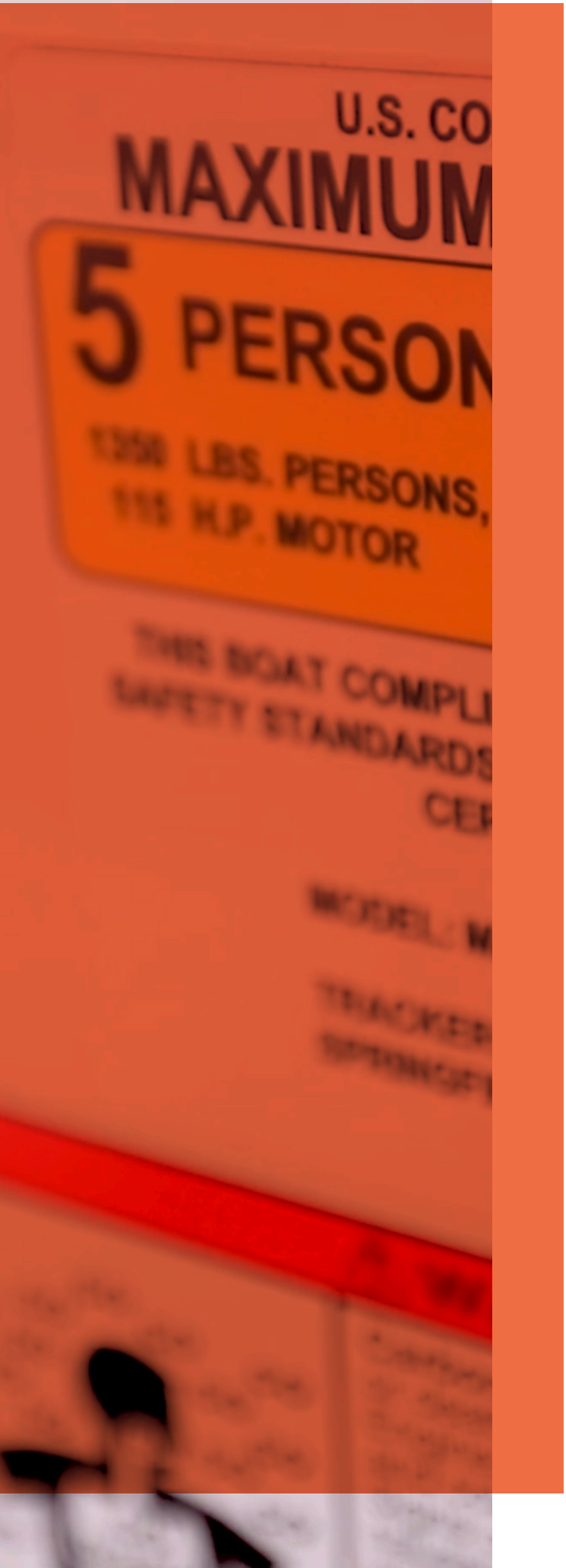


BOAT BUILDER'S HANDBOOK

2021 Edition

FUEL SYSTEMS

33 CFR 183 SUBPART J

Produced under a grant from the Sport Fish Restoration and Boating Trust Fund Administered by the U.S. Coast Guard.

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INTRODUCTION

There are many USCG requirements for the fuel system of gasoline-powered inboard boats. They can be found in 33 CFR Part 183 Subpart J.

There are two important considerations to keep in mind as you review these fuel systems compliance regulations.

1. Fuel system design improvements have in some cases made the CFR requirements obsolete – but the CFR regulations have not (yet) been updated.
2. The Environmental Protection Agency (EPA) has developed fuel system requirements to reduce emissions. Boatbuilders must also meet the applicable EPA regulations.

The EPA requirements are found in 40 CFR Parts 1045 and 1060. To make it easier for boatbuilders to understand and follow the combined the USCG Subpart J and EPA Part 1060 fuel system regulations, this fuel systems chapter inserts EPA rules in the appropriate subject paragraphs. To clarify which rules relate to USCG regulations and which to EPA regulations, the EPA rules are shown in blue ink.

TAKE HEED: Boatbuilder compliance means fully meeting all applicable regulations. The Boatbuilder's Handbook provides a basic introduction and summary of the regulations. Builders need to refer to the actual regulations for the complete text of the regulation to ensure full compliance. It is the boat manufacturer's responsibility to review, understand, and comply with all applicable regulations.

FORMAT

The format of this guideline has been chosen to follow the sequence in the fuel system regulation. This format provides a consistent sequence of information, thereby reducing confusion for the boatbuilders and component manufacturers who use it.

First, a section of the regulations will be stated in plain language – then the topic will be discussed in detail. Often a figure will be added to supplement the discussion. The section will identify the CFR cite; the full text of the regulation is readily available in Appendix 2.

Typical fuel systems are annotated to show the applicable section of the regulation. The systems shown are examples and are not intended to be limiting in any way. Both simpler and more complex systems may be installed on any of the depicted boats. Appendix 1 lists references and resources.

There have been many fuel system technical advances since this regulation was enacted in the 1970's. This guideline must still address the regulations as established, but also recognizes changes in fuel systems such as:

- Carburetors being replaced by fuel injection systems;
- In-tank fuel pumps;
- Special needs for high-pressure fuel systems;
- Changing fuel pump design;
- Fuel hose and fuel hose connection alternatives;
- Environmental Protection fuel system requirements.

1.0 APPLICABILITY

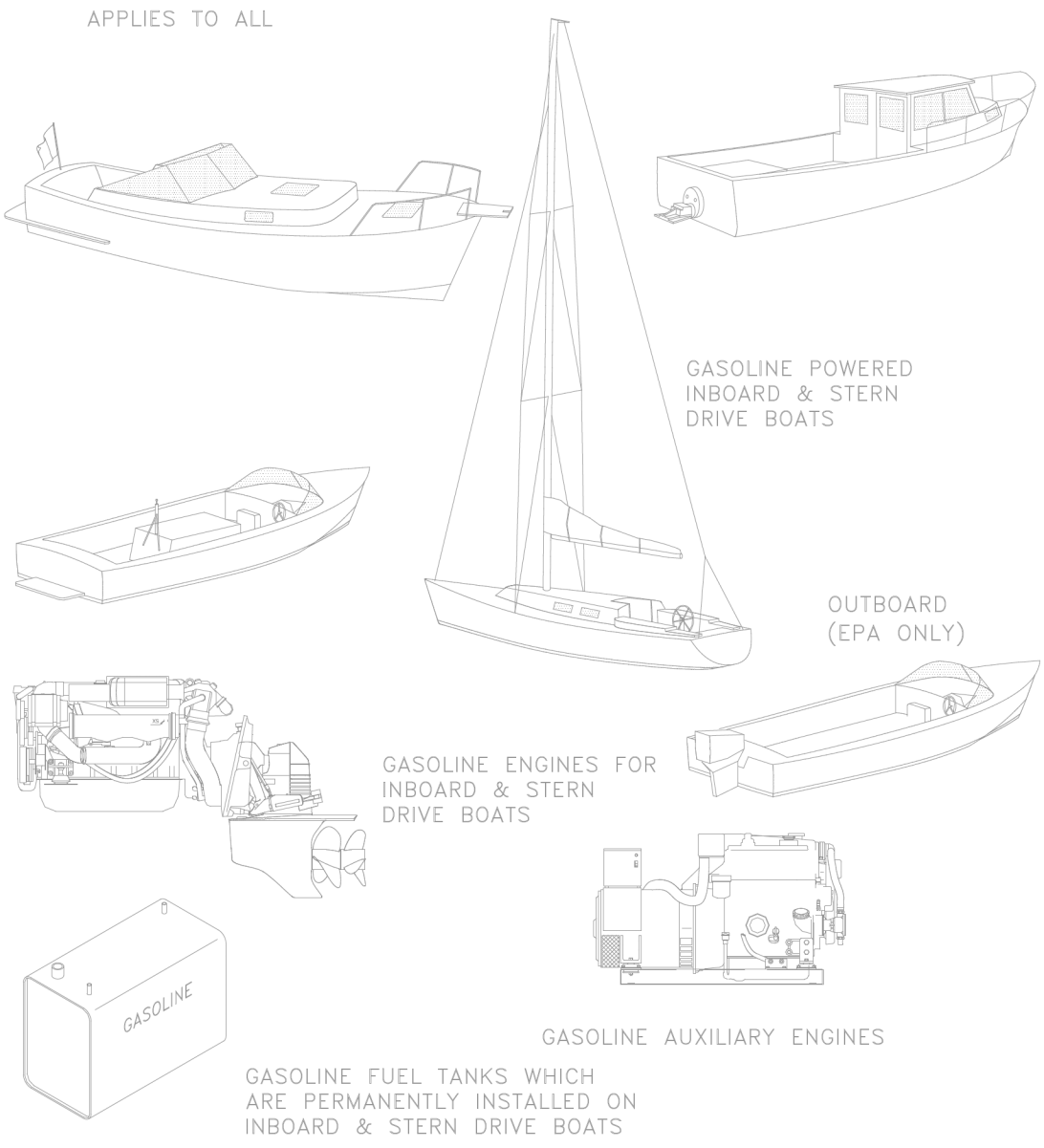
Per 183.501: The fuel systems regulation applies to all boats that have gasoline engines (except outboard engines) for electrical generation, mechanical power, or propulsion.

1060.1 EPA – What evaporative emission requirements apply under this part?
(a) The standards and other requirements in this part 1060 apply to the fuel lines, fuel tanks, couplings and fittings, and fuel caps used or intended to be used in the following categories of new engines and equipment that are fueled with a volatile liquid fuel (such as gasoline, but not including diesel fuel), and to the equipment in which these components are installed, starting with the model years shown in Table 1 to this section:

1045.1 Does this part apply for my products?

(2) The requirements of this part related to evaporative emissions apply to fuel lines and fuel tanks used with marine engines that use a volatile liquid fuel (such as gasoline) as specified in 40 CFR part 1045.112. This includes fuel lines and fuel tanks used with auxiliary marine engines. This also includes portable marine fuel tanks and associated fuel lines.

FIGURE 1 Applicability



Combined USCG and EPA Rules:

The USCG Boatbuilder's Handbook focuses on USCG regulations and safety standards. For fuel system considerations boatbuilders must also be aware of the Environmental Protection Agency (EPA) Evaporative Emissions Rules per 40 CFR 1060.

Additional fuel system design requirements come into play for:

- Fuel lines – regarding both permeation and required marking
- Fuel tanks – regarding both permeation and diurnal emissions
- Fuel fittings
- Fuel caps.

The key EPA rule relates to the control of evaporative emissions from 'non road' (i.e., boats) 'spark ignition engines' (i.e., gasoline powered) and equipment. Marine engine manufacturers and fuel system suppliers must meet the specific emission requirements; boatbuilders must ensure (and certify) that all the fuel system components (including the engines) are compliant.

Boatbuilders must affix an additional EPA compliance certification label affixed to the boat; by USCG policy, this statement is allowed to be included on the certification label. The USCG certification statement will be followed by: "MEETS U.S. EPA EVAP STANDARD USING CERTIFIED COMPONENTS"

The EPA rule applies to gasoline engines on inboards (& stern drives) and those for auxiliary power. The EPA rule applies to the fuel system fuel lines / fuel tanks / fittings / fuel caps on both inboard and outboard powered boats.

40 CFR 1060.102 covers permeation control requirements for FUEL LINES. The limit for hose permeation is 15 g/m2/day. Fuel hose marking are a combination of the USCG (USCG with hose type / year of manufacture / company name or logo) and EPA (EPA / permeation rate / company name or logo) rules.

For example: USCG: USCG Type A1 2021 LH
EPA marking: EPA – LH – A15
Combined : LH EPA USCG Type A1-15 2021

40 CFR 1060.103 covers permeation control requirements for FUEL TANKS. The limit of (both portable and installed) tanks is 1.5 g/m2/day. There will be additional information on fuel tank labels: "EPA COMPLIANT 1.5 g/m2/day"

40 CFR 1060.105 covers diurnal emission control requirements for FUEL TANKS. The emission is 0.40 g/gal/day.

Two primary means to meet the EPA diurnal emissions control requirements have been developed: carbon canister & pressure relief – to reduce the emission of fuel vapor produced during daily warming cycles. Figure 2b shows an EPA compliant system with a carbon canister.

> Per 183.507: Each component of the fuel system (on applicable type boats) must be compliant.

The boat manufacturer, not the manufacturer of each component, is required to certify each boat as complying with this regulation. Component parts of outboard engines and portable equipment, such as a portable self-contained gasoline engine generator unit, are not covered by these regulations.

The Equipment Standards of this regulation appear to impose requirements, and consequently certification responsibilities, on component manufacturers including inboard engine manufacturers. This is not the case. The boat manufacturer is responsible under these regulations and must certify compliance. Purchase orders can stipulate that component manufacturers provide affidavits of compliance that a boat manufacturer may choose to recognize as supporting evidence in certifying the entire fuel system.

2. DEFINITIONS

Section 183.505 lists definitions pertinent to the subject of fuel systems.

Flame Arrester. Flame arrester means a device or assembly that prevents passage of flame through a fuel vent.

A flame arrester for a fuel tank may be a specially designed fitting with flame arresting elements, such as screens, or the vent tubing may itself be effective. Air flows in both directions in the fuel tank vent. Outside air goes into the tank to equalize the pressure when gasoline is used in the engine and fuel vapor-laden air flows out of the tank through the vent when the tank is being filled. Ambient temperature changes also cause airflow in both directions. If the fuel vapor-laden air is ignited outside the fuel tank fittings or discharge point, the flame arrester is to prevent the flame from being propagated through the fuel tank vent into the fuel tank.

If it is intended to qualify a vent system without a specially designed fitting containing flame-arresting elements, it is recommended that extreme caution be exercised to assure safe conduct of any qualifying test.

Fuel System. Fuel system means the entire assembly of the fuel fill, vent, tank, and distribution components including pumps, valves, strainers, carburetors, filters, throttle body, and flame arresters.

A typical fuel system is diagrammed in Figure 2. Other fuel systems may contain more or fewer components, and may be of other materials as permitted under these conditions. Two or more engines in a boat will necessitate a more complicated system, which may include a number of fuel tanks with possible provisions for interconnection. Fuel transfer pumps may also be included in the fuel system.

Static Floating Position. Static floating position means the attitude in which a boat floats in calm water, with each tank filled to its rated capacity, but with no person or item of portable equipment on board.

This is to establish a standard measurement condition with respect to the attitude of the boat. This topic comes into play in various Fuel System sections - with respect to water accumulation on fuel tanks, anti-siphon protection, fuel leakage, and fuel fill overflow.

