ANSI/NFPA 302 An American National Standard February 6, 1989

NFPA 302 Pleasure and Commercial Motor Craft 1989 Edition

National Fire Protection Association Batterymarch Park, Quincy, MA 02269

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, Batterymarch Park, Quincy, MA 02269.

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 which 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.

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 accepts 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.

NFPA 302

Fire Protection Standard for

Pleasure and Commercial Motor Craft

1989 Edition

This edition of NFPA 302, *Fire Protection Standard for Pleasure and Commercial Motor Craft*, was prepared by the Technical Committee on Motor Craft, released by the Correlating Committee on Marine Fire Protection, and acted on by the National Fire Protection Association, Inc. at its Fall Meeting held November 14-17, 1988 in Nashville, Tennessee. It was issued by the Standards Council on January 13, 1989 with an effective date of February 6, 1989, and supersedes all previous editions.

The 1989 edition of this document has been approved by the American National Standards Institute.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

Origin and Development of NFPA 302

This Fire Protection Standard for Motor Craft represents the cumulative result of 63 years of attention to fire safety of power boats by the NFPA. The first edition of this standard was adopted by the Association in 1925. Amended in 1926 and 1930, a revised edition was adopted in 1936. Fifteen successive editions were adopted between 1939 and 1980. The present text consists of amendments to the 1984 edition.

Committee on Marine Fire Protection

Correlating Committee

Robert Loeser, *Chairman*
Underwriters Laboratories Inc.

Richard A. Comstock, Fire Prev. & Engr. Bureau of Texas
Joseph J. Cox, American Inst. of Merchant Shipping
Bolling F. Douglas, Marine Associates Inc.
Warren E. Jackson, Glastonbury, CT

Technical Committee on Motor Craft

Bolling F. Douglas, *Chairman*
Marine Associates Inc.

David Beach, National Marine Mfrs. Assn.
Ernest F. Braatz, Boat Owners Assn. of the US
Russell Chiasson, Russell Chiasson & Assoc. Ltd.
David Cole, Mansfield, OH
Rep. US Power Squadrons
Desmond Connolly, Natl Assn. of Marine Surveyors Inc.
Bruce F. Dining, C. M. Dining Inc.
Rep. NLPGA
David J. Duea, San Diego Fire Equipment Co. Inc.
Rep. NAFED
Brent S. Ehmke, The Ansul Co.
Charles B. Ford, Fire Suppression Sys. Assoc.
E. Charles Game, Hatteras Yachts
Paul O. Huston, Amerex Corp.
Rep. FEMA
Warren E. Jackson, Glastonbury, CT
Ralph E. Lambrecht, Lake Bluff, IL
John A. Langley, Outboard Marine Corp.
Rep. SAEI
Robert Loeser, Underwriters Laboratories Inc.
Kim I. MacCartney, CIGNA Loss Control Services
Ned K. Momany, Harbor Inc/DGA Winner Boats

Alternates

James H. Davis, ICI Americas Inc.
(Alternate to P. O. Huston)
Hal M. Faulconer, Natl LP-Gas Assn.
(Alternate to B. F. Dining)
Jeffrey Hall, Underwriters Laboratories Inc.
(Alternate to R. Loeser)
Donald J. Kerlin, Dept. of Transportation, US Coast Guard
(Alternate to US Coast Guard)
G. James Lippmann, American Boat & Yacht Council Inc.
(Alternate to R. Lambrecht)
Richard P. Schwartz, Boat Owners Assn. of the US
(Alternate to E. F. Braatz)

NFPA Staff Liaison: **Guy Colonna**

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.

Contents

NFPA 302

Fire Protection Standard for

Pleasure and Commercial Motor Craft

1989 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 10 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 the elimination of possible sources of vapor ignition, the provision of adequate ventilation of vital areas, the avoidance of unnecessary use of combustible materials in exposed locations, and the provision of proper fire extinguishing equipment and fire exits.

1-1.2 This standard shall apply to boats of less than 300 gross tons (849 m^3) used for pleasure and commercial purposes.

1-1.3 No requirement of this standard shall be construed as reducing applicable regulations of the United States Coast Guard.

1-2 Purpose. 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. This standard is directed towards making motor craft as free from the hazards of fire as practicable.

The provisions of this document are considered necessary to provide a reasonable level of protection from loss of life and property from fire and explosion. They reflect situations and the state-of-the-art at the time the standard was issued.

Unless otherwise noted, it is not intended that the provisions of this document be applied to facilities, equipment, structures, or installations that were existing or approved for construction or installation prior to the effective date of the document, 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. Where strict compliance with specific requirements of this standard is impractical, alternative means shall be deemed in compliance if it can be shown that equivalent protection is provided.

1-4 Definitions. For the purposes of this standard, the following terms will have the meanings listed below.

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

Accommodation Spaces. Spaces designed for living purposes for persons aboard a boat.

Approved. Acceptable to the "authority having jurisdiction."

NOTE: The National Fire Protection Association does not approve, inspect or certify any installations, procedures, equipment, or materials nor does it approve or evaluate testing laboratories. In determining the acceptability of installations or procedures, equipment or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization concerned with product evaluations which is in a position to determine compliance with appropriate standards for the current production of listed items.

Bonding Conductor. A normally non-current-carrying conductor used to connect normally non-current carrying metal parts of a boat and normally non-current carrying metal parts of direct current devices on the boat to the ground.

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

Engine Exhaust System. The means by which products of combustion are conducted from the engine exhaust manifold to an outboard terminus. It includes related accessories which may be metallic or nonmetallic, such as pipe, 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.

Galvanically Compatible.* Metals which are close to each other in the galvanic series.

Ground. The electrical potential of the earth's surface as established by an electrically conductive connection (intentional or accidental) with the earth, including any conductive part of the wetted surface of the hull.

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

Grounding Conductor. A normally non-current-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 design operating conditions:

(a) It will not ignite a flammable hydrocarbon mixture

surrounding the device when an ignition source causes an internal explosion, or

(b) It is incapable of releasing sufficient electrical or thermal energy to ignite a hydrocarbon mixture, or

(c) The source of ignition is hermetically sealed.

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.

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.

NOTE: The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The "authority having jurisdiction" should utilize the system employed by the listing organization to identify a listed product.

Machinery Space. Any space containing an internal combustion engine.

Open to the Atmosphere. A space or compartment that has at least 15 sq in. (9.68×10^{-3} m^2) of net open area directly exposed to the atmosphere for each cubic foot of net compartment volume.

Permanently Installed. Securely fastened in place and not intended for ready removal.

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

Shall. Indicates a mandatory requirement.

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

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

Chapter 2 Hull

2-1 Arrangement.

2-1.1 The hull shall be arranged so that all compartments are accessible and all escape hatches are unobstructed, readily accessible, and adequate for their designed purposes. Egress to permit escape from accommodation spaces shall be provided that will not be blocked by a fire in the engine room or galley.

2-1.2* Engine compartments shall be separated from accommodation spaces by bulkheads or barriers designed to serve as fire barriers and capable of minimizing the escape of fire extinguishing materials discharged into the engine compartment.

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 which will not permit more than 0.25 oz ($.74 \times 10^{-5}$ m^3) of leakage per hour when the liquid in the bilge is at a height of 12 in. (.305 m) or ⅓ the maximum height of the bulkhead, whichever is less. Above 12 in. (.305 m) or ⅓ the maximum height, the bulkhead may have openings for the passage of conductors, piping, ventilation ducts, mechanical equipment, doors, hatches and access panels providing the maximum annular space around each item is not more than ¼ in. (.006 m).

Exception: Boats using diesel fuel only.

2-1.4 Machinery spaces shall be readily accessible.

2-1.5 The galley or the area used for galley purposes shall be provided with adequate ventilation.

2-1.6 Materials used for thermal and/or acoustical insulation in any compartment or enclosure containing an internal combustion engine or heater shall have a flame spread of 75 or less. Material shall be labeled or certified as having been tested to NFPA 255, *Method of Test of Surface Burning Characteristics of Building Materials.*

2-1.7 Materials used for thermal and/or acoustical insulation shall be resistant to degradation in the presence of hydrocarbon vapors.

2-1.8 Materials used for thermal and/or acoustical insulation shall be designed and installed such that hydrocarbon vapors cannot accumulate within the material thereby reducing its flame spread rate.

2-2* Ventilation.

2-2.1 Powered Ventilation. Each compartment, not open to the atmosphere, that has a permanently installed gasoline or compressed gas fuel engine with a cranking motor must be ventilated by an exhaust blower system.

2-2.2* Natural Ventilation. Each compartment, not open to the atmosphere, must be provided with a natural ventilation system, if it:

(a) Contains a permanently installed gasoline or compressed gas fuel 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 (.023 m^3) portable fuel tank but is not intended for such usage shall be labeled to prohibit its use for fuel storage.

(c) Contains fuel tank compartments containing non-ignition protected components.

2-2.3 Spaces Open to the Atmosphere.

2-2.3.1 Spaces which are open to the atmosphere do not require ventilation.

2-2.3.2 Compartments or spaces connecting with engine or portable fuel tank spaces that are open to the atmosphere do not require ventilation if the connecting space has open area of at least 15 sq in. per cu ft (.34 m^2/m^3) of its net volume. The open area shall be open either to the atmosphere or into another open space providing there is a total area open to the atmosphere for the combined net volumes of the connecting spaces of at least 15 sq in. per cu ft (.34 m^2/m^3).

2-2.3.3 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.

2-2.4 Connecting Compartments or Spaces.

2-2.4.1 Compartments communicating with compartments open to the atmosphere, which have interconnecting openings the area of which is equal to 2 percent or less of the area between the compartments, shall not be considered as connecting compartments.

2-2.4.2 The volume of compartments or spaces that are not open to the atmosphere, and which communicate with a compartment requiring ventilation by means of interconnecting openings whose aggregate area is more than 2 percent of the area between the compartments, must be added to the volume of the compartment or space requiring ventilation when determining ventilation requirements, or must be ventilated separately.

2-2.4.3 An accommodation compartment above a compartment requiring ventilation that is separated from the compartment requiring ventilation by a deck or other enclosure is not considered a connecting compartment.

2-2.5 Powered Ventilation System.

2-2.5.1 Blowers.

2-2.5.1.1 Blowers shall be rated for continuous operation at 120 percent of nominal voltage.

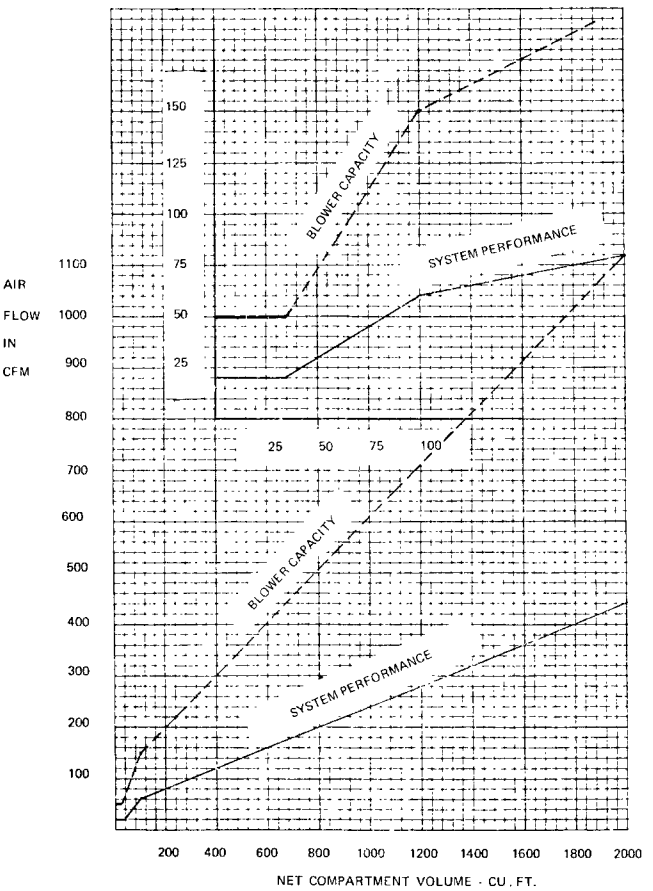
2-2.5.1.2 As installed, no surface temperature shall exceed 150 °C (302 °F) when operating, and with a stalled rotor, at 120 percent of nominal voltage in an ambient temperature of 60 °C (140 °F) for a period of seven hours.

2-2.5.1.3 Blowers shall meet the external ignition protection requirements of UL 1128, Standard for Marine Blowers; UL 1500, Ignition Protection Test for Marine Products; SAE J1171, External Ignition Protection of Marine Electrical Devices; or equivalent standard.

2-2.5.1.4 Blowers shall be rated for air flow in cubic feet per minute, at nominal voltage in accordance with Figure 12 of Air Movement and Control Association (AMCA) Standard 210-74, Test Code of Air Moving Devices, or Underwriters Laboratories UL 1128, Standard for Marine Blowers, or equivalent standard.

2-2.5.2 Installation of Powered Ventilation.

2-2.5.2.1 Blower(s) capacity shall be selected in accordance with the "blower capacity curve" in Figure 2-2.5.2.1. More than one blower may be used.



For SI Units: CFM = 4.719×10^{-4} m^3/s; cu ft = 2.832×10^{-2} m^3

Figure 2-2.5.2.1 Minimum Blower Capacity and System Performance.

NOTE: The blower capacity curve is added for information purposes and represents the average relationship of capacity to performance.

2-2.5.2.2 As installed, the blower system(s) shall exhaust air from the boat at a rate in accordance with the "system performance curve" in Figure 2-2.5.2.1 when the engine is not operating and the blower is operating at the electrical system's nominal voltage.

2-2.5.2.3 Blowers shall be mounted above the normal level of accumulated bilge water.

Exception: Submersible blower motors.

2-2.5.2.4 Blowers shall be installed with ducts whose intake openings are:

(a) Permanently fixed,

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

(c) Above the normal level of accumulated bilge water, and

(d) As nearly as practicable below the engine(s) which it serves.

2-2.5.2.5 Electrical wiring shall be installed in accordance with Chapter 7 or 8.

2-2.5.2.6 Each boat that requires a powered ventilation system shall have a label displaying the information contained below, located in plain view of the operator and as close as practicable to each ignition switch (includes auxiliary equipment).

Powered Ventilation Label

WARNING

Gasoline Vapors Can Explode

Before Starting Engine:

— Check Engine Compartment for Gasoline or Vapors

— Operate Blower for 4 Minutes

— Run Blower When Below Cruising Speed

2-2.6 Natural Ventilation.

2-2.6.1 Each natural ventilation system shall be constructed with at least one intake opening. Each intake opening shall be on the boat's exterior surface.

2-2.6.2* Each compartment requiring natural ventilation shall be equipped with an exhaust duct(s) originating in the lower one-third of the compartment, the duct opening permanently fixed above the normal accumulation of bilge water. If the compartment is an engine compartment, exhaust duct(s) shall be located as nearly as practicable below the engine(s).

2-2.6.3 Each exhaust duct shall be fitted with a cowl or the equivalent, facing aft.

2-2.6.4 Air intake openings inside a compartment shall be separated from exhaust duct openings inside the compartment by at least 24 in. (.61 m), compartment dimensions permitting.

2-2.6.5 The minimum aggregate internal cross-sectional area of intake ducts or openings shall be calculated as follows:

$$A = 5 \log_e (V/5)$$

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 compartment sharing the same ventilation system.

Log_e (V/5) = The natural logarithm of the quantity V/5. (*See Figure 2-2.6.5.*)

2-2.6.6 The minimum aggregate internal cross-sectional area of exhaust ducts or openings shall be calculated in the same manner as for intakes. (*See 2-2.6.5.*)

2-2.6.7 Duct sizes may be selected using cross-sectional areas based on their nominal diameters.

2-2.6.8 The nominal diameter of ventilation ducting shall be at least 2½ in. (.064 m). Openings shall be of at least equivalent cross-sectional area. See Table 2-2.6.8 for standard duct sizes.

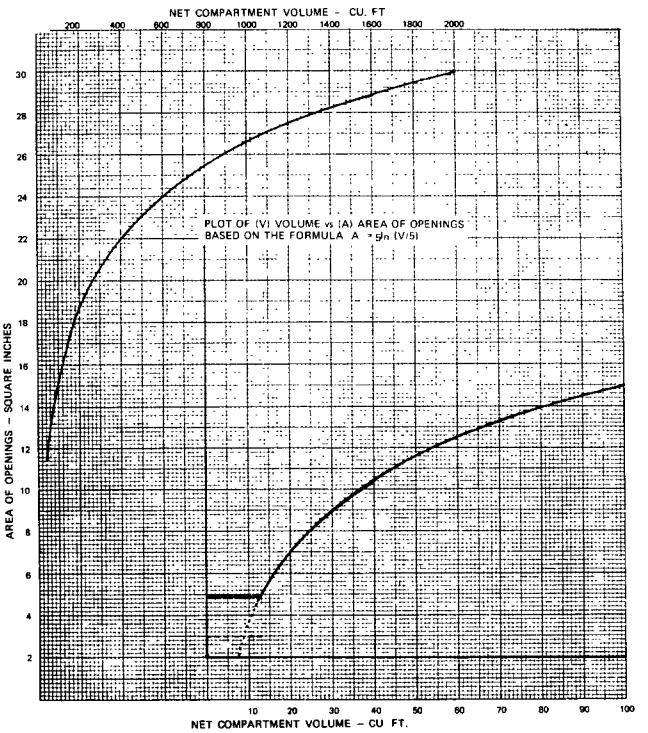


Figure 2-2.6.5 Area of Openings.

For SI Units: 1 sq. in. = 6.45×10^{-4} m²; 1 cu ft = 2.832×10^{-2} m³

Table 2-2.6.8 Standard Duct Sizes

4.91 sq in.	(2½ in. diam.)
7.07 sq in.	(3 in. diam.)
9.62 sq in.	(3½ in. diam.)
12.57 sq in.	(4 in. diam.)
19.63 sq in.	(5 in. diam.)

For SI Units: 1 sq. in. = 6.4×10^{-4} m²;
1 in. = 2.54×10^{-2} m.

2-2.6.9 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.

2-2.7 Arrangements of Openings.

2-2.7.1 Ventilation openings shall be located to prevent entrance of significant amounts of water considering maximum conditions of heel or trim, reverse operation, eccentric loading or wave action.

2-2.7.2 External openings of intakes and exhausts shall be located to minimize re-entry of exhausted fumes.

