


Figure 7-8.1(d) Ignition protection in space containing gasoline engine and fuel line fittings on sailboats.

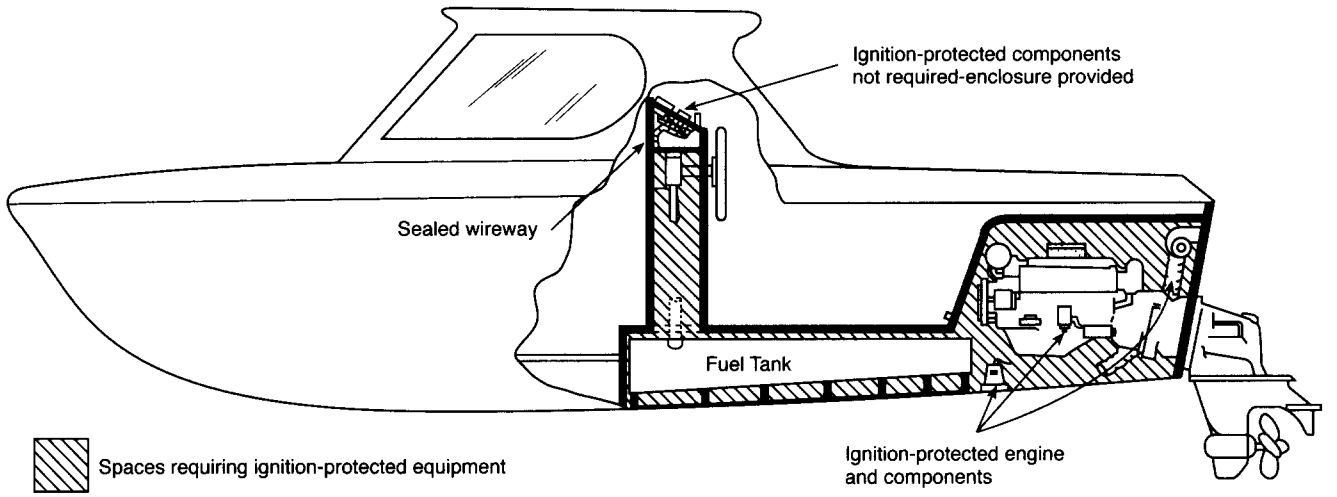
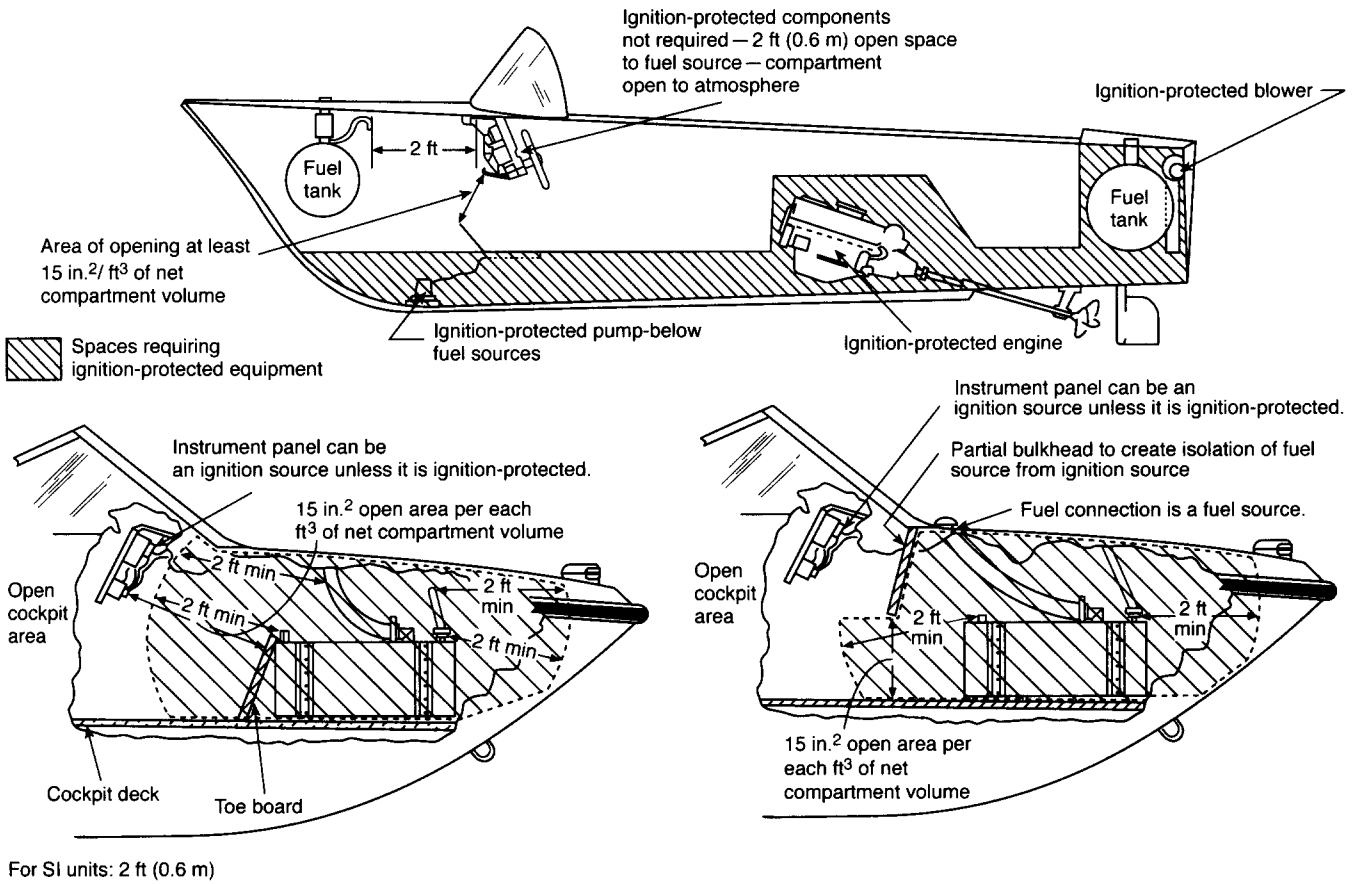


Figure 7-8.1(e) Ignition protection in space containing gasoline engines and fuel line fittings.



For SI units: 2 ft (0.6 m)

Figure 7-8.1(f) Ignition protection with no bulkhead.

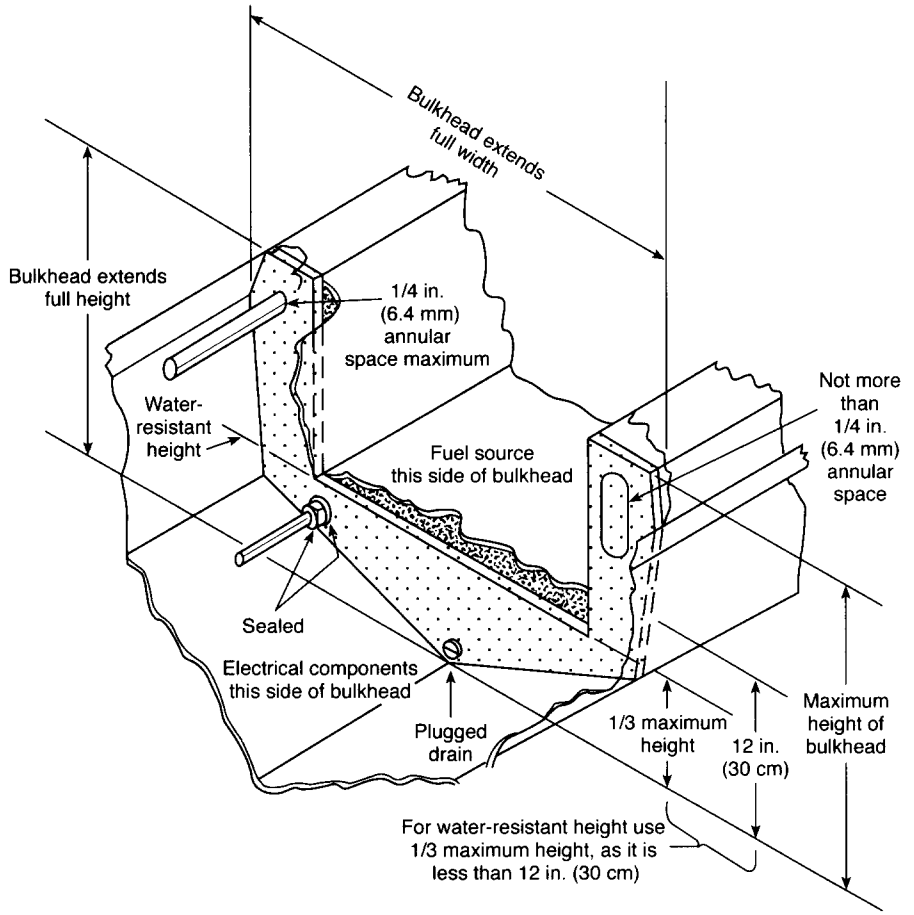


Figure 7-8.1(g) Cutaway illustration showing separation of electrical components from gasoline fuel source.

2. Resists a water level of 12 in. (30 cm) or of greater than 1/3 of the maximum height of the bulkhead, whichever is lower, without seepage of more than 1/4 fl oz (7.4 ml) of fresh water per hour; and

3. Has no opening higher than 12 in. (30 cm) or greater than 1/3 the maximum height of the bulkhead, whichever is lower, unless the opening is used for the passage of conductors, piping, ventilation ducts, mechanical equipment, and similar items or for doors, hatches, and access panels; and unless the maximum annular space around each item, door, hatch, or access panel is not more than 1/4 in. (6.4 mm).

7-9 Overcurrent Protection.

7-9.1 Overcurrent Protection Location. Conductors other than cranking motor conductors shall be provided with overcurrent protection within a distance of 7 in. (18 cm) of the point at which the protection is connected to the source of power measured along the conductor. (*See Diagram 7-9.1.*)

Exception No. 1: Up to 40 in. (102 cm) shall be permitted if the conductor, throughout the required distance, is contained in a sheath or enclosure, such as a junction box, control box, or enclosed panel.

Exception No, 2: If the conductor is connected directly to the battery terminal, the 7-in. (18-cm) distance shall be permitted to be increased to 72 in. (183 cm).

7-9.2 Battery Charging Sources. Battery charging sources shall comply with the following:

7-9.2.1 Each ungrounded DC conductor that runs from the battery charger or other charging source to a battery or other point of connection to the DC system shall be provided with overcurrent protection within a distance of 7 in. (18 cm) of the point of connection to the DC electrical system or battery.

Exception No. 1: Overcurrent protection shall not be required if the charging source is within 72 in. (183 cm) of the battery measured along the conductor.

Exception No. 2: Overcurrent protection shall not be required if the charging source is within 40 in. (102 cm) of a point of connection, other than to the battery, and its entire length is contained within a sheath or enclosure, such as a conduit, junction box, control box, or enclosed panel.

7-9.2.2 Each ungrounded DC output conductor shall be provided with overcurrent protection within the charging source, based on the maximum output.

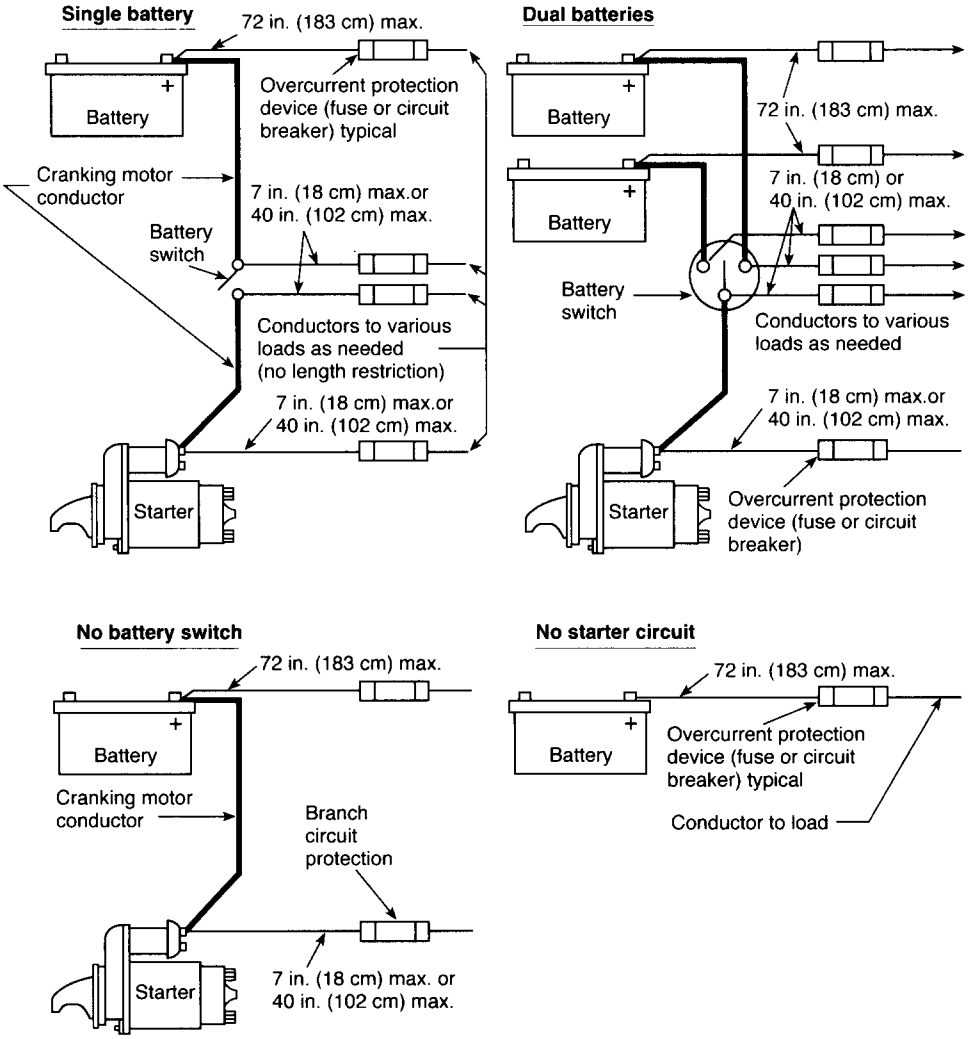


Diagram 7-9.1 Location of overcurrent protection for conductors served by single or dual batteries or without battery switch or starter circuit.

Exception: Self-limiting devices that are not capable of producing current in excess of the current rating of the connecting conductors shall not require overcurrent protection for the DC output conductors.

7-9.3* 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 devices suitable for motor current. The protection provided shall preclude a fire hazard if the circuit, as installed, is energized for 7 hours under any conditions of overload, including locked rotor.

7-9.4 Resistive Loads. The rating of overcurrent protection devices used to protect both the conductor and a load other than a DC motor shall not exceed 150 percent of the current-carrying capacity of the conductor being protected.

7-9.5 Branch Circuits. Each ungrounded conductor of a branch circuit shall be provided with overcurrent protection at the point of connection to the panelboard, unless the main circuit breaker or fuse provides such protection.

7-9.6 Distribution Panels, Panelboards, and Switchboards. A trip-free circuit breaker or a fuse shall be installed at the source of power for the panelboard. The overcurrent protection shall not be greater than 100 percent of the load capacity of the total load of the panelboard and shall not exceed 100 percent of the current-carrying capacity of the feeders to the panelboard. The protection at the power source shall not be greater than 150 percent of either the supply or return conductor ampacity, unless it also is the distribution panel or switchboard overcurrent protection, in which case it shall not exceed 100 percent of the load capacity. (*See Diagram 7-9.6.*)

7-9.7 Circuit Breakers. Circuit breakers shall:

(a) Have a DC voltage rating of not less than the nominal system voltage.

(b) Be of the trip-free type.

(c) Be capable of an interrupting capacity in accordance with Table 7-9.7 and shall meet the marine requirements of UL 489, *Standard for Safety Molded-Case Circuit Breakers and Circuit-Breaker Enclosures*, UL 1077, *Standard for Safety Supplementary Protectors for Use in Electrical Equipment*, or UL

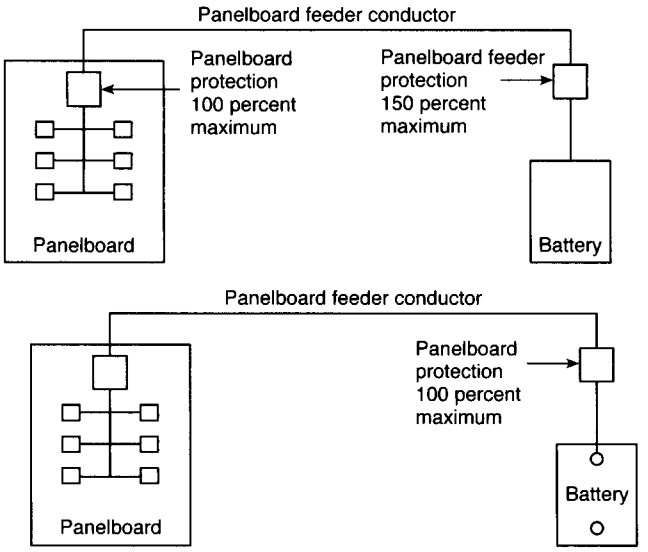


Diagram 7-9.6 Illustration of overcurrent protection for panelboards and panelboard feeder conductors.

1133, *Standard for Safety Boat Circuit Breakers*. Circuit breakers that meet the requirements of UL 1077 shall be permitted to be used as branch circuit breakers if they can interrupt the current specified for branch circuit breakers in Table 7-9.7 alone or in combination with the main circuit breaker.

NOTE: For information on marine circuit breakers, see SAE J1428, *Recommended Practice for Marine Circuit Breakers*.

(d) Meet the requirements of UL 1500, *Standard for Safety Ignition-Protection Test for Marine Products*, at four times their rated current if located in a space that requires ignition protection.

NOTE: For information on external ignition protection of marine electrical devices, see SAE J1171, *Recommended Practice for External Ignition Protection of Marine Electrical Devices*.

7-9.8 Fuses. Fuses shall:

(a) Have a DC voltage rating of not less than the nominal system voltage.

(b) Be capable of an interrupting capacity in accordance with Table 7-9.7.