FIGURE 2a A Typical Fuel System

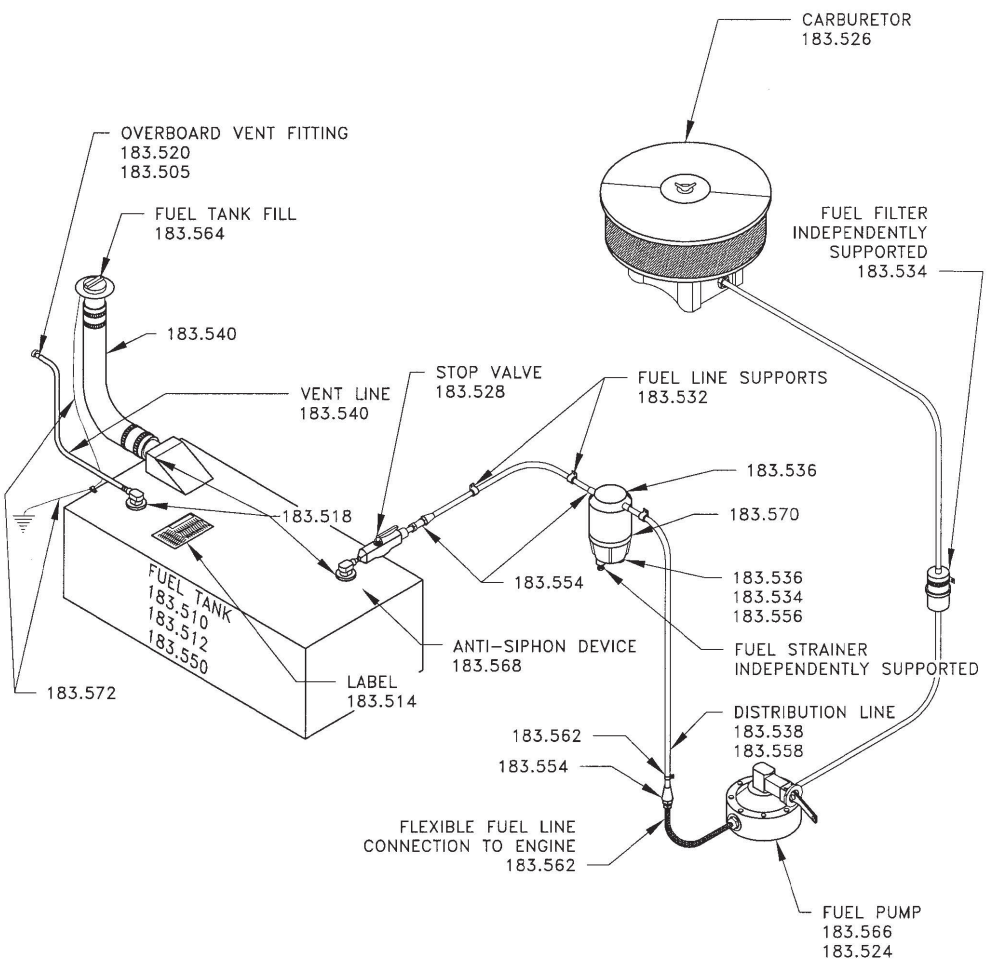


FIGURE 2b An EPA Compliant Fuel System

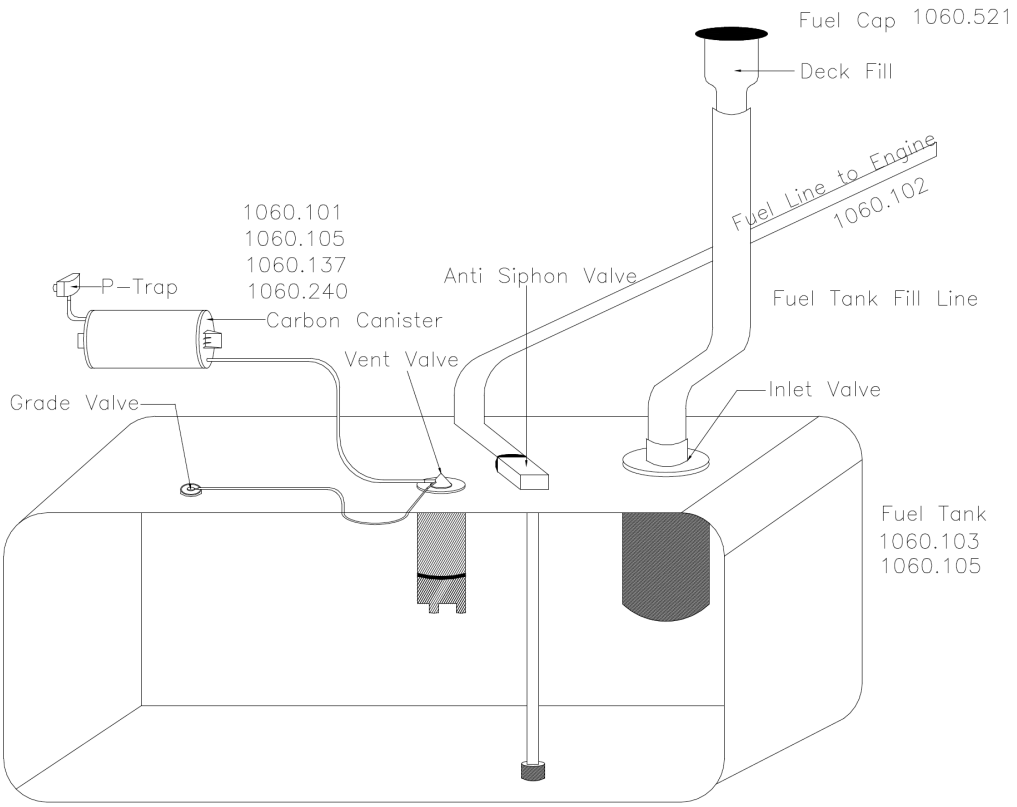
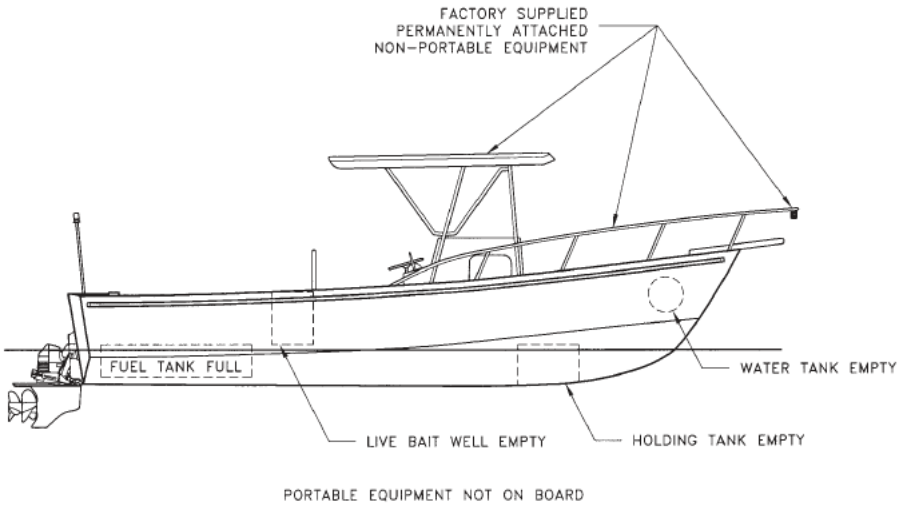


FIGURE 3 Static Float Position



3. EQUIPMENT STANDARDS

3.1 FUEL TANKS

Sections 183.510 through 183.520 cover fuel tank testing, materials, labels, openings, and vent systems.

> Per 183.510 (a) Fuel tank manufacturers need to have pressure tested each tank before installation in a boat.

3.1.1 FUEL TANK PRESSURE TEST

Each fuel tank must be tested to see if it leaks. This leakage test includes all fittings supplied as part of the tank.

The tank manufacturer will likely be the one to test the tank; the boatbuilder is the responsible party to certify compliance.

TEST PRESSURE
The test pressure must be the greater of 3 Pounds per square inch gauge (psig) or 1-1/2 times the pressure created at the lowest point in the fuel system when the fill or vent line, whichever is lower in height, is filled to its top with fuel, as indicated in 183.542. A 3 psig test will cover installations whose height from the lowest point in the fuel system is 6.4 feet to the lower of the fill or vent. See Figure 5 for height covered by various pressures. These heights refer to a head of gasoline and take into account the one and one-half times the head. The determined pressure is the minimum pressure that must appear on the fuel tank label. For the test procedure, refer to 183.580. Normally, the tank manufacturer who applies the tank label conducts the test. The boat manufacturer is responsible for determining that this test has been performed on the tank, in addition to the fuel system pressure test required by 183.542.

FIGURE 4 Fuel Tank Pressure

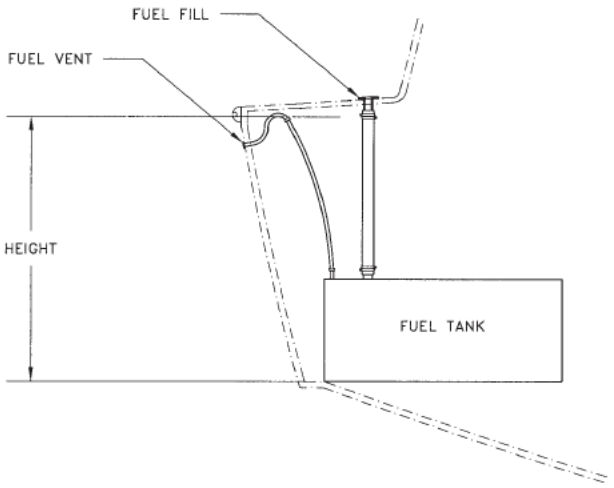
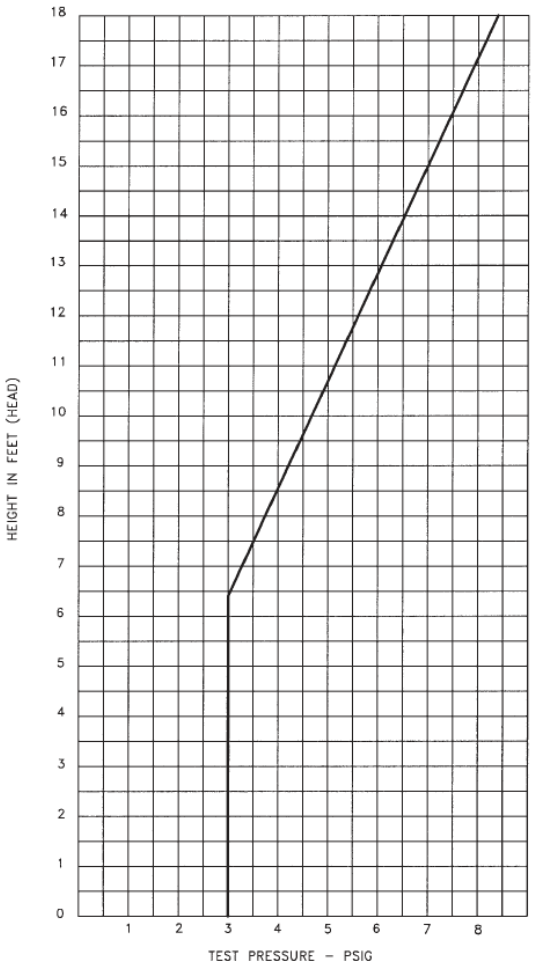


FIGURE 5 Pressure Versus Height



Per 183.510(b): Fuel tanks must not leak IF subjected to fire test.

Each fuel tank must be designed and constructed so that if selected to be fire tested according to one of the procedures of 183.590, it will not leak following the fire test when pressure tested to 0.25 pounds per square inch gauge (psig) in accordance with the test procedure described in 183.580.

Selection for a fire test may be made by the USCG in order to conduct a compliance check. A manufacturer may also select a representative tank and subject it to a fire test in order to assure compliance.

A wide range of fuel tank tests is covered in Section 4.8. Boatbuilders should note that the fuel tank pressure test is mandated – all the other fuel tank tests come with the caveat "IF" tested.

Per 183.510 (c) & (d) & (e): Small fuel tanks (< 25 gallons) must not leak IF shock tested; larger tanks (25 – 199 gallons) must not leak IF submitted to pressure impulse test; large fuel tanks (over 200 gallons) must not leak IF tested under the pressure impulse test or slosh test.

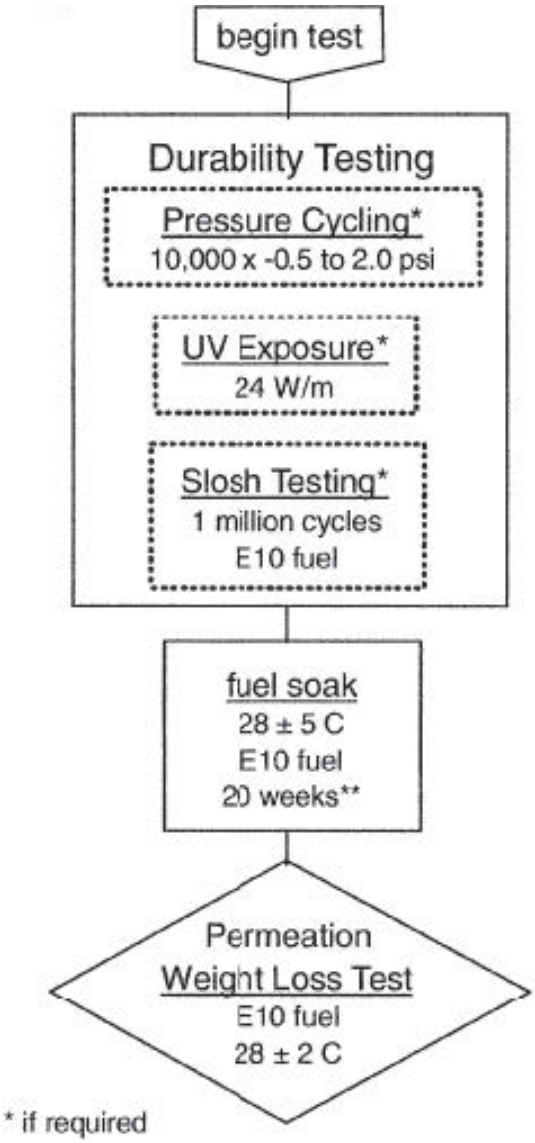
Each fuel tank less than 25 gallons capacity must be designed and constructed so that if selected to be shock tested according to the procedures of 183.584, it will not leak following the shock test when static pressure tested to the pressure marked on its label.