2-2.7.3 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 m) from the gasoline fill and vent fittings.

2-2.7.4 Ventilation openings shall remain outside of weather enclosures.

2-3* Lightning Protection.

2-3.1 General Principles.

2-3.1.1 A lightning protection system offers no protection when the boat is out of water and is not intended to afford protection if any part of the boat comes in contact with power lines while afloat or ashore. Successful protection of persons and watercraft from lightning is dependent upon a combination of proper design and maintenance of equipment, and behavior of personnel. If a lightning protection system is installed, proper design is covered in this and following sections. Maintenance of equipment and personal behavior is covered in Appendix C. In view of the wide variation in structural design of boats, specific recommendations cannot be made for all cases. However, the basic guides contained in this section shall be considered and used in designing and installing a lightning protection system for any given craft.

2-3.1.2 A grounded conductor, or lightning protective mast, will generally divert to itself direct hits which might otherwise fall within a cone-shaped space, the apex of which is the top of the conductor or lightning protective mast and the base is a circle at the surface of the water having a radius which is related to the height. For a mast height not exceeding 50 ft (15 m) above the water, this radius is approximately equal to the mast height (*see Figures 2-3.1.1 and 2-3.1.2*).

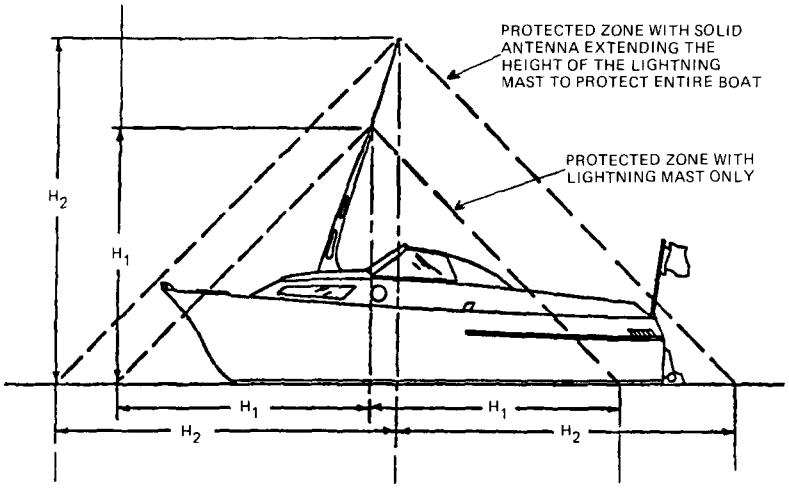


Figure 2-3.1.1 Diagram of Boat with Mast Not Exceeding 50 ft (15 m) Above the Water.

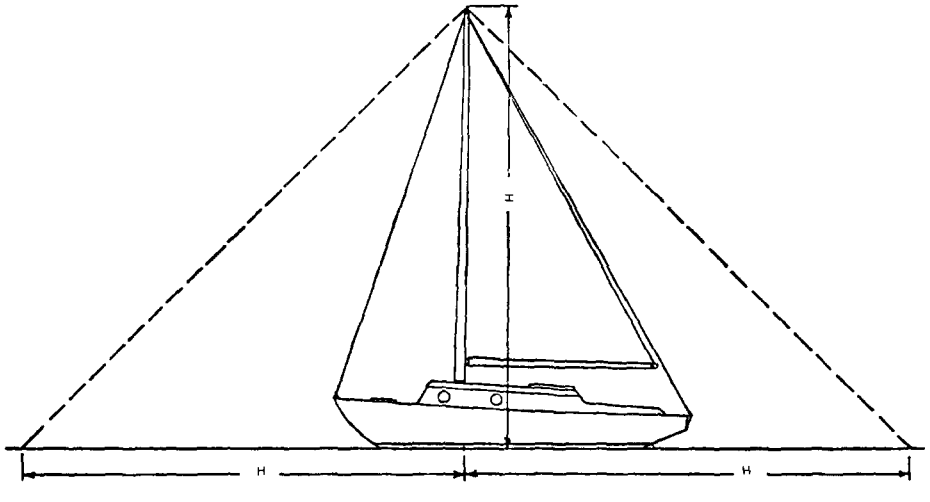


Figure 2-3.1.2 Diagram of Small Sailboat with Mast Not in Excess of 50 ft (15 m).

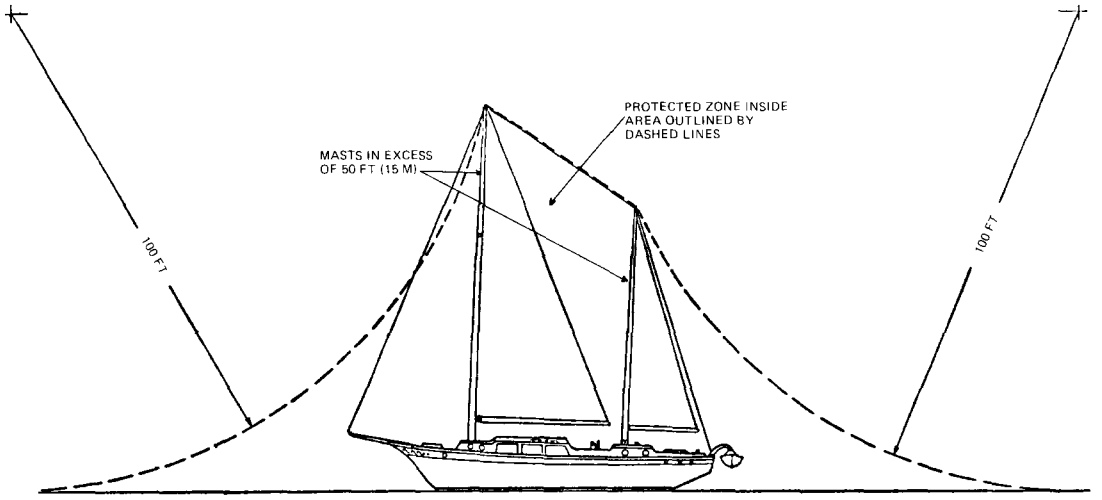


Figure 2-3.1.3 Diagram of Boat with Masts in Excess of 50 ft (15 m) Above the Water — Protection Based on Lightning Striking Distance of 100 ft (30 m).

2-3.1.3 For mast heights in excess of 50 ft (15 m), the zone of protection is based on the striking distance of the lightning stroke. Since the lightning stroke may strike any object within the striking distance of the point from which final breakdown to ground occurs, the zone of protection is defined by a circular arc concave upward (*see Figure 2-3.1.3*). 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.

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, the zone based on a striking distance of 100 ft (30 m) is considered to be adequately protected.

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

2-3.1.4 To provide an adequately grounded conductor or lightning protective mast, the entire circuit from the top of the mast to the ground shall have a conductivity not less than that of a No. 8 AWG copper conductor and the path to ground followed by the conductor shall be essentially straight. To remove all known risk of melting the conductor when carrying lightning current, conductivity equivalent to No. 6 AWG or No. 4 AWG copper would be necessary. However, the risk in using No. 8 AWG is considered adequately small in the applications under consideration, and in many cases will be mitigated by the presence of electrically paralleling stays. This statement shall not be interpreted to permit the use of conductors of conductivity less than that of No. 8 AWG copper.

2-3.1.5 If there are metal objects of considerable size within a few feet of the grounding conductor, there will be a strong tendency for sparks or sideflashes to jump from the grounding conductor to the metal object at the closest point. To prevent damage from such sideflashes, an interconnecting conductor at least equal to No. 8 AWG copper shall be provided at all places where they are likely to occur. Large metallic objects which are not part of the electrical system of the boat and which are not already grounded due to their own functional or other requirements may be grounded directly to the ground plate, provided that it is not practical to interconnect with the lightning conductor or bonding systems (*see 2-3.4*).

2-3.1.6 Lightning protection provisions are quite likely to receive scant attention after installation and therefore their composition and assembly shall be strong and materials used shall be highly resistant to corrosion.

2-3.2 Installation Recommendations.

2-3.2.1 Lightning Protective Mast. A lightning protective mast shall be of adequate height and shall be mechanically strong in order to withstand exposure to use and weather (*see 2-3.1.2, 2-3.1.3 and 2-3.1.4*). If the mast is of non-conducting material, the associated lightning grounding conductor shall: (a) be essentially straight; (b) be securely fastened to the mast; (c) extend at least 6 in. (150 mm) above the mast; (d) preferably terminate in a receiving point; (e) be led directly as practicable to the grounding connection (*see 2-3.5*); and (f) meet the requirements of 2-3.3.

2-3.2.2 Radio Antenna and Outrigger. A radio antenna or outrigger may serve as a lightning protective mast provided it has conductivity equivalent to No. 8 AWG copper and is equipped with lightning arresters, lightning protective gaps, or means for grounding during electrical storms. The grounding of metal rod type radio antennas constitutes sufficient protection for boats, without masts and spars, provided the following conditions are met:

2-3.2.2.1 The antenna and all conductors in the grounding circuit of the antenna have a conductivity equivalent to No. 8 AWG copper in accordance with 2-3.3.3.

2-3.2.2.2 The top of the antenna is not more than 50 ft (15 m) above the water, and a line drawn from the top of the antenna downward toward the water at an angle of 45 degrees to the vertical does not intercept any part of the boat (*see 2-3.1.2*).

2-3.2.2.3 The antenna loading coil is provided with a suitable protective device for bypassing the lightning current.

2-3.2.3 Nonconducting antenna masts with spirally wrapped conductors are not considered suitable for lightning protection purposes.

2-3.3 Materials.

2-3.3.1 The materials used in the making of a protective system shall be resistant to corrosion. The use of combinations of metals that form galvanic or electrolytic couples shall be avoided.

2-3.3.2 In those cases where it is impractical to avoid a junction of dissimilar metals, the corrosion effects can be reduced by the use of suitable platings or special connectors, available for such purposes. Except for the use of conducting materials which are otherwise part of the structure of the boat, only copper shall be used as the conductor.

2-3.3.3 Copper Conductor. Copper cable conductors shall be of a diameter not less than No. 8 AWG. Conductor stranding shall be in accordance with Table 8-14.4, Types 1 or 2. The thickness of any copper ribbon or strip shall be not less than 20 gage and of sufficient width to provide conductivity equal to or greater than No. 8 AWG copper conductor.

2-3.3.4 Conductive Joints. Conductive joints shall be mechanically strong and wiring connections made in accordance with Section 7-15 and supported in accordance with 7-14.6.

2-3.4 Interconnection of Metallic Masses.

2-3.4.1 Metallic masses aboard boats which are a permanent part of the boat or are permanently installed within or about it and whose function would not be seriously affected by grounding shall, with the exception of those of comparatively small size, be made a part of the lightning-conductor system by interconnection with it. (*See 2-3.5, 2-3.6, 2-3.7.*)

2-3.4.2 The object of interconnecting the metal parts of a boat with the conductor is to prevent damage from sideflashes, especially in the case of rather extensive metal objects that are nearby. The main principle to be observed in the prevention of such damage is to identify on a boat the places where sideflashes are most likely to occur and to provide metallic paths for them.

2-3.4.3 To minimize flow of lightning discharge current through engine bearings, it may be preferable to bond engine blocks directly to the ground plate rather than to an intermediate point on the lightning conductor.

2-3.4.4 Exterior Bodies of Metal.

2-3.4.4.1 Metal situated wholly on the exterior of boats shall be electrically connected to the grounding conductor.

2-3.4.4.2 Exterior metal bodies on boats include any large masses such as horizontal guardrails, handrails on cabin tops, smokestacks from galley stoves, electric winches, davits or metal signal masts, and metallic hatches.

2-3.4.5 Interior Bodies of Metal.

2-3.4.5.1 Metal situated wholly in the interior of boats and which at any point comes within 6 ft (1.8 m) of a lightning conductor shall be electrically interconnected with this lightning conductor.

2-3.4.5.2 Interior bodies of metal include engines, water and fuel tanks, and control rods for steering gear or reversing gear. It is not intended that small metal objects such as compasses, clocks, galley stoves, medicine chests, and other parts of the boat's hardware be grounded.

2-3.4.6 Metal which projects through cabin tops, decks or sides of boats above the sheer shall be bonded to the nearest lightning conductor at the point where the metal emerges from the boat and shall be grounded at its lower or extreme end within the boat.

2-3.4.7 Radio transmitter antennas shall be (a) equipped with means for grounding during electrical storms or (b) transmitters and antennas shall be protected by lightning arresters or lightning protective gaps.

2-3.5 Ground Connection. A ground connection for a boat may consist of any metal surface which is normally submerged in the water and which has an area of at least 1 sq ft (0.093 m). Propellers and metallic rudder surfaces may be used for this purpose. The ground plate as required by the Federal Communications Commission for radio transmitters shall be considered adequate. A metal hull itself constitutes an adequate ground.

2-3.6 Vessels with Metal Hulls. If there is an electrical contact between metal hulls and metal masts or other metallic superstructure of adequate height to meet the recommendations of 2-3.2, no further protection against lightning is necessary. Boats with ungrounded or nonconducting objects projecting above the metal masts or superstructure shall have these objects grounded or protected with a grounded conductor, respectively, in order to protect them.

2-3.7 Protection of Sailboats (Nonmetallic).

2-3.7.1 Sailboats with metallic standing rigging will be adequately protected provided that all rigging is grounded, so that the mast and rigging meet the requirements of 2-3.2 and 2-3.3. Sailboats will be adequately protected if all shrouds, back stays, preventors, and continuous metallic track on the mast and boom are grounded and meet the requirements of 2-3.2, 2-3.3 and 2-3.5. All stays and sail tracks shall be grounded since it is assumed that persons will be in their proximity. Grounding of other objects shall be in accordance with 2-3.4.

2-3.8 Protection of Power Boats (Nonmetallic).

2-3.8.1 Power boats shall be adequately protected by a grounded radio antenna, outrigger, or other suitable grounded lightning protective mast as required in 2-3.3 provided the height of the mast meets the requirements for

the zone of protection in 2-3.1.2 or 2-3.1.3. Interconnection and grounding of metallic masses shall be in accordance with 2-3.4.

2-3.8.2 Where the size of the boat is such as to render the use of a single mast impractical, additional lightning protective masts shall be erected to form overlapping zones of protection.

2-3.9 Protection of Small Boats.

2-3.9.1 Small boats shall be protected by means of a temporary lightning protective mast which can be erected when lightning conditions are observed in the distance. Grounding provisions shall be made by means of flexible copper wire and a submerged ground plate of at least 1 sq ft (0.093 m^2) in area.

Chapter 3 Engines

3-1 Engines. Propulsion and auxiliary engines shall be designed for marine use.

3-1.1 No exposed surface of the engine shall exceed 225 °C (437 °F) under any operating condition. Liquid-cooled engines shall be cooled by water from a pump which operates whenever the engine is operating.

3-1.2 Gasoline engine fuel pumps of the diaphragm type shall be designed so that fuel is not released to the engine space should primary diaphragm failure occur. Means shall be provided to determine that diaphragm failure has occurred without having to dismantle the fuel pump.

3-1.2.1 Electrically operated fuel pumps shall operate only when the engine is operating, when the cranking motor is energized, or when operated by a momentary switch for priming.

3-1.3 Marine Carburetors.

3-1.3.1 Marine carburetors shall be designed to prevent leakage of fuel around shafts or other connections and shall not be externally vented.

3-1.3.2 Marine carburetors shall not leak more than 5 cubic centimeters (.305 $in.^2$) of fuel in 30 seconds when the float valve is open, the carburetor is at half throttle and the engine is cranked without starting or the fuel pump is delivering the maximum pressure specified by its manufacturer.

3-1.3.3 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 valve of a backfire or by reverse air flow, and returns collected fuel to the engine induction system after the engine starts.

3-1.3.4 Carburetor air intakes shall be fitted with a means of backfire flame control approved by the U.S. Coast Guard.

3-1.4 Engine electrical components shall comply with applicable parts of Chapters 7 and 8.

3-1.4.1 Electrical components on engines shall be mounted as high above the bilges and as remote from the fuel system as practicable.

3-1.5 Air-Cooled Engines. Air-cooled engines shall comply with 3-1.5.1 through 3-1.5.4.

3-1.5.1 Carburetors and electrical components shall comply with 3-1.3 and 3-1.4.

3-1.5.2 Fuel systems shall comply with Chapter 5.

3-1.5.3 Exhaust systems shall comply with applicable parts of Chapter 4.

3-1.5.4 An audible or visual device shall be installed to warn of excessive engine temperature.

3-1.5.5 If air-cooled engines are enclosed, the following shall apply:

(a) Compartment ventilation shall be adequate to meet the needs of the engine-cooling system.

(b) Installation shall be arranged to ensure the air used to cool the engine is not recirculated within the engine space.

3-1.5.6 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.

3-1.6 Portable engines shall be secured when in use. When not in use, portable engines with integral fuel tanks shall be stowed in an open or ventilated space in accordance with Section 2-2 so that fuel or vapors cannot reach interior spaces.

Chapter 4 Engine Exhaust Systems

4-1 General Requirements.

4-1.1 Exhaust systems shall

(a) Be gastight to hull interiors;

(b) Be designed and installed to prevent water from the exterior of the boat or from the cooling system from returning to the engine including consideration of operating conditions;

(c) Have all connections accessible; and,

(d) Be supported to prevent undue stress that could cause fractures.

(e) Have no fittings into the exhaust system (which rely solely on the threaded connection for securing).

Exception: Engine cooling water.

4-1.2 Wherever personnel or combustibles may come in contact with hot surfaces, effective protection shall be pro-

vided by water-jacketing, lagging, shielding, guards or engine enclosures.

4-1.3 Hangers, brackets, or other means used to support metallic exhaust systems within 6 ft (1.83 m) of the engine connection(s) shall be noncombustible.

4-1.4 A means to indicate loss of exhaust cooling water shall be provided so that it is effective at all helm positions. Devices other than gages may be used provided they are of a type that can be tested by the operator.

Exception: Outboard engines.

4-1.4.1 Auxiliary engines may have automatic shutdown due to high exhaust temperature instead of an audible or visual device.

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, products of combustion, water corrosion, and to the highest normal temperatures which may be encountered.

4-2.2 Copper shall not be used in contact with dry diesel exhaust gases. Copper may be used 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 after a total loss of cooling water for two minutes with the engine operating at full power.

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

Exception: Hoses designed for specific use as part of an engine assembly which shall be clamped.