(c) Meet the requirements of UL 1500, *Standard for Safety Ignition-Protection Test for Marine Products*, at four times their rated current if located in a space that requires ignition protection.

NOTE: For information on external ignition protection of marine electrical devices, see SAE J1171, *Recommended Practice for External Ignition Protection of Marine Electrical Devices*.

7-9.9 Integral Overcurrent Protection Devices. Integral overcurrent protection devices without a manual reset shall be permitted to be used as an integral part of an electrical device, provided the remainder of the circuit is protected by a trip-free circuit protection device(s) or a fuse(s). Integral overcurrent protection shall be sized to protect the accessory in which it is installed.

7-9.10 Pigtails. Pigtails less than 7 in. (18 cm) in length shall be exempt from overcurrent protection requirements.

Table 7-9.7 Circuit Breaker Minimum Amperage Interrupting Capacity

Cold Cranking Current Rating at °F of Total Connected Battery Capacity	Ampere Interrupting Capacity (A.I.C.) (Amperage Available at Circuit Breaker Terminals)	
	Main Circuit Breaker (Amperes) (*See Note 1*)	Branch Circuit Breaker (Amperes) (*See Note 1*)
12 Volts and 24 Volts		
650 or less	1500	750
651 - 1100	3000	1500
Over 1100	5000	2500
32 Volts		
1250 or less	3000	1500
Over 1250	5000	2500

NOTE 1: The main circuit breaker is considered to be the first breaker(s) in a circuit connected in series with the battery. All subsequent breakers connected in series with a main circuit breaker are considered to be branch circuit breakers.

NOTE 2: Under Battery Council International conversion factors, the following approximate correlations are used for °F:

Cold Cranking Amperes	Ampere Hours (20-hour rating)
630	120
1076	205
1260	240

For the purpose of converting the 20-hour amp/hour rating to approximate cold cranking amps, use a value of 5.25 × the amp/hour rating.

7-10 Switches.

7-10.1 Battery Switch Location. If used, a battery switch shall be mounted as close as practicable to the battery and shall be readily accessible without opening the engine space.

7-10.2 Vessels 26 ft (8 m) and over in overall length shall have an approved master battery switch.

Exception: Automatic bilge pumps shall be permitted to be wired to bypass this switch.

7-10.3 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 continuous rating of a battery switch shall not be less than the total of the ampacities of the main overcurrent protection devices connected to the battery switch.

7-10.4 If single-pole switches are used in branch circuits, they shall be installed in the positive conductor of the circuit.

Exception No. 1: Engine-mounted pressure, vacuum, and temperature-operated switches.

Exception No. 2: Switches such as those used for control of alarm systems.

7-10.5* Switches shall have voltage ratings of not less than the system voltage and current ratings of the connected load.

7-11 Appliances and Equipment.

7-11.1 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.

Exception No. 1: Engine-mounted equipment.

Exception No. 2: The following devices shall be permitted to have their negative conductors connected to exposed electrically conductive parts. The polarity of both the positive and negative connections shall be identified, and these devices shall be mounted only on electrically nonconductive material and shall not be bonded.

1. *Communications and audio equipment*
2. *Electronic navigation equipment*
3. *Instruments and instrument clusters*
4. *Cigar lighters*
5. *Liquid level gauge transmitters (for installation on conductive surfaces)*
6. *Navigation lights operating at 12 volts or less.*

7-11.2 Grounded Liquid Level Gauge Transmitters (Senders). Grounded liquid level gauge transmitters mounted on metallic tanks or tank plates shall have the transmitter negative return conductor connected directly to the engine negative terminal, its bus, or, for outboard boats, the battery negative terminal. This conductor also shall serve as the static ground or the bonding conductor, or both. If this conductor is used as the tank system bonding conductor, it shall be minimum No. 8 AWG. No other device shall be connected to this conductor.

Exception: Tank fills and vents shall be permitted to be statically grounded to the tank or the tank plate.

7-11.3 Pigtail connections on submersible devices such as submersible bilge pumps shall not be shorter in length than 16 in. (41 cm).

7-12 System Wiring.

7-12.1 Conductors and flexible cords shall have a minimum rating of 50 volts.

7-12.2 The construction of insulated cables and conductors shall conform with the requirements of SAE J1127, *Standard for Battery Cable*, SAE J1128, *Standard for Low Tension Primary Cable*, or UL 1426, *Standard for Safety Electric Cables for Boats*.

NOTE: For information on marine engine wiring, see SAE J378, *Recommended Practice for Marine Engine Wiring*.

7-12.3 Conductors shall be permitted to be selected from the types provided in Tables 7-12.3 and 8-13.2. The temperature ratings shown assume the routing of wires above bilge water in locations protected from dripping, exposure to weather, spray, and oil.

7-12.4 Flexible cords shall conform with NFPA 70, *National Electrical Code*, and shall be selected from the types specified in Table 8-13.3.

7-12.5 Conductors and flexible cords shall be stranded copper according to Table 7-12.5(a) and shall be sized in accordance with Table 7-12.5(b).

7-12.6 Conductors and flexible cords shall be sized for voltage drop as follows:

(a) Panelboard main feeders — 3 percent

(b) Navigation light circuits — 3 percent

(c) Electronic equipment circuits — 3 percent

(d) Bilge pump, blower, and refrigeration motor circuits — 3 percent

(e) All other noncritical circuits — 10 percent

Table 7-12.3 SAE Conductors

Type	Description	Available Insulation Temp. Rating per SAE J378B
GPT	Thermoplastic insulation, braidless	60°C (140°F) 90°C (194°F) 105°C (221°F)
HDT	Thermoplastic insulation, braidless	60°C (140°F) 90°C (194°F) 105°C (221°F)
SGT	Thermoplastic insulation, braidless	60°C (140°F) 90°C (194°F) 105°C (221°F)
STS	Thermosetting synthetic rubber insulation, braidless	85°C (185°F) 90°C (194°F)
HTS	Thermosetting synthetic rubber insulation, braidless	85°C (185°F) 90°C (194°F)
SXL	Thermosetting cross-linked polyethylene insulation, braidless	125°C (257°F)

Table 7-12.5(a) Conductor Circular Mil (CM) Area and Stranding

Conductor Size (AWG)	Minimum Acceptable CM Area*	Minimum Number of Strands Type 2**	Type 3***
18	1,537	16	—
16	2,336	19	26
14	3,702	19	41
12	5,833	19	65
10	9,343	19	105
8	14,810	19	168
6	25,910	37	266
4	37,360	49	420
2	62,450	127	665
1	77,790	127	836
1/0	98,980	127	1064
2/0	125,100	127	1323
3/0	158,600	259	1666
4/0	205,500	418	2107

*Applies only to systems under 50 volts.
**Conductors with Type 2 stranding, used for central wiring, which is subject to some movement from vibration or minor flexing.
***Conductors with Type 3 stranding, used for any wiring where flexing is involved in normal use.
NOTE: Metric wire sizes are to be used if of equivalent circular mil area. If the circular mil area of the metric conductor is less than that specified, the wire ampacity can be corrected based on the ratio of the circular mil areas.

7-12.7 Conductor sizes shall be permitted to be calculated by means of the following formula based on the voltage drops 3 percent and 10 percent. If the circular mil area is less than the value specified in Table 8-13.4, the next larger size conductor shall be used.

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

Where:

CM = circular mil area of conductor
K = 10.75 (constant representing the mil-foot resistance of copper)
I = load current in amperes
L = length of conductor from the positive power source connection to the electrical device and back to the negative power source connection, measured in feet
E = voltage drop at load in volts (e.g., 12 volt @ 3 percent = 0.36).

Table 7-12.5(b) Allowable Amperage of Conductors for Under 50 Volts

	Temperature Rating of Conductor Insulation												
	60°C (140°F)		75°C (167°F)		80°C (176°F)		90°C (194°F)		105°C (221°F)		125°C (257°F)		200°C (392°F)
Conductor Size English (metric)	Outside Engine Spaces	Inside Engine Spaces	Outside Engine Spaces	Inside Engine Spaces	Outside Engine Spaces	Inside Engine Spaces	Outside Engine Spaces	Inside Engine Spaces	Outside Engine Spaces	Inside Engine Spaces	Outside Engine Spaces	Inside Engine Spaces	Outside or Inside Engine Spaces
18 (0.8)	10	5.8	10	7.5	15	11.7	20	16.4	20	17.0	25	22.3	25
16 (1)	15	8.7	15	11.3	20	15.6	25	20.5	25	21.3	30	26.7	35
14 (2)	20	11.6	20	15.0	25	19.5	30	24.6	35	29.8	40	35.6	45
12 (3)	25	14.5	25	18.8	35	27.3	40	32.8	45	38.3	50	44.5	55
10 (5)	40	23.2	40	30.0	50	39.0	55	45.1	60	51.0	70	62.3	70
8 (8)	55	31.9	65	48.8	70	54.6	70	57.4	80	68.0	90	80.1	100
6 (13)	80	46.4	95	71.3	100	78.0	100	82.0	120	102.0	125	111.3	135
4 (19)	105	60.9	125	93.8	130	101.4	135	110.7	160	136.0	170	151.3	180
2 (32)	140	81.2	170	127.5	175	136.5	180	147.6	210	178.5	225	200.3	240
1 (40)	165	95.7	195	146.3	210	163.8	210	172.2	245	208.3	265	235.9	280
0 (50)	195	113.1	230	172.5	245	191.1	245	200.9	285	242.3	305	271.5	325
00 (62)	225	130.5	265	198.8	285	222.3	285	233.7	330	280.5	355	316.0	370
000 (81)	260	150.8	310	232.5	330	257.4	330	270.6	385	327.3	410	364.9	430
0000(130)	300	174.0	360	270.0	385	330.3	385	315.7	445	378.3	475	422.8	510

7-13 Wiring Installation.

7-13.1 Current-carrying conductors shall be routed as high as practicable above the bilge water level and other areas where water can accumulate.

Exception: Where wiring and connectors are watertight, conductors shall be permitted to be routed through the bilge or other areas where water can accumulate.

7-13.2 Conductors shall be routed as far away as practicable from exhaust pipes and other heat sources. A clearance of at least 2 in. (5 cm) between conductors and water-cooled exhaust components and a clearance of at least 9 in. (23 cm) between conductors and dry exhaust components shall be maintained. This clearance shall be increased to 18 in. (46 cm) where conductors are located directly above a dry exhaust.

Exception No. 1: Wiring on engines.

Exception No. 2: Exhaust temperature sensor wiring.

7-13.3 Battery cables shall not be routed such that they are in contact with metallic fuel system components.

7-13.4 Conductors subject to exposure to physical damage shall be protected by loom, conduit, tape, raceways, or other equivalent protection. The protection shall be self-draining. Conductors passing through bulkheads or structural members shall be protected to minimize insulation damage such as chafing. Conductors also shall be routed clear of sources of chafing such as steering cable and linkages, engine shafts and belts, and throttle connections.

7-13.5 Conductors shall be at least No. 16 gauge.

Exception No. 1: No. 18 gauge conductors shall be permitted to be used if they are included with other conductors in a sheath and do not extend more than 30 in. (75 cm) outside the sheath.

Exception No. 2: Conductors contained completely within equipment or enclosures.

7-13.6 Conductors shall be supported for their entire length or, alternatively, shall be secured at least every 18 in. (46 cm) by one of the following methods:

(a) 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 can result in a hazardous condition. Conductor material shall be resistant to oil, gasoline, and water and shall not break or crack under flexing within a temperature range of -30°F to 250°F (-34°C to 121°C).

(b) Metal straps or clamps with smooth, rounded edges. That section of the conductor or cable located directly under the strap or clamp shall be protected by means of loom, tape, or other suitable wrapping to prevent injury to the conductor.

Exception No. 1: Battery cables within 36 in. (91 cm) of a battery terminal.

Exception No. 2: Cables attached to outboard motors.

(c) Metal clamps lined with an insulating material resistant to the effects of oil, gasoline, and water.

7-14 Wiring Connections.

7-14.1 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.

7-14.2 Wiring connections and terminals shall be designed specifically for use with stranded wire.

7-14.3 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 8-14.9 for the smallest conductor size used in the splice for a 1-minute duration without breaking.

7-14.4 Terminal connectors shall be of the ring or captive spade type.

Exception: Friction-type connectors shall be permitted to be used, provided:

1. The voltage drop from terminal to terminal does not exceed 50 millivolts for a 20-ampere current flow; and

2. The connection does not separate if subjected to a 6-lb (26.7-N) tensile force along the axial direction of the connector for 1 minute.

7-14.5 Connections shall be permitted to be made using a set-screw, pressure-type conductor connector, provided a means is used to prevent the set screw from bearing directly on the conductor strands.

7-14.6 Twist-on connectors (wire nuts) shall not be used.

7-14.7* Solder shall not be the sole means of mechanical connection in any circuit.

Exception No. 1: Battery lugs with a solder contact length of not less than 1.5 times the diameter of the conductor.

Exception No. 2: Conductors contained completely within equipment or enclosures.

7-14.8 Solderless crimp-on connectors shall be attached with the type of crimping tools designed for the connector used.

7-14.9 Each battery terminal post shall not be used for more than one conductor.

Exception No. 1: Connections made for paralleling batteries.

Exception No. 2: One additional conductor shall be permitted where installed in accordance with 7-9.1.

7-14.10 No more than four conductors shall be secured to any terminal stud.

7-14.11 Terminal connectors of the ring and captive spade type shall be the same nominal size as the stud.

7-14.12 Conductors terminating at switchboards, in junction boxes, or at 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.

7-14.13 The shanks of terminals shall be protected against accidental shorting by the use of insulation barriers or sleeves.

Exception: Shanks used in grounding systems.

7-15 Receptacles.

7-15.1 Receptacles shall be installed in locations normally not subject to rain, spray, or flooding. If receptacles are used in areas that are subject to such weather exposure, the following requirements shall apply:

(a) They shall be weatherproof if subject to rain or spray.

(b) They shall be watertight if subject to flooding.

7-15.2 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.

7-16 Plug Connectors. Connectors used in conjunction with harness-type wiring systems shall comply with the following:

(a) Connectors shall incorporate means such as cable clamps, molded connectors, insulation grips, or extended terminal barrels to limit flexing at the connection.

(b) Connectors exposed to weather shall be weatherproof or, if subject to immersion, shall be watertight.

(c) Each terminal in a multiwire connector shall be protected from accidental short-circuiting to adjacent terminals.

(d) Connectors shall have provision for a minimum disengagement force of 6 lb (26.7 N) along the axial direction of the connector for 1 minute.

Chapter 8* Alternating Current (AC) Electrical Systems on Boats

8-1 General. The standards and practices of this chapter establish requirements for the design and installation of alternating current (AC) electrical systems on boats 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.

8-2 Requirements — General.

8-2.1 The system shall be polarized.

8-2.2 A grounded neutral system shall be required, but the neutral shall be grounded only at the power source, e.g., at the onboard generator, at an inverter, at the secondary of an isolation or polarization transformer, or through the shore power connection. The shore power neutral grounded through the shore power cable shall not be grounded on the boat.

Exception: On systems using an isolation or polarization transformer, the generator or inverter neutral shall be permitted to be the transformer. Secondary neutrals shall be permitted to be grounded at a main grounding bus instead of at the generator inverter or transformer secondaries.

8-2.3 Individual circuits shall not be capable of being energized by more than one source of electrical power at a time. Each shore power inlet or generator shall be a separate source of electrical power.

8-2.4 Energized parts of electrical equipment shall be protected against accidental contact by the use of enclosures or other protective means; these shall not be used for nonelectrical equipment. Access to enclosures containing energized parts of the electrical system shall require the use of hand tools.

8-2.5 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 that prevents arcover between sources.

8-3 Marking.

8-3.1 Shore Power Inlet Warning. A permanently mounted, waterproof warning sign shall be located alongside each shore power inlet location on the boat. The warning sign shall include the information shown in the following example.

Marking Example: Shore power inlet warning.

WARNING

To minimize shock and fire hazards:

1. Turn off the boat's shore connection switch before connecting or disconnecting shore cable.
2. Connect shore power cable at the boat first.
3. If polarity warning indicator is activated, immediately disconnect cable.

Exception: This provision shall not be required if a polarity indicator is not required.

4. Disconnect shore power cable at shore outlet first.
5. Close shore power inlet cover tightly.

DO NOT ALTER SHORE POWER CABLE CONNECTORS.

8-3.2 Marking of Controls. All switches and controls shall be marked to indicate their use, unless the purpose of the switch is obvious and if operation of the switch cannot under normal operating conditions cause a hazardous condition.

8-3.3 Marking of Equipment. All electrical equipment shall be marked to indicate:

(a) The manufacturer's identification.
(b) The model number.
(c) The rating in volts and amperes or volts and watts.
(d) The phase identification, if applicable.
(e) Ignition protection, if applicable.

8-4 System Voltage. Nominal system voltages for AC electrical systems shall be selected from the following:

(a) 120 volts AC, single-phase
(b) 240 volts AC, single-phase
(c) 120/240 volts AC, single-phase
(d) 120/240 volts AC, delta three-phase
(e) 120/208 volts AC, wye three-phase.

8-5 Ambient Temperature. The ambient temperature of machinery spaces shall be considered to be 122°F (50°C), and the ambient temperature of all other spaces shall be considered to be 86°F (30°C).

8-6 Ignition Source.

8-6.1 Potential sources of ignition located in machinery and fuel tank spaces, and in spaces containing joints, fittings or other connections between components of the gasoline fuel system, shall be ignition-protected, unless the ignition source is isolated from a gasoline fuel source as described in 8-6.2.

Exception: Boats using diesel fuel as the only fuel.