Each fuel tank with a capacity of 25 to 199 gallons must be designed and constructed so that if selected to be pressure-impulse tested according to the procedures of 183.586, it will not leak. To determine if it leaks, it shall be pressure tested to the pressure marked on its label, using the procedure described in 183.580.

Selection of a tank for a pressure-impulse test may be made by the USCG in order to conduct a compliance check. A manufacturer may also select a representative tank and subject it to a pressure- impulse test in order to assure compliance. This test has proven to be quite effective in finding weak spots in the tanks. It has been found to be effective for plastic tanks.

Each fuel tank with a capacity of 200 gallons or more must be designed and constructed so that it will not fail if subjected to both the pressure-impulse and slosh tests according to procedures of 183.586 and 183.588 respectively. It will not leak when pressure tested to the pressure marked on its label following the pressure-impulse test and the slosh test.

1060.520 EPA – How do I test fuel tanks for permeation emissions



Follow the testing procedure as outlined in the 1060 CFR part 520. This is generally carried out by an independent laboratory, however, it can be completed by the tank manufacturer.

3.1.2 PROHIBITED FUEL TANK MATERIALS

> Per 183.512 (a) & (b) & (c): Certain materials must not be used to make boat fuel tanks. Do not use terneplate to build a fuel tank; do not use black iron or carbon steel with organic coating to build a fuel tank; do not use a ferrous alloy to build a fuel tank if it is encased in cellular or fiber reinforced plastic.

Terneplate. Terneplate is a steel that has been coated with a lead-tin alloy. Since the lead-tin alloy is cathodic relative to steel, the steel, in the presence of an electrolyte such as salt water, can corrode galvanically, weakening the tank's structure.

Permanently installed terneplate fuel tanks are prohibited for use as fuel tanks on boats with inboard gasoline engines.

Organic Coating on Steel. An inorganic sacrificial galvanic coating is a treatment applied to steel that combines the steel base metal with a surface of another metal, such as zinc and aluminum, which are anodic to the base metal. Such materials are known as "hot-dipped galvanized steel" and "aluminized steel."

Organic materials may not be used. Organic materials include paints, resins, epoxy coatings, metallic paints, etc.

Ferrous Alloy. A ferrous alloy is a metal containing the chemical element iron as one of its major components. Materials such as black iron, carbon steel, galvanized steel, aluminized steel, terneplate and stainless steel are all examples of ferrous alloys.

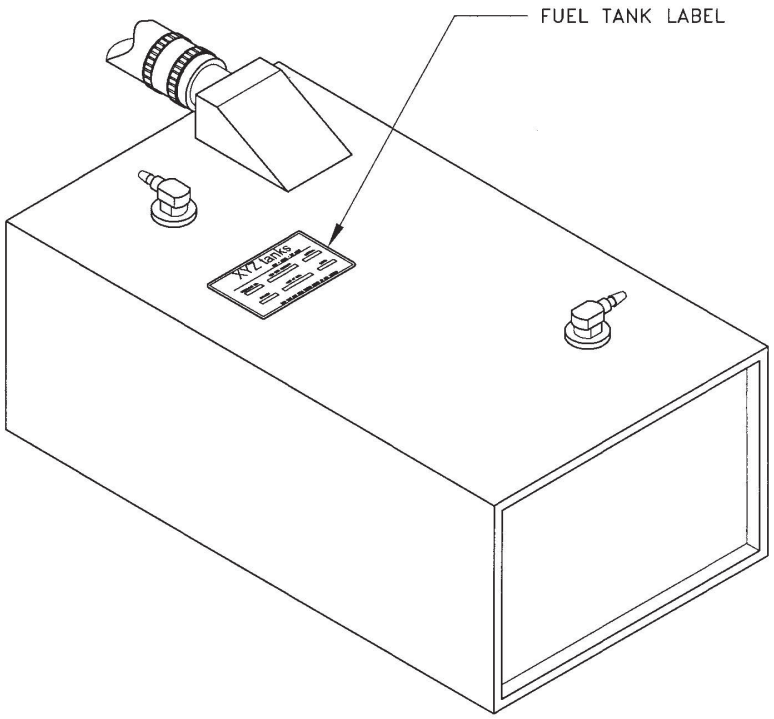
Cellular plastic (foam) and/or fiber-reinforced plastic (fiberglass) may not be used to coat or encase ferrous alloy tanks.

3.1.3 FUEL TANK LABELS

> Per 183.520: Fuel tanks must have a manufacturer label that provides information regarding date of manufacturer, size, capacity, pressure test.

As discussed in the manufacturer requirement section of this guideline this label must be visible after installation in the boat – so the boatbuilder needs to work with the tank supplier to be sure the label in properly placed. It is acceptable to locate the label under an access cover that can be removed with hand tools.

FIGURE 6 Fuel Tank Label



The label must contain the following information:

(1) Fuel tank manufacturer's name (or logo) and address.

(2) Month (or lot number) and year of manufacture.

(3) Capacity in U.S. gallons.

(4) Material of construction.

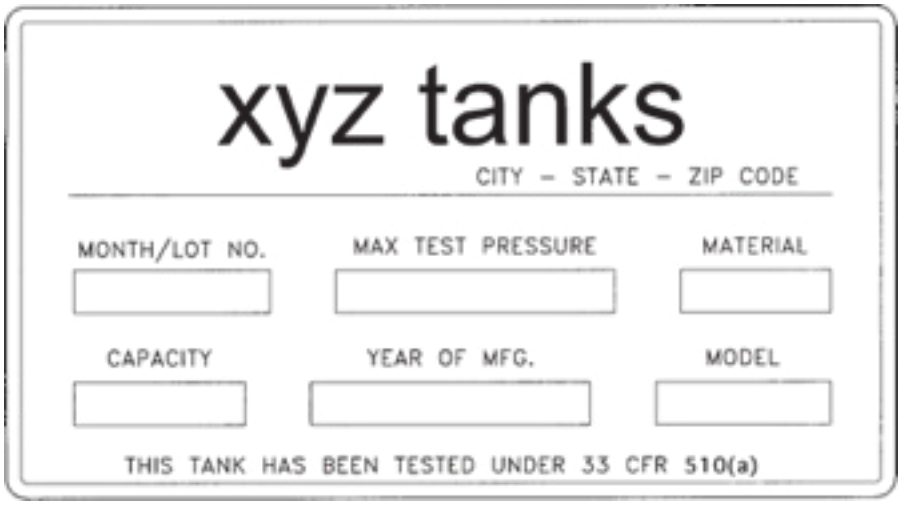
(5) The pressure the tank is designed to withstand without leaking.

(6) Model number, if applicable.

(7) The statement, "This tank has been tested under 33 CFR 183.510(a)."

(8) If the tank is tested under Sec. 183.584 at less than 25g vertical accelerations, the statement, "Must be installed aft of the boat's half-length."

FIGURE 7 Fuel Tank Label



Per 183.514 (c): Fuel tank label characters must be of required size – and be readable.

The minimum fuel tank label letter and number size is one-sixteenth inch in height for the required information. Additional information may be displayed in smaller lettering. This is equivalent to 8 point upper case (capital) lettering in printer's terminology.

THIS IS A SAMPLE OF 8 POINT LETTERING

Dark colored letters on a light colored background or light colored letters on a dark colored background will be easier to read. For example, black letters on a white or yellow background, or white letters on a black, blue or red background may be used to satisfy the contrast requirement.

Raised letters that are stamped into the label are also permitted. Embossing, debossing, stamping, engraving, molding and etching are examples of ways to raise or lower the lettering from the background surface of the label. Care must be taken not to damage the tank if the label is embossed while attached to the tank.

Per 183.514 **(d)**: The fuel tank label must be weather resistant – and tamper proof.

Labels are required to be durable so they may be used to identify a fuel tank and provide the information required in 183.514(b). Labels should be used that have demonstrated durability, either by experience in service or by test, considering all the listed exposure items.

Labels shall be designed, manufactured or installed so that any effort to remove or change the information thereon is apparent. Some pressure sensitive labels will self-destruct upon removal. Printed labels that have raised letters make it difficult to alter information.

§ 1060.135 How must I label and identify the engines and equipment I produce?

(5) Readily visible in the final installation. It may be under a hinged door or otherreadily opened cover. It may not be hidden by any cover attached with screws or any similar designs. Labels on marine vessels must be visible from the helm.

§ 1060.137 How must I label and identify the fuel-system components I produce?

(1) All fuel tanks, except for metal fuel tanks that are deemed certified under §1060.103(f).

(b) Label your certified fuel-system components at the time of manufacture. The label must be—

(1) Attached so it is not removable without being destroyed or defaced. This may involve printing directly on the product. For molded products, you may use the mold to apply the label.

(2) Durable and readable for the equipment's entire life. (3) Written in English.

(c) Except as specified in paragraph (d) of this section, you must create the label specified in paragraph (b) of this section as follows:

(1) Include your corporate name. You may identify another company instead of yours if you comply with the provisions of §1054.640.

(2) Include EPA's standardized designation for the emission family.

(3) State: "EPA COMPLIANT".

(4) Fuel tank labels must identify the FEL, if applicable.

(i) Identify the applicable numerical emission standard (such as 15 g/m2 /day).

(ii) Identify the applicable emission standards using EPA classifications (such as EPA Nonroad Fuel Lines).

(iii) Identify the applicable industry standard specification (such as SAE J30 R12).

1060.137

(b) Label your certified fuel-system components at the time of manufacture. The label must be—

(1) Attached so it is not removable without being destroyed or defaced. This may involve printing directly on the product. For molded products, you may use the mold to apply the label.

(2) Durable and readable for the equipment's intended life.

3.1.4 CELLULAR PLASTIC USED TO ENCASE FUEL TANKS

> Per 183.516: Cellular plastic used to encase fuel tanks must not change volume, must not absorb water, meet strength requirements, meet density requirements

If cellular plastic (foam) is to be used to encase a metallic fuel tank, it must as a minimum comply with the properties and tests specified in the regulation. These include:

- ASTM tests to show volume does not change more than 5% in listed liquid chemicals
- MIL spec to show no more water absorption than 0.12 pound of water per square foot of surface
- ASTM check of compressive strength of at least 60 pounds per square inch
- ASTM check of density of at least 2.0 pounds per cubic foot.

If the foam used for encasing a metallic fuel tank is to be counted as part of the flotation required for boats under 20 feet in length by Title 33 CFR 183 Subpart F, it will be required to comply with additional properties and tests. Refer to the 'Flotation Guideline'.

TABLE 1 Foam Requirements If Used For Both Fuel Tank Encasement And Flotation

	24-HOUR IMMERSION	30-DAY IMMERSION	WATER ABSORPTION	COMPRESSIVE STRENGTH OR DENSITY	SATURATED GASOLINE
LOCATION	183.516 (a)(1)		183.516 (a)(2)	183.516(b) OR (c)	VAPOR
ENGINE COMPARTMENT					
Below 12" height		•	•	•	
Above 12" height	•		•	•	•
OUTSIDE ENGINE COMPARTMENT					
Below 4" height		•	•	•	
Above 4" height	•		•	•	

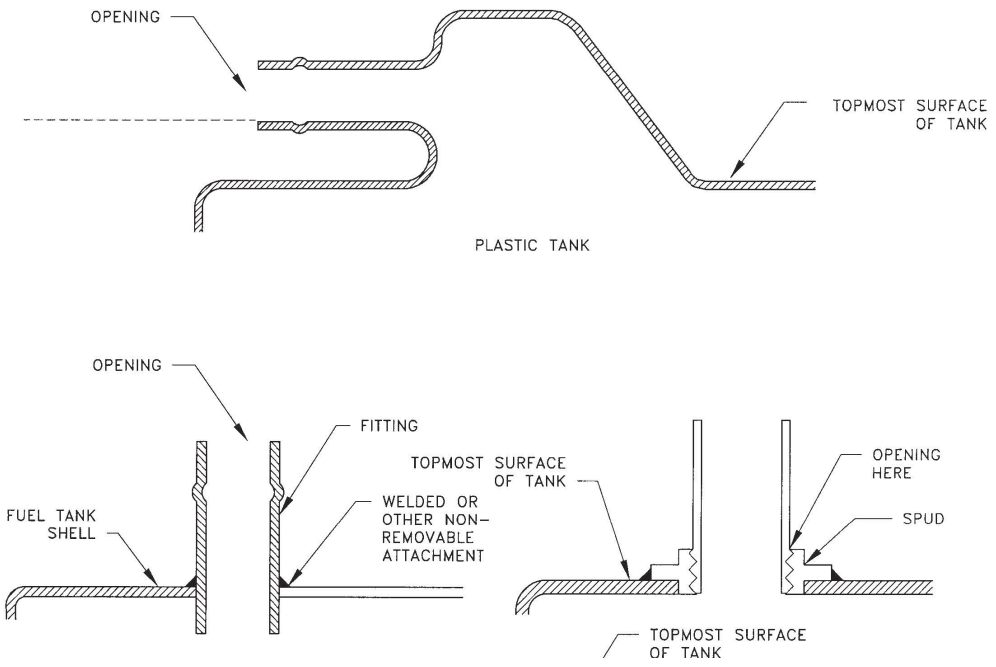
Typically a boatbuilder will accept a foam supplier's certification to these requirements – rather than complete such complicated tests. Still, boatbuilders are ultimately responsible for the compliance of all boat building requirements.

3.1.5 FUEL TANK OPENINGS

> Per 183.518: Each fuel tank opening must be at or above the top of the tank.

Fuel tank openings refer to holes into which fittings may be installed or fuel lines attached. Fuel tank fill, fuel tank vent, fuel distribution, fuel tank sounding, and fuel level sender fitting accesses are examples of such openings. If the attachment fitting is welded or attached by other non-removable means to the fuel tank, the opening is considered at the top of the attachment. The sketches below clarify this interpretation.

FIGURE 8 Fuel Tank Openings



3.1.6 FUEL TANK VENT SYSTEMS

> Per 183.520: Fuel tank vent systems must prevent pressure build up, provide flame arrester, not allow overflow into the boat.

Pressure. Pressure build-up can occur in a fuel tank due to temperature changes and during filling. The fuel tank vent system must be designed and installed to prevent the pressure build-up from exceeding 80 percent of the pressure marked on the tank label.

Unless there is trapped liquid or a clogged vent, temperature changes should not cause pressure problems. Filling a fuel tank at the normal rate of liquid flow (9 to 12 gallons per minute) found with most fuel dispensing pumps (some may put out more), might present a problem if too small a vent line is selected or if there are restrictions in the line. Blow-back through the fill opening will occur if the vent system is plugged. It has been generally found that a 9/16 inch inside diameter vent line with not less than 7/16 inch inside diameter fittings, provides sufficient flow capability to allow the fuel tank to breathe without excessive pressure build-up. It must be emphasized that vent lines be installed so that there are no potential liquid traps.