4-4 Temperature Protection. The turbine side of non-water jacket turbochargers and unjacketed single wall dry exhaust components shall be installed so that the temperature of adjacent combustible surfaces will not exceed 250 °F (93.3 °C).

4-5 Labeling. Except for components designed for use as part of a specific engine assembly, all nonmetallic exhaust components shall be labeled or designated "marine exhaust."

Chapter 5 Fuel Systems

5-1 Scope.

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

5-1.2 The requirements of this chapter apply to all tanks that are permanently installed and any tank of more than 7 gallons capacity.

5-2 General Requirements.

5-2.1 Except as specifically noted for diesel systems, all fuel systems shall be designed and installed to comply with the minimum requirements of the U.S. Coast Guard fuel systems regulations of 33 CFR 183 Subpart J.

5-2.2 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 environment.

5-2.3 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 failure resulting in leakage of liquid or vapor.

Exception No. 1: Fuel distribution lines on boats need not comply with 5-2.3 if a break at any point in the line will result in a discharge of not more than 5.0 oz (1.48×10^{-4} m³) of fuel within 2½ minutes. (See 5-6.2.2.)

Exception No. 2: Self-draining fuel tank vent hose located outside the engine compartment need not comply with 5-2.3.

5-2.4 To ground static electricity the resistance between ground and each metallic or metallic plated component of the fuel fill system and fuel tank which is in contact with fuel shall be less than 100 ohms.

5-2.5 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 in metal-hulled boats.

5-3.2 Materials for fuel tanks shall be corrosion resistant. Materials meeting the specifications listed in Table 5-3.2 shall be considered as satisfying this corrosion resistance requirement. Any departure from these specifications shall be specifically listed and labeled.

5-3.3 Nonmetallic materials meeting the applicable requirements of Chapter 5 may be used, providing the aggregate permeability rate of such tanks does not exceed 1.2 grams (.42 oz) of fuel loss in 24 hours per cu ft (.084 hr/min³) of net compartment volume or, if the compartment volume is less than 1 cu ft (.028 m³), the permeability rate does not exceed 1.2 grams (.42 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.

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

Material	Specification	Minimum Nominal Sheet Thickness	Gage[1]
Nickel-Copper[2,3]	ASTM B127 Class A	0.031 in.	22
Copper-Nickel	ASTM B122	0.045 in.	17
Steel[4]	ASTM A93	0.0747 in.	14
Aluminized Steel[5]	ASTM A463	0.0478 in.	18
Aluminum	Alloy 5052 Alloy 5083 Alloy 5086	0.090 in.	
Stainless Steel[6]	316L	.031	22

For SI Units: 1 in. = 2.54×10^{-2} m

Notes to Table 5-3.2:

1. Gages listed in the table are U.S. Standard for nickel-copper, AWG for copper-nickel, and Manufacturers Standard for steel.

2. U.S. Standard No. 18 [0.05-in. (.0013-m)] nickel-copper may be used only with oxyacetylene, shielded arc, atomic hydrogen, and electric resistance seam welding, as well as brazed joints and riveted and brazed joints.

3. U.S. Standard No. 22 [0.031-in. (.00079-m)] nickel-copper may be used for tanks up to 30 gal (.114 m^3) capacity provided they are formed with electric resistance seam welds.

4. Steel tanks, except those used for diesel fuel, shall be galvanized inside and outside by the hot-dip process.

5. Aluminized steel tanks of less than 0.0785 in. (.002 m) thickness shall only be installed above the cockpit floor or above deck if no clearly defined cockpit exists.

6. Stainless steel tanks shall be cylindrical with domed heads and a capacity less than 20 gal (.076 m^3).

(b) Openings for fill, vent, and feed pipes and level gages (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 cleanout purposes.

Exception: Diesel fuel tanks need not comply with 5-4.1.

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

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

Table 5-4.3 Minimum Thread Engagement

I.P.S.	Minimum Length of Thread Engagement
¼ in.	⅜ in.
⅜ in.	⅜ in.
½ in.	½ in.
¾ in.	9/16 in.
1 in.	⅝ in.
1¼ in.	⅝ in.
1½ in.	⅝ in.
2 in.	11/16 in.

For SI Units: 1 in. = 2.54×10^{-2} m

5-4.4 Fuel tanks 25 gal (.095 m^3) or over capacity shall not leak when subjected to the pressure impulse test requirement of 33 CFR 183.586.

5-4.5 Fuel tanks less than 25 gal (.095 m^3) capacity shall not leak when subjected to the shock test requirement of 33 CFR 183.584.

5-4.6 Fuel tanks of 200-gal (.76-m^3) capacity or more shall not leak when subjected to the slosh test of 33 CFR 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 may additionally 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) The statement "This tank has been tested under 33 CFR 183.510(a)."

(i) If the tank is tested under 33 CFR 183.584, at less than 25 g vertical accelerations, the statement "Must be installed aft of the half length of the boat."

5-4.10 All fuel tanks shall be tested by the manufacturer for fuel tightness at 3.0 psig (2.07×10^4 Pa) or 1.5 times the maximum head to which it may be subjected in service, whichever is greater.

5-4.11 Because the tank may flex in service, the design of the pickup tube shall preclude damage to the tank bottom.

5-4.12 The use of gage 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 will ensure complete drainage of water from all exterior tank surfaces, as installed.

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

5-5.3 Fuel tanks shall be installed and restrained to prevent permanent deformation and to provide as close to no movement as is practicable.

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

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

(b) Have a warning label including the information in the following sample label:

WARNING: To prevent hull and tank damage due to expansion of the tank 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 effectively insulated from contact with tank surfaces by a nonabrasive and nonabsorbent material.

5-5.7 Aluminized steel tanks of thicknesses less than 0.0785 in. (.199 $\times 10^{-2}$ m) 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 may be foamed in place if they comply with the requirements of 33 CFR 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 hose 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 .032 in. (.08 $\times 10^{-2}$ m).

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 U.S.C.G. Type B-1 hose, where 2½ minutes minimum fire resistance is not required. (*See 5-2.3.*)

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

5-6.2.4 Plastic fittings shall not be used in fuel distribution, vent lines, and fill lines. (*See 5-2.3.*)

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 damaging movement or vibration by using noncombustible clips or straps having no rough surfaces or sharp edges. Clips and straps shall be of equivalent fire resistance to the requirement of the line it supports.

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

5-6.2.7 When making flared tubing connections, it is essential that tubing 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 need only indicate 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 so that liquid and vapor overflow cannot escape to the inside of the hull and to provide protection against escaping vapors flowing into the hull.

5-6.3.2 No liquid fuel shall enter the boat from the fill due to an overflow of 5 gpm (3.16 $\times 10^{-4}$ m³/s) 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 the rate of 2 gpm (1.26 $\times 10^{-4}$ m³/s) shall not enter the boat.

5-6.3.4 The minimum inside diameter of the fill pipe system shall be 1¼ in. (32 mm) [minimum hose diameter of 1½ in. (38 mm)].

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

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

5-6.3.7 If a nonmetallic hose is used in the fill pipe system, it shall be tightly secured with a minimum of two corrosion-resistant metal clamps of ½ in. (1.27 $\times 10^{-2}$ m) 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 when filling at a rate of 9 gpm (5.68 $\times 10^{-4}$ m³/s) from ¼ to ¾ of the capacity of the tank label.

5-6.3.10 The vent pipe connection shall be at the highest point of the tank, as 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 hull vent line fittings shall be corrosion-resistant, shall have cleanable screens of 30 × 30 mesh or equivalent noncorrosive metal, shall be fitted at the hull vent opening, and shall be an effective flame arrester.

Exception: If metallic vent lines are used and serve as effective flame arresters, the hull vent fitting does not have 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 operated by a momentary switch for priming and shall be located either on or within 12 in. (30 cm) of that 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 which are exempted from the requirements of 5-2.3 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:

(a) Keeping all parts of the fuel distribution lines above the tank top when the boat is in its static floating position.

(b) Installing an anti-siphon valve at or above the tank withdrawal fitting.

(c) Installing an electrically operated valve at or above the tank withdrawal fitting which is open only when the engine is energized and having provisions 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 fuel systems provided with anti-siphon protection. If the fuel tank(s) is/are located in the same compartment as internal combustion machinery, a means of closing the valve(s) without exposing the operator to injury 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 5-6.2.2.

5-6.4.6 The fixed fuel line shall be fastened to structure within 4 in. (.102 m) 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 Appliances shall be labeled or designated for marine use. Printed instructions for proper installation, operation, and maintenance shall be furnished. A durable and permanently legible sign covering safe operation shall be provided and installed on or adjacent to the appliance.

6-1.2 Appliances using gasoline for fuel shall not be used aboard boats.

Exception: Sealed combustion chamber heaters complying with 6-4.6.

6-1.3 The area in which a fuel burning appliance is installed shall comply with the ventilation requirement of 2-1.5.

6-1.4 Appliances shall be securely fastened when in use and when stored.

6-1.5 Any burner system that may adversely affect safety by reason of normal motion of the boat shall not be used.

6-2 Cooking Appliances.

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

6-2.2 Fabrics above and within 3 ft (.91 m) of a galley stovetop, 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.*

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

6-3.1 Coal, charcoal, and wood burning stoves shall be either mounted on a noncombustible base (preferably hollow tile) or mounted on legs providing clearance of at least 5 in. (.13 m) between stove bottom and deck and the deck shall be effectively insulated with a noncombustible material or sheathing. Sides and backs of uninsulated stoves shall have a minimum clearance of 9 in. (.23 m) from the exposed materials and finishes which must meet 6-2.1 or be separated by fire-resistant thermal insulation. Sides and backs of insulated stoves shall have a minimum clearance as specified by the manufacturer.

6-3.2 Single wall smoke pipes and stacks shall have a minimum clearance of 9 in. (.23 m) 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.

6-3.3 Smoke pipes or stacks shall terminate with smoke heads designed to prevent water entry, spark emission, and back draft.

6-3.4 Coal and wood shall be stowed in a ventilated locker or bin.

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

6-4 Liquid Fuel Appliances.

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

6-4.2 Fuel supply tanks shall be constructed of corrosion-resistant metal with welded or brazed joints and fittings.

6-4.2.1 Pressure tanks integrally installed with stoves shall withstand a test pressure of at least 200 psig (1.38×10^8 Pa). They shall be effectively protected from the heat of burners.

6-4.2.2 Pressure tanks for remote installation shall be able to withstand a test pressure of at least 100 psig (6.9×10^7 Pa). They shall be rigidly secured in an accessible location permitting convenient filling and pump operation.

6-4.2.3 Gravity tanks shall be substantially secured. They shall be so located or shielded that, under continuous operation at maximum output, the temperature of contained fuel will not be substantially raised by heat from the burners.

6-4.2.4 No gravity tank shall have a capacity exceeding 2 gal (7.57×10^{-3} m³). Tanks of larger capacity shall meet the requirements of Section 5-3.

6-4.2.5 Gravity tanks shall have provisions for filling and venting outside the galley space.

6-4.3 If fuel tanks are remotely located, as is preferred for gravity feed systems, stop valves shall be installed close to tanks and fuel lines shall be installed with as few fittings as practicable between valves and stove connections.

6-4.4 If solidified fuel is used, the containers shall be properly secured on a fixed base to prevent sliding or overturning due to a sudden roll of the vessel.

6-4.5 Stacks and stoves shall comply with the applicable requirements of Section 6-3.

6-4.6 Sealed combustion chamber heaters burning gasoline or fuel oil may 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.

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

6-5.1 The use or storage of stoves with attached LPG or CNG containers is prohibited on boats having enclosed accommodation spaces.

6-5.2 All component parts of the systems shall be design compatible for the fuel used.

6-5.3 All component parts of LPG and CNG systems subject to container pressures shall have a rated working pressure of not less than that of the container. LPG and CNG containers shall comply with U.S. Department of Transportation or ASME standards.

6-5.4 Ignition protection shall be provided in accordance with 7-9.2 and 8-7.2

6-5.5 With each LPG or CNG system installed on a boat, at least two signs required by 6-1.1 shall be provided.

6-5.5.1 These signs shall include:

(a) The signal word "WARNING."

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

6-5.5.2 These signs shall also provide information in accordance with the following sample wording:

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

(b) The following directions:

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.

NOTE: This statement is not required on the sign at the container.

4. Test system for leakage at least twice a month, when system is serviced or container changed as follows:

With the appliance valves closed and all other valves open, note pressure on the gage. Close container valve. The pressure should remain constant for at least 10 minutes. If pressure drops, locate leakage by application of soapy water solution at all connections. Repeat test for each container in multi-container systems. NEVER USE FLAME TO CHECK FOR LEAKS. NEVER USE SOAP CONTAINING AMMONIA.

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

5. Container locker for storage of (LPG or CNG) containers only.

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

NOTE: This statement is not required on the sign at the appliance.

6-5.6 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,

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

6-5.7.2 Containers shall be condemned and withdrawn from service when they leak, when corrosion, denting, bulging or other evidence of rough usage exists to the extent they may be weakened appreciably, or if exposed to a fire.

6-5.7.3 A container shall not be charged with fuel unless it bears the proper markings of the code under which it

was fabricated, its water weight capacity, and its tare weight.

6-5.7.4 No container which is due for requalification shall be charged with fuel until it has been retested or otherwise qualified for service in accordance with U.S. Department of Transportation requirements.

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, which can be operated without the use of tools.

6-5.8.2 All containers shall be provided with safety relief devices as required by U.S. Department of Transportation regulations or equivalent regulations.

6-5.8.3 LPG container valves and safety relief devices shall have direct connection with the vapor space of the cylinder.

6-5.8.4 In addition to the shutoff valve required in the container, a dual container system shall be arranged so that replacement of containers can be made without shutting off the flow of gas to the appliances.

6-5.8.5 All relief valves shall discharge to the open atmosphere at a point at least 2 ft (.61 m) from any opening to a cabin or hull interior or from an engine exhaust terminus.

6-5.8.6 Valve outlets on containers shall be equipped with an effective seal such as a plug, cap, or an approved quick closing coupling. This seal shall be in place whenever the container is not connected for use, and the valve shall be kept tightly closed.

6-5.8.7* A remotely operated valve, if installed, shall be located at the regulator and shall be operable from the vicinity of the appliance.

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 18 in. of water (approximately 0.653 psig) for LPG systems or 6 in. of water (approximately 0.217 psig) for CNG systems.

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

6-5.9.3 Low pressure relief valve discharge shall conform to 6-5.7.5.

6-5.9.4 The relief valve vent outlet shall be located and designed to prevent water from entering the discharge system.

6-5.9.5* Each reducing regulator shall be fitted with a pressure gage on the high pressure side. A leak detector may be used in addition to the gage.

6-5.9.6 Regulating devices shall be made of materials that are compatible with the specific gas and shall resist the corrosive elements associated with normal marine service.

6-5.9.7 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 the vent system designed pressure limits.

6-5.10 Piping and Fittings.

6-5.10.1 All low pressure distribution piping between the regulator and appliances shall be galvanically compatible for a marine environment and shall be:

(a) In LPG systems, either copper tubing of standard Type K or L, or equivalent.

(b) In CNG systems, internally tinned copper tubing of standard Type K or L, or equivalent.

(c) In LPG or CNG systems, flexible hose certified and labeled for the fuel used.

6-5.10.2 Connecting fittings shall be accessible. Metallic connections, if soldered, shall be soldered or brazed with a material having a melting point exceeding 1000 °F (538 °C).

6-5.10.3 Distribution lines shall be protected from physical damage and shall be accessible for inspection.

6-5.10.3.1 Lines shall be secured against vibration.

6-5.10.3.2 Lines shall be protected from abrasion wherever they pass through decks or bulkheads.

6-5.10.3.3 Lines shall be continuous lengths of tubing, without joints, except to feed other appliances.

6-5.11 Appliances.

6-5.11.1 Appliances designed for operation with continuous pilot lights or automatic glow plugs are prohibited except for sealed combustion chamber heaters complying with 6-5.11.3.

6-5.11.2 A cooking stove is considered to be an attended appliance; however, a cooking stove with an oven shall incorporate an oven flame failure safety device that will prevent gas from flowing to the oven burner if flame is not present at the oven burner.

6-5.11.3 Cabin space heaters 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.

Exception: A cabin heater need not be of the sealed combustion chamber type provided that it conforms with all of the following:

1. It is a vented appliance.

2. It incorporates provisions for introduction of combustion air from outside the cabin.

3. It incorporates a safety control system that will prevent burner operation under any operating conditions that would allow products of combustion to discharge into the interior of the cabin.

4. It incorporates provisions either integral with the heater design or by use of a safety control system(s) to protect against ignition of flammable materials which could come in contact with a heat source or part of the heater.

5. It is listed for commercial and pleasure craft installation and is installed with the terms of the listing.

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 housing or locker.

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

6-5.12.1.1 The protective housing or 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, other enclosed spaces, or accumulate in a cockpit.

Exception: CNG systems where a single container of not more than 100 cu ft (2.83 m³) at 14.7 psia (101.4 kPa) and 70 °F (21 °C) is connected to the system; and the volume of the compartment and connecting spaces is at least 20 times the container capacity at STP.

6-5.12.1.2 Protective housings or lockers with a top opening shall be vented as follows:

(a) For LPG systems, a vent pipe of at least ½ in. (.013 m) internal diameter led outboard without water traps through the hull from the bottom of the locker or housing terminating at a discharge point above the waterline lower than its bottom.

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 gage 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 for containers in use. Valves to containers, even those considered empty, shall be kept tightly closed and effectively sealed with a plug or cap.

6-5.12.5 After installation, distribution tubing shall be tested prior to its connection to the regulator and appliance by an air pressure of not less than 5 psig (3.45×10^4 Pa). 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, the master shutoff valve (if provided) on the appliance open, and with one container valve open, note the pressure on the gage.

(b) Close the container valve.

(c) Pressure should remain constant for at least 10 minutes.

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

(e) Never use flame to check for leaks.

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

6-6 Heating Equipment.

6-6.1 Service Water Heating Units.

6-6.1.1 Open flame heating units shall be installed well above accommodation flooring and in compliance with applicable requirements of Sections 6-1, 6-2, 6-3, 6-4, and 6-5.

6-6.1.2 A vent stack shall be fitted at the top of each heating unit and led to the atmosphere with an effective device for preventing flame extinguishment or flareback from back draft.

6-6.1.3 Dampers shall not be installed in vent stacks.

6-6.2 Cabin Heaters.

6-6.2.1 Cabin heating equipment shall comply with applicable provisions of Sections 6-1, 6-2, 6-3, 6-4, and 6-5.