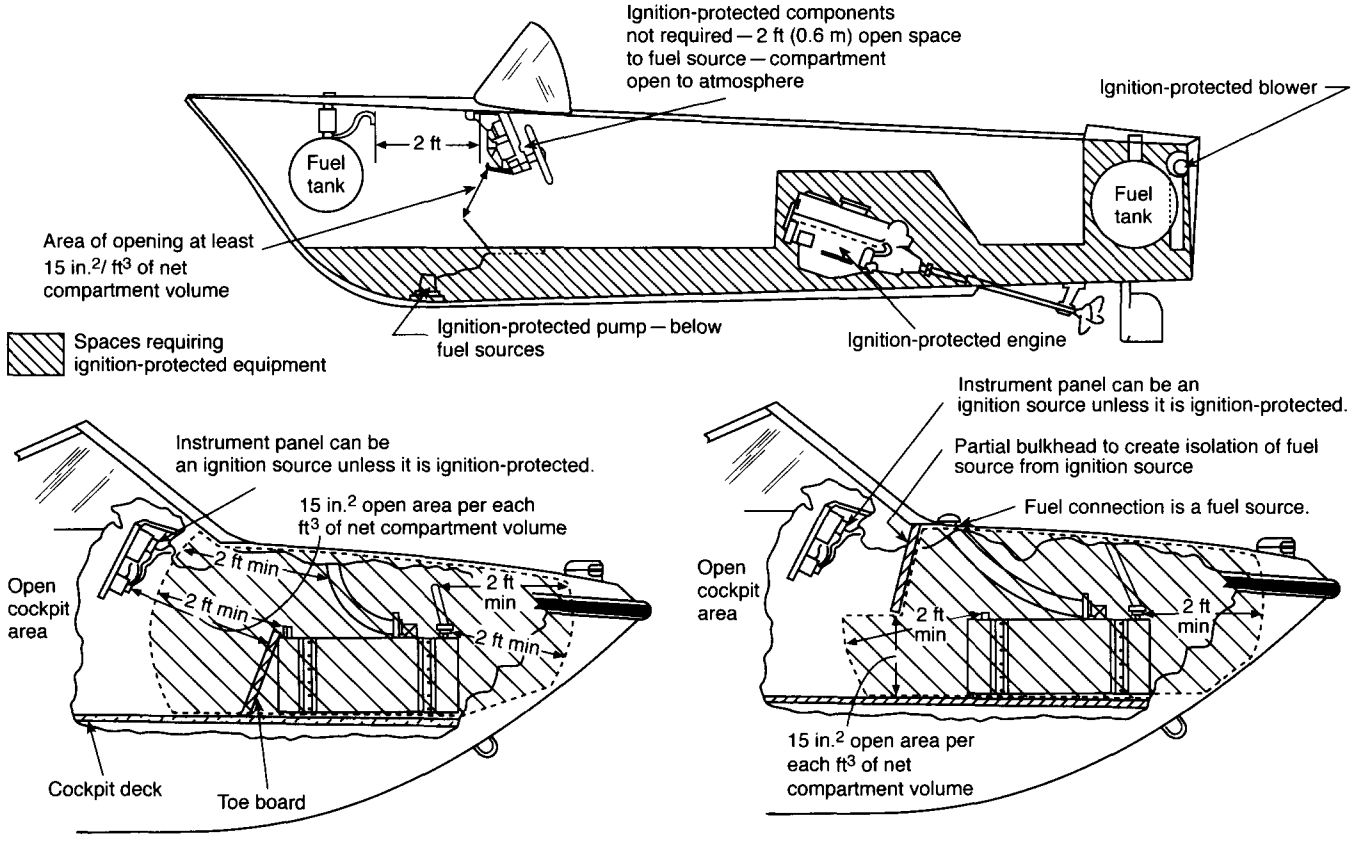


Figure 8-6.1 Ignition protection with no bulkhead.

8-6.2 An electrical component shall be considered to be isolated from a fuel source provided:

(a) A bulkhead that meets the requirements of 8-6.3 is located between the electrical component and the fuel source;

(b) The electrical component is located:

(1) Below the fuel source and a means is provided to prevent fuel and fuel vapors that can leak from the fuel sources from exposure to the electrical component; or

(2) Above the fuel source and a deck or other enclosure is located between the ignition source and the fuel source; or

(c) There is a space between the electrical component and the fuel source of at least 2 ft (0.6 m) and the space is open to the atmosphere.

8-6.3 Each bulkhead shall:

(a) Separate the electrical component from the fuel source and extend the length of both the vertical and horizontal distances of the open space between the fuel source and the ignition source; and

(b) Resist a water level of 12 in. (30 cm) or of greater than 1/3 the maximum height of the bulkhead, whichever is lower, without seepage of more than 1/4 fl oz (7.4 ml) of fresh water per hour; and

(c) Have no opening higher than 12 in. (30 cm) or greater than 1/3 the maximum height of the bulkhead, whichever is lower, unless the opening is used for the passage of conductors, piping, ventilation ducts, mechanical equipment, and similar items or for doors, hatches, and access panels; and unless the maximum annular space around each item, door, hatch, or access panel is not more than 1/4 in. (6.4 mm).

NOTE 1: Seepage of not more than 1/4 fl oz (7.4 ml) per hour is permitted below the water-resistant height. This includes bulkhead fastenings and space around hatches, doors, access panels, and items passing through the bulkhead.

NOTE 2: Openings above the water-resistant height cannot have more than 1/4 in. (6.4 mm) annular space around items passing through the openings

8-7 Shore Power Polarity Devices.

8-7.1 Reverse-polarity indicating devices having a continuous visible or audible signal shall be installed in 120 VAC shore power systems, provided:

(a) The polarity of the system is maintained for the proper operation of electrical devices in the system; or

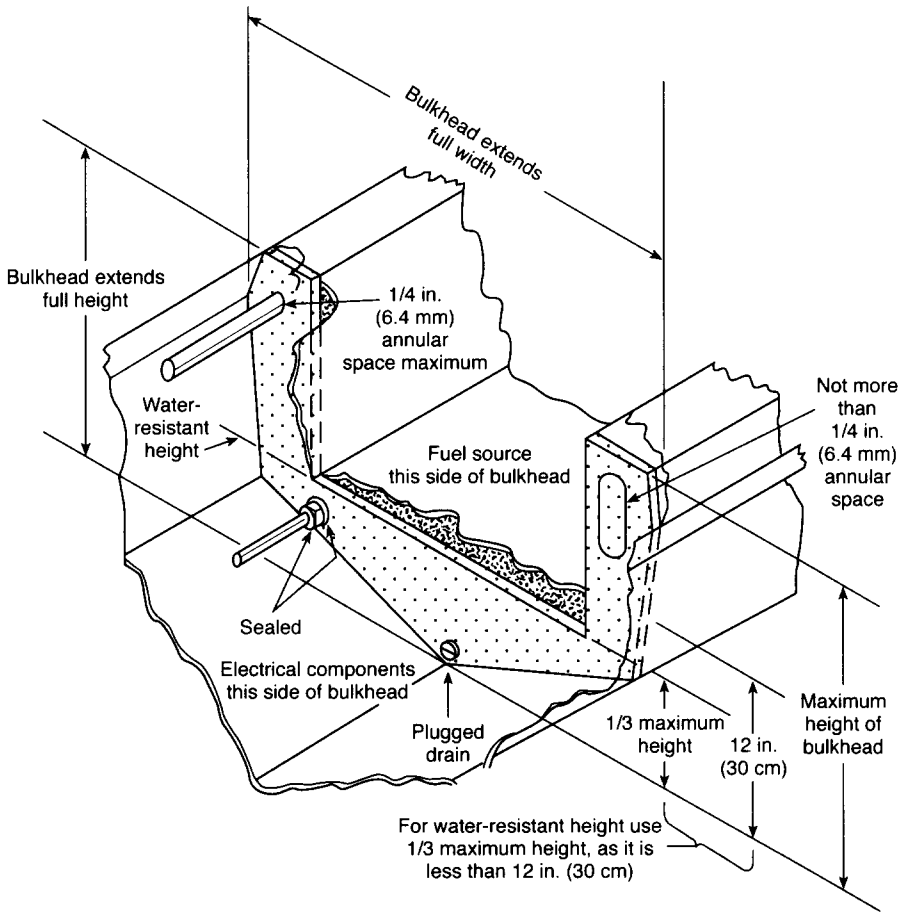


Figure 8-6.3 Cutaway illustration showing separation of electrical components from gasoline fuel source.

(b) A branch circuit is provided with overcurrent protection in the ungrounded current-carrying conductors only.

Exception: Systems with polarization or isolation transformers that establish the polarity of the onboard system.

NOTE 1: Reverse-polarity indicating devices should respond only to reversal of the ungrounded conductors and the grounded (white) conductor where there is continuity of the grounding (green) conductor to shore.

NOTE 2: Reverse-polarity indicating devices should not be required to respond to reversals of the ungrounded conductors and the grounding (green) conductor, the grounded (white) conductor and the grounding (green) conductor, or to reversal of three-phase conductors.

8-7.2 The total impedance of polarity-indicating and protection devices connected between normal current-carrying conductors and the grounding conductor shall not be less than 25,000 ohms at 120 volts, 60 hertz at all times.

8-7.3 Conductors shall be identified to indicate polarity according to Diagrams 8-7.3(a) through (i).

8-8 Overcurrent Protection.

8-8.1 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 (e.g., in machinery space or other space). The rating of the overcurrent protection device shall not exceed the maximum current-carrying capacity of the conductor being protected.

8-8.2 Circuit Breakers. Circuit breakers shall:

(a) Meet the marine requirements of UL 489, *Standard for Safety Molded-Case Circuit Breakers and Circuit-Breaker Enclosures*, UL 1077, *Standard for Safety Supplementary Protectors for Use in Electrical Equipment*, or UL 1133, *Standard for Safety Boat Circuit Breakers*.

(b) Be of the trip-free type.

(c) Be capable of an interrupting capacity in accordance with Table 8-8.2.

(d) Be of the manual reset type.

(e) Meet the requirements of UL 1500, *Standard for Safety Ignition-Protection for Marine Products*, at four times their rated current if located in a space that requires ignition protection.

NOTE: For information on external ignition protection of marine electrical devices, see SAE J1171, *Recommended Practice for External Ignition Protection of Marine Electrical Devices*.

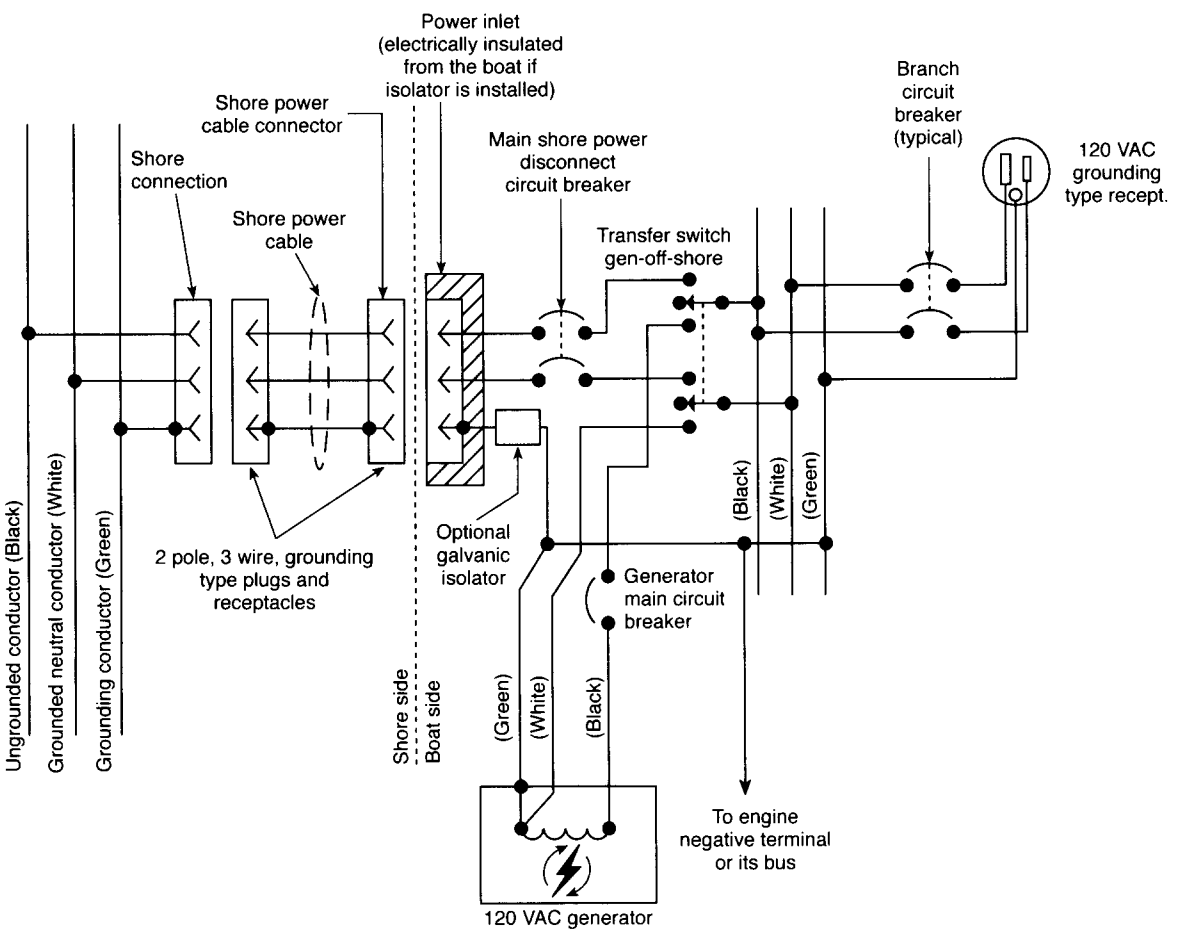


Diagram 8-7.3(a) Single-phase 120-volt auxiliary generator shore power selector switch circuit.

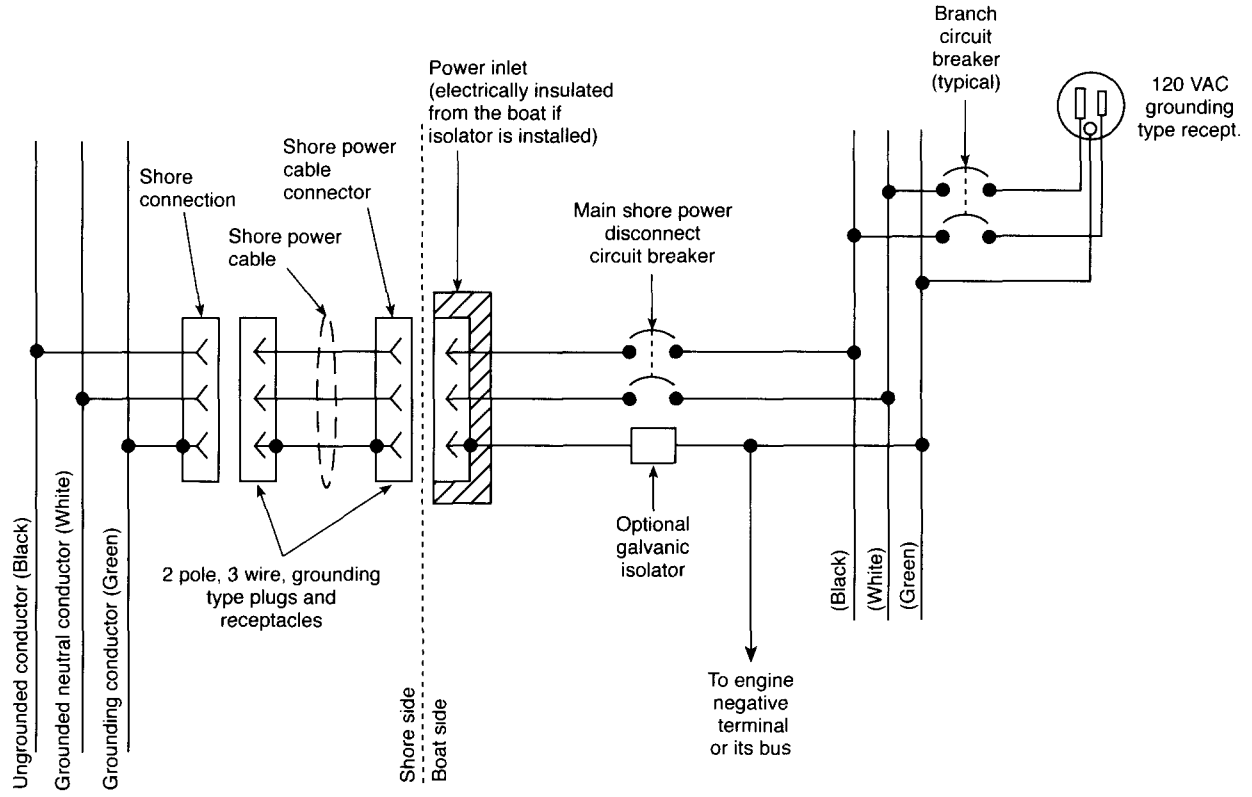


Diagram 8-7.3(b) Single-phase 120-volt system with shore-grounded neutral conductor and shore grounding conductor.