Flame Arrester. Fuel tank vent flame arresters must be able to be cleaned so they will not adversely restrict the breathing of a fuel tank. Flying particles, debris and salts from sea spray can attach to flame arrester elements. There must be some means to free the arrester from this contamination. Access to the arrester may be from outside or inside the boat as long as it can be accomplished in a normal servicing manner. Removal of the vent fitting is also acceptable. 46 CFR Subpart 58.10 states that a backfire flame arrester should comply with SAE J-1928 or UL 1111 and be so marked.

It is possible that a fuel tank vent system itself may perform the function of a flame arrester. The diameter and length of the vent tubing and its routing are considerations in designing a fuel tank vent system that is itself a flame arrester. There are no recommendations of proper diameters and lengths at this time. The burden of proof as to whether or not a fuel tank vent system performs is on the boat manufacturer.

Vent Overflow. The fuel tank vent outlet fitting must be located so that overflowing fuel coming out of the vent at a rate of up to 2 gallons per minute will not enter the boat. This requirement may involve deck design, cockpit coaming design, air vent location, hawsehole design for under deck cleating of lines and any other opening where fuel would overflow into the boat.

Deck joints in riveted metal decks, or wooden decks, could provide a path for fuel to flow to the boats interior unless they are caulked to resist such fuel leakage.

3.2 FUEL PUMPS

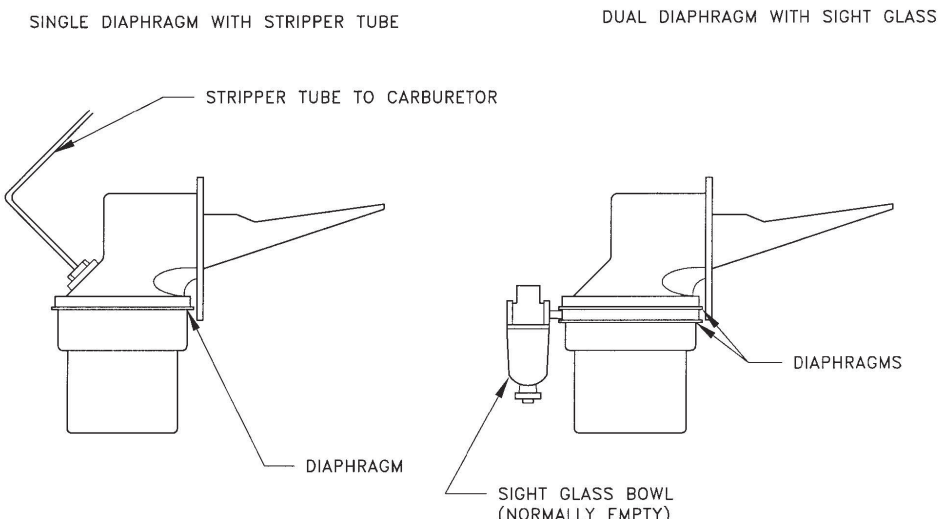
> Per 183.524: There are requirements regarding diaphragm pump leakage, electrical pump operation, and pump leakage after a fire test.

Diaphragm Pump. A diaphragm pump is the usual type of fuel pump found on marine engines. This requirement calls for means to prevent fuel from leaking into the interior of the boat or into the bilge if the main diaphragm fails. Some means presently used to accomplish this are:

1. A second diaphragm with a means of identifying failure of the primary diaphragm, such as a sight glass bowl, and
2. A sealed fuel pump hosing connected to the crankcase or equipped with a stripper tube connected to the carburetor.

Automotive fuel pumps are vented. In a vehicle, fuel leaking from a ruptured diaphragm falls harmlessly on the ground; in a boat, this type of pump would allow leaking fuel to accumulate in the bilge.

FIGURE 9 Fuel Pumps, Diaphragm Type



Electric Pump Operation. Electric fuel pumps are not permitted to be operable except:

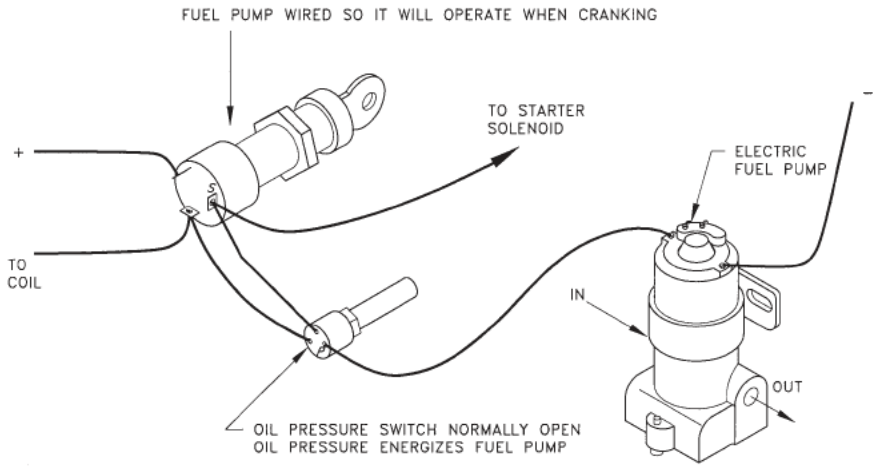
1. during the engine starting procedure, and
2. while the engine itself is operating.

This requirement does not apply to electric fuel pumps used to transfer fuel between tanks.

Compliance is typically achieved as follows:

1. wire the electric fuel pump to operate only when the starter is operating, and
2. by means of an oil pressure switch, only allow the pump to operate only as long as the engine is running.

FIGURE 10 Wiring Diagram For Electric Fuel Pump



Fire Test. Fuel pumps must be able to withstand the 2-1/2 minute fire test as described in 183.590 of this regulation. The fuel pump may be tested separately in a fire chamber or as installed on the engine. If a fuel pump can be mounted either on the engine or remotely such as an electrically operated fuel pump, it may be tested according to where it is located in a specific installation. For example:

1. If the electric fuel pump is to be mounted on an engine, it may be fire tested on an engine.
2. If it is to be mounted remote from the engine, but in compliance with 183.566 (within 12 inches of the engine), it may be fire tested with the engine, providing the fire pan under the engine includes the fuel pump.
3. If it is to be mounted remote from the engine, such as a fuel transfer pump, it must be tested in a fire chamber as a separate component.
4. A fuel pump may be qualified for installation in any permitted location by conducting the fire test in a fire chamber.

Following the fire test, the fuel pump will be subjected to a 3-foot head of fuel in order to determine if it exceeds the permitted 5ounces leakage of fuel in 2-1/2 minutes. While the pump manufacturer usually performs the fire test, the boatbuilder must remember that leakage from an associated fuel filter or strainer must be included. The content of an engine-mounted fuel line from the fuel pump to the carburetor must be added, if it will drain through the pump.

3.3 CARBURETORS

> Per 183.526: Carburetors must meet leakage criteria and meet specific fuel control criteria.

While computerized fuel injection systems have taken the place of carburetors for most production vehicles, the CFR regulation regarding carburetors is still on the books.

Leakage. There are two leakage tests for carburetors. The first is to confirm the integrity of the fuel metering equipment and is conducted as follows:

1. the float valve is free to operate normally
2. the throttle is in the half open position.

The marine engine manufacturer and the carburetor manufacturer would perform this test. Additional information and requirements for marine fuel metering devices may be found in SAE J1223 Marine Carburetors and Throttle Body Injection. Crank the engine without starting for 30 seconds. During this period there shall be no more than 5 cc observed gasoline flow coming from the carburetor fuel bowl, vent port or any other place on the exterior of the carburetor. This test includes only external flow, not fuel flowing down the throat of a downdraft carburetor.

The second leakage test for carburetors is to confirm the integrity of the float valve with a remote fuel pump and is conducted as follows:

1. the float valve is free to operate normally
2. the throttle is in the fully closed position.

Connect the fuel pump with the largest pressure intended for use with the carburetor and run it for 30 seconds. During this period there shall be no more than 5 cc observed gasoline flow coming from the carburetor fuel bowl, vent port or any other place on the exterior of the carburetor. This test includes only external flow, not fuel flowing down the throat of a downdraft carburetor.

Fuel Control. If an engine uses an updraft or a horizontal draft carburetor, then it must be fitted with a means to collect fuel from flooding and return it to the engine so it will be consumed. Some auxiliary generators and some small propulsion engines have updraft or horizontal draft carburetors.

The collector for the fuel must be capable of holding or delivering to the engine a quantity of fuel that collects during 12 ten-second periods of cranking without external leakage from the air inlet or dripping of liquid fuel from joints in the air inlet components. The collector and carburetor must be designed so that fuel will run into the collector rapidly to prevent fuel collection in the carburetor horn where it can be expelled during a backfire or "spit-back."

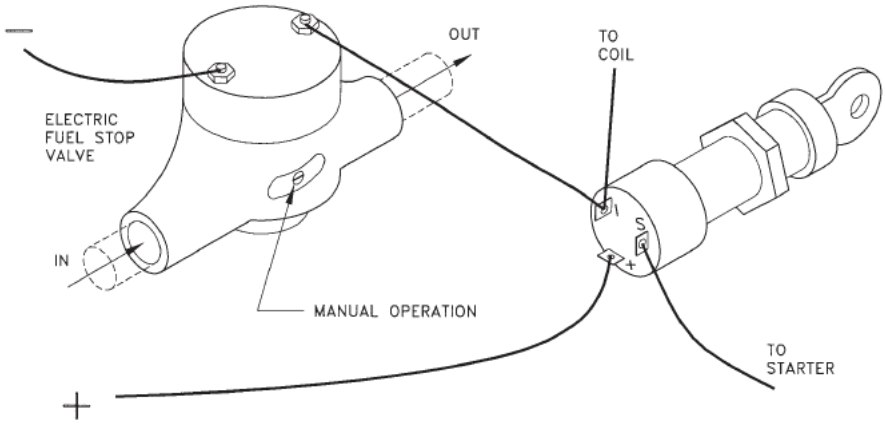
The collector must be fitted with a stripping means to return the collected fuel to the engine for combustion. Typically, this stripper is a tube connected to the throat of the carburetor so the manifold vacuum will pull the fuel out of the collector.

3.4 FUEL STOP VALVES

> Per 183.528 Fuel stop valves must meet electric control and fire test fuel leakage standard.

Electric Control. If an electrically operated fuel stop valve is in the fuel system, it must be wired to the ignition switch so it will open only when the ignition switch is on. It must also have a means to manually open the valve in the event of loss of electricity. This is often a slot for a screwdriver to turn the valve.

FIGURE 11 Electrically Operated Fuel Stop Valve



Fire Test. All fuel stop valves installed in metallic fuel lines or Type A1 hoses, whether they are of the manual type or electrically operated and equipped with the required means for manual operation, must withstand the 2-1/2 minute fire test. Fuel stop valves must be tested in a fire chamber described in 183.590(c) regardless of where they are installed.

After the fire test there shall be no leakage of fuel when subjected to the head as installed or a 36-inch head of fuel applied on the inlet side of the valve. Internal leakage such as could be expected with a soft seat type would not be considered leakage as long as it remained inside the fuel system.

Fuel stop valves installed in systems permitted to use USCG Type B hose need not be fire resistant.

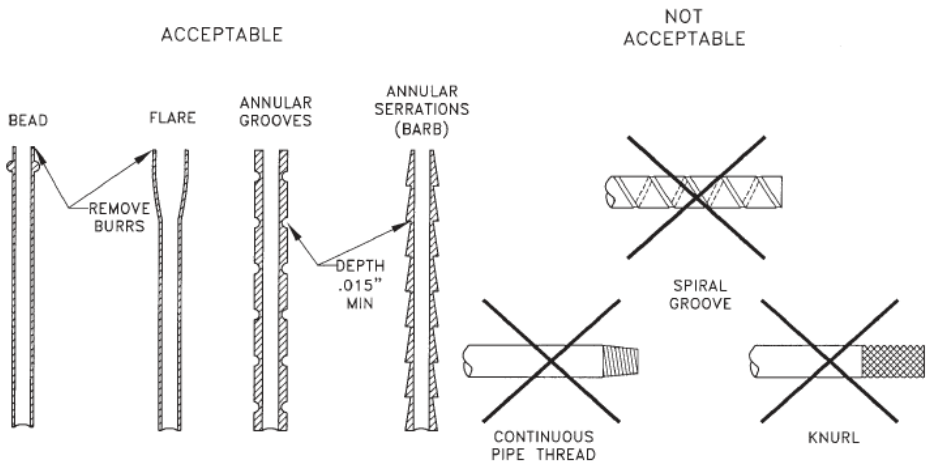
3.5 FUEL SYSTEM FITTINGS

> Per 183.530: Item covers spud, pipe, and hose fittings.

Spud, pipe and hose fittings require a bead, flare or series of grooves to be to be acceptable for use with hoses and hose clamps.

The regulation prohibits continuous helical threads (pipe threads), knurls or grooves that can provide a path for fuel leakage. Figure 12 depicts a number of acceptable types and some of those that are not acceptable.

FIGURE 12 Spud, Pipe and Hose Fittings



Per 183.532: Fuel system clips, straps, and hose clamps must be corrosion resistance and non-abrasive – and clamps must survive a fire test.

Corrosion Resistance. A clip, strap, or hose clamp used anywhere in the fuel system must resist corrosion. It is recognized that all materials are corrosion resistant to a degree; however, the intent is to accept all stainless steel, plated steel, plastic coated steel, plastics and non-ferrous metals as suitable materials for clips, straps, and hose clamps.

Abrasion. The surfaces in contact with the fuel line must be smooth and their edges such that there will be no cutting or wearing of the fuel line.

Fire Test. Hose clamps used to connect metallic or 'USCG Type 1A hose fuel lines in a fuel system must withstand a 2-1/2 minute fire test conducted in a fire chamber as described in 183.590(c). At the end of the 2-1/2 minute fire test, the hose clamp must withstand a 1-pound force.

3.6 FUEL FILTERS AND STRAINERS

Per 183.534 & 183.538: Fuel filters and strainers must not leak after a fire test.
Filter and strainer seal and gaskets must not leak as result of pressurized test in gasoline.

Fire Test. Fuel filters, strainers, and their connections must withstand a 2-1/2 minute fire test conducted as described in 183.590. The fire test may be performed on an engine for filters and strainers designed to be engine-mounted or may be performed in a fire chamber to qualify a filter or strainer to be mounted anywhere in the fuel system.

After the fire test, the filter or strainer is to be subjected to a 3-foot head of fuel to determine its rate of leakage. Acceptable leakage is up to 5 ounces of fuel in 2-1/2 minutes, but must include leakage from an associated fuel pump and fuel line. Internal leakage, destruction of straining or filtering elements, and impairment of function are acceptable.