6-6.2.2 Cabin heating equipment using liquid or gaseous fuel shall be equipped with a means for automatic fuel shutoff in the event the flame goes out.

6-7 Auxiliary Appliances.

6-7.1 Lamps and Lanterns.

6-7.1.1 Gasoline shall not be used for fuel.

6-7.1.2 Oil lamps and lanterns shall be approved for marine use.

6-7.1.3 Oil lamps shall have metal bodies and shall be hung in gimbals.

6-7.1.4 Oil lamps shall not be located directly over galley stoves or heating units.

6-7.1.5 Metal shields shall be secured above chimneys.

6-7.1.6 Oil lanterns, if suspended, shall be secured by clips or lashings.

6-7.1.7 Lantern stowage shall be in a noncombustible enclosure.

Chapter 7 Electrical Systems Under 50 Volts

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

Exception: Any wire permanently attached to an outboard engine and extending not more than 72 in. (1.83 m) from the outboard engine.

7-2 Definitions.

Battery Cold Cranking Rating. The discharge load in amperes which a battery at 0 °F (-17.8 °C) can deliver for 30 seconds and maintain a voltage of 1.2 volts per cell or higher.

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

Bonding Conductor. A normally non-current-carrying conductor used to connect normally non-current carrying metal parts of a boat and normally non-current carrying metal parts of direct current devices on the boat to the ground.

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

Ground. Ground applies to the 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 connected to the side of the source which is intentionally maintained at ground potential.

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

(a) It will not ignite a flammable hydrocarbon mixture surrounding the device when an ignition source causes an internal explosion, or

(b) It is incapable of releasing sufficient electrical or thermal energy to ignite a hydrocarbon mixture, or

(c) The source of ignition is hermetically sealed.

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

NOTE 1: It is not the intention to require such devices to be "explosionproof" as that term is defined in the *National Electrical Code®* of the NFPA pertaining to shore systems, or 46 CFR 110.15-65(e) of CG 259, Subchapter J-Electrical Engineering. It is intended that the protection provided be generally equivalent to that of wiring permitted by this standard wherein a definite short or break would be necessary to produce an open spark.

NOTE 2: Devices that are "explosionproof" are considered to be ignition protected when installed with the appropriate fittings to maintain their "explosionproof" integrity.

NOTE 3: It is not the intention to require such devices to be "intrinsically safe" per Article 500 of the *National Electrical Code* of the NFPA or 46 CFR 111.80-5(a)(3) of CG 259, Subchapter J-Electrical Engineering.

NOTE 4: Devices that are "intrinsically safe" are considered to be ignition-protected.

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. A single panel or group of panel units designed for assembly in the form of a single panel; including buses, overcurrent devices, and with or without switches for the control of light, heat or power circuits; designed to be placed in a permanently mounted enclosure, accessible only from the front.

Pigtails. External conductors that originate within an electrical component or appliance.

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

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

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

Watertight. Enclosed so that equipment does not leak when a stream of water from a hose with a nozzle one inch in diameter that delivers at least 65 gallons per minute (246 lpm) is played on the enclosure from any direction from a distance of 10 feet (3.1 m) for 5 minutes.

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

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

7-3 Requirements — In General.

7-3.1 Two-Wire System. All direct current electrical distribution systems shall be of the two-wire type, using insulated conductors. The feed and return wires shall run together where the wiring is routed near compasses or other magnetically sensitive equipment. See Diagrams 7-4.1(1) and 7-4.1(2).

Exception: See Section 7-12.

7-3.2 Return Circuit. A metal hull, bonding conductor or grounding conductor shall not be used as a return circuit.

Exception: See Section 7-12.

7-3.3 Grounded Systems. If one side of a two-wire direct current system is connected to ground, it shall be the negative side and the system shall be polarized.

7-3.4 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.

7-4 Batteries.

7-4.1 Batteries shall not be tapped for voltages other than the total voltage of all the cells comprising the battery.

7-4.2 Batteries shall be located so that hydrogen gas generated during charging will not accumulate or be trapped in the boat.

7-4.3 Batteries shall be restrained to provide as close to no movement as practicable. (*See Code of Federal Regulations, 33 CFR Part 183.*)

7-4.4 Acid batteries shall be located in a liquid-tight tray or battery box of adequate capacity to retain normal spillage or boilover of electrolyte. The tray shall be constructed of or lined with materials resistant to deterioration by the electrolyte.

7-4.5 A nonconductive perforated cover or other means shall be provided to prevent accidental shorting of the ungrounded battery terminals and cell connectors.

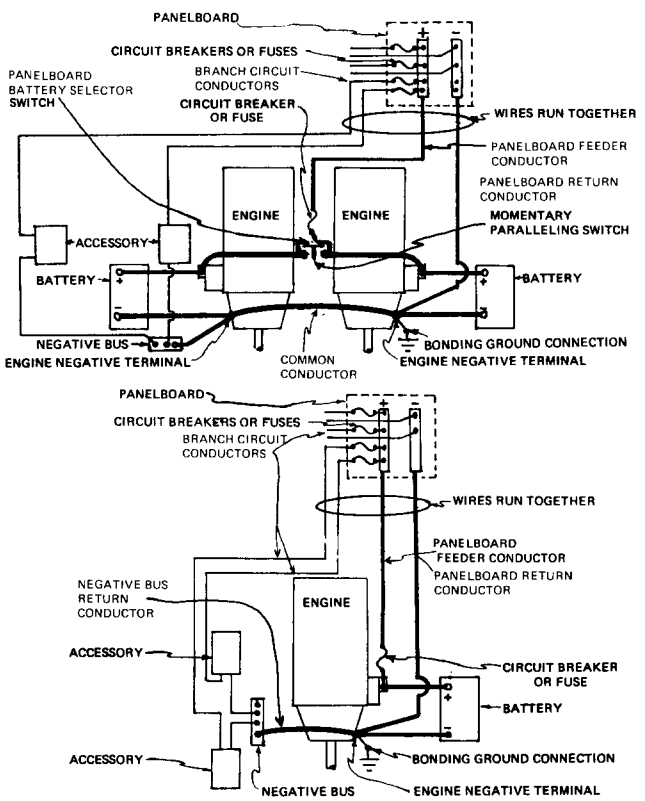


Diagram 7-4.1(1)

7-4.6 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.

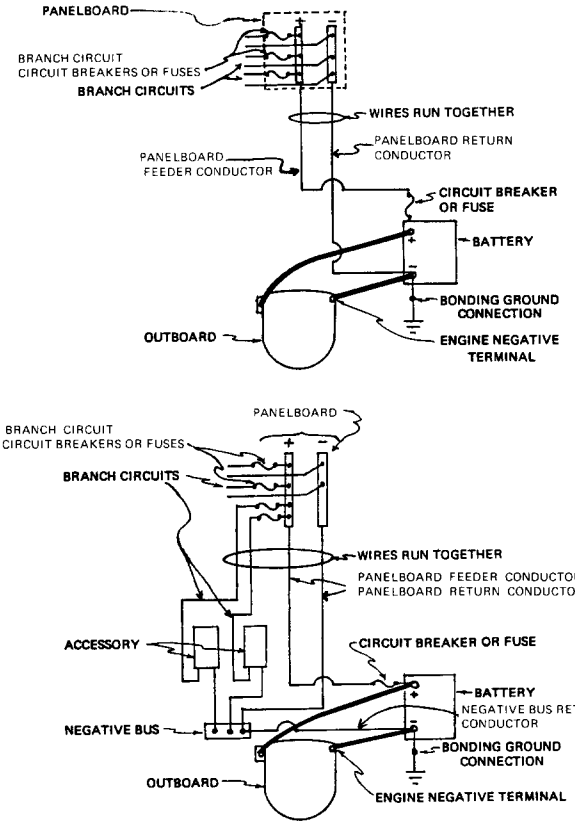


Diagram 7-4.1(2)

7-4.7 Each metallic fuel line and fuel system component within 12 in. (.305 m) and above the horizontal plane of the battery top surface as installed shall be shielded with dielectric material. (*See Code of Federal Regulations, 33 CFR Part 183.*)

7-4.8 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.

7-4.9 Battery terminal connections shall not depend on spring tension.

7-5 Power Distribution System Negative Connections.

7-5.1 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 may use the battery negative terminal.

7-5.2 Separate Negative Bus. A separate negative bus may be created off the engine, or, in the case of outboard boats, off the battery providing:

(1) All accessories connected to the bus are branch circuit from the same panelboard.

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

(3) The negative return conductor from the panelboard feeding the branch circuits using the separate negative bus shall remain equal in size to the positive feeder to the panelboard.

7-6 Energized Parts.

7-6.1 Continuously Energized Parts. Except for circuits provided with overcurrent protection in accordance with 7-10.6, continuously energized parts, such as positive battery terminal and both ends of all wires connected thereto, shall be protected by boots, sleeving or other insulation to prevent accidental short circuit.

7-7 Marking.

7-7.1 Marking. Switches and electrical controls shall be marked to indicate their usage.

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

7-7.2 Marking of Equipment. Electrical equipment, except a part of an identified assembly, such as an engine, shall be marked or identified to indicate:

(1) Manufacturer.

(2) Identifying number.

(3) DC electrical rating in volts. Rated current of electrical equipment shall be available and may be marked on the device.

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

(5) Ignition protection if applicable.

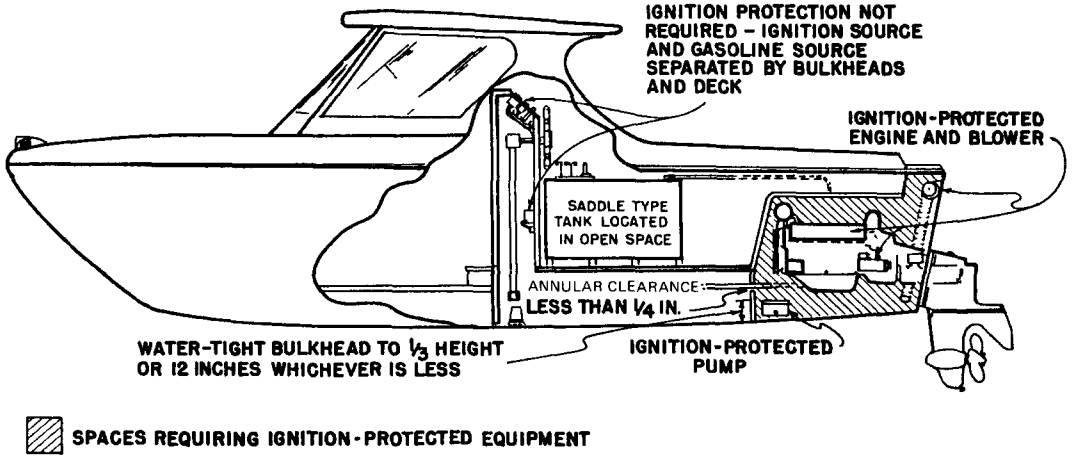
7-8 Ambient Temperature.

7-8.1 The ambient temperature of machinery spaces is considered to be 50 °C (122 °F) and of all other spaces is considered to be 30 °C (86 °F).

7-9 Ignition Sources.

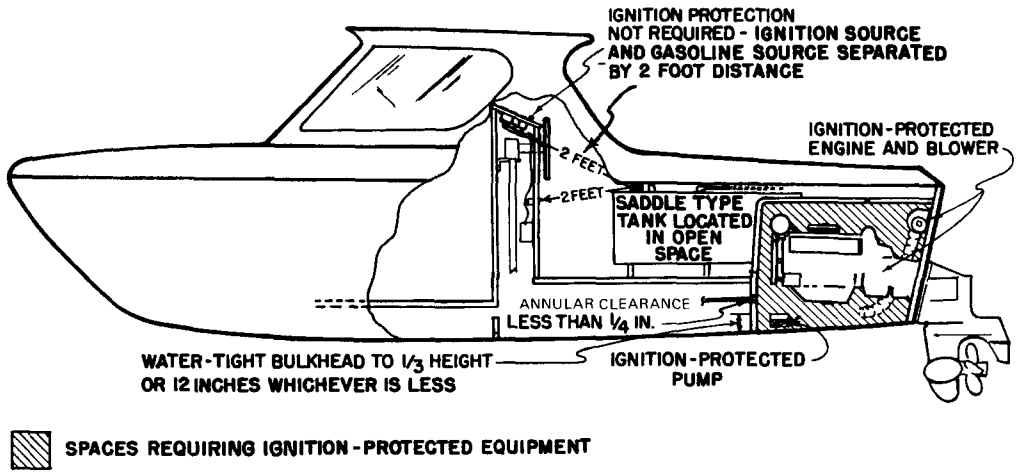
7-9.1 Potential sources of ignition located in gasoline powered machinery and fuel tank spaces, and in spaces containing joints, fittings or other connections between components of the gasoline fuel system shall be ignition-protected, unless the electrical component is isolated from a gasoline fuel source as described in Figures 7-9.1(1) through (7).

Exception: Boats using diesel fuel as the only fuel.



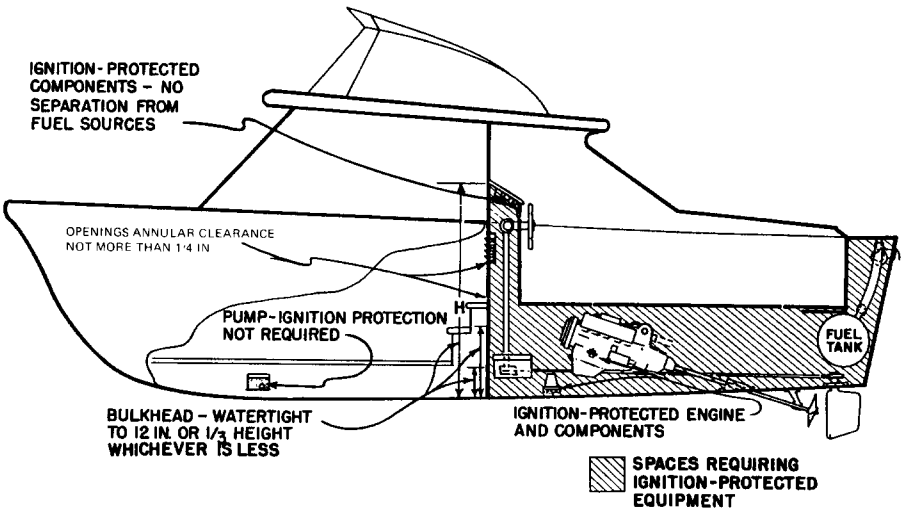
For SI Units: 1 in. = 2.54×10^{-2} m

Figure 7-9.1(1)



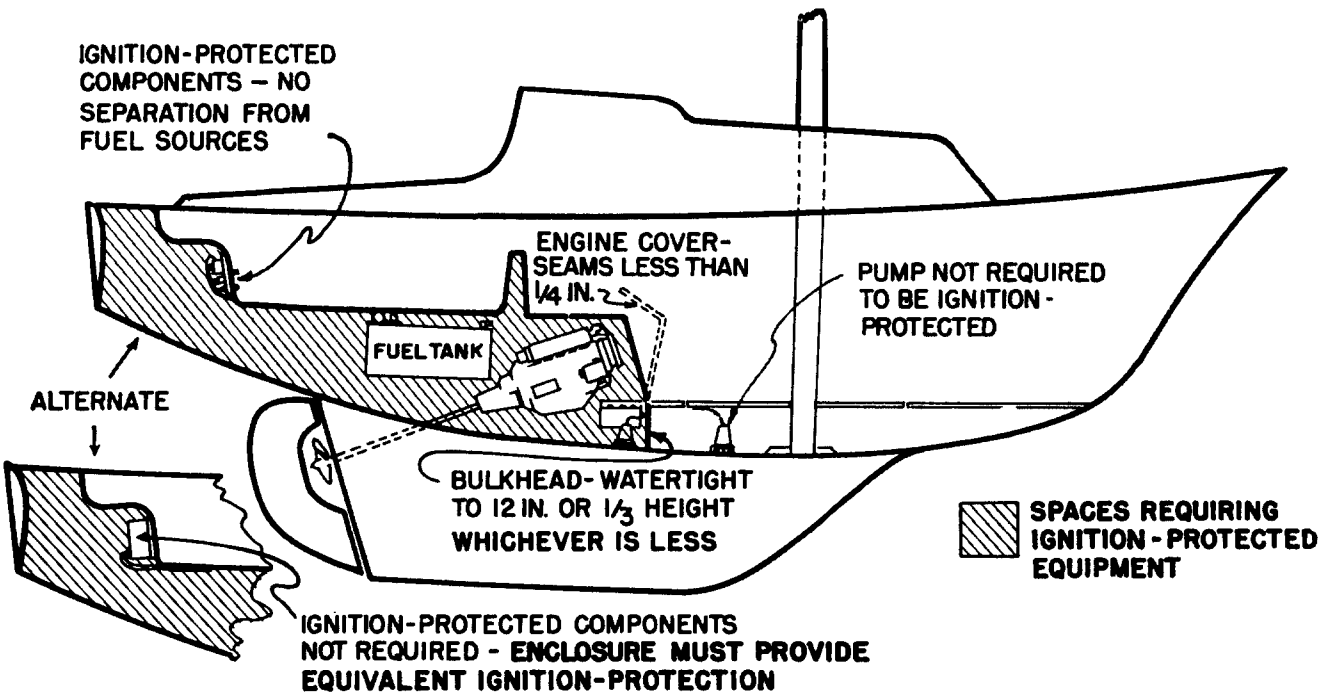
For SI Units: 1 in. = 2.54×10^{-2} m; 1 ft = 3.048×10^{-1} m

Figure 7-9.1(2)



For SI Units: 1 in. = 2.54×10^{-2} m

Figure 7-9.1(3)



For SI Units: 1 in. = 2.54 m

Figure 7-9.1(4)