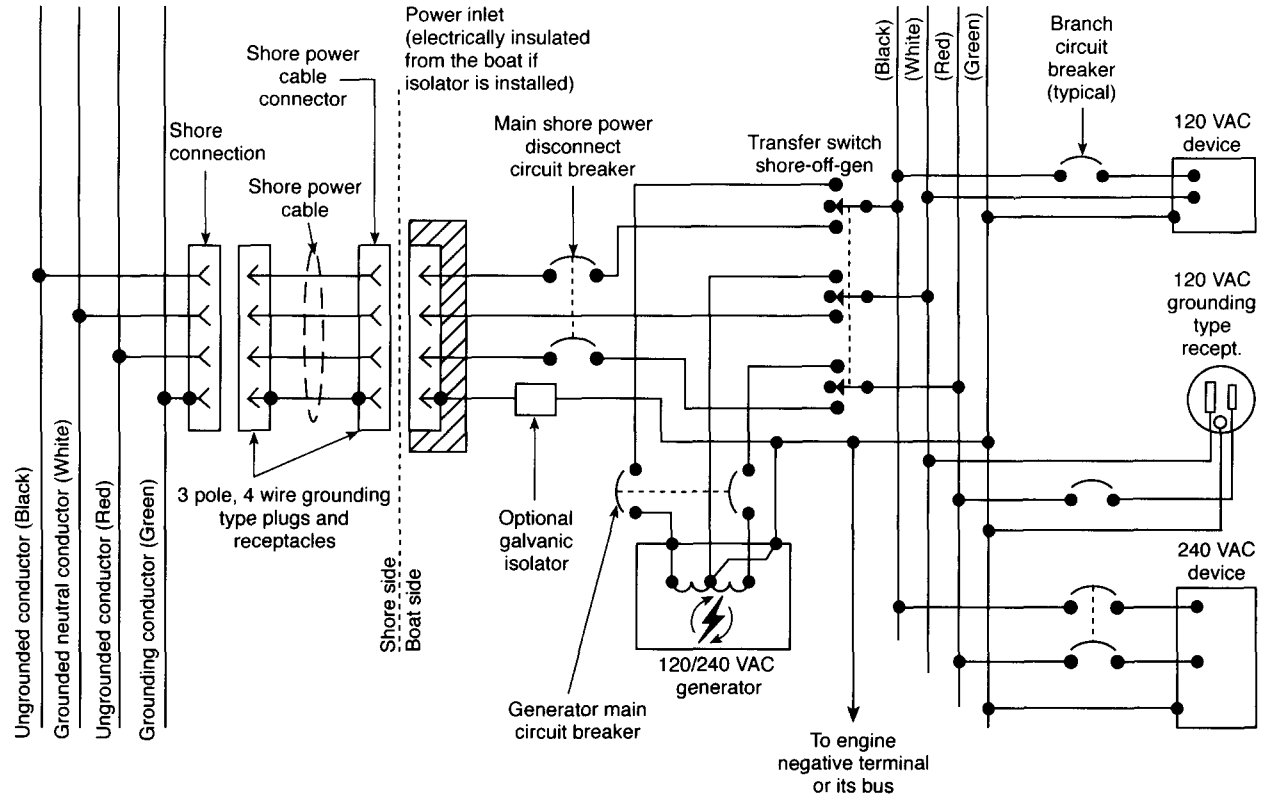


Diagram 8-7.3(c) Single-phase 120/240-volt system with shore-grounded neutral conductor and grounding conductor.

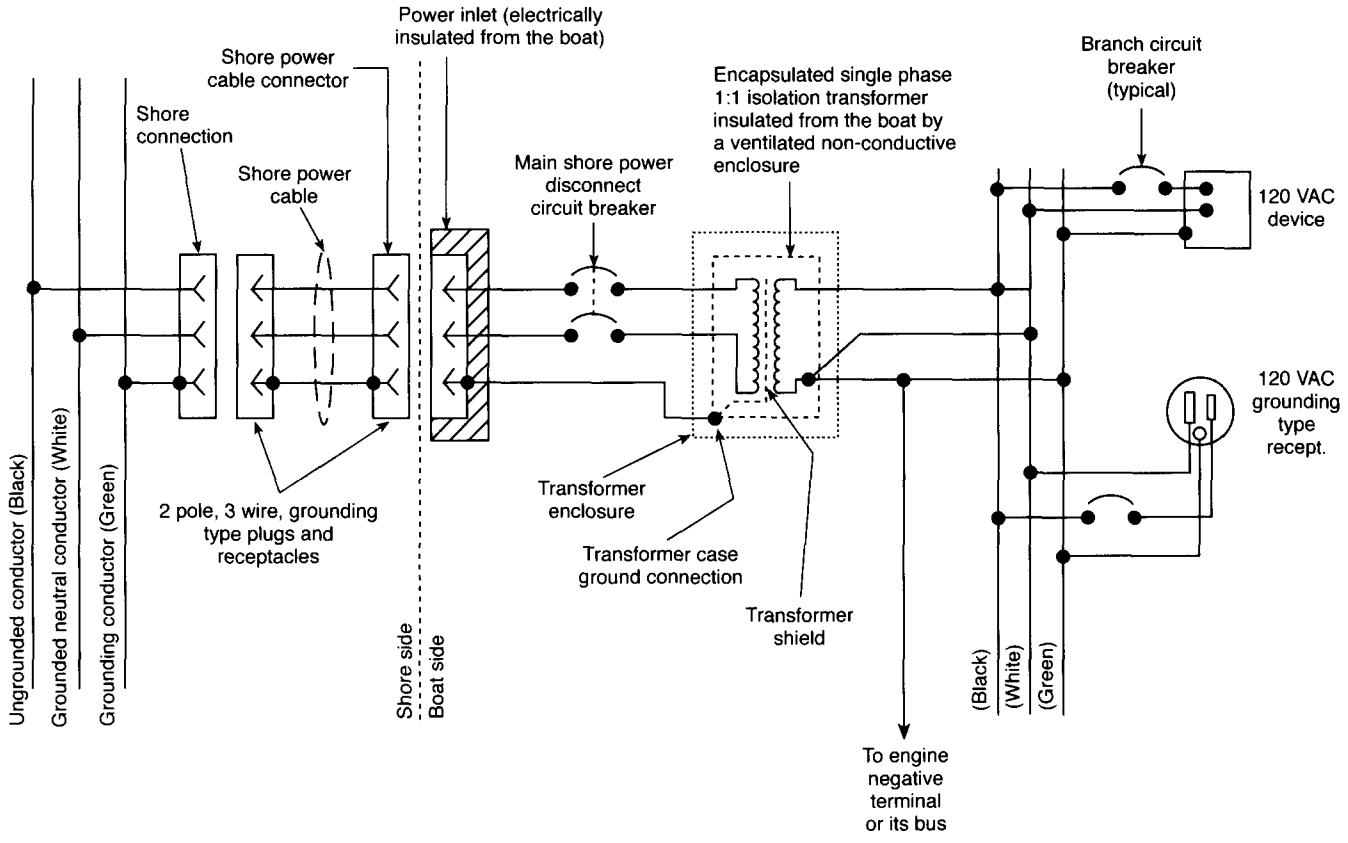


Diagram 8-7.3(d) Single-phase 120-volt isolation transformer system with grounded secondary.

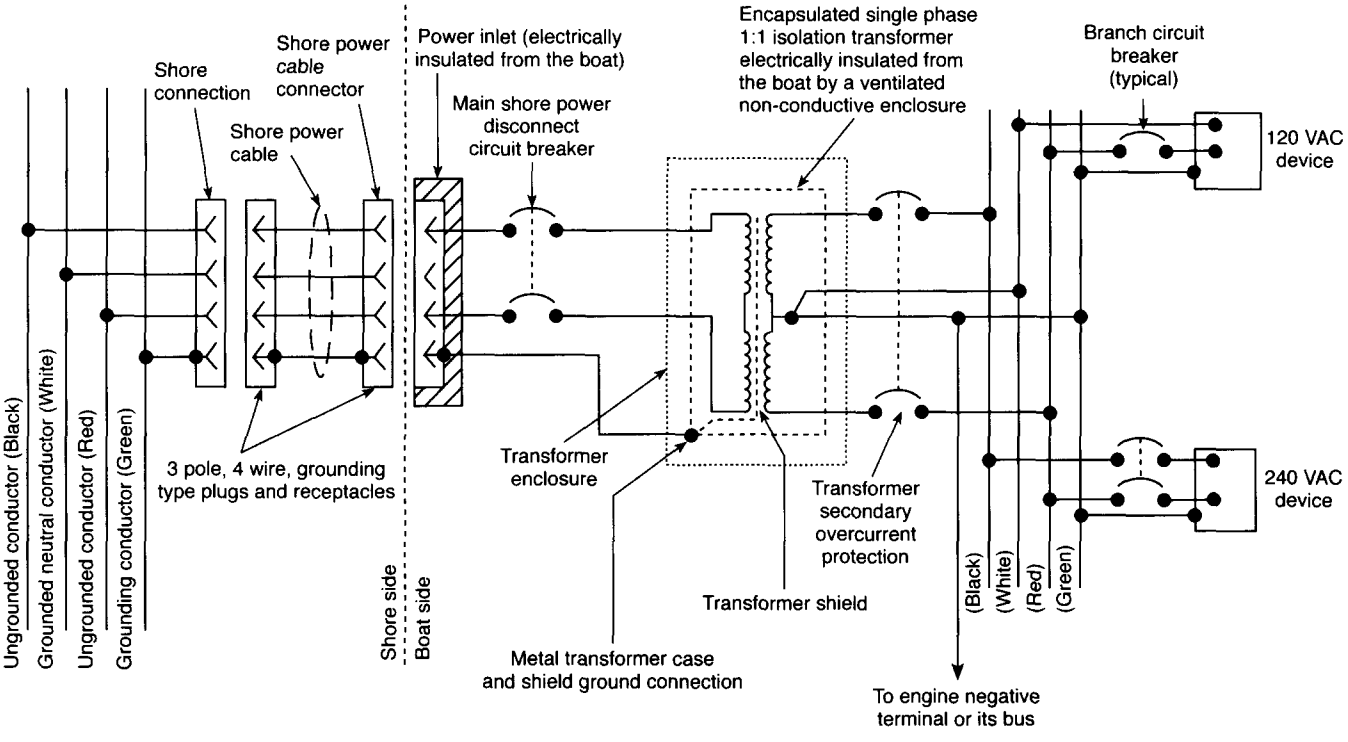


Diagram 8-7.3(e) Isolation transformer system with single-phase 240-volt input and 120/240-volt single-phase output.

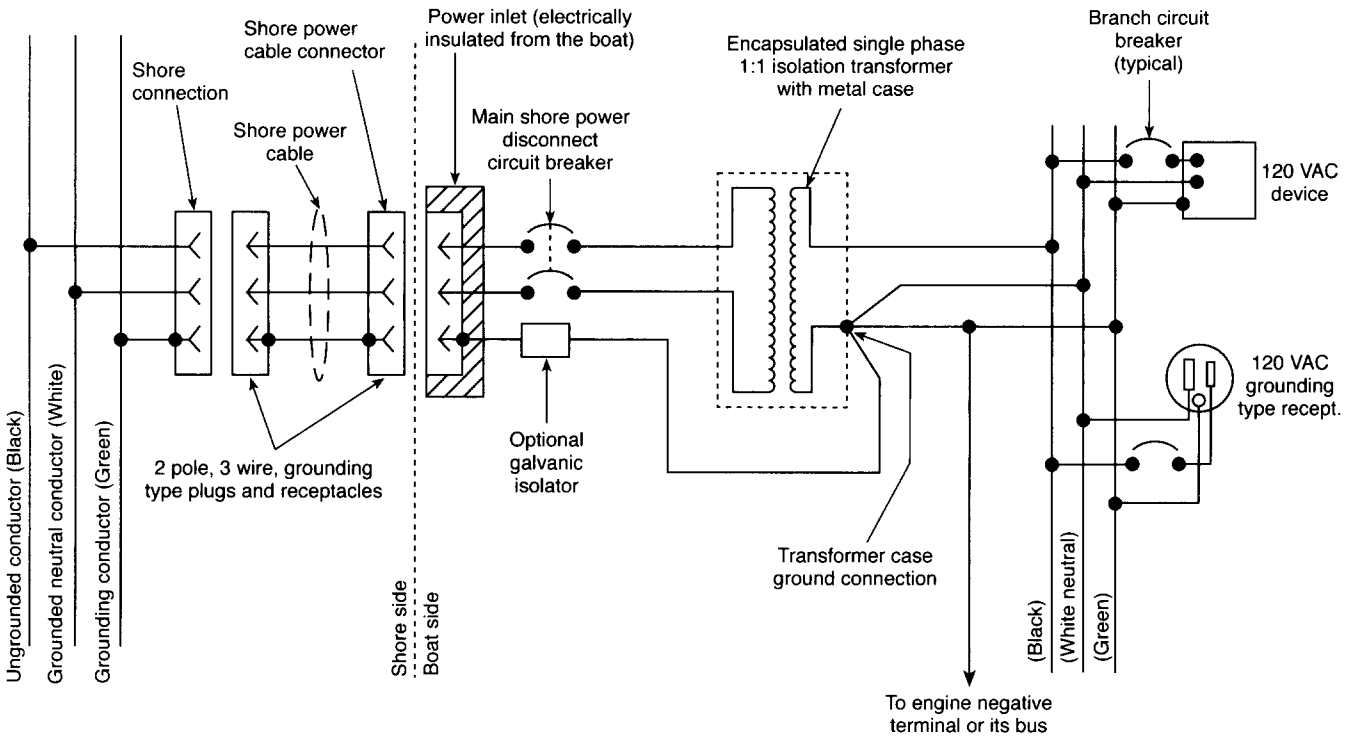


Diagram 8-7.3(f) Single-phase 120-volt polarization transformer system with shore grounding wire protection of transformer primary.

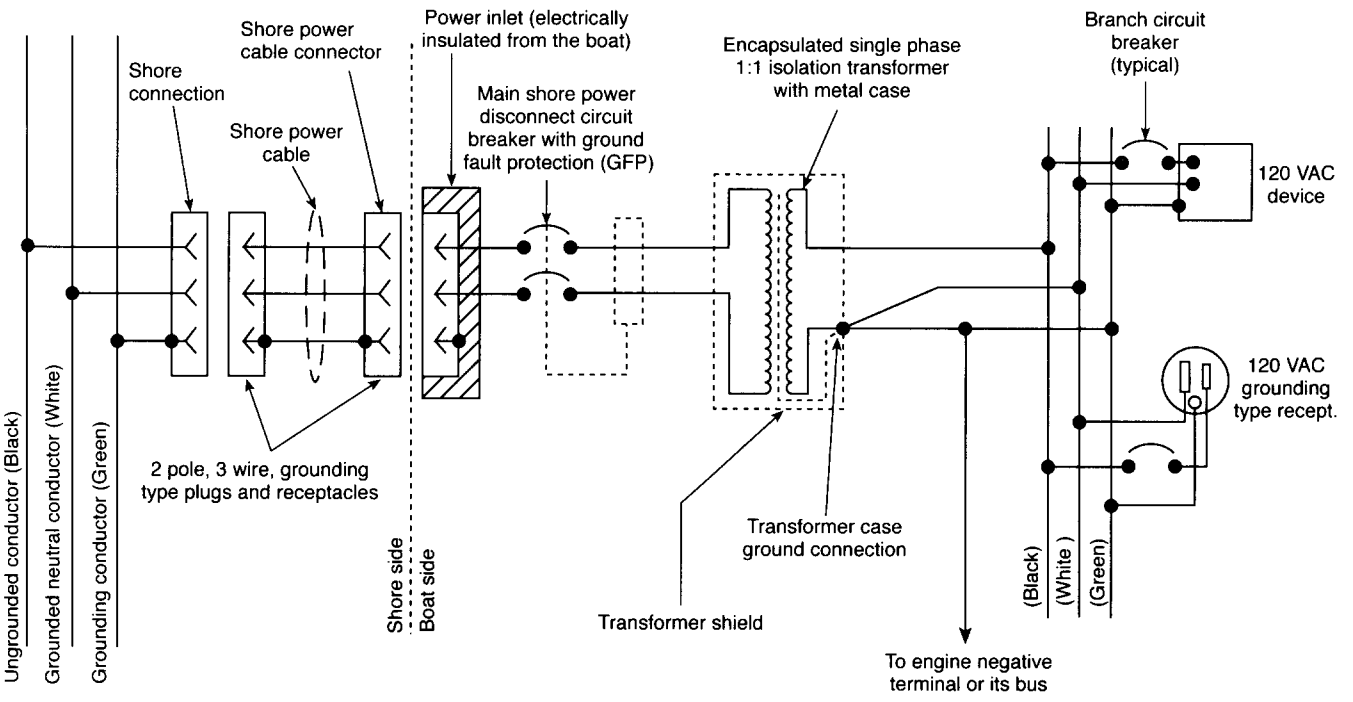


Diagram 8-7.3(g) Single-phase 120-volt isolation transformer system with ground-fault circuit-interrupter (GFCI) protection of transformer primary.

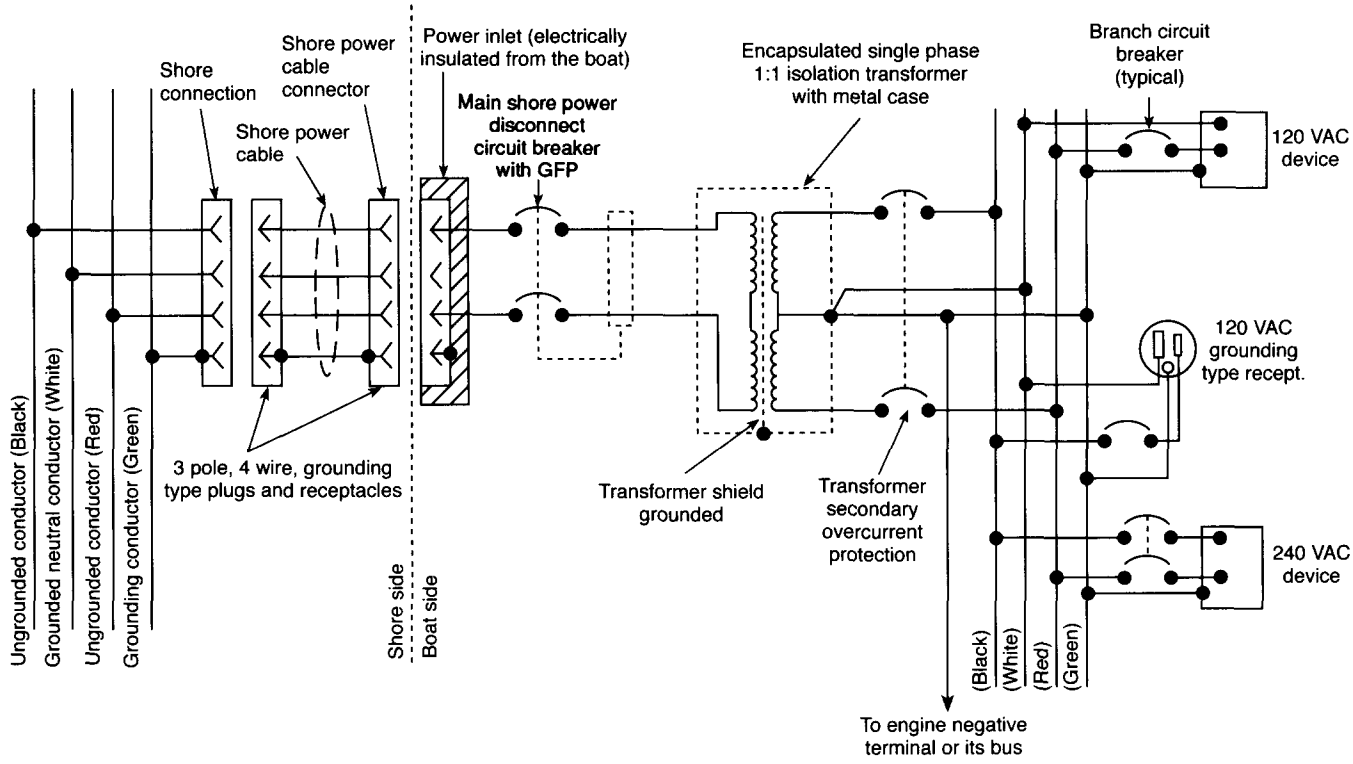


Diagram 8-7.3(h) Isolation transformer system — single-phase 240-volt input and 120/240-volt single-phase output with ground-fault circuit-interrupter (GFCI) protection of transformer primary.