Pressurized Gasoline Immersion Test. Fuel is made up of basic petroleum products in various quantities or concentrations. Depending on the amount of these components, fuel may have varying effects on the materials used for gaskets and seals. Fuels with high aromatic content have been found to damage fuel system components such as gaskets, seals, hoses and other usually non-metallic items.

To test gaskets and seals, it is required to subject samples to gasoline with at least a 50 percent aromatic content for a period of 24 hours. The described fuel is to be placed in the filter or strainer at a minimum head of 3-feet. After the 24-hour period, there shall be no leakage external to the tested unit.

3.7 METALLIC FUEL LINES

Per 183.538 Fuel system metallic fuel lines must meet certain material and size restrictions.

If metal is used for any portion of the fuel line (except for fittings) from the tank connection to the engine connection (usually at the fuel pump), the metallic fuel line portions must be seamless, annealed:

- Copper;
- Nickel copper (Monel); or
- Copper-nickel.

Also, the thickness of the tubing wall must be at least 0.029 inches unless the fuel line portion is a corrugated or accordion type of flexible fuel line. Tubing is available with thinner wall thicknesses, but they SHALL NOT be used.

Metal fuel lines used on the engine, i.e. the fuel line from the fuel pump to the carburetor, may be made of materials other than those listed. This line is usually supplied with the engine.

3.8 FUEL SYSTEM HOSES

Per 183.540: Gives fuel system hose definitions of 'USCG Type' definitions and specifies the required hose markings – including character size & permanence.

USCG Type Designations.

(a) USCG Type A1" hose means hose that meets the performance requirements of:

(1) SAE Standard J1527 DEC85, Class 1 and the fire test in Sec.183.590; or

(2) Underwriters' Laboratories, Inc. (UL) Standard 1114.

(b) "USCG Type A2" hose means hose that meets the performance requirements of SAE Standard J1527 DEC85, Class 2 and the fire test in Sec 183.590;

(c) "USCG Type B1" hose means hose that meets the performance requirements of SAE Standard J1527 DEC85, Class 1.

(d) "USCG Type B2" hose means hose that meets the performance requirements of SAE Standard J1527 DEC85 Class 2.

NOTE:
SAE Class 1 hose has a permeation rating of 100 grams or less fuel loss per square meter of interior surface in 24 hours.
SAE Class 2 hose has a permeation rating of 300 grams or less fuel loss per square meter of interior surface in 24 hours.

The permeation rating of the hose refers to the quantity of fuel that will pass through the walls of the hose out into the boat when the hose is filled with fuel. You could think of this as a slow leak. Fortunately, the fuel vapors formed by this low level of permeation are readily dissipated by the ventilation system.

The required placement of the various USCG type hoses is covered in the next 'Manufacturer Requirements' section of this guideline.

USCG Type Hose Markings.

(a) Each "USCG Type A1," "USCG Type A2," "USCG Type B1," and "USCG Type B2" hose must be identified by the manufacturer by a marking on the hose.

(b) Each marking must contain the following information in English:

- The statement "USCG Type (insert A1 or A2 or B1 or B2)." The additional EPA marking gives the permeability limit (such as A1 – 15).
- The year in which the hose was manufactured.
- The manufacturer's name or registered trademark.

(c) Each character must be block capital letters and numerals that are at least one-eighth inch high.

(d) Each marking must be permanent, legible, and on the outside of the hose at intervals of 12 inches or less.

The use of a fire sleeve does not automatically qualify a hose as "USCG Type A." Hose and sleeve must be properly matched. Hose and sleeve suppliers should be consulted to obtain a certification that the hose-sleeve combination will qualify as "USCG Type A."

All lettering, numerals, and trademarks used on hose must be at least one-eighth inch high. Markings must be permanent, legible and on the outside of the hose. Hose markings must be repeated along the length of the hose so there is a complete marking within every 12-inch section of the hose. Short pieces of hose, which do not show the complete label, are permitted, provided it is shown that the longer pieces of the same hose and the inventory of hose comply.

1060.137 (continued)

(5) Fuel line labels must identify the applicable permeation level. This may involve any of the following approaches:

(i) Identify the applicable numerical emission standard (such as 15 g/m2 /day).

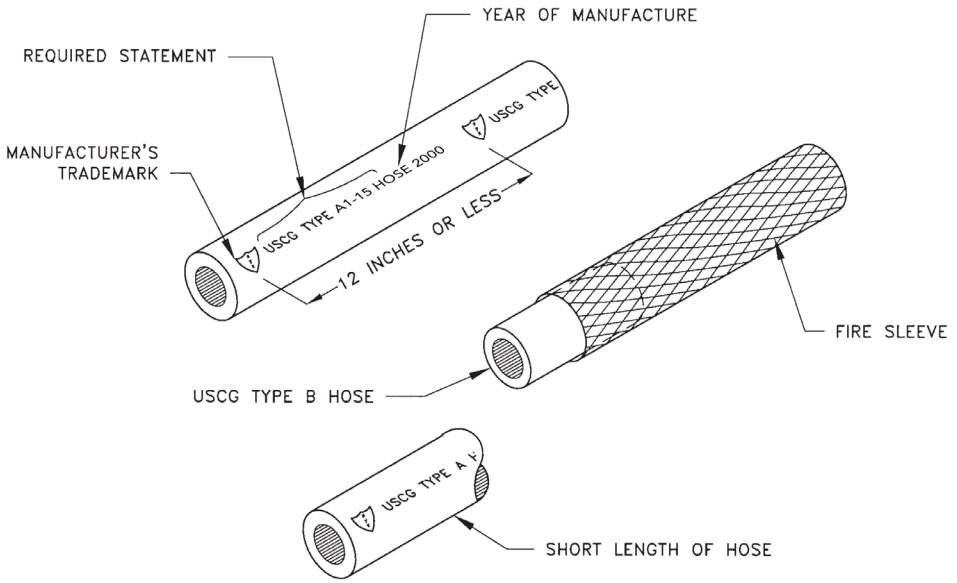
(ii) Identify the applicable emission standards using EPA classifications (such as EPA Nonroad Fuel Lines).

(iii) Identify the applicable industry standard specification (such as SAE J30 R12).

(6) Fuel line labels must be continuous, with no more than 12 inches before repeating. We will consider labels to be continuous if the space between repeating segments is no longer than that of the repeated information. You may add a continuous stripe or other pattern to help identify the particular type or grade of your products.

(d) You may create an abbreviated label for your components. Such a label may rely on codes to identify the component. The code must at a minimum identify the certification status, your corporate name, and the emission family. For example, XYZ Manufacturing may label its fuel lines as "EPA–XYZ–A15" to designate that their "A15" family was certified to meet EPA's 15 g/m2 /day standard. If you do this, you must describe the abbreviated label in your application for certification and identify all the associated information specified in paragraph (c) of this section.

FIGURE 13 Hose Marking



3.9 FUEL SYSTEM TEST

> Per 183.542 The entire fuel system must be pressure tested by the manufacturer – on each and every boat produced.

This system test is not the same as the fuel tank test [per 183.510(a)] completed by the tank supplier. This is a complete fuel system test that must be completed by the manufacturer.

The entire fuel system up to the engine fuel inlet, as installed in a boat, must be pressure tested by the boat manufacturer prior to the boat being sold to a customer. The entire fuel system includes:

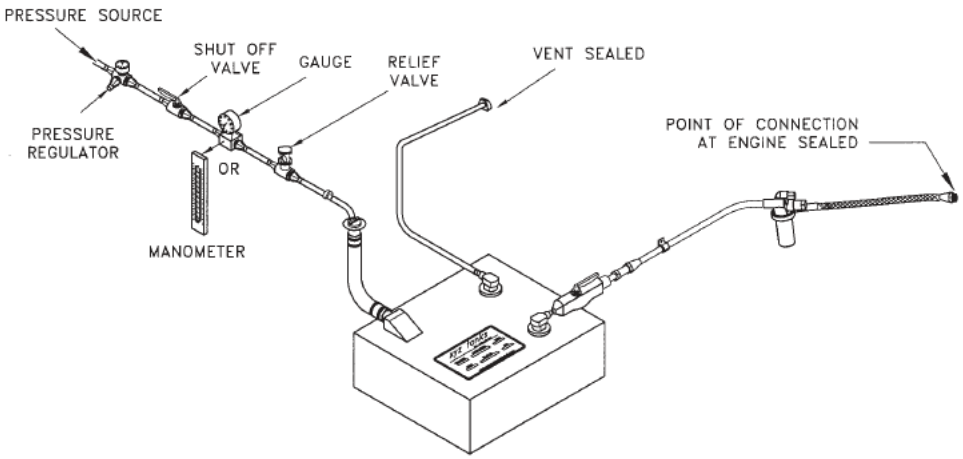
- Fuel fill(s)
- Fuel vent(s)
- Fuel tank(s)
- Fuel distribution(s)
- All components and accessories in fuel distribution lines, to the attachment point on the engine. The attachment point may be a fuel filter, fuel pump or carburetor, depending on what components are supplied with, and mounted on the engine.

The pressure test will normally be three pounds per square inch. On larger boats the test pressure will be one and one-half times the pressure created in the lowest part of the fuel system when it is filled.

The test pressure is usually obtained with air. There is no set time for the duration of the test; if the system holds pressure for the amount of time takes to check the entire system for leaks – that is sufficient.

Each boat manufactured must be tested as part of the certification of compliance with this Federal regulation.

FIGURE 14 Fuel System Pressure Test



4.0 Manufacturer Requirements

This section regarding 'Manufacturer Requirements' covers most of the same topics already discussed as part of the 'Equipment Standards' section. The requirement for the manufacturer to complete a fuel system test was discussed in section 3.0.

4.1 FUEL TANKS – INSTALLATION RESTRICTIONS

Per 183.550 & 183.552: There are several restrictions with respect to fuel tank installation.

4.1.1 NOT INTEGRAL WITH HULL (OR MOUNTED ON ENGINE)

Each fuel tank intended to be permanently installed, must be made as a separate component and then installed in the boat. Portions of a boat's structure, i.e. hull surfaces, bulkheads, stringers, floors, decks, frames, etc., may not form part of a fuel tank.

Fuel tanks glued, bonded or foamed-in-place are not considered integral and are therefore acceptable. However, that installation must comply with the applicable portions of this regulation.

Fuel tanks may not be mounted on an engine, except if the engine is part of a portable piece of equipment that is not permanently installed in the boat. If a fuel tank is removed from an engine to be installed in the boat, the installation must comply with the requirements of this standard. Particular attention is directed to the fuel tank vent requirements and the requirements for all openings to be in or at the topmost surface. Many tanks installed on engines have a bottom fuel supply; this fuel tank is not acceptable for installation in a boat.

4.1.2 TANK MOVEMENT RESTRICTED

The basic intent of this requirement is to restrict the movement of an installed fuel tank with respect to its mounting surfaces to a minimum amount. No movement would be best. To establish a quantitative test, one-fourth inch in any direction has been selected.

4.1.3 DOES NOT SUPPORT STRUCTURAL PART

A fuel tank is not permitted to be a structural part of a boat to the extent that it provides support for a deck, bulkhead or other boat structure. To determine whether the intent of this regulation is met, the following question must be answered in the affirmative — Is the deck, bulkhead or other structural component properly supported to function as intended with the fuel tank removed? If the answer is no, the tank is providing support that is not acceptable.

It is not intended to prohibit incidental contact of a deck, or hatch with a fuel tank, or to prevent the use of protective covers or panels for fuel tanks. The Coast Guard has also accepted fuel tanks specifically designed to be walked or sat upon: Protective mats or panels resting on the tank top to provide a walking surface have also been accepted by the Coast Guard.

4.1.4 WATER DOES NOT COLLECT ON TOP OF METAL FUEL TANK

Metallic fuel tanks must be designed, installed, or a provision made to drain water from the surface when the boat is in its static floating position. (See 183.505 for the definition of static floating position). It is recognized that irregularities in the top surface of a flat-topped fuel tank may be able to retain water by surface tension. The intent of this requirement is to prevent the entrapment of water that may occur with lipped edges or saucer type tops on fuel tanks.

Foamed-in-place metallic (must be non-ferrous) fuel tanks must be installed with a provision made to prevent water from collecting on top of the metal surface of the fuel tank, such as might occur if the foam formed a basin around fuel tank fittings. An alternate method is to coat the metal fuel tank surface with a barrier coating, other than paint, which will effectively prevent water from contacting the metal surface.

4.1.5 NON-INTEGRAL TANK SUPPORTS ARE MOISTURE INSULATED

Unless a metallic fuel tank has built-in means for supporting and holding the metallic fuel tank in place, a non-moisture absorbing material must be placed between the fuel tank surface and the support, chock or strap. The non-moisture absorbing quality of the material is necessary to prevent localized corrosion of the fuel tank that might occur if moisture was trapped at the support tank interface for prolonged periods of time.

Basically, this requirement provides for the isolation of the metallic fuel tank from a potentially moisture laden support system and also from abrasion by the supports, chocks and straps. The following list gives some materials that are suitable and some that should be avoided.

FUEL TANK ISOLATION MATERIALS

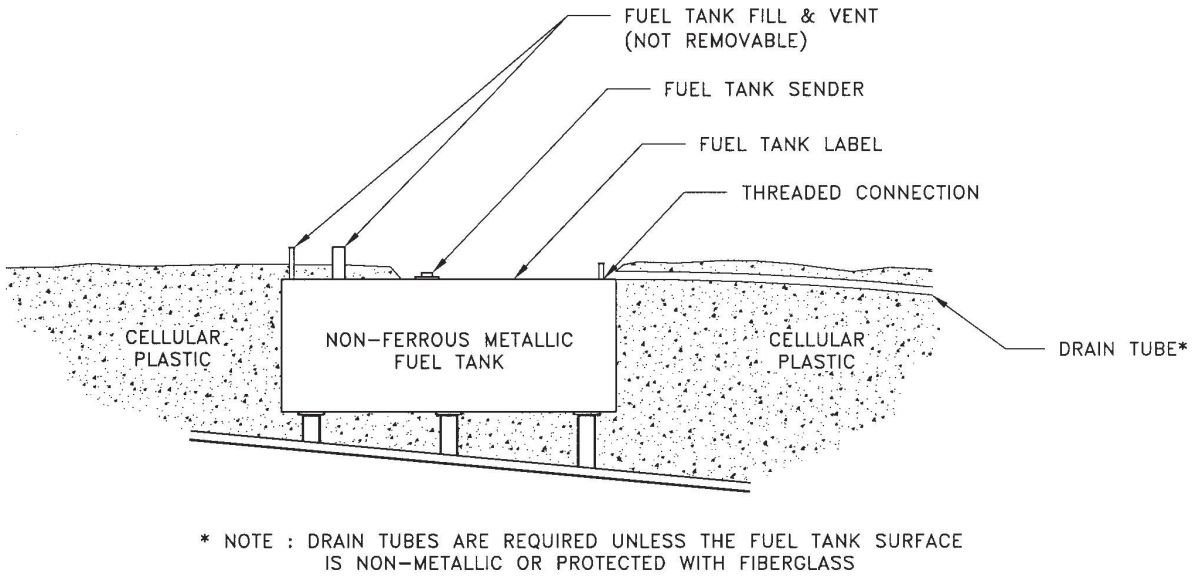
SUITABLE	UNSUITABLE
Neoprene	Cardboard
Teflon	Carpeting
High Density Plastics	Unpainted Wood Felt
	Canvas
	Foams

The isolation materials should be bonded (glued) to the tank so that moisture (from condensation) cannot be trapped next to the tank.