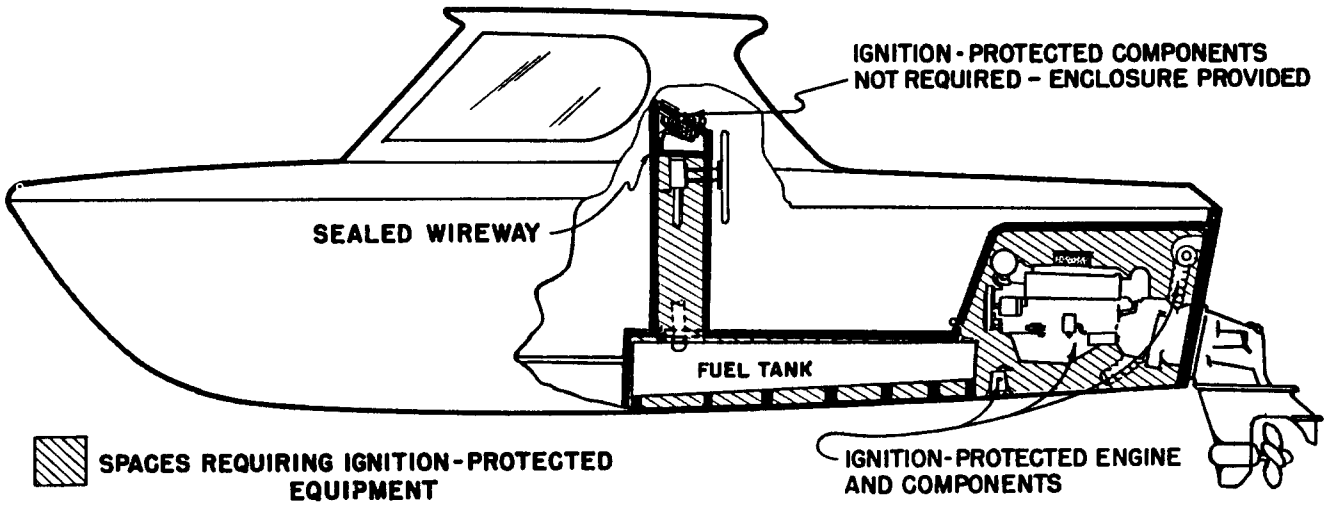
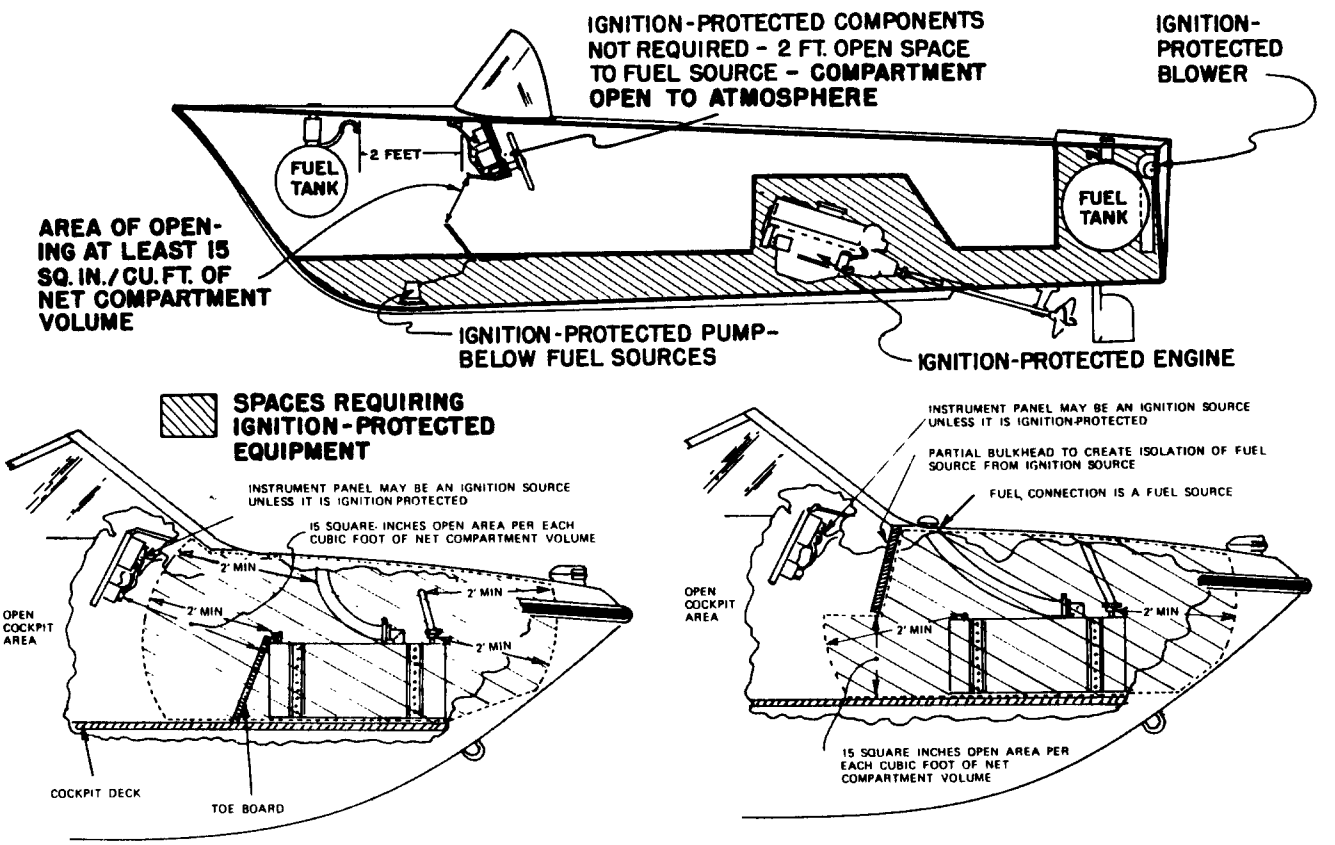
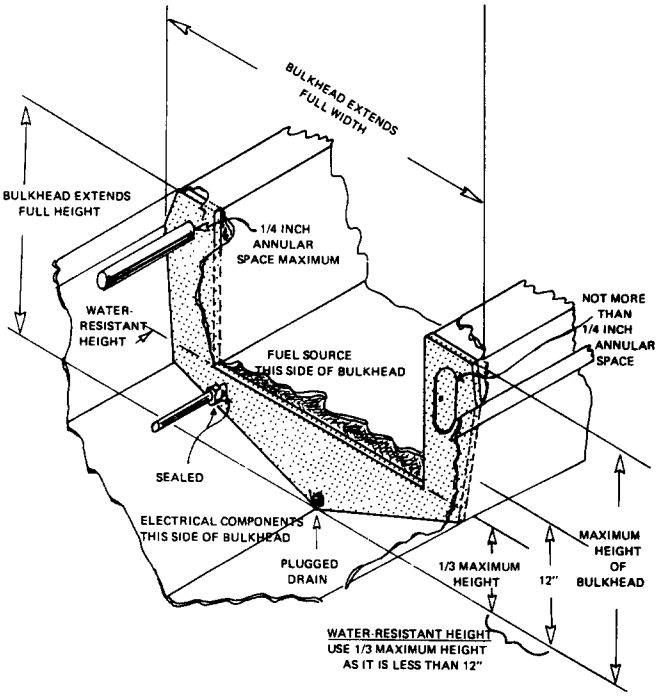


Figure 7-9.1(5)



For SI Units: 1 in. = 2.54×10^{-2} m; 1 ft = 3.048×10^{-1} m; 1 sq in. = 6.45×10^{-4} m^2; 1 cu ft = 2.83×10^{-2} m^3

Figure 7-9.1(6)



For SI Units: 1 in. = 2.54 × 10^{-2} m

Figure 7-9.1(7)

NOTE 1: Seepage of not more than ¼ fluid ounce (7.4 × 10^{-6} m^3) per hour permitted below the water-resistant height. This includes bulkhead fastenings and space around hatches, doors, access panels, etc. and items passing through the bulkhead.

NOTE 2: Openings above the water-resistant height may not have more than ¼ in. (7.4 × 10^{-6} m^3) annular space around items passing through the openings.

7-9.2 If LPG or CNG is provided on the boat, electrical devices which can function or cycle automatically without the presence of a person shall be ignition-protected.

Exception: The ignition protection requirements will not be extended beyond those in 7-9.1 if the following conditions are met.

(1) Only one gas appliance is provided on the boat.

(2) The gas supply at the tank can be shut off by means of an automatic or manually operated control that is an integral part of, or is located in the vicinity of, the gas appliance. Manual controls shall have a warning light or warning device to indicate when the gas supply valve is open.

7-9.3 An electrical component is isolated from a gasoline fuel source if:

(a) The distance between the electrical component and the fuel source is at least 2 ft (.61 m) and the space is open to the atmosphere.

(b) The electrical component is:

(1) Lower than the gasoline fuel source and a means is provided to prevent gasoline fuel and gasoline fuel vapors, that may leak from the gasoline fuel sources, from becoming exposed to the electrical component, or

(2) Higher than the gasoline fuel source and a deck or other enclosure is between it 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 both vertically and horizontally the distance of the open space between the gasoline fuel source and the ignition source, and

(2) Resists a water level that is 12 in. (.305 m) high or ⅓ of the maximum height of the bulkhead, whichever is less, without seepage of more than ¼ fluid ounce (7.4 × 10^{-6} m^3) of fresh water per hour, and

(3) Has no opening higher than 12 in. (.305 m) or ⅓ the maximum height of the bulkhead whichever is less, unless the opening is used for the passage of conductors, piping, ventilation ducts, mechanical equipment, and similar items, or doors, hatches, and access panels; and the maximum annular distance around each item or door, hatch or access panel is not more than ¼ in. (.64 × 10^{-2} m).

7-10 Overcurrent Protection.

7-10.1 Overcurrent Protection Location. Conductors other than cranking motor conductors shall be provided with overcurrent protection within a distance of 7 in. (.18 m) of the point at which it is connected to the source of power measured along the conductor. See Diagram 7-10.1.

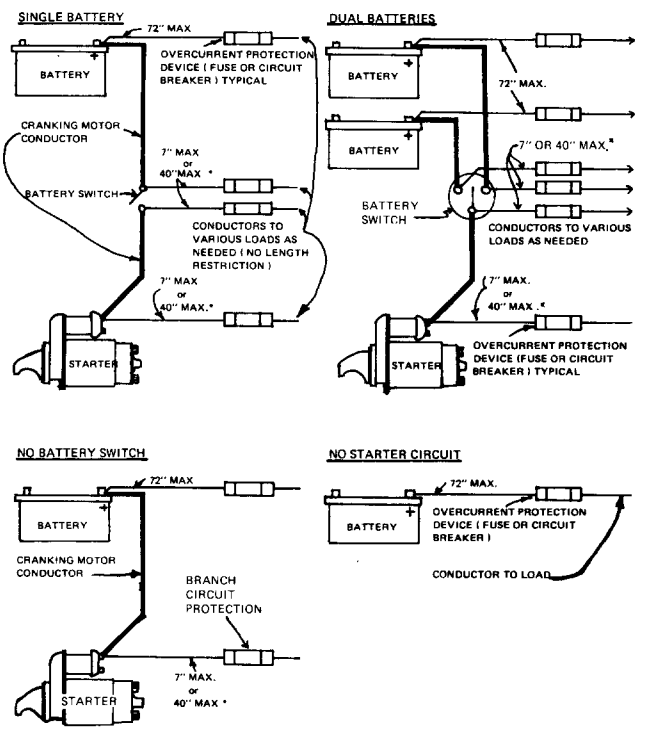


Diagram 7-10.1

For SI Units: 1 in. = 2.54 × 10^{-2} m

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

Exception No. 1: If the conductor is connected directly to the battery terminal the 7-in. (.18-m) distance may be increased to 72 in. (1.83 m).

Exception No. 2: If the conductor is between the source of power, other than the battery terminal, and the required overcurrent protection device, and is contained throughout its entire distance in a sheath or enclosure such as a conduit, junction box, control box or enclosed panel, the 7-in. (.18-m) distance may be increased to 40 in. (1.02 m).

7-10.2 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 seven hours under any conditions of overload, including locked rotor. This may require the use of thermally responsive protection devices on the equipment or system if the motor is not capable of operating continuously at maximum possible loading.

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

7-10.3 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.

7-10.4 Branch Circuits. Each ungrounded conductor of a branch circuit shall be provided with overcurrent protection at the point of connection to the panelboard or unless the main circuit breaker or fuse provides such protection.

7-10.5 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 more 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.

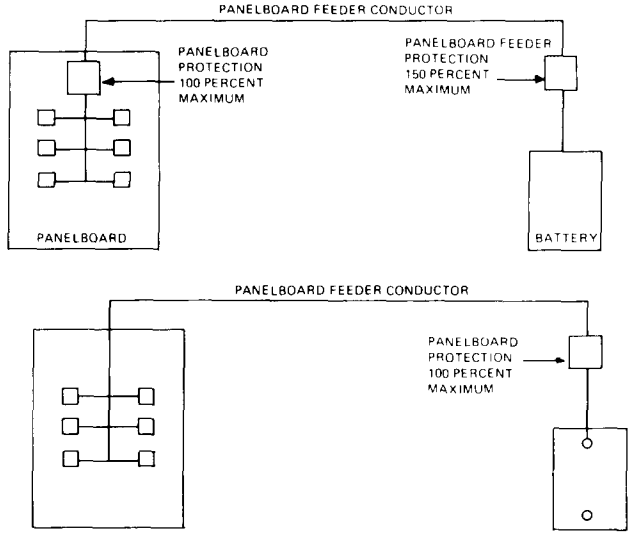


Diagram 7-10.5

7-10.6 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 according to Table 7-10.6 and meet the marine requirements of UL 489, Molded Case Circuit Breakers and Circuit Breaker Enclosures or UL 1077, Supplementary Protectors for Use in Electrical Equipment or SAE J1428, Marine Circuit Breakers. Circuit breakers which meet the requirements of UL 1077 may be used as branch circuit breakers if they can interrupt the current specified for branch circuit breakers in Table 7-10.6 alone or in combination with the main circuit breaker.

(d) Meet the requirements of UL 1500, Test Procedure for Ignition-Protection or SAE J1171, External Ignition Protection of Marine Electrical Devices at 4 times their rated current if located in a space that requires ignition protection.

Table 7-10.6 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" shall be 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 shall be considered to be "Branch Circuit Breakers."

NOTE 2: Under Battery Council International conversion factors the following approximate correlations are offered 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 x the amp/hour rating.

7-10.7 Fuses. Fuses shall:

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

(b) Be capable of an interrupting capacity according to Table 7-10.6.

(c) Meet the requirements of UL 1500, Test Procedure for Ignition-Protection or SAE J1171, External Ignition Protection of Marine Electrical Devices at 4 times rated

current if located in a space that requires ignition protection.

7-10.8 Integral Overcurrent Protection Devices. Integral overcurrent protection devices without a manual reset may be used as an integral part of an electrical device provided the rest of the circuit is protected by a trip-free circuit protection device(s) or a fuse(s). Integral overcurrent protection shall be sized to protect the accessor in which it is installed.

7-10.9 Pigtails. Pigtails less than 7 in. (.18 m) in length are exempt from overcurrent protection requirements.

7-11 Switches.

7-11.1 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.

7-11.2 Vessels 26 ft (7.9 m) and over in overall length shall have an approved master battery switch.

NOTE: Automatic bilge pumps may be wired to bypass this switch.

7-11.3 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 which 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.

7-11.4 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 used for control of alarm systems.

7-11.5 Switches shall have voltage ratings not less than the system voltage and current rating not less than the connected load.

NOTE: Consideration shall be given to selection of special switches for use with high current inductive loads.

7-12 Appliances and Equipment.

7-12.1 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 may have the negative conductor 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 not be bonded.

(a) Communications and audio equipment.

(b) Electronic navigation equipment.

(c) Instruments and instrument clusters.

(d) Cigar lighters.

(e) Liquid level gage transmitters (for installation on conductive surfaces).

(f) Navigation lights operating at 12 volts or less.

7-12.2 Grounded Liquid Level Gage Transmitters (Senders). Grounded liquid level gage 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 shall also serve as the static ground and/or the bonding conductor. If this conductor is used as the tank system bonding conductor it shall be at least No. 8 AWG. No other device shall be connected to this conductor.

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

7-12.3 Pigtail connections on submersible devices such as submersible bilge pumps shall be not less than 16 in. (.41 m) long.

7-13 System Wiring.

7-13.1 Conductors and flexible cords shall have a minimum rating of 300 volts.

7-13.2 The construction of insulated cables and conductors shall conform with the requirements of SAE J378, J1127, J1128 or UL 1426, Boat Cable.

7-13.3 Conductors may be selected from the types listed in Tables 7-13.3 and 8-14.2. The temperature ratings shown contemplate the routing of wires above bilge water in locations protected from dripping, exposure to weather, spray and oil.

Table 7-13.3 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)

7-13.4 Flexible cords shall conform with the *National Electrical Code* and shall be selected from the types listed in Table 8-14.3.

7-13.5 Conductors and flexible cords shall be stranded copper according to Table 8-14.4 and sized according to Table 8-14.5.

7-13.6 Conductors and flexible cords shall be sized for voltage drop in accordance with the following:

(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 Non-Critical Circuits — 10 percent.

7-13.7 Conductor sizes may be calculated by means of the following formula based on the 3 percent and 10 percent voltage drop. If the circular mil area is found to be less than the value in Table 8-14.4 the next larger size conductor is to be used.

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

Legend

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% = 0.36).

7-14 Wiring Installation.

7-14.1 Current-carrying conductors shall be routed as high as practicable above the bilge water level and other areas where water may accumulate.

Exception: If conductors must be routed in the bilge or other areas where water may accumulate, the wiring and connectors shall be watertight.

7-14.2 Conductors shall be routed as far away as practicable from exhaust pipes and other heat sources. A clearance of at least 2 in. (.051 m) between conductors and water-cooled exhaust components and a clearance of at least 9 in. (.23 m) between conductors and dry exhaust components shall be maintained. The clearance shall be increased to 18 in. (.46 m) directly above a dry exhaust.

Exception No. 1: Wiring on engines.

Exception No. 2: Exhaust temperature sensor wiring.

7-14.3 Battery cables shall not be routed such that they are in contact with metallic fuel system components.

7-14.4 Conductors which may be 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 shall also be routed clear of sources of chafing such as steering cable and linkages, engine shafts and belts and throttle connections.

7-14.5 Conductors shall be at least 16 gage.

Exception: Eighteen gage conductors may be used if included with other conductors in a sheath and do not extend more than 30 in. (.76 m) outside the sheath.

7-14.6 Conductors shall be supported throughout their length or, alternatively, shall be secured at least every 18 in. (.46 m) by one of the following methods:

(1) Nonmetallic clamps of a size to hold the conductors firmly in place. Nonmetallic straps or clamps shall not be used over engine(s), moving shafts, other machinery or passageways if failure would result in a hazardous condition. The material shall be resistant to oil, gasoline, and water and shall not break or crack under flexing within a temperature range of 34 °C (-30 °F) to 121 °C (250 °F).