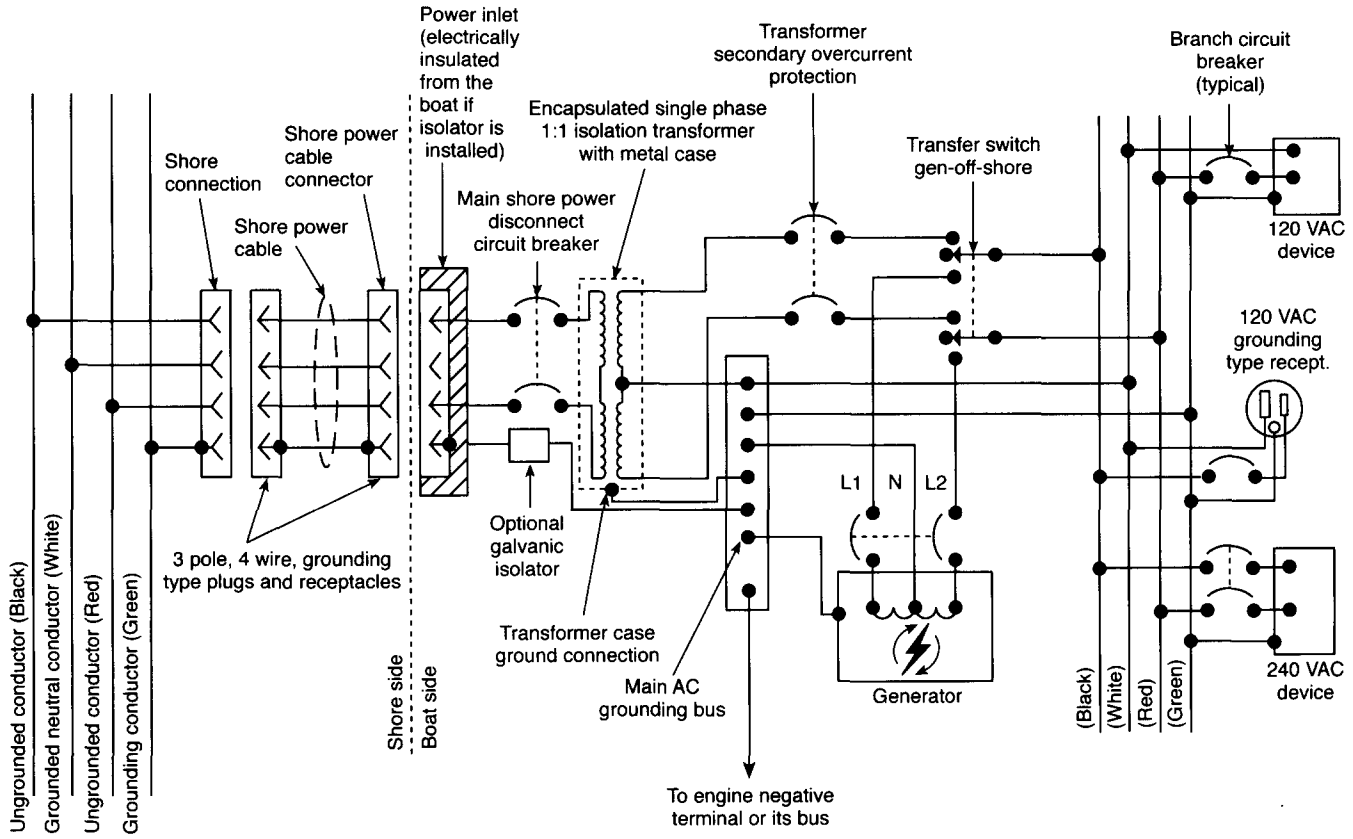


Diagram 8-7.3(i) Single-phase polarization transformer system with single-phase 240-volt input and 120/240-volt single-phase output — shore grounding protection of transformer.

Table 8-8.2 Circuit Breaker Interrupting Capacity (Amperes)

Shore Power Source	Main Shore Power Disconnect Circuit Breaker	Branch Breaker
120V - 30A	3000	3000
120V - 50 A	3000	3000
120/240V - 50 A	5000	3000
240V - 50 A	5000	3000
120/208V-3-phase/wye 30A	5000	3000
120/240V - 100 A	5000	3000
120/208V-3-phase/wye 100A	5000	3000

NOTE 1: The main circuit breaker shall be considered the first circuit breaker connected to a source of AC power. All subsequent breakers, including submain breakers connected in series with a main circuit breaker, are considered to be branch breakers.
NOTE 2: A fuse in series with, and ahead of, a circuit breaker shall be permitted to be required by the circuit breaker manufacturer to achieve the interrupting capacity specified in Table 8-8.2.

8-8.3 Fuses. Fuses shall:

(a) Have a voltage rating of not less than the nominal system voltage.

(b) Be capable of an interrupting capacity at a rated system voltage of at least 5,000 amperes for the feeders between the shore power inlet and the main circuit breaker and 3,000 amperes for branch circuits.

(c) Meet the requirements of UL 198C, *Standard for Safety High-Interrupting Capacity Fuses, Current-Limiting Types*, UL 198E, *Standard for Safety Class R Fuses*, UL 198F, *Standard for Safety Plug Fuses*, or UL 198H, *Standard for Safety Class T Fuses* for Class J, L, R, S, or T fuses.

(d) Meet the requirements of UL 1500, *Standard for Safety Ignition-Protection for Marine Products*, at four times their rated current if located in a space that requires ignition protection.

NOTE: For information on external ignition protection of marine electrical devices, see SAE J1171, *Recommended Practice for External Ignition Protection of Marine Electrical Devices.*

8-8.4 Fuse Holders. Fuse holders shall meet the requirements of UL 512, *Standard for Safety Fuseholders*, for the class of fuse being used.

8-9 Main Supply.

8-9.1 Common-trip circuit breakers shall be provided in main supply conductors as follows:

(a) 120-volt AC, single-phase — ungrounded and grounded conductors (white)

(b) 240-volt AC, single-phase — both ungrounded conductors

(c) 120/240-volt AC, single-phase — both ungrounded conductors

(d) 120/240-volt AC, delta three-phase — all ungrounded conductors

(e) 120/208-volt AC, wye three-phase — all ungrounded conductors.

8-9.2 If the main supply feeder from the shore power inlet to the main circuit breaker exceeds 10 ft (3 m) in length, additional fuses or circuit breakers shall be provided within 10 ft (3 m) of the shore power inlet. If additional fuses are used, their rating shall be such that circuit breakers trip before the fuses open the circuit in the event of overload.

8-9.3 Overcurrent protection for AC-generator power feeders, if required, shall be within 7 in. (18 cm) of the output connection or shall be permitted to be within 40 in. (102 cm) of the output connections if the unprotected insulated conductors are contained for their entire length within a sheath or enclosure such as a conduit, junction box, control box, or enclosed panel.

8-10 Branch Circuits.

8-10.1 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 not be rated in excess of the current rating of the smallest conductor between the fuse or circuit breaker and the load.

8-10.2 In branch circuits, circuit breakers and switches shall open all grounded and ungrounded conductors simultaneously.

Exception No. 1: A polarized circuit with a polarity indicator.

Exception No. 2: The neutral leg of a grounded secondary of a polarization or isolation transformer.

8-10.3 Fuses shall not be used in the grounded conductor.

8-10.4 If circuits contain two or more ungrounded current-carrying conductors that are protected by fuses, means shall be provided to disconnect all energized legs of the circuit simultaneously or to remove all fuses from the circuit simultaneously.

8-10.5 AC Motors. Each motor or motor-operated device shall be protected by an overcurrent protection device that is responsive to the motor current. The overcurrent protection device shall not be rated at more than 125 percent of the motor full-load current rating and shall be permitted to be integral and of an automatic resetting type.

Exception: Motors that do not overheat under locked rotor conditions.

8-10.6 Battery Chargers. Each ungrounded conductor to a battery charger shall be provided with overcurrent protection at the point of connection to the main switchboard, the distribution panel, or the battery. In addition, the ungrounded conductor shall be provided with overcurrent protection within the battery charger, based on the maximum output of the charger, unless the battery charger output is current-limited.

8-11 Ground-Fault Circuit-Interrupters.

8-11.1 A ground-fault circuit-interrupter (GFCI) shall be permitted to be used on any single-phase AC circuit and shall be used for all receptacles in the head, the galley, and machinery spaces and on weather decks.

8-11.2 Ground-Fault Circuit-Interrupter (GFCI) Breakers.

(a) GFCI breakers shall meet the requirements of UL 943, *Standard for Safety Ground-Fault Circuit-Interrupters*, and UL 489, *Standard for Safety Molded-Case Circuit Breakers and Circuit-Breaker Enclosures.*

(b) If installed in a head, galley, or machinery space or on a weather deck, the receptacle shall be protected by a Type A (nominal 5 milliampere) ground-fault circuit-interrupter.

(c) GFCI breakers shall be permitted to be installed as panelboard feeder breakers to protect all associated circuits or in individual branch circuits.

8-11.3 Ground-Fault Circuit-Interrupter (GFCI) Receptacle Devices.

(a) GFCI receptacle devices shall meet the requirements of UL 943, *Standard for Safety Ground-Fault Circuit-Interrupters*, and UL 498, *Standard for Safety Attachment Plugs and Receptacles*.

(b) GFCI receptacle devices shall be permitted to be installed as part of a convenience outlet installation, either in single outlet applications or in multiple "feed-through" installations.

8-11.4 Isolation Transformer Primary. GFCI circuit breakers shall be permitted to be installed as the main breaker on the primary side of isolation transformers.

NOTE: This GFCI breaker provides ground-fault protection for the primary winding of the transformer only.

8-12 Appliances and Equipment.

8-12.1 Appliances and fixed AC electrical equipment used on boats shall be designed so that the current-carrying parts of the device are insulated effectively from all exposed electrically conductive parts.

8-12.2 All exposed electrically conductive noncurrent-carrying parts of fixed AC electrical equipment and appliances intended to be grounded shall be connected to the grounding system.

8-12.3 If an appliance has a neutral-to-ground bonding strap, the bonding strap shall be removed.

8-13 Conductors and Flexible Cords.

8-13.1 Conductors shall have a minimum rating of 600 volts. Flexible cords shall have a minimum rating of 300 volts.

8-13.2 Conductors shall be selected from the types specified in Table 8-13.2.

8-13.3 Flexible cords shall be selected from the types specified in Table 8-13.3.

8-13.4 Conductors and flexible cords shall be of stranded copper with circular mil area and stranding in accordance with Table 8-13.4.

8-13.5 Conductor sizes, as determined by Table 8-13.4, shall not carry current greater than that indicated in Table 8-13.5, based on the temperature rating of the wire and the following derating factors:

(a) Conductors used in or routed through an engine space shall be corrected in accordance with Note 1 of Table 8-13.5.

(b) Current-carrying conductors that are bundled shall be derated in accordance with Note 2 of Table 8-13.5.

8-13.6 Conductors shall be at least No. 16 AWG.

Exception: Conductors contained completely within equipment or enclosures.

Table 8-13.2 Acceptable Insulation Types

Types	Description	Available Insulation Temperature Rating
THW	Moisture- and heat-resistant, thermoplastic	75°C (167°F)
TW	Moisture-resistant, thermoplastic	60°C (140°F)
THWN	Moisture- and heat-resistant, thermoplastic	75°C (167°F)
XHHW	Moisture- and heat-resistant, cross-linked synthetic polymer	90°C (194°F)
MTW	Moisture-, heat-, and oil-resistant, thermoplastic	90°C (194°F)
AWM	Moisture-, heat-, and oil-resistant, thermoplastic	105°C (221°F)
Style Nos.*: 1230 1231 1275 1276 1329 1335 1336 1337 1339 1340 1345 1388 3403	Thermosetting	
UL 1426	Boat cable	(*See UL 1426, Standard for Safety Electric Cables for Boats*)

*Numbers listed are style numbers.

8-13.7 All conductors shall meet the applicable standards of Underwriters Laboratories Inc. and shall be so labeled.

8-14 Installation.

8-14.1 All connections normally carrying current shall be made in enclosures with interior surfaces having a flame spread rating of not more than 25.

8-14.2 All conductors shall be supported to relieve strain on connections. Where AC and DC conductors are run together, the AC conductors shall be sheathed, bundled, or otherwise kept separate from the DC conductors.

Exception: Conductors contained completely within equipment or enclosures.

8-14.3* Conductors shall be supported for their entire length or, alternatively, shall be secured at least every 18 in. (46 cm) by one of the following methods:

(a) 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 can result in a hazardous condition. Conductor material shall be resistant to oil, gasoline, and water and shall not break or crack under flexing within a temperature range of -30°F to 250°F (-34°C to 121°C).

Table 8-13.3 Flexible Cords

Type	Description	Insulation Temperature Rating	Application
SO	Hard service cord—oil-resistant compound	60°C (140°F) 75°C (167°F) & higher	General use except for machinery space General use
ST	Hard service cord—thermoplastic	60°C (140°F) 75°C (167°F) & higher	General use except for machinery space General use
STO	Hard service cord—oil-resistant thermoplastic	60°C (140°F) 75°C (167°F) & higher	General use except for machinery space General use
SJO	Junior hard service cord—oil-resistant compound	60°C (140°F) 75°C (167°F) & higher	General use except for machinery space General use
SJT	Junior hard service cord—thermoplastic	60°C (140°F) 75°C (167°F) & higher	General use except for machinery space General use
SJTO	Junior hard service cord—thermoplastic	60°C (140°F) 75°C (167°F) & higher	General use except for machinery space General use

Table 8-13.4 Conductor Circular Mil (CM) Area and Stranding

Conductor Size (AWG)	Nominal CM Area*	Minimum Type 2**	Number of Strands Type 3***
18	1,620	16	—
16	2,580	19	26
14	4,110	19	41
12	6,530	19	65
10	10,380	19	105
8	16,510	19	168
6	26,240	37	266
4	41,740	61	420
2	66,360	127	665
1	83,690	127	836
1/0	105,600	127	1064
2/0	133,100	127	1323
3/0	167,800	259	1666
4/0	211,600	418	2107

* To recognize stranded conductors made of AWG elements, note that the actual nominal CM area can differ from the specified nominal CM area but by no more than 7 percent. The circular mil area is equal to the mathematical square of the specified diameter of the AWG standard solid copper conductor measured in one thousandths of an inch.

$$\text{Area (sq in.)} = \frac{\text{pi} \times \text{(circular mils)}}{4\ (1{,}000{,}000)}$$

** Conductors with Type 2 stranding shall be permitted to be used for wiring that is subject to movement from vibration or minor flexing. If four or more conductors are run in a cable, Type 2 stranding shall be permitted to be used for frequent flexing applications.

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

NOTE: Metric wire sizes can be used if of equivalent circular mil area. If the circular mil area of the metric conductor is less than that listed, the wire ampacity needs to be corrected based on the ratio of the circular mil areas.

(b) 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 located directly under the strap or clamp shall be protected by means of loom, tape, or other suitable wrapping to prevent injury to the conductor.

(c) Metal clamps lined with an insulating material resistant to the effects of oil, gasoline, and water.

8-14.4 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. 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 space is used to achieve this, the minimum space shall be 1/4 in. (6.4 mm).

8-14.5 Unused openings in boxes, cabinets, and weatherproof enclosures shall be closed.

8-14.6 Current-carrying conductors shall be routed as high as practicable above the bilge water level and other areas where water can accumulate. If conductors are forced to be routed through the bilge or other areas where water can accumulate, the wiring shall be of a submersible type and connections shall be watertight.

8-14.7 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 in. (5 cm) between conductors and water-cooled exhaust components and a clearance of at least 9 in. (23 cm) between conductors and dry exhaust components shall be maintained. Where conductors are located directly above a dry exhaust, the clearance shall be increased to 18 in. (46 cm). Conductors that are exposed to physical damage shall be protected by loom, conduit, tape, raceways, or other equivalent protection. The protection shall be self-draining. Conductors passing through bulkheads or structural members shall be protected to minimize insulation damage such as chafing. Conductors also shall be routed clear of sources of chafing such as steering cable and linkages, engine shafts, and throttle connections.

8-14.8 All permanently installed appliances and utilization equipment shall be mounted securely to the boats structure.

8-14.9 Wiring Connections.

(a) Wiring connections shall be designed and installed to make mechanical and electrical joints without damage to the conductors.

(b) 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.

(c) 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 8-14.9 for the smallest conductor size used in the splice for a 1-min duration without breaking.

Table 8-13.5 Ampacities of Insulated Conductors

Conductor Size AWG	Temperature Rating of Conductor Insulation 60°C (140°F)	75°C (167°F)	80°C (176°F)	90°C (194°F)	105°C (221°F)	125°C (257°F)	200°C (392°F)
18	10	10	15	20	20	25	25
16	15	15	20	25	25	30	35
14	20	20	25	30	35	40	45
12	25	25	35	40	45	50	55
10	40	40	50	55	60	70	70
8	55	65	70	70	80	90	100
6	80	95	100	100	120	125	135
4	105	125	130	135	160	170	180
3	120	145	150	155	180	195	210
2	140	170	175	180	210	225	240
1	165	195	210	210	245	265	280
0	195	230	245	245	285	305	325
00	225	265	285	285	330	355	370
000	260	310	330	330	385	410	430
0000	300	360	385	385	445	475	510

NOTE 1: Engine room temperature derating factor:

	60°C (140°F)	75°C (167°F)	80°C (176°F)	90°C (194°C)	105°C (221°F)	125°C (257°F)	220°C (392°F)
Temperature rating of conductor	0.58	0.75	0.78	0.82	0.85	0.89	1.00

NOTE 2: Current-carrying conductor bundling derating factor:

Number of Energized Wires in a Bundle	Correction factor
3	0.70
4 to 6	0.60
7 to 24	0.50
25 and above	0.40

(d) Terminal connectors shall be of the ring or captive spade type.