4.1.6 CELLULAR PLASTIC NOT SOLE SUPPORT OF METALLIC FUEL TANK

The previous section already established that cellular plastic cannot be used to encase ferrous alloy tanks. So this regulation primarily applies to aluminum fuel tanks. Non-ferrous metallic fuel tanks may be foamed-in-place if the installation provides support for the fuel tank that is independent of the cellular plastic (as shown in Figure 14). Other restrictions above have covered tank movement and water collection on top of the tank. It is recognized that the foam, upon curing, will assume some of the support for the tank.

FIGURE 15 Foamed in Place Non-Ferrous Metallic Tank



4.1.7 CELLULAR PLASTIC SUPPORTING NON-METALLIC FUEL TANK

Cellular plastic (foam) may provide the only support for non-metallic fuel tanks. Fiberglass reinforced plastic fuel tanks and other suitable plastics used for fuel tanks may be installed in foam. In order to use foam as the only support for these non-metallic tanks, the foam must meet or exceed the ASTM and MIL spec requirements covered in the previous section [183.516(b)].

4.1.8 INSTALLATION IN AFT HALF

This relates to boat fuel tanks that have been shock tested. Fuel tanks which are labeled "Must be installed aft of the boat's half-length" are to be installed with the fuel tank's center of gravity toward the stern of the mid-length of the boat. These fuel tanks have been qualified at lower strength criteria than those fuel tanks capable of installation at any location in a boat. The shock loading or impacts felt by boats are more severe in the forward portion of a boat than in the aft section.

Fuel tanks that are meant for installation at any location in a boat shall be shock [183.584(e)] tested at 25 g vertical accelerations, or they must be tested in accordance with either the pressure impulse test (183.586), or both that test and the slosh test (183.588), depending on their capacity. Fuel tanks meant only for installation aft of the boat's half-length may be shock tested at 15 g accelerations if their capacity is less than 25 gallons. Table 3 shows the strength test for fuel tanks according to the tank's capacity and intended location in a boat.

TABLE 2 Strength Tests for Fuel Tanks

CAPACITY	STRENGTH TESTS		
	SHOCK	PRESSURE-IMPULSE	SLOSH
FUEL TANK LOCATED ANYWHERE IN BOAT			
Less than 25 gallons	183.584 [use (e) (1)]	–	–
25 to less than 100 gallons	–	183.586	–
100 gallons or more	–	183.586	–
FUEL TANK'S CENTER OF GRAVITY AFT OF HALF-LENGTH			
Less than 25 gallons	183.584 [use (e) (2)]	–	–
25 to less than 100 gallons	–	183.586	–
100 gallons or more	–	183.586	183.588

4.1.9 PLASTIC ENCASED FUEL TANK INSTALLATION RESTRICTIONS

Accessibility. Plastic encased fuel tanks must have connections, fittings, and label accessible.

The connections at the tank for the fuel tank fill, fuel tank vent, fuel distribution fittings, fuel level gauge and the fuel tank label must all be located to be available for inspection and servicing when using foam or fiberglass for the fuel tank installation.

If the fuel tank connections are welded to the fuel tank, then the top of the fuel tank may be covered with foam. If the fuel tank connections are screw-type spuds in the fuel tank surface, these connections and joints must be accessible.

Accessibility may be achieved by removable panels, hatches, access ports and boat components. Seats, fish boxes and consoles that are designed so they may be removed also provide accessibility.

Water Collection. Water must not collect in or be drawn to space between plastic and surface of tank.

Encased metallic fuel tanks (only non-ferrous tanks are permitted) might corrode in the presence of stagnant moisture. This moisture could be held against a fuel tank surface by tight fitting, slip-in foam blocks or other plastic materials not bonded to the fuel tank surfaces.

Unless the encasement materials are bonded to the fuel tank surfaces, there must be an air space between the fuel tank surface and the encasement materials to allow water to run off. This space must be sufficient to prevent water droplets from bridging the space and being held in place by capillary action. One-fourth inch has proven satisfactory in many installations; however, in installations where this may be a problem, the installation should be evaluated.

Supports, chocks or straps and the insulation material between these items and the fuel tank surface are not included in this requirement (see 183.550(e)). An intervening plastic film between the encasement materials and the fuel tank surface does NOT meet the intent of this requirement unless water is prevented from collecting against the surface of the fuel tank.

Adhesive Strength. If plastic is bonded to tank surface of metallic tank the plastic/metal adhesive strength must be greater than the cohesive strength of the plastic.

Encasement of metallic (only non-ferrous tanks are permitted) fuel tanks must be done carefully to avoid accelerated corrosion. The adhesion of the encasement materials to the surface of the fuel tank must prevent water from contacting the fuel tank's metallic material. This is the reason for the requirement that the plastic's cohesive strength be less than the strength of the adhesive bond to the fuel tank. If a failure of the encasement material is to occur, it should fail within the encasement material rather than pulling away from the surface of the fuel tank.

4.2 FUEL SYSTEM FITTINGS

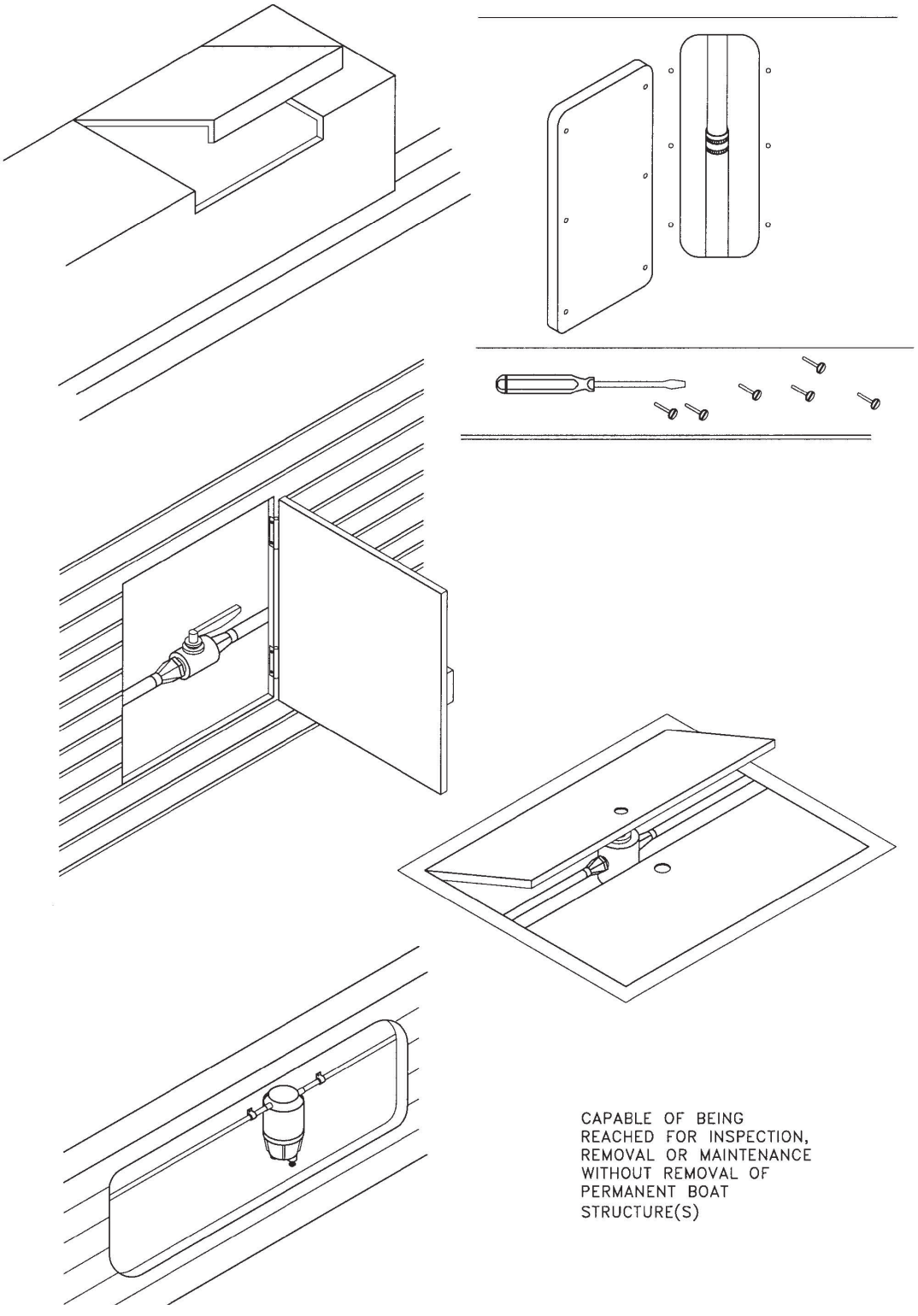
> Per 183.554: Each full fitting, joint, and connection must be reached for inspection / removal (without removal of boat structure).

The fuel system must be installed and the boat must be designed and constructed to provide access to every fuel system fitting, joint and connection. This access must permit:

1. inspection of these items for leakage and deterioration (mirrors may be used to see the hidden portion),
2. removal of these fuel system components for repair or replacement, and
3. maintenance of these fuel system components to preserve the integrity and reliability of the fuel system.

All fuel system fittings, joints and connections must be accessible for inspection, removal and maintenance. This requirement does not apply to fuel tanks, only to the fuel tank fittings. Long runs of fuel hose likewise must be accessible for inspection, but only the fittings must be readily accessible. In a long run of hose, it is acceptable to disconnect the fittings and to pull the hose out to inspect it. The entire run of hose does not have to be immediately accessible. Access may be gained by means of removable panels, hatches, ports, doors, removable seats, removable consoles or other means designed for such access. It is intended that these items be reached without cutting portions of the boat. Bolts, screws and other fastenings may be removed in order to move panels, flooring, furnishings and other items to gain access. Caulking and sealants do not make a part permanently attached so long as it can be removed and replaced without destruction of boat structure. Figure 16 depicts typical means of access.

FIGURE 16 Examples of a Fuel System Accessability



Per 183.556: There must not be a fuel system drain – (with the exception) –
fuel filter plug must have proper fitting.

Fuel System Drain. There shall be no fitting or component in the fuel system with the purpose of draining fuel from the fuel system. Fuel tank drains, valves or plugged tee fittings in fuel lines, and drain or bleed valves at engine connections are prohibited.

Fuel Filter Plug. Fuel filters and strainers may have a servicing plug or screw fitting; however, they must be either:

1. a tapered pipe-thread type of plug, or
2. a screw-type of plug incorporating or provided with a locking means other than a split lock washer. Gaskets and seals must be an un-split ring.

The locking device should provide for repetitive removal and replacement without leakage. Some types of a locking device, such as a star lock washer, can damage surfaces upon repetitive disassembly and assembly, potentially affecting the ability of the filter or strainer to remain leak-proof.

4.3 FUEL SYSTEM HOSES

Section 3.8 defined the various USCG Type hoses. This section specifies where the various type hoses must be used.

Per 183.558: Specifies what USCG Type hoses must be used,
the manner of securing the hose ends, and how to match hose size to connecting fitting size.

1060.101
(2) Fuel-line fittings. The following requirements apply for fuel-line fittings that will be used with fuel lines that must meet permeation emission standards:

(i) Use good engineering judgment to ensure that all fuel-line fittings will remain securely connected to prevent fuel leakage throughout the useful life of the equipment.

(ii) Fuel lines that are intended to be detachable (such as those for portable marine fuel tanks) must be self-sealing when detached from the fuel tank or engine

Fuel Line Between Fuel Pump and Carburetor (i.e., Engine Connection).

If a hose is used in the fuel line running between the fuel pump and the carburetor, the hose must be "USCG Type A1" and so labeled as required by 183.540. This requirement is applicable whether the fuel pump is engine mounted or mounted remotely from the engine, as permitted by 183.566.

This requirement does not apply to a tube used to detect fuel pump diaphragm failure.

Fuel Hoses for Vent Line or Fill Line

(i) "USCG Type A1" or "USCG Type A2"; or

(ii) "USCG Type B1" or "USCG Type B2" if no more than five ounces of fuel is discharged in 2-1/2 minutes when:

(a) The hose is severed at the point where maximum drainage of fuel would occur,

(b) The boat is in its static floating position, and

(c) The fuel system is filled to the capacity marked on the tank label under Sec. 183.514(b)(3).

Fuel Hoses From the Fuel Tank to the Fuel Inlet Connection on the Engine:

(i) "USCG Type A1"; or

(ii) "USCG Type B1" if no more than five ounces of fuel is discharged in 2-1/2 minutes when:

(a) The hose is severed at the point where maximum drainage of fuel would occur,

(b) The boat is in its static floating position, and

(c) The fuel system is filled to the capacity marked on the tank label under Sec. 183.514(b)(3).

The selection of the type of hose to be used in a fuel system is evaluated in accordance with the following:

(a) The boat must be in its static floating position as defined by 183.505. The fuel system is filled to the capacity marked on the fuel tank label as specified by 183.514(b)(3). Normally this quantity of fuel may fill the fuel tank to its topmost surface but will not fill the fuel tank fill or vent lines. Fuel is required to fill the fuel distribution line to the carburetor connection in order to determine the quantity of fuel that will leak in 2-1/2 minutes if a hose is severed.

Table 3 shows the length of hose or tubing of various diameters, that if filled with fuel will contain five ounces. You will see that only a short portion of fuel fill or vent hose will require that hose to be "USCG Type A1 or A2"; Most fuel fill and fuel tank vent installations will permit the use of "USCG Type B1," but particular care must be taken if the fuel fill line and/or fuel tank vent line are run horizontally from the fuel tank connection. Any dips below the topmost surface of a fuel tank may cause a need for "USCG Type A1 or A2".

To determine what type of hose may be used for the fuel distribution line, it is necessary to:

(a) determine where, in the hose portion of the fuel line, maximum drainage could occur.