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

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

Exception No. 2: Cables attached to outboard motors.

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

7-15 Wiring Connections.

7-15.1 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.

7-15.2 Wiring connections and terminals shall be specifically designed for use with stranded wire.

7-15.3 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 8-15.9 for the smallest conductor size used in the splice for a one-minute duration and not break.

7-15.4 Terminal connectors shall be the ring or captive spade types.

Exception: Friction type connectors may be used if:

(1) The voltage drop from terminal to terminal does not exceed 50 millivolts for a 20-amp 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 one minute.

7-15.5 Connections may be made using a set-screw pressure-type conductor connector providing a means is used to prevent the set screw from bearing directly on the conductor strands. Set-screw type conductor connectors without such means shall be used only on seven-strand conductors.

7-15.6 Twist-on connectors (wire nuts) shall not be used.

7-15.7 Solder shall not be the sole means of mechanical connection in any circuit.

Exception: Battery lugs with a solder contact length of not less than 1.5 times the diameter of the conductor.

7-15.8 Solderless crimp-on connectors shall be attached with the type of crimping tools designed for the connector used.

7-15.9 Each battery terminal post shall not be used for more than one conductor.

7-15.10 No more than four conductors shall be secured to any one terminal stud.

7-15.11 Ring and captive spade type terminal connectors shall be the same nominal size as the stud.

7-15.12 Conductors terminating at switchboards, in junction boxes or fixtures shall be arranged to provide a length of conductor to relieve tension, to allow for repairs and to permit multiple conductors to be fanned at terminal studs.

7-15.13 The shanks of terminals shall be protected against accidental shorting by the use of insulation barriers or sleeves, except for those used in grounding systems.

7-16 Receptacles.

7-16.1 Receptacles shall be installed in locations not normally subject to rain, spray or flooding. If receptacles are used in such areas, the following shall apply:

(a) Weatherproof if subject to rain or spray.

(b) Watertight if subject to flooding.

7-16.2 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.

7-17 Plug Connectors.

7-17.1 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 multi-wire 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 one minute.

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

8-1 General. The following practices and standards establish the requirement 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 Definitions.

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

Ground. Ground applies to the 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.

Ground-Fault Circuit-Interrupter. A device intended to interrupt the electric circuit to the load when a fault current to ground exceeds some predetermined value that is less than that required to operate the overcurrent protective device of the supply circuit.

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

NOTE: This may be referred to as the neutral (white) conductor in AC electrical systems.

Grounding Conductor (Green). A conductor, not normally carrying current, 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 design operating conditions:

(a) It will not ignite a flammable hydrocarbon mixture surrounding the device when an ignition source causes an internal explosion, or

(b) It is incapable of releasing sufficient electrical or thermal energy to ignite a hydrocarbon mixture, or

(c) The source of ignition is hermetically sealed.

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

NOTE 1: It is not the intention to require such devices to be "explosionproof" as that term is defined in the *National Electrical Code* of the NFPA pertaining to shore systems, or 46 CFR 110.15-65(e) of CG 259, Subchapter J-Electrical Engineering. It is intended that the protection provided be generally equivalent to that of wiring permitted by this standard wherein a definite short or break would be necessary to produce an open spark.

NOTE 2: Devices that are "explosionproof" are considered to be ignition-protected when installed with the appropriate fittings to maintain their "explosionproof" integrity.

NOTE 3: It is not the intention to require such devices to be "intrinsically safe" per Article 500 of the *National Electrical Code* of the NFPA or 46 CFR 111.80-5(a)(3) of CG 259, Subchapter J-Electrical Engineering.

NOTE 4: Devices that are "intrinsically safe" are considered to be ignition-protected.

Isolator. A device installed in series with the grounding (green) conductor of the shore-power cable to effectively block galvanic current flow but permit the passage of alternating currents (AC) normally associated with the grounding (green) conductor.

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 and/or distributing power on a boat. It may include devices such as circuit breakers, fuses, switches, instruments and indicators. Panelboards are intended to be installed in enclosures and may be accessible from the front or the rear.

Polarized System. A system in which the grounded

(white) and ungrounded conductors are connected in the same 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 the *National Electrical Code*, Article 555.

Pigtails. External conductors that originate within an electrical component or appliance.

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

Shore-Power Inlet. The fitting designed for mounting on the boat, of a reverse-service type, requiring a female connector on the shore-power cable in order to make the electrical connection.

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

Watertight. Enclosed so that equipment does not leak when a stream of water from a hose with a nozzle one inch in diameter that delivers at least 65 gallons per minute (246 lpm) is played on the enclosure from any direction from a distance of 10 feet (3.1 m) for 5 minutes.

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

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

8-3 Requirements — In General.

8-3.1 The system shall be polarized.

8-3.2 A grounded neutral system is required, but the neutral shall be grounded only at the power source, i.e., at the on-board generator, or the secondary of the isolation transformer, or through the shore-power connection.

8-3.3 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 is a separate source of electrical power.

8-3.4 Energized parts of electrical equipment shall be guarded against accidental contact by the use of enclosures or other protective means; these shall not be used for non-electrical equipment. Access to enclosures containing energized parts of the electrical system shall require the use of hand tools.

8-4 Marking.

8-4.1 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 informational elements shown in Figure 8-4.1 except item (3) is not required if a polarity indicator is not required.

8-4.2 Marking of Controls. All switches and controls shall be marked to indicate their usage, unless the purpose of the switch is obvious and if operation of the switch could not under normal operating conditions cause a hazardous condition.

Figure 8-4.1 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.

(4) Disconnect shore-power cable at shore-outlet first.

(5) Close shore-power inlet cover tightly.

DO NOT ALTER SHORE-POWER CABLE CONNECTORS.

8-4.3 Marking of Equipment. All electrical equipment shall be marked to indicate:

(a) Manufacturer's identification.

(b) Model number.

(c) Rating in volts and amperes or volts and watts.

(d) Phase identification if applicable.

(e) Ignition-protected if applicable.

8-5 System Voltage.

8-5.1 Nominal system-voltages for AC electrical systems shall be selected from the following:

120 volts AC, single phase

240 volts AC, single phase

120/240 volts AC, single phase

120/240 volts AC, delta three-phase

208Y/120 volts, three-phase

8-6 Ambient Temperature.

8-6.1 The ambient temperature of machinery spaces is considered to be 50 °C (122 °F) and of all other spaces is considered to be 30 °C (86 °F).

8-7 Ignition Source.

8-7.1 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 electrical component is isolated from a gasoline fuel source as described in 8-7.3.

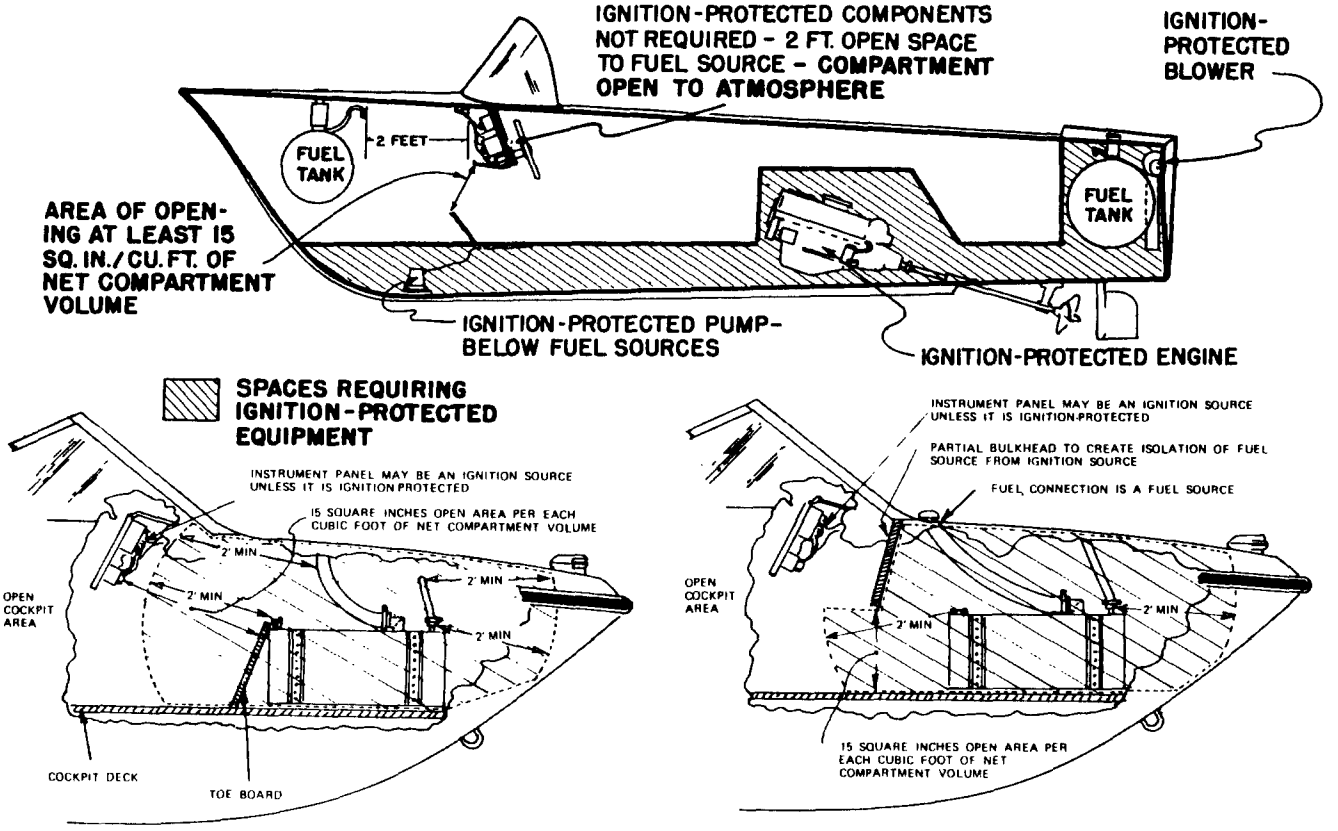
Exception: Boats using diesel fuel as the only fuel.

8-7.2 If LPG or CNG is provided on the boat, all unattended potential sources of ignition below the main deck shall be ignition-protected.

Exception: The ignition protection requirements will not be extended beyond those in 8-7.1 if all of the following conditions are met:

(a) Only one gas appliance is provided on the boat.

(b) The gas supply at the tank can be shut off by means of an automatic or manually operated control that is an integral part of, or is located in the vicinity of, the gas appliance. Manual controls shall have a warning light or warning device to indicate when the gas supply valve is open.



For SI Units: 1 ft = 3.05 × 10^{-1}; 1 sq in. = 6.45 × 10^{-4} m^2; 1 cu ft = 2.83 × 10^{-2} m^3

Figure 8-7.1

8-7.3 An electrical component is isolated from a fuel source if:

(a) A bulkhead that meets the requirements of 8-7.4 is between the electrical component and the fuel source;

(b) The electrical component is:

(1) Lower than the fuel source and a means is provided to prevent fuel and fuel vapors that may leak from the fuel sources from becoming exposed to the electrical component; or

(2) Higher than the fuel source and a deck or other enclosure is between it and the fuel source; or

(c) The space between the electrical component and the fuel source is at least 2 ft (.61 m) and the space is open to the atmosphere.

8-7.4 Each bulkhead shall:

(a) Separate the electrical component from the fuel source and extend both vertically and horizontally the distance of the open space between the fuel source and the ignition source; and

(b) Resist a water level that is 12 in. (.305 m) high or ⅓ of the maximum height of the bulkhead, whichever is less, without seepage of more than ¼ fluid ounce (7.4 × 10^{-6} m^3) of fresh water per hour; and

(c) Have no opening higher than 12 in. (.305 m) or ⅓ the maximum height of the bulkhead, whichever is less, unless the opening is used for the passage of conductors, piping, ventilation ducts, mechanical equipment, and similar items, or doors, hatches, and access panels; and the maximum annular space around each item or door, hatch or access panel must not be more than ¼ in. (.64 × 10^{-2} m).

8-8 Shore-Power Polarity Devices.

8-8.1 Reverse polarity indicating devices providing a continuous visible or audible signal shall be installed in 120 VAC shore-power systems, if:

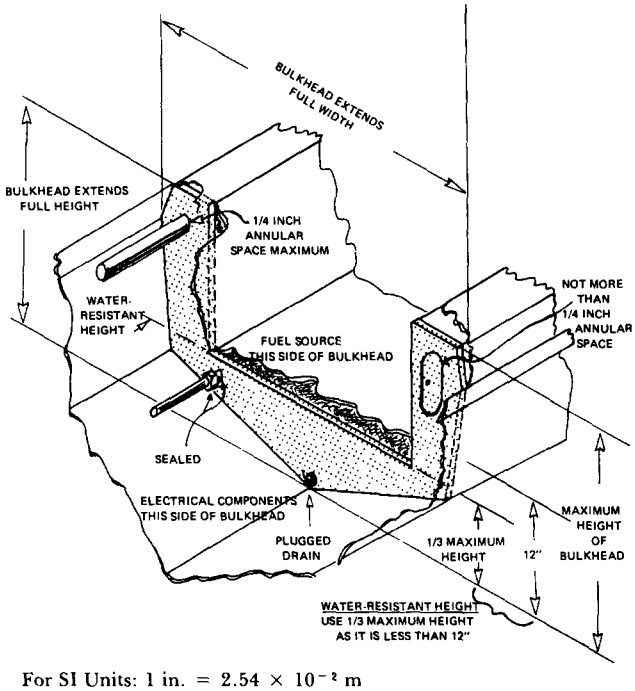
(a) The polarity of the system must be maintained for the proper operation of electrical devices in the system, or;

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

Exception: Systems with polarization or isolation transformers which establish the polarity of the on-board system.

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

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



For SI Units: 1 in. = 2.54 × 10^{-2} m

Figure 8-7.4

NOTE 1: Seepage of not more than ¼ fluid ounce per hour permitted below the water-resistant height. This includes bulkhead fastenings and space around hatches, doors, access panels, etc. and items passing through the bulkhead.

NOTE 2: Openings above the water-resistant height may not have more than ¼ in. (.64 × 10^{-2} m) annular space around items passing through the openings.

8-8.2 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.

8-8.3 Conductors shall be identified to indicate polarity according to Diagrams 8-8.3(1) through (9).

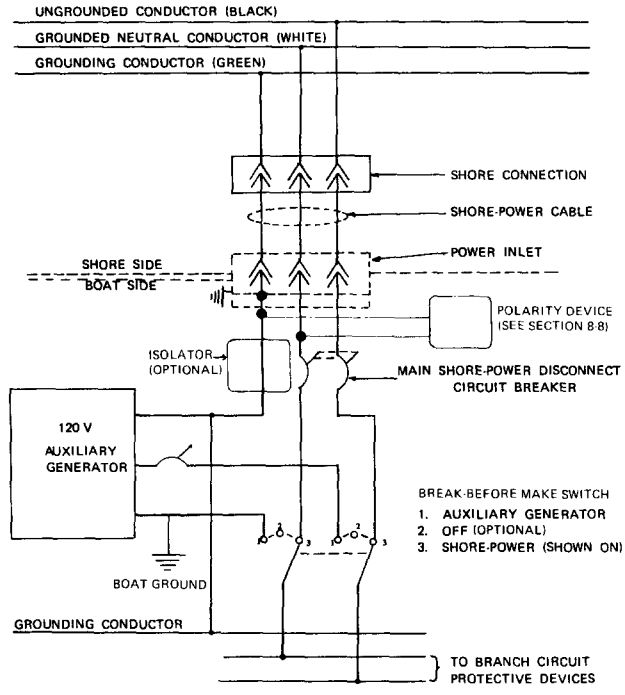
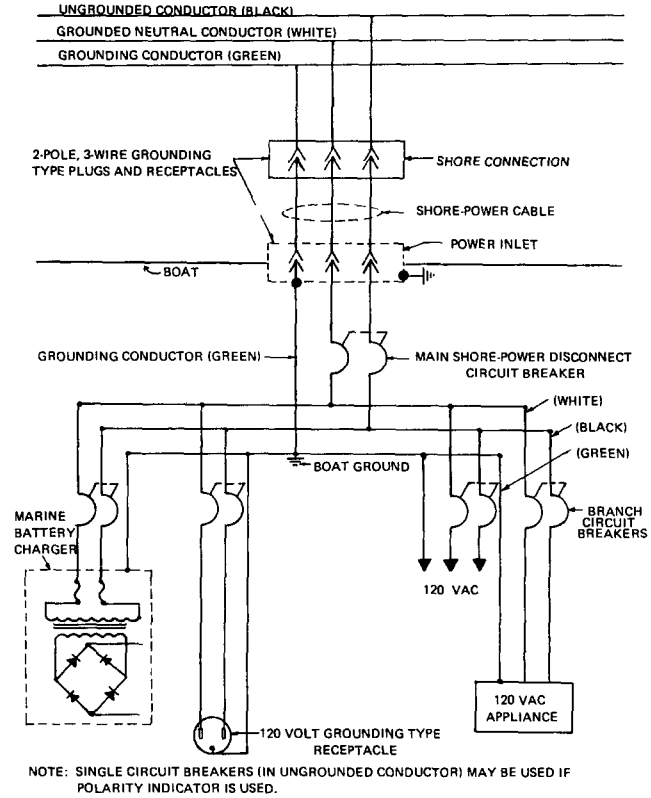


Diagram 8-8.3(1) Typical Single-Phase 120-Volt Auxiliary Generator

Shore-Power Selector Switch Circuit



NOTE: SINGLE CIRCUIT BREAKERS (IN UNGROUNDED CONDUCTOR) MAY BE USED IF POLARITY INDICATOR IS USED.