Exception: Friction-type connectors shall be permitted to be used on components, provided:

1. The circuit is rated at not more than 10 amperes;

2. The voltage drop from terminal to terminal does not exceed 50 millivolts for a 20-ampere current flow; and

3. The connection does not separate if subjected to a 6-lb (26.7-N) tensile force along the axial direction of the connector for 1 min.

Table 8-14.9 Tensile Test Values for Connections

Conductor Size	Tensile Force (lb/N)		Conductor Size (gauge)	Tensile Force (lb/N)	
18	10	44	4	70	311
16	15	66	3	80	355
14	30	133	2	90	400
12	35	155	1	100	444
10	40	177	0	125	556
8	45	200	00	150	667
6	50	222	000	175	778
5	60	266	0000	225	1000

8-14.10 Connections shall be permitted to be made using a set-screw, pressure-type conductor connector, provided a means is used to prevent the set screw from bearing directly on the conductor strands. Set-screw-type conductor connectors without such means shall be used only on seven-strand conductors.

8-14.11 Twist-on connectors (wire nuts) shall not be used.

8-14.12 Solder shall not be the sole means of mechanical connection in any circuit.

Exception: Conductors contained completely within equipment or enclosures.

8-14.13 Solderless crimp-on connectors shall be attached with the type of crimping tools designed for the connector used.

8-14.14 No more than four conductors shall be secured to any terminal stud. If additional connections are necessary, two or more terminal studs shall be connected together by means of jumpers or copper straps.

8-14.15 Terminal connectors of the ring and captive spade type shall be the same nominal size as the stud.

8-14.16 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.

8-14.17 The shanks of terminals shall be protected against accidental shorting by the use of insulation barriers or sleeves.

Exception: Shanks used in grounding systems.

8-15 Receptacles.

8-15.1 Receptacles shall be installed in locations normally not subject to rain, spray, or flooding, but if receptacles are used in areas that are subject to such weather exposure, the following requirements shall apply:

(a) Receptacles installed in locations subject to rain, spray, or splash shall be weatherproof to the degree provided by a spring-loaded, self-closing cover.

(b) Receptacles installed in areas subject to flooding or momentary submersion shall be of as watertight a design as can be provided by a threaded, gasketed cover.

8-15.2 Receptacles shall be of the grounding type with a terminal provided for the grounding (green) conductor in accordance with ANSI/NEMA WD-6, *Wiring Devices — Dimensional Requirements*.

8-15.3 Receptacles and matching plugs used on AC systems shall not be interchangeable with receptacles and matching plugs used on DC systems.

8-15.4 Power wiring for receptacles shall be connected so that the grounded (white) conductor attaches to the terminal identified by a letter(s) or a light color (normally silver). The ungrounded conductor(s) shall be attached to the terminal identified by a letter(s) or a dark color (normally brass or copper).

8-15.5 A branch circuit supplying a combination of receptacle loads and permanently connected loads shall not supply fixed loads in excess of the following:

(a) 600 watts for a 15-ampere circuit

(b) 1000 watts for a 20-ampere circuit.

8-15.6 Receptacles provided for the galley shall be located so appliance cords can be plugged in without crossing a traffic area, galley stove, or sink.

8-15.7 If installed in a head, galley, or machinery space or on a weather deck, the receptacle shall be protected by a Type A (nominal 5 milliamperes) ground-fault circuit-interrupter (GFCI).

8-15.8 Electrical systems not equipped with polarity indicators using two-pole circuit breakers shall use two-pole GFCI in place of single-pole GFCI receptacles in those circuits that supply receptacles.

8-16 Main Panelboard.

8-16.1 A main panelboard shall be installed in a readily accessible location, shall be weatherproof or protected from weather and splash, and shall be permitted to serve as a distribution center.

8-16.2 Boats equipped with both DC and AC electrical systems shall have their distribution on separate panelboards, or there shall be a partition to separate the AC sections and the DC sections of the panelboard when the panel is open for service.

8-16.3 Panelboards shall be permanently marked with the system voltage and either "VAC" or the system frequency (e.g., "120 VAC" or "120V-60 hertz").

8-16.4 If the frequency is other than 60 hertz, the frequency shall be indicated. For three-phase systems, the system voltage, phase, and number of conductors shall be indicated.

8-16.5 A system voltmeter shall be installed, provided:

(a) The system is designed to supply motor circuits; or

(b) An onboard generator is installed.

8-17 AC Generators.

8-17.1 AC generators shall be connected to the electrical distribution system through a selector switch in accordance with 8-2.3 and Diagram 8-7.3(a).

8-17.2 The power feeders from the AC generator shall be sized to accommodate at least the generator's maximum rated output and shall be protected at the generator with overcurrent protection devices in accordance with Section 8-8. The rating of these overcurrent protection devices shall not exceed 120 percent of the generator's rated output.

Exception: Self-limiting generators having a maximum overload current not exceeding 120 percent of their rated current output shall not require additional external overcurrent protection.

8-18 Isolation of Galvanic Currents.

8-18.1 Boats with aluminum or steel hulls or aluminum outdrives subject to accelerated galvanic corrosion (via the grounding conductor) shall use an isolation transformer system in accordance with 8-22.4 or 8-22.7 or a galvanic isolator in the grounding conductor in accordance with 8-18.2.

8-18.2 The isolator shall [*see Diagram 8-7.3(a)*]:

(a) Effectively block galvanic current flow through the grounding (green) wire.

(b) Withstand the application of power from a test circuit capable of delivering 5000 amperes RMS symmetrical at the test terminals when tested in series with a 25-ft (7.6-m) length of shore power cable and a circuit breaker of the same rating as the isolator.

(c) Not introduce a voltage drop in excess of 2.5 volts at 100 percent of the shore-power cable ampacity rating in addition to the voltage drop of the shore power cable and connections.

8-19 Shore Power.

8-19.1 Power Inlet. The receptacle installed to receive a connecting cable to carry AC shore power aboard shall be a male-type connector.

(a) Power inlets installed in locations subject to rain, spray, or splash shall be weatherproof to the degree provided by a spring-loaded, self-closing cover, the integrity of which shall not be affected when the receptacle is in use (female-type connector inserted).

(b) Power inlets installed in areas subject to flooding or momentary submersion shall be of as watertight a design as can be provided by a threaded, gasketed cover.

(c) See Marking Example 8-3.1 for shore-power inlet warning sign.

(d) If a boat uses an isolation transformer or an isolator to prevent galvanic current flow through the grounding conductor, the metallic shell of the shore power inlet shall be insulated from metallic surfaces or any contact with a boat ground. [*See Diagrams 8-7.3(d), (e), (f), (g), (h), and (i).*]

8-19.2 Shore Power Cable. Boats with an AC electrical system(s) intended to use shore power provided in accordance with NFPA 70, *National Electrical Code*, Article 555, and NFPA 303, *Fire Protection Standard for Marinas and Boatyards*, shall be provided with a shore power cable that:

(a) Is provided with a male locking and grounding-type connection that conforms to NFPA 70, *National Electrical Code*, Article 555, and to ANSI/NEMA WD-6, *Wiring Devices — Dimensional Requirements*, if a configuration for that service exists in ANSI/NEMA WD-6.

(b) If provided, shall have a female boat connection of the locking and grounding type and in conformance with ANSI/NEMA WD-6, *Wiring Devices — Dimensional Requirements*, if a configuration for that service exists in ANSI/NEMA WD-6.

(c) Has a minimum length of 25 ft (7.6 m) and meets the marine requirements of UL 817, *Standard for Safety Cord Sets and Power-Supply Cords*.

8-20 Devices Employing Isolation Transformers. Devices employing isolation transformers, such as battery chargers, shall be permitted to be connected directly to the shore conductors or to the secondary of the system isolation transformer.

8-21 Application of Types of Shore Power Circuits.

8-21.1 Single-Phase 120-Volt System with Shore-Grounded Neutral and Shore Grounding Conductor. This system, wired in accordance with the basic circuit shown in Diagram 8-7.3(b), shall be permitted to be used on any nonmetallic hull boat with underwater hardware of metal alloys that are at least as galvanically noble as manganese bronze. This system also shall be permitted to be used with metal hull boats if protection against galvanic corrosion is provided by means of a cathodic protection system or a galvanic isolator.

8-21.2 Single-Phase 120/240-Volt System with Shore-Grounded Neutral and Shore Grounding Conductor. This system, wired in accordance with the basic circuit shown in Diagram 8-7.3(c), shall be permitted to be used on any nonmetallic hull boat with underwater hardware of metal alloys that are at least as galvanically noble as manganese bronze. This system also shall be permitted to be used with metal hull boats if protection against galvanic corrosion is provided by means of a cathodic protection system or a galvanic isolator.

8-21.3 Single-Phase 120-Volt Primary and Secondary Isolation Transformer System. With shore grounding protection of the transformer core, this system, wired in accordance with the basic circuit shown in Diagram 8-7.3(d), shall be permitted to be used with any metallic or nonmetallic hull boat. In this system, the grounded transformer core and the metallic shell of the shore power inlet shall be insulated from contact with any boat ground. The transformer secondary shall be grounded on the boat.

8-21.4 Isolation Transformer with Single-Phase 240-Volt Input and 120/240-Volt Output with Shore Grounding Protection of Transformer Core. This system, wired in accordance with the basic circuit shown in Diagram 8-7.3(e), shall be permitted to be used with any boat and shall be used on all metal hull boats if other means of protection against galvanic corrosion, such as a galvanic isolator, is not provided. The metallic shell of the shore power inlet shall be insulated from contact with any boat ground. The center leg of the transformer secondary shall be grounded on the boat, establishing a new neutral for the boat system.

8-21.5 Single-Phase 120-Volt Primary and Secondary Polarization Transformer System with Shore-Grounded Neutral and Shore Grounding Protection of Transformer. This system, wired in accordance with the basic circuit shown in Diagram 8-7.3(f), shall be permitted to be used on any nonmetallic hull boat with underwater hardware of metal alloys that are at least as galvanically noble as manganese bronze. This system also shall be permitted to be used with metal hull boats if protection against galvanic corrosion is provided by means of a cathodic protection system or a galvanic isolator. The transformer secondary shall be grounded on the boat.

8-21.6 Single-Phase 120-Volt Primary and Secondary Polarization Transformer System with Shore-Grounded Neutral and GFCI Protection of Transformer Primary. This system, wired in accordance with the basic circuit shown in Diagram 8-7.3(g), shall be used with any metallic or nonmetallic hull boat. The metallic shell of the shore power inlet shall be insulated from contact with any boat ground. The transformer secondary shall be grounded on the boat.

8-21.7 Single-Phase Isolation Transformer with 240-Volt Input and 120/240-Volt Secondary with GFCI Protection of Transformer Primary. This system, wired in accordance with the basic circuit shown in Diagram 8-7.3(h), shall be permitted to be used with any metallic or nonmetallic hull boat. The metallic shell of the shore power inlet shall be insulated from contact with any boat ground. The central leg of the transformer secondary shall be grounded on the boat, establishing a new neutral for the boat system.

8-21.8 Single-Phase Polarization Transformer with 240-Volt Input and 120/240-Volt Secondary and Shore Grounding Conductor Protection of Transformer Core. This system, wired in accordance with the basic circuit shown in Diagram 8-7.3(i), shall be permitted to be used on any nonmetallic hull boat with underwater hardware of metal alloys that are at least as galvanically noble as manganese bronze. This system also shall be permitted to be used with metal hull boats if protection against galvanic corrosion is provided by means of a cathodic protection system or a galvanic isolator. The center leg of the transformer secondary shall be grounded on the boat, establishing a new neutral for the boat system.

Chapter 9 Lightning Protection

9-1* General Principles. A lightning protection system, if installed, shall be installed in accordance with the provisions of this chapter.

9-1.1 The probability of a lightning strike varies with geographic location and the time of the year, but when the conditions that create an electrical charge between clouds and the earth exist, there is nothing that can be done to

prevent a lightning discharge. A boat can be struck in open water or while tied to a dock. A lightning protection system for a boat is a system of electrical conductors designed to provide a low resistance path that extends directly from a point above the boat to the water so as to dissipate a charge as quickly and efficiently as possible. Successful protection of persons and watercraft from lightning is dependent upon a combination of proper design, maintenance of the system, and training of personnel. Maintenance and personnel behavior are covered in Appendix C. Unless special protective metallic enclosures are provided and circuit wiring can be disconnected, electronic equipment connected to the vessel's wiring system can be damaged by a lightning strike, even with the use of a lightning protection system. Because of the wide variation in structural designs and materials of watercraft construction, specific guidelines cannot be provided for individual watercraft. However, the basic guidelines contained in this chapter shall be considered and used in installing a lightning protection system for any given watercraft.

Exception No. 1: A lightning protection system offers no protection for a watercraft that is out of water.

Exception No. 2: A lightning protection system affords no protection, and is not intended to afford protection if any part of the boat contacts a power line or other high-voltage source while afloat or ashore.

9-1.2 A grounded vertical lightning protection mast projecting above the boat with a conductivity equivalent to No. 4 AWG copper conductor (41,740 circular mil area) generally can divert to itself direct lightning strikes that otherwise fall within a cone-shaped space, the apex of which is the top of the conductor or lightning protective mast and the base of which is a circle at the surface of the water that has a radius related to the height. [*See Figures 9-1.2(a) and 9-1.2(b).*]

9-1.3 Rods, Masts, and Overhead Ground Wires.

9-1.3.1 The zone of protection of a lightning protection mast is based on the striking distance of the lightning stroke (the distance over which final breakdown of the initial stroke-to-ground, or to a grounded object, occurs). Since the lightning stroke can strike any grounded object within the striking distance of the point from which final breakdown occurs, the zone of protection is defined by an upward circular concave arc [*see Figure 9-1.3.1(a)*]. The radius of the arc is the striking distance, and the arc passes through the tip of the mast and is tangent to the ground. Where more than one mast is used, the arc passes through the tips of adjacent masts. [*See Figures 9-1.3.1(b) and 9-1.3.1(c).*]

9-1.3.2 The striking distance is related to the peak stroke current and, thus, to the severity of the lightning stroke; the greater the severity of the stroke, the greater the striking distance. In the vast majority of cases, the striking distance exceeds 100 ft (30 m). Accordingly, a zone that is protected based on a striking distance of 100 ft (30 m) shall be considered to be adequately protected. Where more than one mast is used, the arc passes through the tips of adjacent masts.

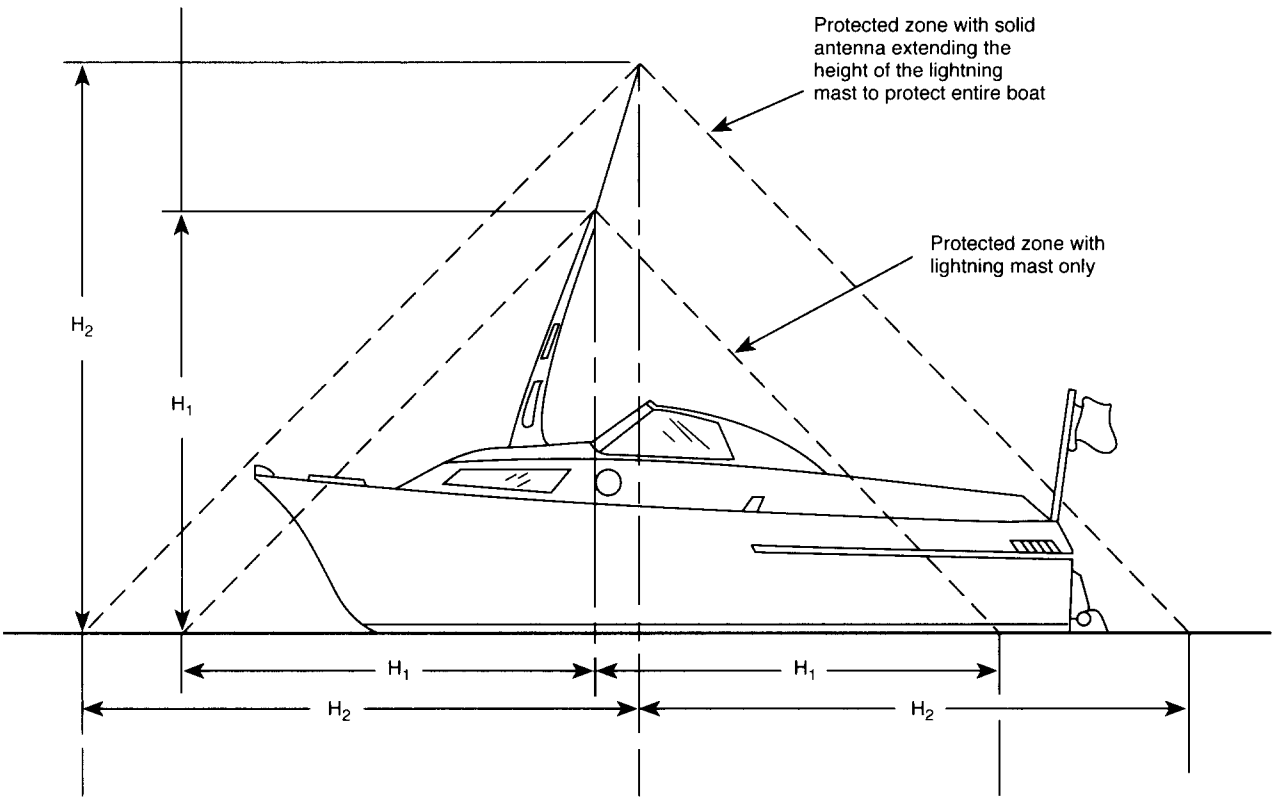


Figure 9-1.2(a) Diagram of boat with mast not exceeding 50 ft (15 m) above the water.