(b) cut the hose at the maximum drainage point. The intent is to cut the hose completely through and then support the hose at both sides of the cut at their original location.

(c) measure the fuel leakage from this opening in the fuel hose for a period of 2-1/2 minutes. If more than five ounces leaks, use "USCG Type A1." If less than five ounces leaks, you may use "USCG Type B1."

"USCG Type A" hose may be used for all hose portions, regardless of whether the installation proves that "USCG Type B" hose is acceptable. If "USCG Type A" hose is used, there is no need to test for five ounces of fuel leakage in 2-1/2 minutes.

TABLE 3 Length of Hose vs. Five Ounce Fuel Capacity

Hose Inside Diameter	Length in Inches
1/4	184
5/16	118
3/8	82
7/16	60
1/2	46
9/16	36
5/8	29
3/4	20
1	11
1-1/4	7
1-1/2	5
2	3

Table 4 shows the length of hose or tubing of various diameters, that if filled with fuel will contain five ounces.

Fuel Hose Connections

Each hose must be secured by:

- A swaged sleeve
- A sleeve and threaded insert, or
- A hose clamp.

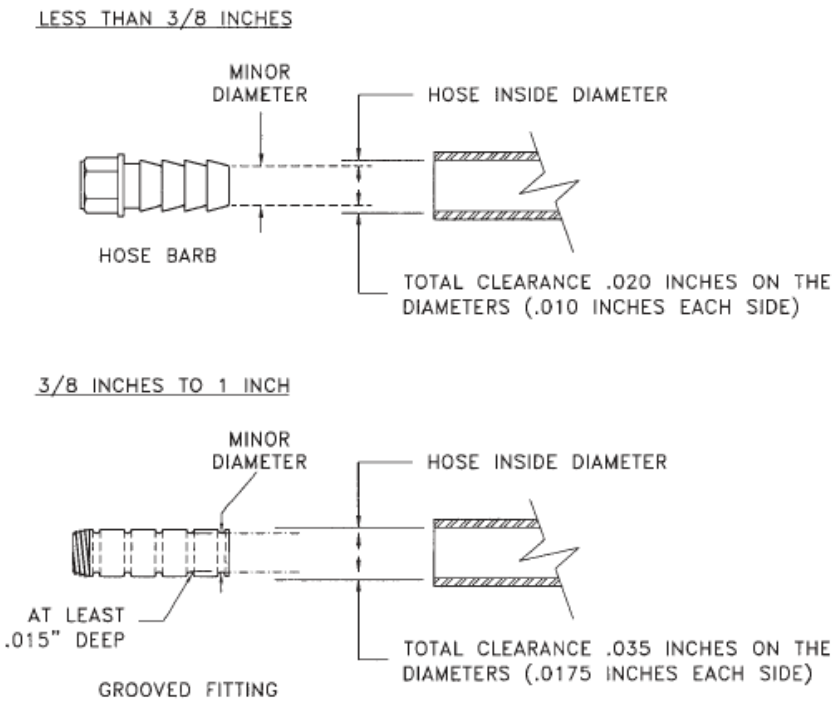
This requirement does not apply to the tube used to detect fuel pump diaphragm failure. Hose connections may be made by one of the following means:

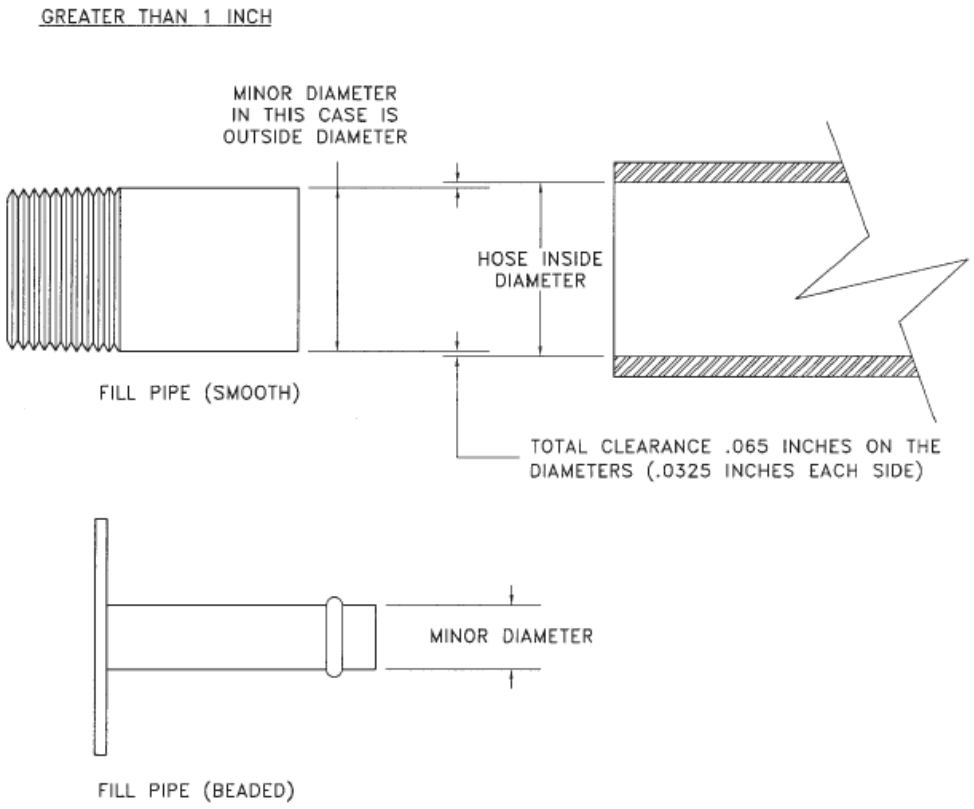
SWAGED SLEEVE: The supplier of a hose assembly usually makes this type of connection since special machinery or apparatus is necessary to perform the swaging operation. The attachment to the fuel system is usually made by means of a threaded hose fitting.

SLEEVE AND THREADED INSERT: an installer using normal shop tools usually can make this type of connection. Usually the sleeve is placed on the outside of the hose and the threaded insert is screwed into the inside of the hose and sleeve. There are also connections in which the sleeve is installed on the hose after the insert is installed. The attachment to the fuel system is usually made by means of a threaded hose fitting.

HOSE CLAMP: This type of connection is usually made upon installation using normal shop tools. The device usually has a mechanically operated tightening mechanism such as a screw or bolt but may require a specific means of deformation to secure the connection. A hose clamp is usually slipped on each end of the hose in a loosened condition, the hose installed and the hose clamp tightened. The attachment to the fuel system is usually made by means of a beaded, flared or serrated spud, pipe or hose fitting.

FIGURE 17 Hose Connections





NOTE: Hose connections using hose clamps must comply with 183.530 which requires a bead, a flare or series of annular grooves or serrations at least .015 inches deep, on the connecting fitting. Fuel tank fill pipe connections may be made on smooth pipe.

Matching Fuel Hose to Fitting

The inside diameter of a hose must not exceed the actual minor outside diameter of the connecting spud, pipe, or fitting by more than the distance shown in Table 4 (aka 'Table 8' in CFR).

TABLE 4

If minor outside diameter of the connecting spud, pipe or fitting is:	The inside diameter of the hose must not exceed the minor outside diameter of the connecting spud, pipe, or hose fitting by more than the following distance:
Less than 3/8 in	0.020 in.
3/8 in. to 1 in	0.035 in.
Greater than 1 in	0.065 in.

This requirement does not apply to a tube used to detect fuel pump diaphragm failure.

To assure a leak-proof hose connection, certain permitted hose to spud clearances have been established. Figure 26 depicts these clearances as applied to some spuds, pipes or fittings.

Hose Clamp Installation. The following installation requirements apply to fuel system hose clamps.

Intended Use. Clamps must be used on hoses designed for clamps.

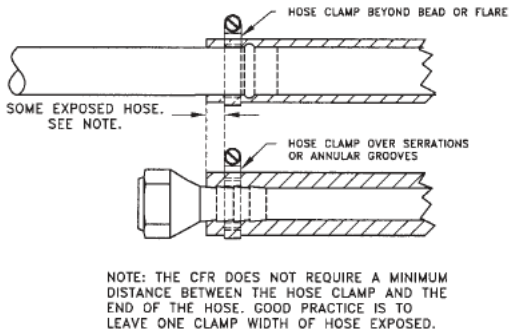
> Hoses may or may not be designed to be clamped, particularly wire or the mesh reinforced hoses. The proof of whether or not a hose is satisfactory is that the hose connection does not leak when subjected to the "Static Pressure Test for Fuel Systems" as required by 183.542.

Location. Clamps must be beyond the bead or flare – or over the serrations on the connecting fitting.

> Any hose to be used with hose clamps and installed in the fuel tank vent line, the fuel line between the fuel pump and the carburetor; or the fuel distribution line between the fuel tank and the fuel inlet connection at the engine is required to be assembled with the hose clamp beyond a bead or flare, or over serrations or annular grooves.

There is no CFR requirement regarding a distance of the clamp from the end of the hose but a good practice is to allow a clamp width (or at least one-quarter inch) from the end of the hose.
Examples are given in Figure 18 Satisfactory Clamp Installations.

FIGURE 18 Examples of Satisfactory Installations



Type. Clamps cannot rely on spring tension for the compressive force.

Hose clamps are available that use different means for securing the hose to the hose fitting, pipe or spud.

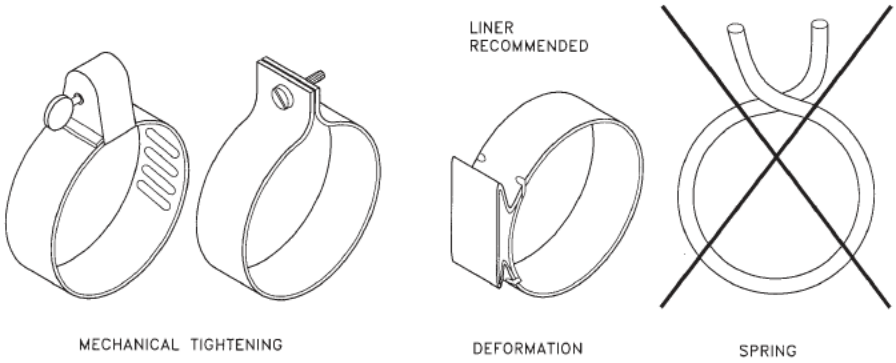
MECHANICAL TIGHTENING: This type employs a screw or bolt to apply pressure to the connection. A screwdriver, pliers or wrench is used to adjust the hose clamp depending on the adjustment configuration. These clamps are reusable.

DEFORMATION OF THE CLAMP MATERIAL: This type usually depends on the use of a special tool for installation. The clamp material is bent or formed in such a manner as to apply pressure to the hose thereby securing the hose connection. Generally this type of clamp is not reusable and may be difficult to tighten in the event of a leak. This style of clamp requires a specific tool for correct application. Since technicians in the field will not have access to these tools, these clamps should not be used on connections where routine disconnection for servicing may be required.

SPRING TYPE: This type is prohibited. The compressive force depends on the clamp material and there is no positive mechanical type of fastening.

Double clamping is allowed but not required – except for the fuel fill hose connections. If using double clamps it is important to avoid the clamp being placed on or beyond the barb as it will deform the hose and weaken the connection.

FIGURE 19 Hose Clamp Types



4.4 METALLIC FUEL LINES

Per 183.562: There are requirements regarding how metallic fuel lines are to be installed.

Connection to Engine With Flexible Fuel Lines.

Metallic fuel lines are relatively rigid and need protection from vibration. This is particularly true for the fuel lines attached to the boat structure that runs from the fuel tank to the engine.

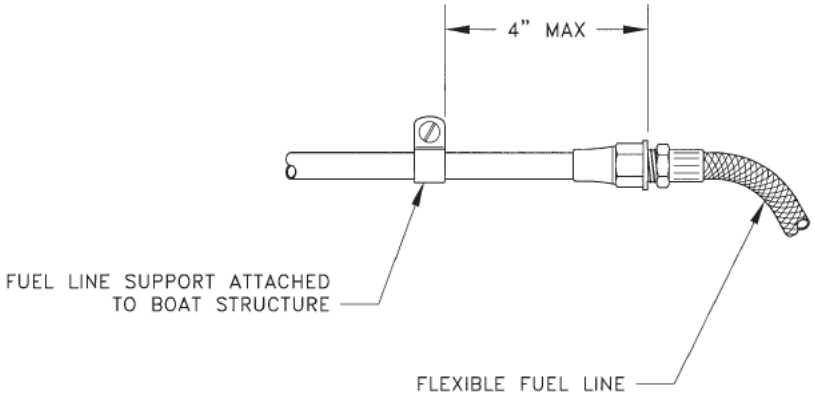
A boat responds to forces created by waves and resultant pounding by the hull twisting and moving. An engine vibrates and moves in its resilient mounts. If a rigid fuel line is connected directly to the engine, unusual stress is likely to be transmitted to its connections, probably resulting in leakage. For these considerations, a flexible portion of fuel line is required to connect the metallic fuel line that is attached to the boat to the engine connection.

The flexible fuel line may be hose, "USCG Type A1" or "USCG Type B1," depending on compliance with the criteria of 183.558.

Connection to Boat Structure

To prevent damaging stresses on the metallic fuel line at the connection of the flexible fuel line, there must be a means of support for the metallic fuel line within four inches of the connection. This support must be installed wherever a flexible fuel line is used and attached to a rigid metallic fuel line. The closer the support is to the end of the metallic fuel line, the better the protection of the metallic fuel line.

FIGURE 20 Metallic Fuel Line Support



4.5 FUEL TANK FILL SYSTEM

> Per 183.564 (a): Each fuel fill fitting must be located so that an overflow will not enter the boat.

The overflow rate is given as up to five gallons per minute for at least five seconds. Doing the math - to make this spill rate more meaningful: that would be about 1.67 quarts of gasoline in that five seconds – about as fast as one could pour a half gallon of liquid out of a wide mouth bottle.

The regulations also specifies that the boat be in the static floating position – but a slight boat angle is not going to change this spill test rate significantly.