Diagram 8-8.3(2) Single-Phase 120-Volt System with Shore Grounded Neutral Conductor and Shore Grounding Conductor

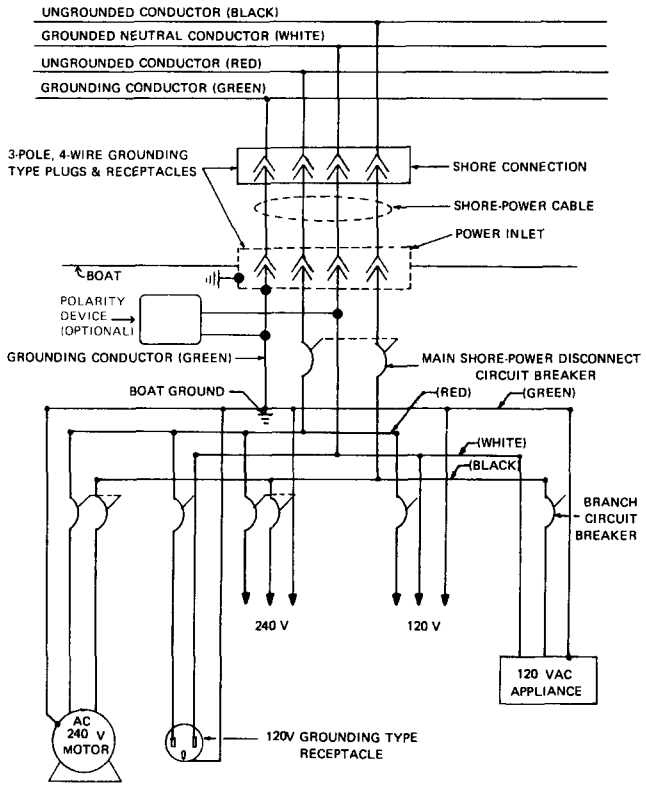


Diagram 8-8.3(3) Single-Phase 120/240-Volt System with Shore Grounded Neutral Conductor and Grounding Conductor

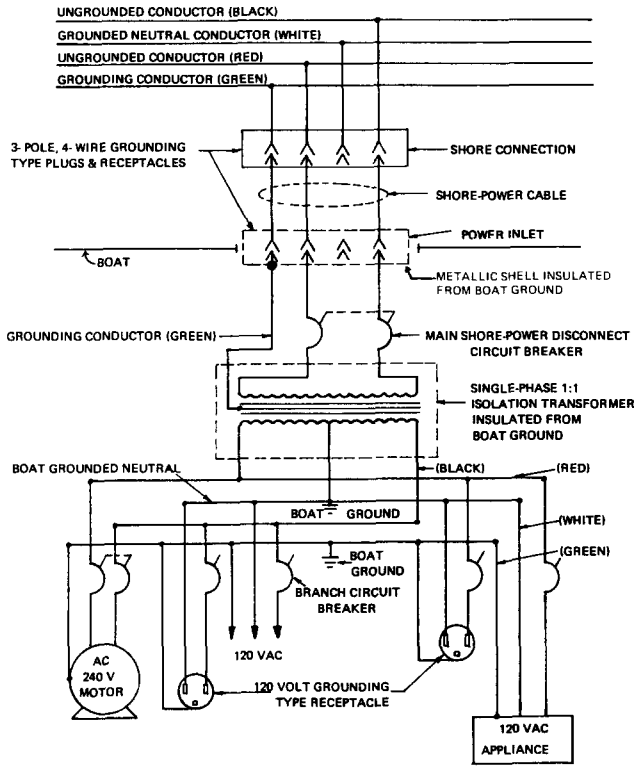


Diagram 8-8.3(5) Isolation Transformer System with Single-Phase 240-Volt Input and 120/240-Volt Single-Phase Output

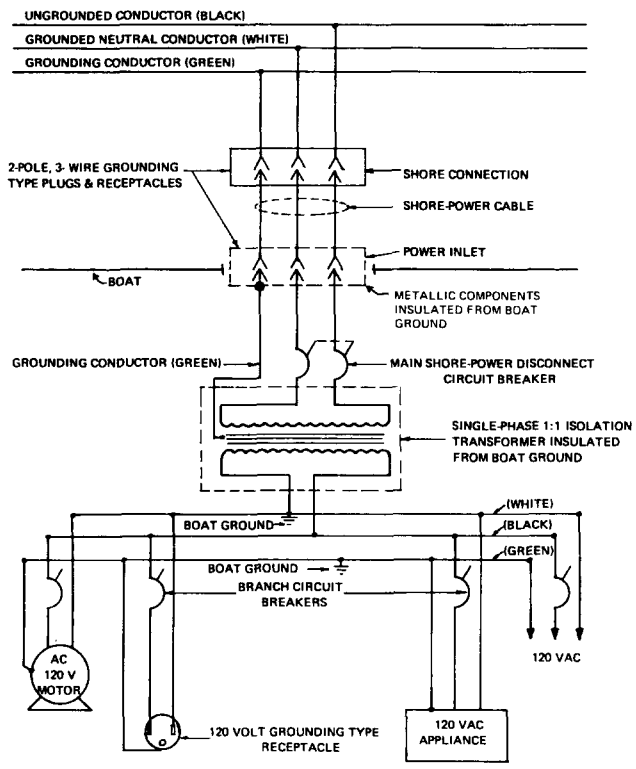


Diagram 8-8.3(4) Single-Phase 120-Volt Isolation Transformer System with Grounded Secondary

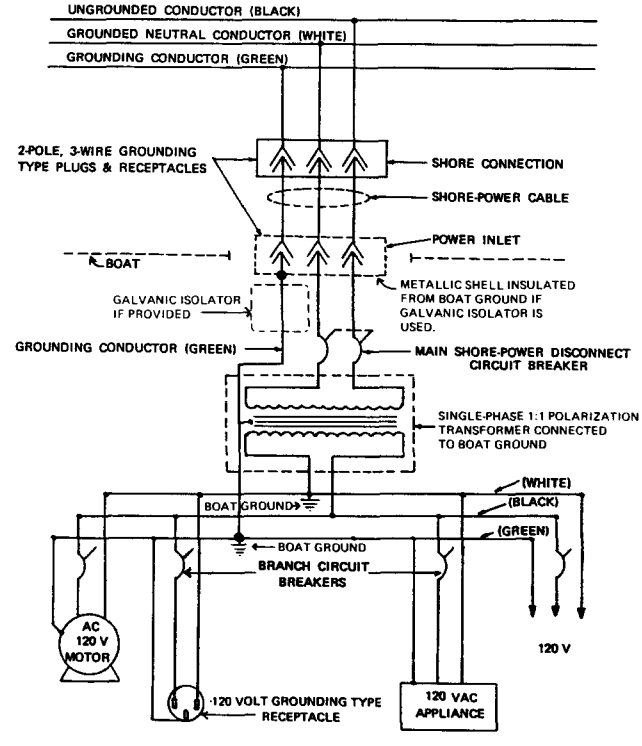


Diagram 8-8.3(6) Single-Phase 120-Volt Polarization Transformer System with Shore Grounding Wire Protection of Transformer Primary

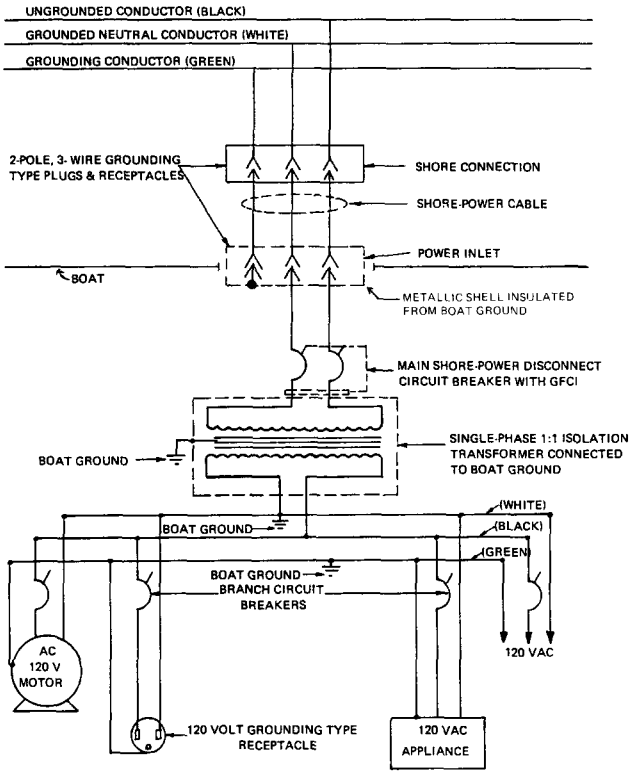


Diagram 8-8.3(7) Single-Phase 120-Volt Isolation Transformer System with GFCI Protection of Transformer Primary

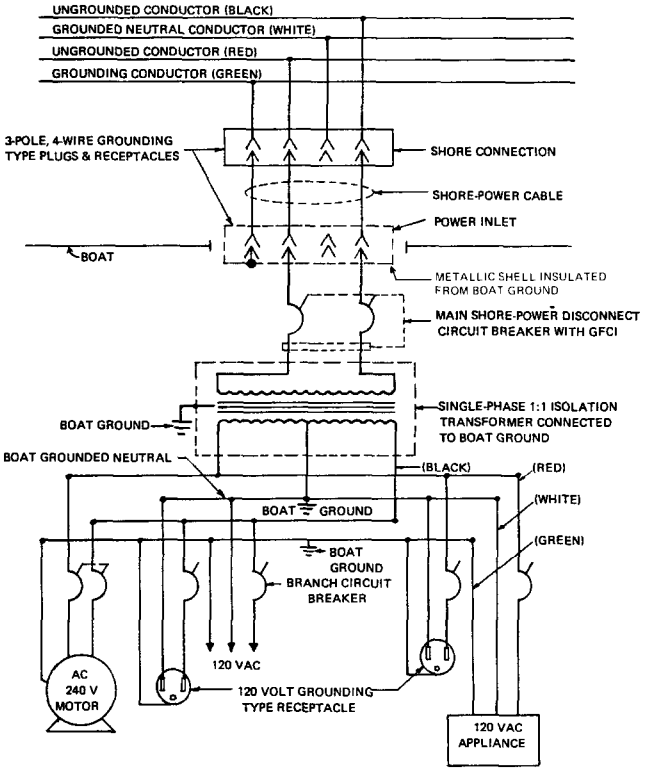


Diagram 8-8.3(8) Isolation Transformer System — Single-Phase 240-Volt Input and 120/240-Volt Single-Phase Output with GFCI Protection of Transformer Primary

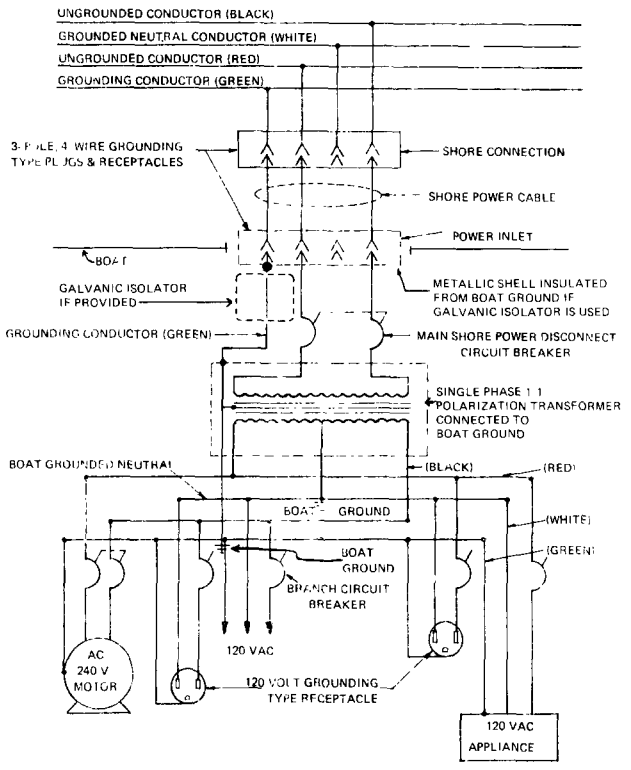


Diagram 8-8.3(9) Single-Phase Polarization Transformer System with Single-Phase 240-Volt Input and 120/240-Volt Single-Phase Output — Shore Grounding Protection of Transformer

8-9 Overcurrent Protection.

8-9.1 Rating of Overcurrent Protection Devices. Overcurrent protection devices shall have a temperature rating and demand load characteristics consistent with the protected circuit and their location in the boat, i.e., machinery space or other space. The rating of the overcurrent protection device shall not exceed the maximum current-carrying capacity of the conductor being protected.

8-9.2 Circuit Breakers. Circuit breakers shall:

(a) Meet the marine requirements of Underwriters Laboratories Inc. Standards UL 489, Molded Case Circuit Breakers and Circuit Breaker Enclosures; UL 1077, Supplementary Protectors for Use in Electrical Equipment; or UL 1133, Boat Circuit Breakers.

(b) Be of the trip-free type, and

(c) Be capable of an interrupting capacity at rated system voltage of at least 5000 amperes for main circuit breakers and at least 3000 amperes for branch-circuit breakers.

(d) Be of the manual reset type.

(e) Meet the requirements of UL 1500, Test Procedure for Ignition Protection or SAE J1171, External Ignition Protection of Marine Electrical Devices at 4 times their rated current if located in a space that requires ignition protection.

8-9.3 Fuses. Fuses shall:

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

(b) Be capable of an interrupting capacity at 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 198 for Class J, L, R, S or T fuses.

(d) Meet the requirements of UL 1500, Test Procedure for Ignition Protection or SAE J1171, External Ignition Protection of Marine Electrical Devices at 4 times their rated current if located in a space that requires ignition protection.

8-9.4 Fuse holders. Fuse holders shall meet the requirements of UL 512, Fuse Holders, for the class of fuse being used.

8-10 Main Supply.

8-10.1 Common-trip circuit breakers shall be provided in main supply conductors as follows:

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

240 volt AC, single phase — both ungrounded conductors

120/240 volt AC, single phase — both ungrounded conductors

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

120/208 volt AC, wye three-phase — all ungrounded conductors

8-10.2 If the main supply feeder from the shore-power inlet to the main circuit breaker is in excess of 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.

8-10.3 Overcurrent protection for AC generator power-feeders, if required, shall be within 7 in. (.18 m) of the output connection or may be within 40 in. (1.02 m) of the output connections if the unprotected insulated conductors are contained throughout their entire distance in a sheath or enclosure such as a conduit, junction box, control box, or enclosed panel.

8-11 Branch Circuits.

8-11.1 Branch Circuits. Each ungrounded conductor of a branch circuit shall be provided with overcurrent protection at the point of connection to the panelboard bus. Each circuit breaker or fuse used for this purpose shall be rated not to exceed the current rating of the smallest conductor between the fuse or circuit breaker and the load.

8-11.2 In branch circuits, circuit breakers and switches shall simultaneously open all grounded and ungrounded conductors.

Exception: In branch circuits, switches, circuit breakers, or fuses may open only the ungrounded current-carrying conductors in the circuit if:

(a) The wiring from shore-power inlets throughout the boat is polarized, including lighting fixtures, and a polarity indicator is installed to indicate the polarity of the feeder conductors between the shore-power inlets and main circuit breakers, or

(b) The neutral leg of the secondary of an isolation transformer is grounded.

NOTE: Fuses shall not be used in the grounded conductor.

8-11.3 If circuits contain two or more ungrounded current-carrying conductors which are protected by fuses, means shall be provided to disconnect all energized legs of the circuit simultaneously or remove all fuses from the circuit simultaneously.

8-11.4 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 may be integral and an automatic resetting type. Motors that will not overheat under locked rotor conditions are exempt from the above overcurrent protection.

8-11.5 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.

8-12 Ground-Fault Circuit-Interrupter.

8-12.1 Ground-fault circuit-interrupters (GFCIs) may be used on any single-phase AC circuit and shall be used for all receptacles in the head, galley, machinery spaces and on weatherdecks.

8-12.2 GFCI Breakers.

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

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

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

8-12.3 GFCI Receptacle Devices.

(a) GFCI receptacle devices shall meet the requirements of Underwriters Laboratories Inc. Standard UL 943, Ground Fault Circuit Interrupters and UL 498, Electrical Attachment Plugs and Receptacles.

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

8-12.4 Isolation Transformer Primary. GFCI circuit breakers may be installed as the main breaker on the primary side of isolation transformers.

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

8-13 Appliances and Equipment.

8-13.1 Appliances and fixed AC electrical equipment used on boats shall be designed so that the current-carrying parts of the device are effectively insulated from all exposed electrically conductive parts.

8-13.2 All exposed electrically conductive non-current-carrying parts of fixed AC electrical equipment, and appliances intended to be grounded shall be connected to the grounding system.

NOTE: If an appliance has a neutral-to-ground bonding strap, it must be removed.

8-13.3 Integral overcurrent protection may be provided.

8-14 Conductors and Flexible Cords.

8-14.1 Conductors shall have a minimum rating of 600 volts. Flexible cords shall have a minimum rating of 300 volts.

8-14.2 Conductors shall be selected from the types listed in Table 8-14.2.

8-14.3 Flexible cords shall be selected from the types listed in Table 8-14.3.

8-14.4 Conductors and flexible cords shall be stranded copper with circular mil area and stranding according to Table 8-14.4.

8-14.5 Conductor sizes, as determined by 8-14.4, shall not carry current greater than that indicated in Table 8-14.5 based on the temperature rating of the wire and the following derating factors:

(a) Conductors used in or routed through an engine space must be corrected in accordance with Note(1) of Table 8-14.5.

(b) Current-carrying conductors which are bundled shall be derated in accordance with Note (2) of Table 8-14.5.

8-14.6 Conductors shall be at least No. 16 AWG.

8-14.7 All conductors shall meet the applicable standards of Underwriters Laboratories Inc. and shall be so labeled.

Table 8-14.2 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 STYLE NOS: 1230 1231 1275 1276	Moisture-, Heat- and Oil-Resistant, Thermoplastic, Thermosetting 1329 1338 3403 1335 1339 1336 1340 1337 1345	105°C (221°F)
UL 1426	Boat Cable	(See UL 1426)

Table 8-14.3 Flexible Cords

Type	Description	Insulation Temperature Rating	Application
SO	Hard Service Cord – Oil-Resistant Compound	60°C (140°F)	General Use except for machinery space
		75°C (167°F) & higher	General Use
ST	Hard Service Cord – Thermoplastic	60°C (140°F)	General Use except for machinery space
		75°C (167°F) & higher	General Use
STO	Hard Service Cord – Oil-Resistant Thermoplastic	60°C (140°F)	General Use except for machinery space
		75°C (167°F) & higher	General Use
SJO	Junior Hard Service Cord – Oil-Resistant Compound	60°C (140°F)	General Use except for machinery space
		75°C (167°F) & higher	General Use
SJT	Junior Hard Service Cord – Thermoplastic	60°C (140°F)	General Use except for machinery space
		75°C (167°F) & higher	General Use
SJTO	Junior Hard Service Cord – Thermoplastic	60°C (140°F)	General Use except for machinery space
		75°C (167°F) & higher	General Use

Table 8-14.4 Conductor Circular Mil (cm) Area and Stranding

Conductor Size AWG	Nominal CM Area	Minimum Acceptable CM Area[1]	Minimum Number of Strands Type 1*	Type 2**	Type 3***
18	1,620	1537	7	16	-
16	2,580	2336	7	19	26
14	4,110	3702	7	19	41
12	6,530	5833	7	19	65
10	10,380	9343	7	19	105
8	16,510	14810	7	19	168
6	26,240	25910	-	37	266
4	41,740	37360	-	61	420
2	66,360	62450	-	127	665
1	83,690	77790	-	127	836
1/0	105,600	98980	-	127	1064
2/0	133,100	125100	-	127	1323
3/0	167,800	158600	-	259	1666
4/0	211,600	205500	-	418	2107

*Type 1 Conductors with Type 1 stranding shall be used only where the wire is firmly attached to a rigid structure and is not subject to movement or vibration.