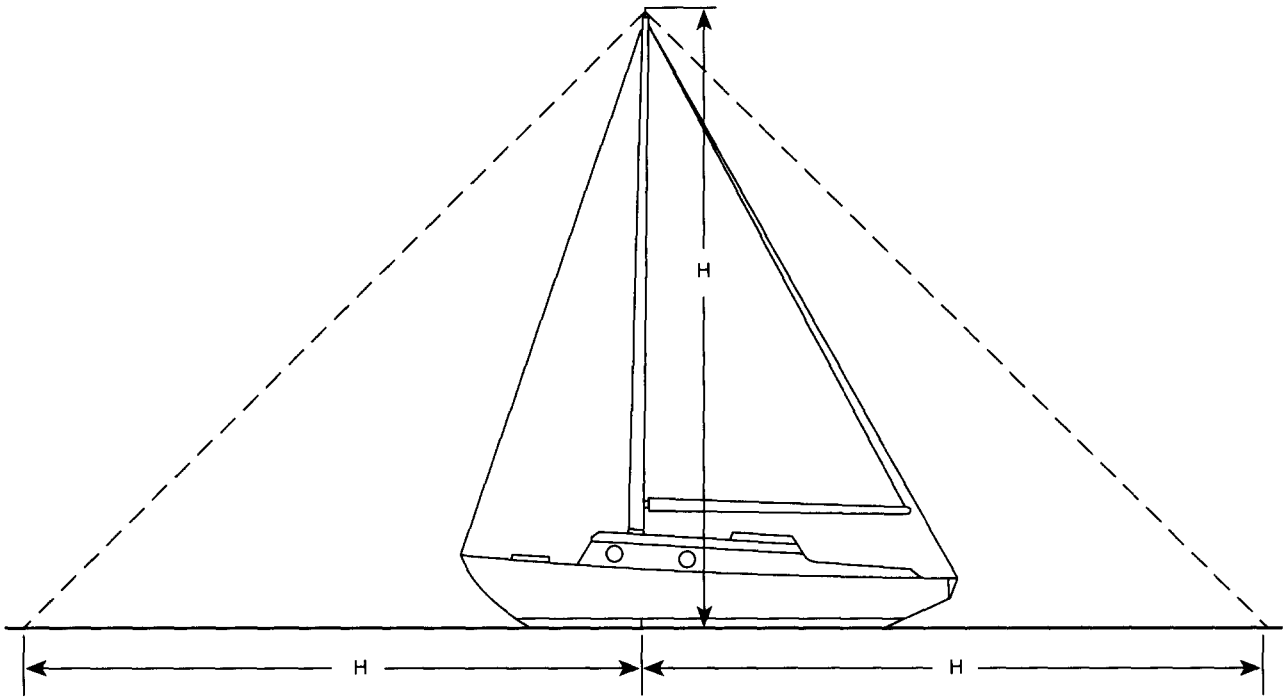
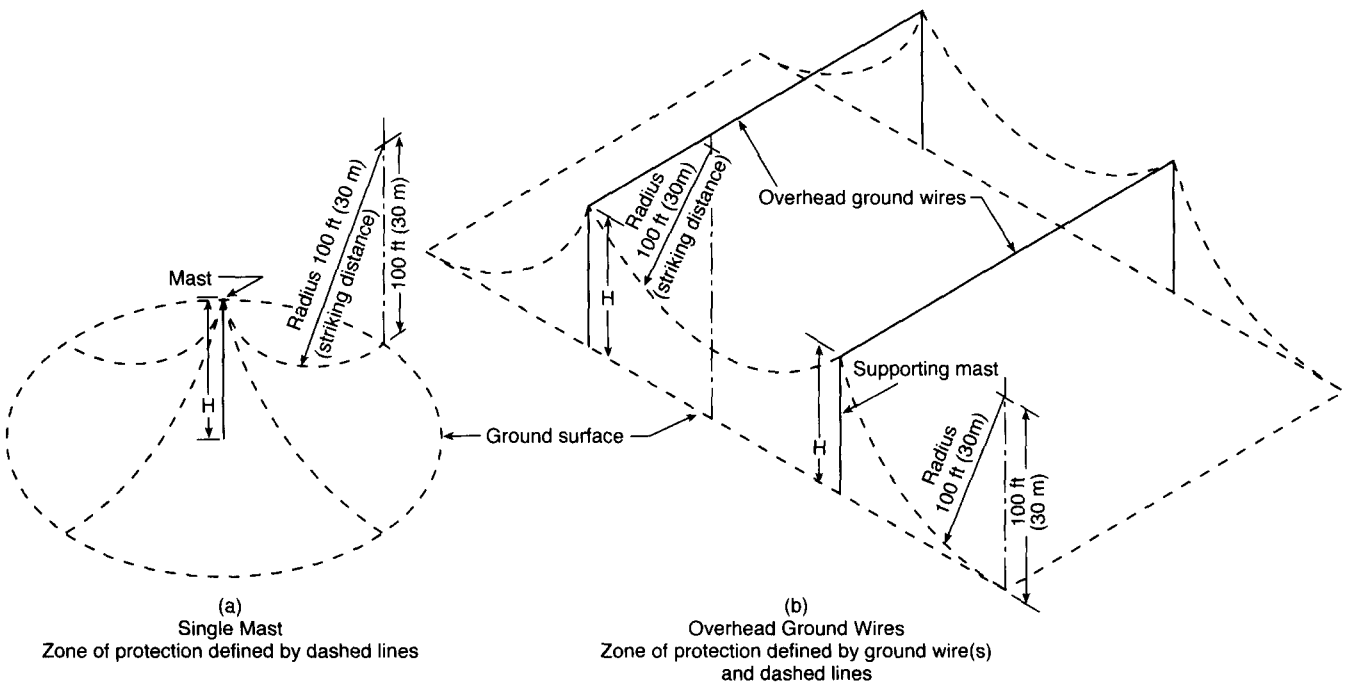
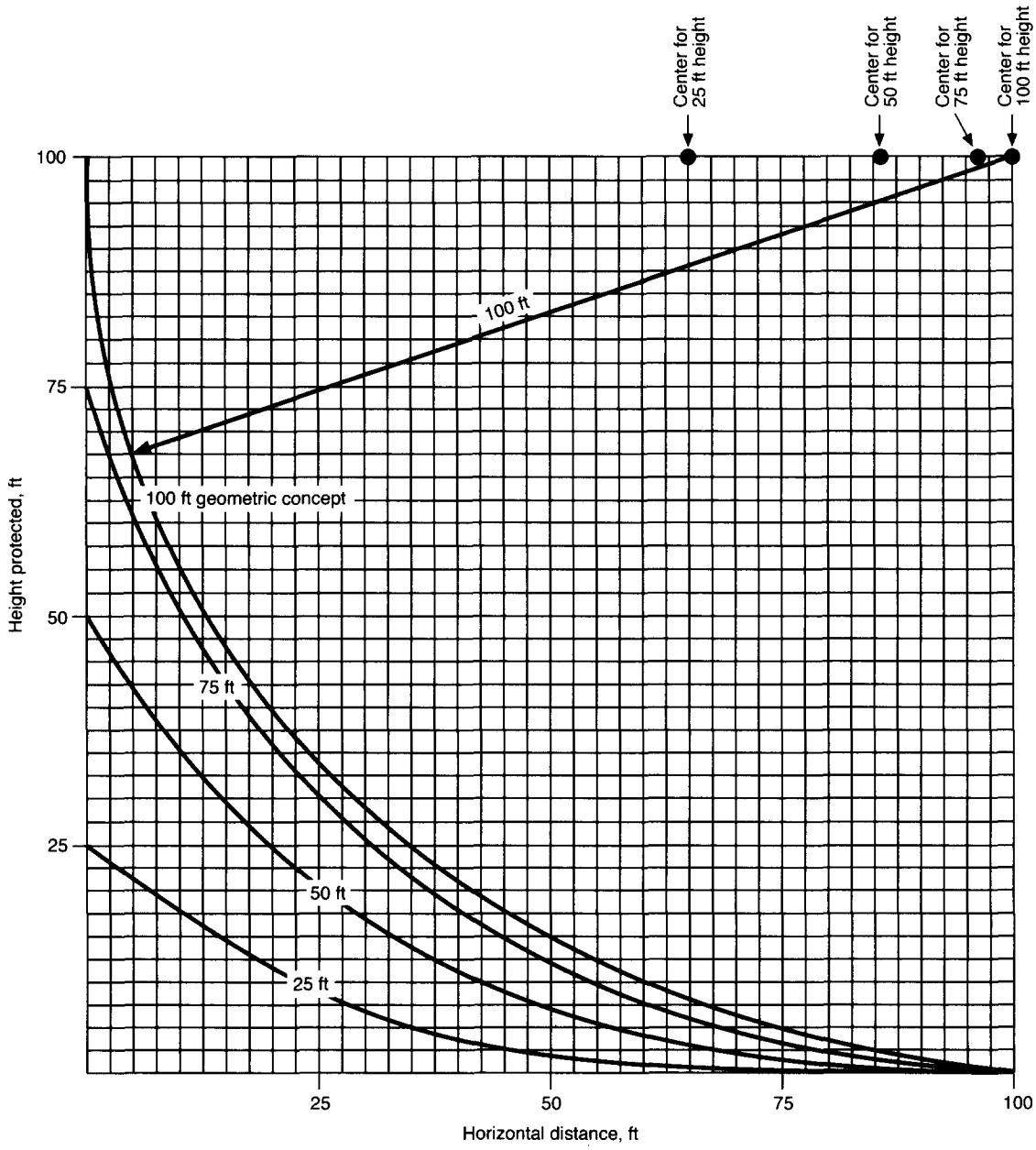


Figure 9-1.2(b) Diagram of small sailboat with mast not in excess of 50 ft (15 m).



Figures 9-1.3.1(a) and (b).



Note: The distance can be determined analytically for a 100 ft (30 m) striking distance with the following equation:

$$d = \sqrt{h_1 (200 - h_1)} - \sqrt{h_2 (200 - h_2)}$$

where: d = horizontal distance, ft
h_1 = height of higher mast, ft
h_2 = height of lower mast, ft
SI units : 1 ft = 0.30 m

Figure 9-1.3.1(c) Zone of protection — 100 ft (30 m) striking distance.

9-1.3.3 The zone of protection afforded by any configuration of masts or other elevated, conductive objects can be readily determined graphically. Increasing the height of a mast above the striking distance will not increase the zone of protection.

9-1.4 For metallic masts, the bonding conductor from the mast to the lightning grounding plate or lightning grounding strip shall have a conductivity equivalent to No. 4 AWG (41740 CMA) copper conductor.

9-1.5 Where a nonmetallic mast with an air termination point (generally a pointed stainless steel rod) or a cap is used, the down conductor from the air termination point to the lightning ground plate or strip shall have conductivity equivalent to No. 4 AWG (41740 CMA) copper conductor. The

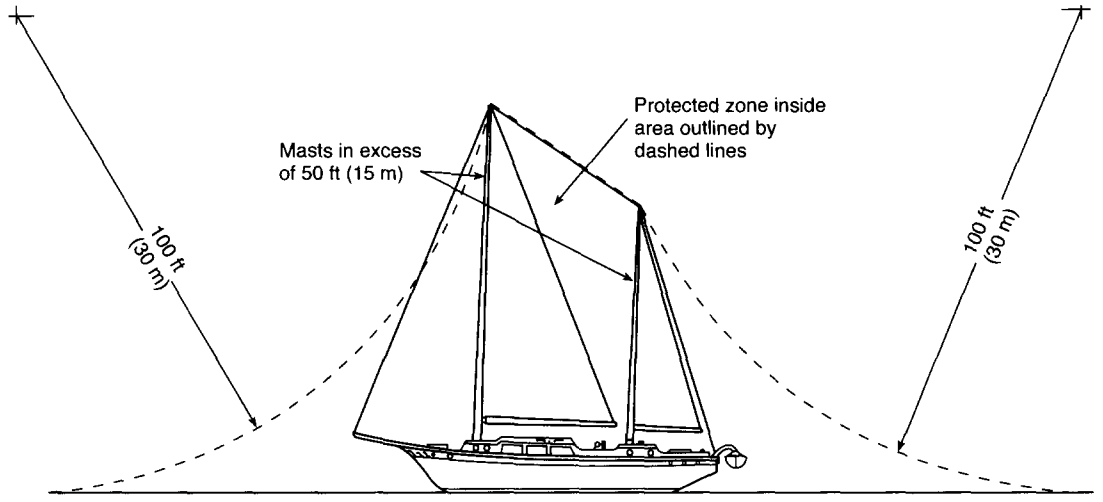


Figure 9-1.3.2 Diagram of boat with masts in excess of 50 ft (15 m) above the water — protection based on lightning striking distance of 100 ft (30 m).

path-to-ground from the air termination point shall be essentially vertical and as straight as possible. Where multiple shrouds and stays are used as part of the lightning conductive path-to-ground, the aggregate conductivity shall not be less than that of No. 4 AWG (41740 CMA) copper conductor, including the mast. Where stainless steel shrouds and stays are used in the lightning protection system, every shroud and stay shall be connected at its lower end, or at the chainplates, directly to the lightning grounding plate or lightning grounding strip, with conductors of at least No. 8 AWG (16510 CMA). (*See Section 9-4.*)

9-1.6 To minimize damage from sideflashes, an interconnecting conductor equivalent to at least No. 8 AWG (16510 CMA) copper conductor shall be provided at all locations where sideflashes are likely to occur. Large metallic masses that are subject to sideflashes shall be connected to the lightning grounding plate, to the lightning grounding strip, or to the equalization bus, if provided, in accordance with Section 9-5. Sideflashes are most likely to occur if the routing of the main lightning grounding conductor is horizontal for any distance and if the metal object provides a more direct vertical path-to-ground. Metallic tanks shall be connected directly to the lightning ground plate, lightning grounding strip, or equalization bus, and routing of the grounding wire with other boat wiring shall be avoided.

9-1.7 The lightning grounding conductors shall be routed as remotely as possible from the boat's wiring to minimize both sideflashes and to avoid introducing high voltages into the boat's wiring. The lightning grounding conductors and the boat's wiring shall be routed so that the two wiring systems are separated from one another as far as possible and so that the boat wiring is not parallel to lightning grounding conductors.

9-1.8 Lightning protection provisions are likely to receive scant attention after installation, and, therefore, their composition and assembly shall be strong, and the materials used shall be highly resistant to corrosion.

9-2 Installation.

9-2.1 Lightning Protection Mast. The lightning protection mast shall be so located and of sufficient height to provide a zone of protection that covers the entire boat. (*See Section 9-1.*)

9-2.2 Permanent Lightning Protective Mast. A permanent lightning protective mast shall be located near the center of the deck plan area. The mast shall be mechanically strong to withstand exposure to the roll and pitching action of the hull and to heavy weather. The mast shall be fitted with a lightning air terminal that extends at least 6 in. (15 cm) above the mast. The air terminal shall be connected either to the mast, if metallic, or, in the case of a nonmetallic mast, to a copper conductor or copper strip securely fastened to the mast. The metallic mast or the lightning conductor fastened to a nonmetallic mast shall be equivalent to No. 4 AWG (41740 CMA) conductor. The mast shall be permitted to be raked at an angle but shall be substantially vertical. If the mast penetrates the cabin top and extends to the cabin sole, the mast shall be permitted to be fastened directly to the lightning ground plate or strip with a No. 4 AWG (41740 CMA) conductor. If the mast is stepped on deck, a No. 4 AWG (41740 CMA) conductor secured to the mast at the base shall be routed as vertically and directly as possible to the lightning grounding plate, the lightning grounding strip, or the equalization bus. If the conductor is routed around a passageway located directly below the mast, two No. 6 AWG (26240 CMA) conductors connected in parallel and routed on both sides of the opening shall be used. The mast and the conductors connecting the mast to the lightning ground plate shall be positioned, routed, or covered to minimize physical contact by persons on the boat.

9-2.3 Temporary Lightning Mast. On small boats that cannot be equipped with a permanent lightning mast due to trailer transportation or for other reasons, a plug-in mast shall be permitted to be provided. The base of the plug-in mast shall be located as close to the geometric center of the boat as possible, but, if necessary, shall be permitted to be offset, provided the zone of protection covers the entire boat when the mast is plugged in. The location of the mast base shall be such that persons on the boat can avoid physical contact with the mast or the base. The base shall extend as high as possible, and provision shall be made to plug in the upper section of the lightning mast so

that it cannot be displaced by rolling and pitching of the boat in rough water. The plug-in length shall not be permitted to be less than 3 in. (7.5 cm), unless a threaded coupling that can be tightened is provided. The plug-in mast shall be entirely of metal, aluminum, or steel tubing and equivalent to at least No. 4 AWG (41740 CMA) conductor.

Exception: A solid stainless steel whip antenna or equivalent shall be permitted to be used because of its higher melting temperature, but it does not provide as low a resistance path for the lightning.

9-2.4 Radio Antennas and Outriggers. A solid metal-type vertical radio antenna shall be permitted to serve as a lightning mast, provided provision is made to ground the metal antenna base with a conductor equivalent to No. 4 AWG (41740 CMA) copper conductor that is routed vertically to the lightning grounding plate, to the lightning grounding strip under the boat, or to an equalization bus. The height of the antenna shall be sufficient to provide the required zone of protection for the boat and occupants. Because a loading coil presents a high impedance to the flow of lightning currents, the coil shall be provided with a suitable surge suppression device (lightning arrester) for bypassing the lightning current. The path to the lightning ground shall be permitted to be completed by means of a changeover switch that selects either radio operation or lightning protection or by means of the lightning gap across the loading coil to the lightning grounding system. The gap limits the voltage rise to the radio equipment to some extent, but damage is possible, depending on the severity of the strike.

9-2.4.1 Nonmetallic radio antennas with spiral-wrapped conductors shall not be permitted to serve as lightning protection.

9-2.4.2 Stainless steel shrouds of small diameter and stays on small sailboats that are trailered do not have the conductivity (less than that of No. 8 AWG (16510 CMA) conductor) necessary to conduct lightning currents to ground. Therefore, such shrouds and stays shall be grounded at their lower ends and used in addition to the grounding of the mast, which shall serve as the primary lightning grounding conductor.

9-3 Materials.

9-3.1 The materials used in the lightning protection system shall be resistant to corrosion. The use of combinations of metals that form detrimental galvanic couples shall be avoided.

9-3.2 In those cases where it is impractical to avoid a junction of dissimilar metals, the corrosion effect shall be permitted to be reduced by the use of suitable plating or special connectors, such as stainless steel connectors used between aluminum and copper alloys.

Exception: For those components made of conductive materials that are part of the structure of the boat, such as aluminum masts, only copper shall be used in a lightning conductor system. Where copper is used, it shall be of the grade ordinarily required for commercial electrical work, which generally is designated as providing 98 percent conductivity where annealed.

9-3.3 Copper Conductor. Copper cable conductors shall be of a diameter not less than No. 4 AWG (41740 CMA) for the main down conductor, not less than No. 6 AWG (26240 CMA) for two parallel paths, or No. 8 AWG (16510 CMA) for more than two paths, such as those to shrouds and stay connections on sailboats. The size of any single strand in a copper conductor shall not be less than No. 17 AWG (2048 CMA). The thickness of any copper ribbon or strip shall not be less than No. 20 AWG (1022 CMA). Where other materials are used, the gauge shall be such that it provides conductivity equal to or greater than the required conductor size.

9-3.4 Joints. Joints shall be mechanically strong and shall be made so that they shall not have an electrical resistance in excess of that of 2 ft (0.6 m) of conductor.

9-4 Exterior Grounding Plate or Grounding Strip.

9-4.1 Vessels with Metal Hulls. If an electrical connection exists between metallic hulls and a lightning protection mast or other metallic superstructure of adequate height to provide the zone of protection required in Section 9-2, no further protection against lightning shall be required; however, surge suppression in accordance with 9-5.5 shall be provided. Nonconducting objects projecting above metal masts or superstructures shall have such objects grounded with a grounding conductor connected to the grounded hull or superstructure.

9-4.2 External Ground Plate. An exterior grounding plate of copper, copper alloys, stainless steel, or aluminum shall be permitted to be provided by a strip having an area of at least 1 ft^2 (0.09 m^2) that shall be located, as closely as possible, directly below the lightning protection mast. The connection to the ground plate shall be a fastener having a conductivity equivalent to No. 4 AWG (41740 CMA) copper conductor. The boat's propellers, shaft, metallic rudders, and other metallic surfaces that meet the required 1-ft^2 (0.09-m^2) area shall be permitted to be used effectively only on small boats where the lightning protection mast is located at the stern above the in-water metallic objects used as the lightning system ground. The stern mast shall be tall enough to provide a zone of protection that extends to the bow of the boat.

9-4.2.1 Boats that use a lightning grounding plate instead of a lightning grounding strip shall ground backstays or other objects aft to the engine negative terminal using a metallic rudder or other external ground at the aft end of the boat. The lightning ground shall not be routed through the boat to the lightning grounding plate forward under the lightning mast.

9-4.3 Grounding Strip. An external grounding strip of copper, copper alloys, stainless steel, or aluminum installed under the boat in a fore and aft direction shall be permitted to be used as the earth ground connection for the lightning system. The strip shall have a minimum thickness of $\frac{3}{16}$ in. (4.8 mm) and a minimum width of $\frac{3}{4}$ in. (19 mm). The length of the strip shall be permitted to extend from a point located directly below the lightning protection mast to the aft end of the boat, where a direct connection can be made to the vessel's engine, but the total length of the strip shall not be less than 4 ft (1.2 m). In a sailing vessel, the backstay and engine shall be connected to the aft end of the strip. The strip shall be secured to the hull with one, or preferably two, galvanically compatible through-bolts at each end. The bolts shall have a minimum conductivity equivalent to No. 4 AWG (41740 CMA) copper conductor. The use of these bolts at each end, spaced 1 in. to 2 in. (2.5 cm to 5 cm) apart, helps to prevent any tendency of the strip to rotate when the electrical connections are made inside the hull. The strip shall be located so that it is submerged under all operating conditions. If the strip is not located so as to be submerged when a sailboat is heeled to port or starboard, then a strip shall be

required on both the port and starboard sides. All connections to the strip shall be as short and direct as possible. Additional through-hull bolts shall be permitted to be located along the length of the strip for additional connections, such as those on a two-mast sailboat. Because of the possibility of stray current corrosion of the securing bolts, the number of through-hull bolts shall be kept to a minimum. To minimize through-hull bolt connections, an equalization bus shall be permitted to be installed in accordance with Section 9-5.

Exception: Stainless steel grounding strips shall have a minimum thickness of 1/8 in. (3.2 mm).

9-4.3.1 The aft end of the lightning grounding strip shall be connected directly to the engine negative ground terminal to provide a path inside the hull for any DC stray currents that are imposed on the through-hull bolts from the lightning grounding strip where those bolts contact bilge water.

9-5 Interconnection of Metallic Masses.

9-5.1 Equalization Bus. On larger vessels where several connections are made to the lightning grounding strip, an equalization bus shall be permitted to be installed inside the boat to minimize the number of through-hull bolts necessary. The equalization bus, if used, shall be installed inside the boat parallel to the underwater lightning grounding strip. Permanently installed large metallic masses inside the boat shall be connected directly to the equalization bus. The equalization bus shall be connected to the underwater lightning grounding strip at both ends.

9-5.2 Seacocks and Through-Hull Fittings. Seacocks and through-hull fittings, if connected to the lightning grounding system, shall not be connected to the main down conductor but shall be permitted to be connected to the underwater grounding strip, the lightning ground plate, or the equalization bus.

9-5.3 Metal masses, such as engines, generators, metallic tanks, steering systems inside the boat, and other items such as metal life rails, that come within 6 ft (1.8 m) of the lightning conductor at any point shall be connected to the lightning grounding underwater strip or ground plate or to the equalization bus as directly as possible.

9-5.4 To minimize the flow of lightning discharge currents through engine bearings, it shall be permissible to ground the engine block directly to the lightning grounding plate or lightning grounding strip rather than to an intermediate point in the lightning protection system.

9-5.5 Protection of Equipment. Wherever possible, electronic equipment shall be enclosed in metal cabinets that are connected to the lightning grounding system with minimum No. 8 AWG (16510 CMA) conductor. Surge suppression devices shall be installed on all wiring entering or leaving electronic equipment.

9-6 Protection of Nonmetallic Sailboats.

9-6.1 Sailboats. Sailboats without inboard engines that are equipped with metallic masts and metallic rigging shall be considered to be protected adequately if the mast and the rigging are connected to a lightning grounding plate or lightning grounding strip located directly below the mast.

9-6.2 Open Day-Sailers. Because the stainless steel rigging and preventors usually are not equivalent to No. 8 AWG (16510 CMA) conductor, adequate protection depends on the grounding of the rigging as well as the metal masts or the continuous metallic tracks on nonmetallic masts. These shall be connected at the lower ends to a lightning grounding plate or a lightning strip located directly below the mast. Metallic rudders at the aft end of the boat shall not be used as the lightning ground for the mast because of the need for a long, horizontal conductor to be run to the aft end of the boat. The tiller or other connections to metallic rudders with which the operator will come into contact shall be of nonconductive materials. Metallic keels or centerboards shall be connected directly to the lightning grounding plate or strip or shall be permitted to serve as the lightning grounding means if they provide the 1-ft^2 (0.09-m^2) area required for contact with the water. If a centerboard is used as the lightning grounding means, a warning sign shall be provided that clearly states that the centerboard shall be in the down position in order to function as a lightning ground.

9-6.3 Cruising Sailboats. All shrouds, stays, sail tracks, and metallic masts shall be connected to the lightning grounding system, since it is assumed that occupants of the boat will be in proximity of forestays, backstays, and shrouds during the normal operation of the boat. Grounding of all metallic masses on the boat shall be in accordance with all applicable sections of this standard.

Chapter 10 Fire Protection Equipment

10-1 General Requirements. Portable fire extinguishers shall meet the requirements of and be inspected and maintained in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*, and shall be U.S. Coast Guard-approved or UL Marine-listed.

10-2 Equipment.

10-2.1* All boats shall be equipped with portable fire extinguishers at least to the extent of the minimum requirements of Tables 10-2.1(a) and (b) and the requirements of this section.

Exception No. 1: CO_2 and Halon 1211 extinguishers having USCG Type B-I classification shall be permitted to be used.

Exception No. 2: CO_2 and Halon 1211 extinguishers having USCG Type B-I or Type B-II classification shall be permitted to be used.

10-2.1.1 All required fire extinguishers located in accommodation spaces shall have Class A capability. All extinguishers shall be located adjacent to exit paths. It shall not be necessary to travel more than half the length of the boat or 33 ft (10 m), whichever is less, to reach an extinguisher.

10-2.1.2 At least one extinguisher shall be located at each occupied level.

Table 10-2.1(a) Number and Distribution of Fire Extinguishers [Boats up to but not including 65 ft in (19.7 m) length]

Type of Boat	No. of Existing	Minimum ANSI/UL Rating (See Notes 2 and 3)	Minimum USCG Rating (See Note 1)	Location
Open boats under 16 ft (4.8 m) with fiberglass or metal hulls and a light load of flammable Class A materials	1	5 B:C	B-1	Steering position
Open boats under 16 ft (4.8 m)	1	1A: 10B:C	B-1	Steering position
Boats 16 ft (4.8 m) to, but not including, 26 ft (8 m)	2	1A: 10B:C	B-1	Steering position and galley, when onboard, or cockpit
Open boats 16 ft (4.8 m) to, but not including, 26 ft (8 m)	2	1A: 10B:C	B-1	Steering position and galley or cockpit
Boats 26 ft (8 m) to, but not including, 40 ft (12 m)	3	1A: 10B:C	B-1	Outside engine compartment, steering position, and near galley or passenger cockpit
Boats 40 ft (12 m) to, but not including, 65 ft (20 m)	4	1A: 10B:C	B-1	Outside engine compartment, steering position, crew quarters, and galley, when onboard, or cockpit

NOTE 1: If a discharge port is installed, a USCG Type B-1 portable fire extinguisher might not be adequate. [See Table 10-2.1(a).]
NOTE 2: Extinguishers intended for machinery space protection are not required to have a Class A rating.
NOTE 3: Boats under 26 ft (8 m) in length without enclosed accommodation spaces or enclosed galleys shall be permitted to be equipped with a bucket with attached lanyard in lieu of Class A rated portable fire extinguishers.

Table 10-2.1(b) Number and Distribution of Fire Extinguishers [Boats equal to and greater than 65 ft (19.7 m) in length]

Gross Tonnage	No. of Extinguishers	Minimum ANSI/UL Rating	Minimum USCG Class.	Location
Under 50	1 (*See Note 1*)	4A: 60B:C	B-II	Outside engine compartment
	1 (*See Note 2*)	4A: 60B:C	B-II	Helmsman's position
	3 (*See Note 2*)	1A: 10B:C	B-I	Galley, crew quarters, and cabin
50 to less than 100	1 (*See Note 1*)	4A: 60B:C	B-II	Outside engine compartment
	2 (*See Note 2*)	4A: 60B:C	B-II	Helmsman's position and galley
	2 (*See Note 2*)	1A: 10B:C	B-I	Crew quarters and cabin
100 to less than 300	1 (*See Note 1*)	4A: 60B:C	B-II	Outside engine compartment
	3 (*See Note 2*)	4A: 60B:C	B-II	Helmsman's position galley and crew quarters
	1 (*See Note 2*)	1A: 10B:C	B-I	Cabin

NOTE 1: If the total horsepower exceeds 1000 bhp, an additional Type B-II portable fire extinguisher is required for each additional 1000 bhp or fraction thereof.
NOTE 2: The required Type B-I or Type B-II portable fire extinguisher shall be permitted to be distributed among the recommended locations as desired.

10-2.2* All inboard-powered boats with an enclosed engine compartment shall have provisions for discharging extinguishing agent directly into the space immediately surrounding the engine without opening the primary access. Where portable equipment is provided for use, a small, suitably labeled, readily accessible port to the enclosure shall be provided that shall permit the extinguisher to remain upright during discharge.

Exception: If the access port cannot be positioned so as to allow the portable extinguisher to remain upright, the portable extinguisher shall be equipped with a discharge hose.

10-2.2.1 Where portable equipment is provided for use, size shall be as specified in Table 10-2.2.1.

10-2.2.2 If an extinguisher is portable and readily removable from its fixed mounting, it shall be permitted to be credited as one of the extinguishers required in Tables 10-2.1(a) and (b).

Table 10-2.2.1 Minimum Gaseous Portable Extinguisher Sizes for Flooding an Engine Compartment

Agent	Minimum Extinguisher Size	Maximum Compartment Volume
CO_2	5 lb (2.3 kg)	66 ft^3 (1.9 m^3)
CO_2	10 lb (4.5 kg)	133 ft^3 (3.8 m^3)
CO_2	15 lb (6.8 kg)	200 ft^3 (5.7 m^3)
CO_2	20 lb (9.1 kg)	266 ft^3 (7.5 m^3)
Halon	2½ lb (1.1 kg)	108 ft^3 (3.1 m^3)
Halon	3 lb (1.4 kg)	130 ft^3 (3.7 m^3)
Halon	4 lb (1.8 kg)	174 ft^3 (5.0 m^3)
Halon	5 lb (2.3 kg)	217 ft^3 (6.2 m^3)
Halon	9 lb (4.1 kg)	391 ft^3 (11.1 m^3)
Halon	13 lb (5.9 kg)	565 ft^3 (16.0 m^3)

For SI units: 1 lb = 454 gm; 1 ft^3 = 0.028 m^3

NOTE 1: Table 10-2.2.1 represents extinguishers containing concentrations of 45 percent CO_2 at 70°F (21°C) based on 0.075 lb agent /ft^3 (1.2 kg/m^3) or 5 percent halon at 70°F (21°C) based on 0.023 lb agent/ft^3 (0.37 kg/m^3).
NOTE 2: Halon means Halon 1211, Halon 1301, or a mixture thereof.

10-2.3* Fixed Systems.

10-2.3.1 Systems shall be permitted to be manually or automatically operated, or both. Carbon dioxide systems that are installed to protect accommodation compartments or to protect engine compartments that normally can be occupied shall be equipped with a predischarge alarm.

10-2.3.2 If spaces are connected, such spaces shall be considered as a single space when determining the capacity of the system. In determining the extent of connecting spaces, the requirements of Section 9-5 shall be used. The actuation of the system shall be such that all the connecting spaces are flooded. If multiple units are used to provide the required capacity, they shall discharge simultaneously.

10-2.3.3* If a manual or manual/automatic fixed system is installed, the system shall be installed and maintained in accordance with the manufacturer's instructions and NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*, NFPA 12B, *Standard on Halon 1211 Fire Extinguishing Systems*, or NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, as appropriate, and shall be U.S. Coast Guard-approved or UL Marine-listed. The system shall incorporate a visible or audible means outside of the protected space to indicate that the system has discharged.

10-3 Installation.

10-3.1 Portable fire extinguishers shall be located to be readily accessible from outside the compartment that they are intended to serve. Extinguishers shall be secured with a marine bracket to permit immediate release.

10-3.2* Fixed extinguishing systems shall be installed in accordance with the manufacturer's installation procedures and with NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*, NFPA 12B, *Standard on Halon 1211 Fire Extinguishing Systems*, or NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, as appropriate.

10-3.2.1 Extinguishing agent cylinders shall be mounted a minimum of 2 in. (5 cm) above moist or wet surfaces to reduce the danger of corrosion.

10-3.2.2* Manual controls shall be located to be readily accessible from outside the spaces served by the systems.

10-3.2.3 Systems shall be designed for one of the following modes of application (*see 10-2.3.2*):

(a) An independent system installed to cover one of various unconnected protected spaces;

(b) A single system of sufficient capacity to flood all protected spaces simultaneously; or

(c) A single system of sufficient capacity for the largest protected space, distributed to the selected space by valves at the controls.

Chapter 11 Referenced Publications

11-1 The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

11-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 10, *Standard for Portable Fire Extinguishers*, 1994 edition.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, 1993 edition.

NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*, 1992 edition.

NFPA 12B, *Standard on Halon 1211 Fire Extinguishing Systems*, 1990 edition.

NFPA 52, *Standard for Compressed Natural Gas (CNG) Vehicular Fuel Systems*, 1992 edition.

NFPA 70, *National Electrical Code*, 1993 edition.

NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*, 1990 edition.

NFPA 303, *Fire Protection Standard for Marinas and Boatyards*, 1990 edition.

NFPA 701, *Standard Methods of Fire Tests for Flame-Resistant Textiles and Films*, 1989 edition.

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, 1994 edition.

11-1.2 Other Publications.

11-1.2.1 AMCA Publication. Air Movement and Control Association, 30 W. University Drive, Arlington Heights, IL 60004-1893.

AMCA/ANSI 210-85, *Laboratory Methods of Testing Fans for Rating.*

11-1.2.2 ANSI Publications. American National Standards Institute, 11 West 42nd Street, New York, NY 10036.

ANSI Z21.57-90, *Recreational Vehicle Cooking Gas Appliances.*

ANSI/NEMA WD-6-88, *Wiring Devices — Dimensional Requirements.*

11-1.2.3 ASTM Publications. American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM A90M-93, *Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.*

ASTM A463-88, *Standard Specification for Steel Sheet, Cold-, Rolled, Aluminum-Coated, Type 1 and Type 2.*

ASTM B122M-A-92, *Standard Specification for Copper-Nickel-Tin Alloy, Copper-Nickel-Zinc Alloy (Nickel Silver), and Copper-Nickel Alloy Plate Sheet, Strip, and Rolled Bar.*

ASTM B127-93, *Standard Specification for Nickel-Copper Allow Plate, Sheet, and Strip.*

ASTM D471-79, *Standard Test Method for Rubber Property, Effect of Liquids.*

11-1.2.4 NEMA Publication. National Electrical Manufacturers Association, 2101 L Street, NW, Suite 300, Washington, DC 20037.

NEMA 250, *Enclosures for Electrical Equipment (1000 V Maximum)*, 1991 edition.

11-1.2.5 SAE Publications. Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.

SAE J1127-88, *Standard for Battery Cable.*

SAE J1128-88, *Standard for Low Tension Primary Cable.*

SAE J2031-90, *Standard for High Tension Ignition Cable.*