**Type 2 Conductors with Type 2 stranding shall be used for central wiring which is subject to some movement from vibration or minor flexing.

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

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

[1]Applies only to systems under 50 volts.

Table 8-14.5 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°F)	105°C (221°F)	125°C (257°F)	200°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:

	Correction Factor
3	0.70
4 to 6	0.60
7 to 24	0.50
25 and above	0.40

8-15 Installation.

8-15.1 All connections normally carrying current shall be made in enclosures whose interior surfaces have a flame spread rating of not more than 25.

8-15.2 All conductors shall be supported and/or clamped to relieve strain on connections.

8-15.3 Junction boxes, cabinets and other enclosures in which electrical connections are made shall be weatherproof or installed in a protected location to minimize the entrance or accumulation of moisture or water within the boxes, cabinets or enclosures. In wet locations, metallic boxes, cabinets or enclosures shall be mounted to minimize the entrapment of moisture between the box, cabinet or enclosure and the adjacent structure. If air spacing is used to accomplish this, the minimum shall be ¼ in. (6 mm).

8-15.4 Unused openings in boxes, cabinets and weatherproof enclosures shall be closed.

8-15.5 Current-carrying conductors shall be routed as high as practicable above the bilge water level and other areas where water may accumulate. If conductors must be routed in the bilge or other areas where water may accumulate, the wiring shall be a submersible type and connections shall be watertight.

8-15.6 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. (.051 m) between conductors and water-cooled exhaust components and a clearance of at least 9 in. (.23 m) between conductors and dry exhaust components shall be maintained. Directly above a dry exhaust the clearance shall be increased to 18 in. (.46 m). Conductors which may be exposed to physical damage shall be protected by loom, conduit, tape, raceways or other equivalent protection. The protection should be self-draining. Conductors passing through bulkheads or structural members shall be protected to minimize insulation damage such as chafing. Conductors should also be routed clear of sources of chafing such as steering cable and linkages, engine shafts and throttle connections.

8-15.7 Conductors shall be supported throughout their length or, alternatively, shall be secured at least every 18 in. (.46 m) 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 would result in a hazardous condition. The material shall be resistant to oil, gasoline, and water and shall not break or crack under flexing within a temperature range of -34 °C (-30 °F) to 121 °C (250 °F).

(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 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 or water.

8-15.8 All permanently installed appliances and utilization equipment shall be securely mounted to the boat's structure.

8-15.9 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.

Table 8-15.9 Tensile Test Values for Connections

Conductor Size Gage	Tensile Force Pounds/Newtons		Conductor Size Gage	Tensile Force Pounds/Newtons	
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

(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 8-15.9 for the smallest conductor size used in the splice for a one-minute duration and not break.

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

Exception: Friction type connectors may be used on components if:

(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 amp 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 one minute.

8-15.10 Connections may be made using a set-screw pressure-type conductor connector providing a means is used to prevent the set screw from bearing directly on the conductor strands. Set-screw-type conductor connectors without such means shall be used only on seven strand conductors.

8-15.11 Twist-on connectors (wire nuts) shall not be used.

8-15.12 Solder shall not be the sole means of mechanical connection in any circuit.

8-15.13 Solderless crimp-on connectors shall be attached with the type of crimping tools designed for the connector used.

8-15.14 No more than four conductors shall be secured to any one terminal stud. If additional connections are necessary, two or more terminal studs shall be connected together by means of jumpers or copper straps.

8-15.15 Ring and captive spade type terminal connectors shall be the same nominal size as the stud.

8-15.16 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.

8-15.17 The shanks of terminals shall be protected against accidental shorting by the use of insulation barriers or sleeves, except for those used in grounding systems.

8-16 Receptacles.

8-16.1 Receptacles should be installed in locations not normally subject to rain, spray or flooding, but if receptacles are used in such areas, the following shall apply:

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

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

8-16.2 Receptacles shall be of the grounding type with a terminal provided for the grounding (green) conductor as shown in ANSI C73.

8-16.3 Receptacles and matching plugs used on AC systems shall not be interchangeable with receptacles and matching plugs used on DC systems.

8-16.4 Power wiring for receptacles shall be connected so that the grounded (white) conductor attaches to the terminal identified by letter(s) or a light color (normally silver). The ungrounded conductor(s) shall be attached to the terminal identified by letter(s) or a dark color (normally brass or copper).

8-16.5 A branch circuit supplying a combination of receptacle loads and permanently connected loads shall not supply fixed loads in excess of the following:

600 watts for a 15 ampere circuit

1000 watts for a 20 ampere circuit.

8-16.6 Receptacles provided for the galley shall be located so appliance cords may be plugged in without crossing a traffic area, galley stove or sink.

8-16.7 If installed in a head, galley, machinery space or on a weather deck the receptacle shall be protected by a Type A (nominal 5 milliamperes) Ground-Fault Circuit-Interrupter (GFCI).

8-16.8 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 the circuits supplying receptacles.

8-17 Main Panelboard.

8-17.1 A main panelboard shall be installed in a readily accessible location, shall be weatherproof or protected from the weather and splash and may serve as a distribution center.

8-17.2 Panelboards shall be permanently marked with the system voltage and either "VAC" or system frequency.

Example: 120 VAC or 120V-60 hertz

8-17.3 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.

8-17.4 A system voltmeter shall be installed if:

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

(b) An on-board generator is installed.

8-18 AC Generator.

8-18.1 AC generators shall be connected to the electrical distribution system through a selector switch in accordance with 8-3.3.

8-18.2 The power feeders from the AC generator shall be sized to at least accommodate the generator's maximum rated output and shall be protected at the generator with overcurrent protection devices in accordance with Section 8-9. The rating of these overcurrent protection devices shall not exceed 120 percent of the generator rated output.

Exception: Self-limiting generators, whose maximum overload current does not exceed 120 percent of their rated current output, do not require additional external overcurrent protection.

8-19 Isolation of Galvanic Currents.

8-19.1 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 8-23.4 or 8-23.7 or an isolator in the grounding conductor in accordance with 8-19.2.

8-19.2 The isolator shall: [*see Diagram 8-8.3(1).*]

(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 (6.35-m) length of shore 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.

8-20 Shore-Power.

8-20.1 Power Inlet. The receptacle, or receptacles, installed to receive a connecting cable to carry AC shore-power aboard shall be a male-type connector.

(a) Power inlets installed in locations subject to rain, spray or splash shall be weatherproof as may be provided by a spring-loaded, self-closing cover, the integrity of which is not 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 a watertight design as may be provided by a threaded, gasketed cover.

(c) See Figure 8-4.1 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 8-8.3(4), (5), (6), (7), (8) and (9).

8-21 Shore-Power Cable. Boats with an AC electrical system(s) intended to use shore-power provided in accordance with Article 555 of the *National Electrical Code* and NFPA 303, *Standard for Marinas and Boatyards*, shall be provided with a shore-power cable that:

(a) Is provided with a shore connection that is a male locking and grounding type which conforms to ANSI C73 and Article 555 of the *National Electrical Code.*

(b) Is provided with a female boat connection of the locking and grounding type that conforms to ANSI C73.

(c) Has a minimum length of 25 ft (6.35 m) and a maximum length of 50 ft (12.7 m) and meets the marine requirements of UL 817, Standard for Cord Sets and Power Supply Cords.

8-22 Devices Employing Isolation Transformers.

8-22.1 Devices employing isolation transformers, such as battery chargers, may be connected directly to the shore conductors or to the secondary of the system isolation transformer.

8-23 Application of Types of Shore-Power Circuits.

8-23.1 Single-Phase 120-Volt System with Shore-Grounded Neutral and Shore Grounding Conductor. This system, wired in accordance with the basic circuit in Diagram 8-8.3(2), may be used on any nonmetallic-hulled boat with underwater hardware of metal alloys which are at least as galvanically noble as manganese bronze. This system may also be used with metal-hulled boats if protection against galvanic corrosion is provided by means of a cathodic protection system or a galvanic isolator is used.

8-23.2 Single-Phase 120/240-Volt System with Shore-Grounded Neutral and Shore Grounding Conductor. This system, wired in accordance with the basic circuit in Diagram 8-8.3(3), may be used on any nonmetallic-hulled boats with underwater hardware of metal alloys which are at least as galvanically noble as manganese bronze. This system may also be used with metal-hulled boats if protection against galvanic corrosion is provided by means of a cathodic protection system or a galvanic isolator is used.

8-23.3 Single-Phase 120-Volt Primary and Secondary Isolation Transformer System. With shore grounding protection of transformer core, this system, wired in accordance with the basic circuit in Diagram 8-8.3(4), may be used with any metallic or nonmetallic-hulled 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 is grounded on the boat.

8-23.4 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 in Diagram 8-8.3(5), may be used with any boat and shall be used on all metal-hulled 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 is grounded on the boat establishing a new neutral for the boat system.

8-23.5 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 in Diagram 8-8.3(6), may be used on any nonmetallic-hulled boat with underwater hardware of metal alloys which are at least as galvanically noble as manganese bronze. This system may also be used with metal-hulled boats, if protection against galvanic corrosion is provided by means of a cathodic protection system or a galvanic isolator is used. The transformer secondary is grounded on the boat.

8-23.6 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 in Diagram 8-8.3(7), shall be used with any metallic or nonmetallic hulled boat. The metallic shell of the shore-power inlet shall be insulated from contact with any boat ground. The transformer secondary is grounded on the boat.

8-23.7 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 in Diagram 8-8.3(8), may be used with any metallic or nonmetallic hulled 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 is grounded on the boat, establishing a new neutral for the boat system.

8-23.8 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 in Diagram 8-8.3(9), may be used on any nonmetallic hulled boat with underwater hardware of metal alloys which are at least as galvanically noble as manganese bronze. This system may also be used with metal hulled boats if protection against galvanic corrosion is provided by means of a cathodic protection system or a galvanic isolator is used. The center leg of the transformer secondary is grounded on the boat establishing a new neutral for the boat system.

Chapter 9 Fire Protection Equipment

9-1 General Requirements.

9-1.1 Portable fire extinguishers shall meet the requirements of and be inspected and maintained in accordance with NFPA 10 and shall be U.S. Coast Guard approved.

9-2 Equipment.

9-2.1 All boats shall be equipped with portable fire extinguishers at least to the extent of the minimum requirements of Tables 9-2.1(a) and (b) and the requirements of this section.

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 of the length of the boat or 33 ft (10 m), whichever is less, to reach an extinguisher.

9-2.2* All inboard-powered boats with the engine compartment enclosed shall have provisions for discharging the extinguishing agent directly into the space immediately surrounding the engine without opening the primary access. Where portable equipment is to be used, a small, suitably labeled, readily accessible port to the enclosure shall be provided which allows the extinguisher to remain upright during discharge.

Exception: If the access port cannot be positioned so as to permit the portable extinguisher to remain upright the port shall be positioned low or in a horizontal surface providing the portable extinguisher is equipped with a discharge hose.

9-2.2.1 If the above extinguisher is portable and readily removable from its fixed mounting, it may also be credited as one of the extinguishers required in Table 9-2.1.

Table 9-2-1(a) Number and Distributions of Fire Extinguishers

Type of Boat	Class of Extinguishers	Minimum Required	Recommended Locations
Open boats under 16 ft	B-I	1	Helmsman's position
Open boats over 16 ft	B-I	2	Helmsman's position and passenger space
Boats under 26 ft	B-I	2	Helmsman's position and cabin[4]
Boats 26-40 ft	B-I	3	Engine compartment, helmsman's position, and cabin [3,4]
Boats 40 65 ft	B-I	4	Engine compartment, helmsman's position, crew quarters, and cabin [3,4]
Boats 65-75 ft	B-I	5	Engine compartment, helmsman's position, crew quarters, and cabin [3,4]
Boats 75-100 ft	B-I	6	Engine compartment, helmsman's position, crew quarters, and cabin [3,4]

For SI Units: 1 ft = 3.048×10^{-1} m

Notes to Table 9-2.1:

[1]One of the required extinguishers shall additionally have the capability of extinguishing Class A fires.

[2]If more than three B-I units are required, the extinguishing capacity may be made up of a smaller number of larger units, provided each recommended location is protected with an extinguisher readily accessible, e.g., 3 B-II units may be used in lieu of 4, 5, or 6 of the smaller B-I units.

[3]Extinguishers recommended for "engine compartment" shall not be located inside such compartment but near an entrance to the compartment unless someone is normally present in the compartment.

[4]On boats having galley stoves, one of the required extinguishers of suitable types shall be readily accessible thereto.

Table 9-2-1(b)
Minimum Supplemental Requirements for Vessels Propelled by Machinery Over 65 Feet

Gross Tonnage Over	Gross Tonnage Not Over	Minimum Number of B-II Portable Fire Extinguishers
	50	1
50	100	2
100	500	3
500	1000	6
1000	—	8

NOTE 1: In addition to the above hand portable fire extinguishers, ONE B-II hand portable fire extinguisher shall be carried on board for each 1000 brake horsepower (BHP) of main engines or fraction thereof. However, not more than SIX such B-II extinguishers need be carried.

NOTE 2: Vessels over 300 gross tons must carry either ONE B-III semi-portable fire extinguisher or an approved fixed fire extinguishing system installed in the machinery space.

9-2.3* Fixed Systems.

9-2.3.1 Systems can be manually and/or automatically operated. Carbon dioxide systems which are installed to protect accommodation compartments or to protect engine compartments which can be normally occupied shall be equipped with a predischarge alarm.

9-2.3.2 If spaces are connected, such spaces shall be considered as one in determining the capacity of the system. In determining the degree of connecting spaces the require-

ments of 2-3.4 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.

9-2.3.3* If a manual or manual/automatic fixed system is used in lieu of one required portable extinguisher, the system shall be in accordance with the manufacturer's U.S. Coast Guard approved instructions manual and NFPA 12, 12A or 12B as appropriate and shall incorporate a visible or audible means outside of the protected space indicating that the system has discharged.

9-3 Installation.

9-3.1 Portable fire extinguishers shall be placed so that they are readily accessible from outside the compartment which they are intended to serve.

9-3.1.1 Extinguishers shall be secured with a marine bracket to permit immediate release.

9-3.2* Fixed extinguishing systems shall be installed in accordance with the manufacturer's installation procedures and with NFPA 12, 12A or 12B as appropriate.

9-3.2.1 Extinguishing agent cylinders shall be mounted a minimum of 2 in. (.051 m) above moist or wet surfaces to reduce danger of corrosion.

9-3.2.2* Manual controls shall be placed so they are readily accessible outside the spaces served by the systems.

9-3.2.3 Systems shall be designed for one of the following modes of application (*see 9-2.3.2*).

(a) Independent systems installed to cover the various unconnected protected spaces.

(b) Single system of sufficient capacity to flood all protected spaces simultaneously.

(c) Single system of sufficient capacity for the largest protected space, distributed to the selected space by valves at the controls.

Chapter 10 Referenced Publications

10-1 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.

10-1.1 NFPA Publications. National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

NFPA 10-1988, *Standard for Portable Fire Extinguishers*

NFPA 12-1989, *Standard on Carbon Dioxide Extinguishing Systems*

NFPA 12A-1987, *Standard on Halon 1301 Fire Extinguishing Systems*

NFPA 12B-1985, *Standard on Halon 1211 Fire Extinguishing Systems*

NFPA 52-1988, *Standard for Compressed Natural Gas Vehicular Fuel Systems*

NFPA 58-1989, *Standard for the Storage and Handling of Liquefied Petroleum Gases*

NFPA 70-1987, *National Electrical Code*

NFPA 255-1984, *Standard Method of Test of Surface Burning Characteristics of Building Materials*

NFPA 303-1986, *Fire Protection Standard for Marinas and Boatyards*

NFPA 701-1977, *Standard Method of Fire Tests for Flame-Resistant Textiles and Films.*

10-1.2 Other Publications.

10-1.2.1 AMCA Publication. Air Movement and Control Association, 30 W. University Drive, Arlington Heights, IL 60004.

AMCA 210-74, *Test Code of Air Moving Devices.*

10-1.2.2 ANSI Publication. American National Standards Institute, 1430 Broadway, New York, NY 10018.

ANSI C73-1973 (including supplement C73a-1980), *Dimensions of Attachment Plugs and Receptacles.*

10-1.2.3 SAE Publications. Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.

SAE Standard J378C-84, *Marine Engine Wiring*

SAE Standard J1127-80, *Battery Cable*

SAE Standard J1128-75, *Low-Tension Primary Cable*

SAE Standard J1171-86, *External Ignition Protection of Marine Electrical Devices*

SAE Standard J1428-85, *Marine Circuit Breakers.*

10-1.2.4 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062.

UL 489-86, *Molded Case Circuit Breakers and Circuit Breakers Enclosures*

UL 198C-86, *High-Interrupting Capacity Fuses, Current-Limiting Types*

UL 198E-82, *Class R Fuses*

UL 198F-88, *Plug Fuses*

UL 198H-82, *Class T Fuses*

UL 498-86, *Attachment Plugs and Receptacles*

UL 943-85, *Ground-Fault Circuit Interrupters*

UL 1077-87, *Supplementary Protection for Use in Electrical Equipment*

UL 1128-88, *Marine Blowers*

UL 1133-88, *Boat Circuit Breakers*

UL 1426-86, *Boat Cable*

UL 1500-82, *Ignition Protection Test for Marine Products.*

10-1.2.5 U.S. Government Publications. U.S. Government Printing Office, Superintendent of Documents, Washington, DC 20402.

Code of Federal Regulations, 46 CFR Parts 110-113

Code of Federal Regulations, 33 CFR Part 183