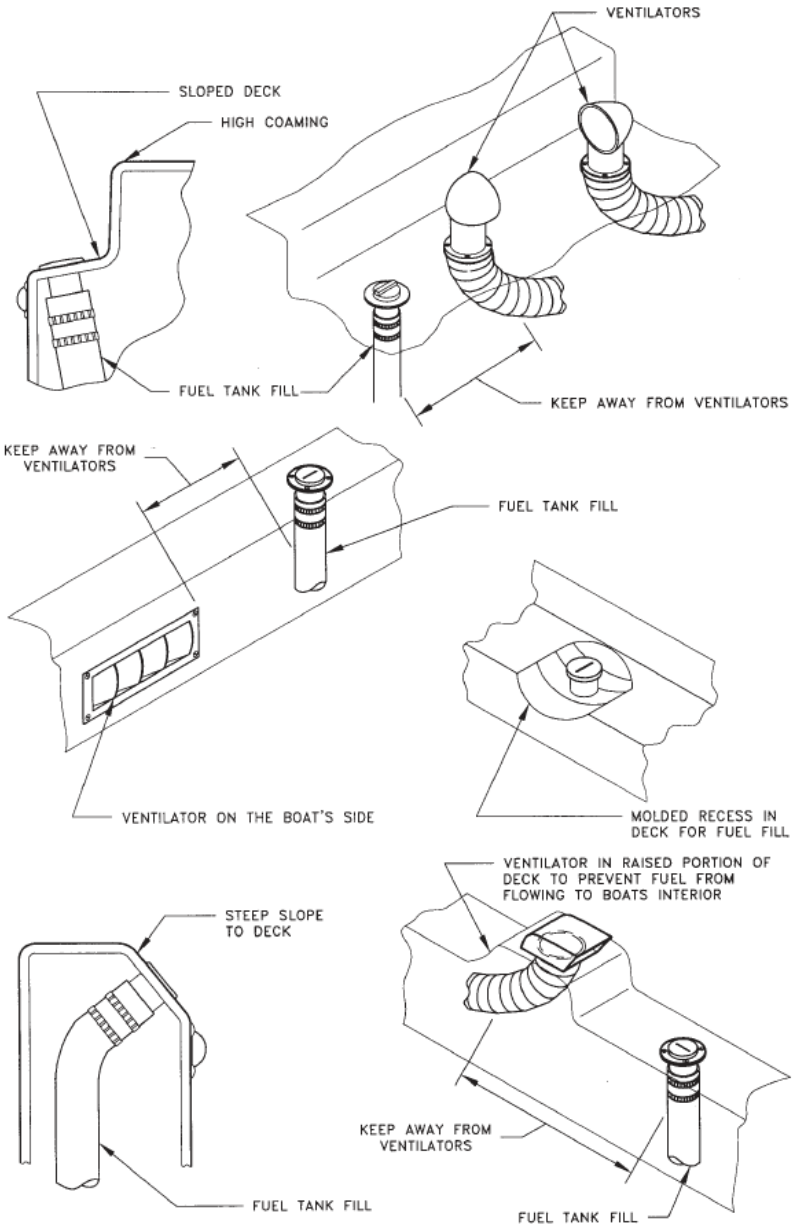
It is best to design the fuel fill to not allow any fuel fill spillage to flow into the boat.

One of the key principles of this regulation is to prevent gasoline from getting inside a boat where it can vaporize and create an explosive atmosphere. Overflow at the fuel fill opening is one potential source of fuel that could get inside a boat unless precautions are taken.

The location of the fuel tank fill opening must be chosen with the following considerations in mind:

- Nearby ventilators, on deck or on the side of a boat, could provide access for fuel to flow inside a boat. The distance between the fuel fill opening and ventilators may have to be increased over that which is normally considered adequate for keeping vapors from entering ventilators.
- The deck configuration and its slope could channel overflow fuel into a boat.
- High coamings or cabin sides can offer protection against overflow from flowing into a boat,
- Deck joints in riveted construction or wooden construction could provide a path for fuel to flow into the boat's interior unless they are caulked to resist such fuel leakage.

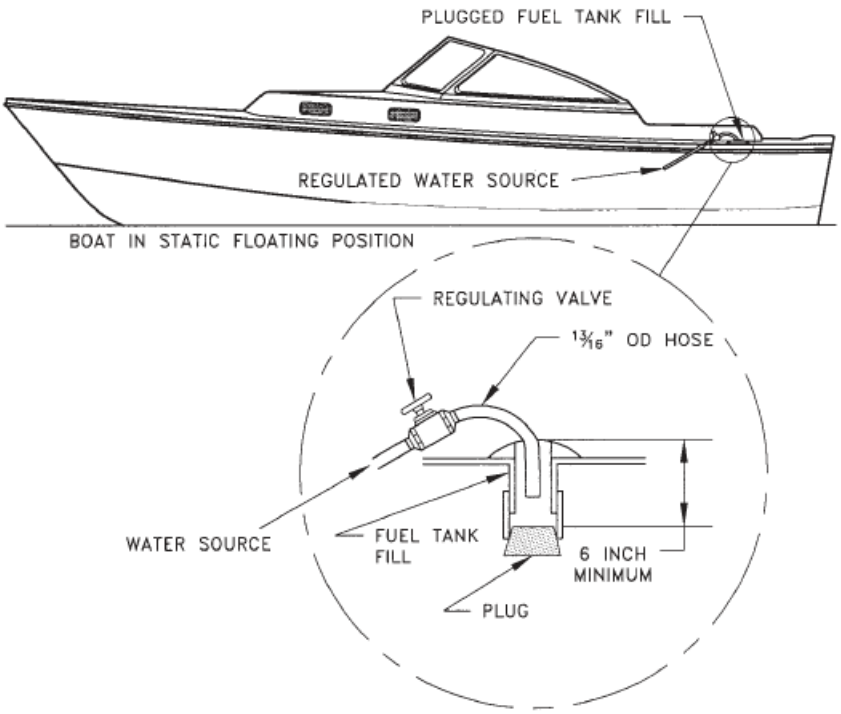
FIGURE 21 Fuel Fill Locations



The test to determine compliance is as follows:

- Place the boat in its static floating position — see 183.505
- Plug the fuel tank fill line at least a distance of six inches below the fuel tank fill opening.
- Insert a 13/16 outside diameter hose into the fuel tank fill opening.
- Discharge water at a rate of five gallons per minute (53.3 ounces in five seconds).
- Time the overflowing water for five seconds and shut off the flow.
- Investigate to determine if any of the overflowing water got into the boat. None is permitted in order to comply. Overflow entering a self-bailing cockpit is considered entering the boat and is not permitted.

FIGURE 22 Fuel Overflow Test



Per 183.564 (b) & (c) & (d): Each hose in the fuel tank fill system must be secured in the prescribed manner.

The fuel fill hoses must be secured to a pipe, spud, or hose fitting by:

- A swaged sleeve
- A sleeve and threaded insert; or
- Two adjacent metallic hose clamps.

Fuel tank fill system hose connections shall be made to a pipe (smooth pipe is acceptable), a spud or a hose fitting. The hose connections may be made by one of the following means:

1. SWAGED SLEEVE: the supplier of a hose assembly usually makes this type of connection, since special machinery or apparatus is necessary to perform the swaging operation. The attachment to the fuel system is usually made by means of a threaded hose fitting.
2. SLEEVE AND THREADED INSERT: an installer using normal shop tools usually can make this type of connection. Usually the sleeve is placed on the outside of the hose and the threaded insert screwed into the inside of the hose and sleeve. There are connections in which the sleeve is installed on the hose after the insert is installed. The attachment to the fuel system is usually made by means of a threaded hose fitting.
3. TWO ADJACENT METALLIC HOSE CLAMPS THAT DO NOT DEPEND SOLELY ON THE SPRING TENSION OF THE CLAMPS FOR COMPRESSIVE FORCE: For a fuel tank fill line, 2 hose clamps are usually slipped on each end of the hose in a loosened condition, the hose installed and the hose clamps tightened. The attachment to the fuel system is usually made by means of a beaded, flared or serrated spud, pipe or hose fitting. Hose clamps are to be installed side by side, not on top of each other. Two clamps are required for mechanical strength and to resist any tendency for the hose to twist.

Each hose clamp in the fuel full system must be used with a hose designed for clamps.

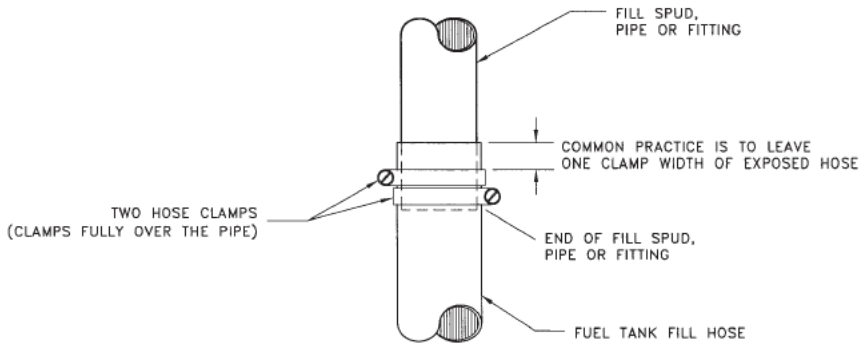
Hoses may or may not be designed to be clamped, particularly wire or wire mesh reinforced hose. The proof of whether or not a hose is satisfactory is that the hose connection does not leak when subjected to the "Static Pressure Test for Fuel Systems" as required by 183.542.

The fuel fill system clamps must have a bandwidth of one-half inch.

The fuel fill system clamps must be over a spud, pipe, or hose fitting.

Hose and hose clamp installations must be made so the hose is pushed onto the spud, pipe (smooth pipe is permitted for fuel tank fill systems) or hose fitting far enough to permit two hose clamps to be fully over the spud pipe or hose fitting.

FIGURE 23 Fuel Tank Hose Clamping



1060.101 (3) Refueling.
For any equipment using fuel tanks that are subject to diurnal or permeation emission standards under this part, you must design and build your equipment such that operators can reasonably be expected to fill the fuel tank without spitback or spillage during the refueling event. The following examples illustrate designs that meet this requirement:

(i) Equipment that is commonly refueled using a portable gasoline container should have a fuel tank inlet that is larger than a typical dispensing spout. The fuel tank inlet should be located so the operator can place the nozzle directly in the fuel tank inlet and see the fuel level in the tank while pouring the fuel from an appropriately sized refueling container (either through the tank wall or the fuel tank inlet). We will deem you to comply with the requirements of this paragraph (f)(3)(i) if you design your equipment to meet applicable industry standards related to fuel tank inlets.

(ii) Marine SI vessels with a filler neck extending to the side of the boat should be designed for automatic fuel shutoff. Alternatively, the filler neck should be designed such that the orientation of the filler neck allows dispensed fuel that collects in the filler neck to flow back into the fuel tank. A filler neck that ends with a horizontal or nearly horizontal segment at the opening where fuel is dispensed would not be an acceptable design.

4.6 FUEL PUMPS – PLACEMENT

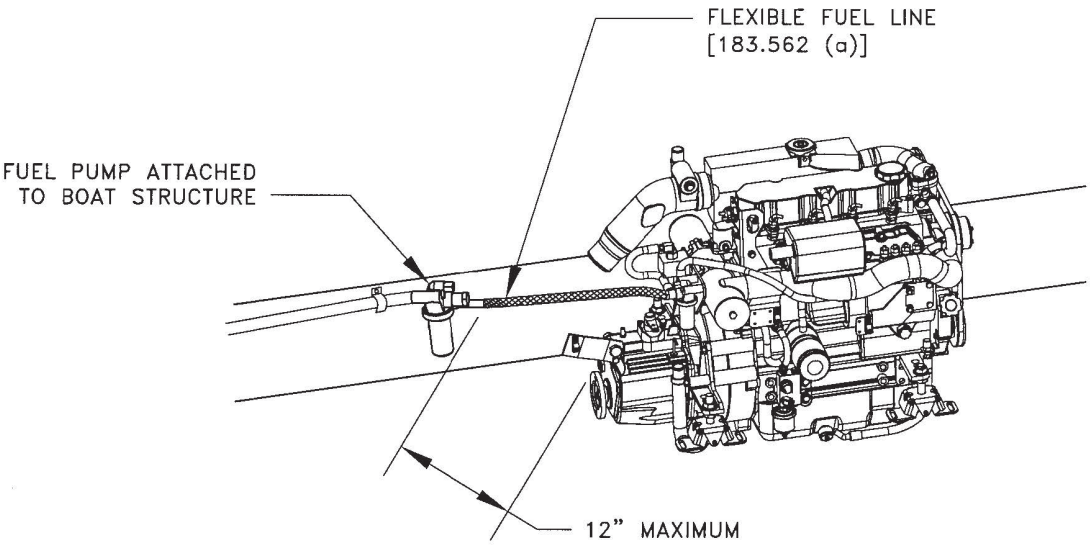
Per 183.566: Each engine fuel pump must be on the engine or within 12 inches of the engine.

Most engines are equipped by the engine manufacturer with a fuel pump as an installed engine. In order to keep the length of the pressurized portion of the fuel distribution line at a minimum, it is required that a remote fuel pump be installed within 12-inches of the engine. The 12-inches are measured directly to the engine, not along the fuel line.

This restriction does not apply to pumps used to transfer fuel from one tank to another.

FIGURE 24 Remote Fuel Pump

4.7 ANTI-SIPHON PROTECTION



Anti-siphon protection is a critically important fuel system safety requirement that requires boatbuilder strict compliance.

Anti-siphon protection is a term applied to the means of preventing the siphon action of permitting fuel

> Per 183.568: The fuel line from the fuel tank to the engine must meet anti-siphon protection.

to continue to flow out of the fuel tank in the event there is a break or rupture in a fuel distribution line, or if a fitting in the fuel line loosens, creating a leak.

"Anti-siphon protection" may be accomplished by one or more of the following methods:

- Keep all parts of the fuel line from the fuel tank to the fuel line connection at the engine above the level of the top of the fuel tank. The tank top level is determined with the boat in its "static floating position." Practically, the fuel pump and fuel filter(s) must also be above the tank top.
- Install an anti-siphon device at the tank withdrawal fitting. Such devices will usually look like a normal fuel (open) fitting. Builders must ensure the proper device is installed.
- Install an anti-siphon device at a location where a line from the fuel tank will no longer remain above the fuel tank top level. The anti-siphon device will then protect the portion of the line that must run below the tank top level. The portion of the line that is above the fuel tank top level will be automatically taken care of.
- Install an electrically operated fuel stop valve at the fuel tank withdrawal fitting. This valve

requires electrical power to open and must be connected to operate only when the ignition switch is on. A filter may be installed between this valve and the fuel tank withdrawal fitting. Electrically operated fuel stop valves must comply with 183.528.

- Install an electrically operated fuel stop valve at the point in a fuel line where it must run lower than the fuel tank top level. This valve requires electrical power to open and must be connected to operate only when the ignition switch of the engine it serves is on. Electrically operated fuel stop valves must comply with 183.528.

With the last four options, the fuel distribution line may then run below the level of the tank top. A filter may be installed between the fuel tank withdrawal fitting and the anti-siphon device.

4.7.1 ANTI-SIPHON DEVICES

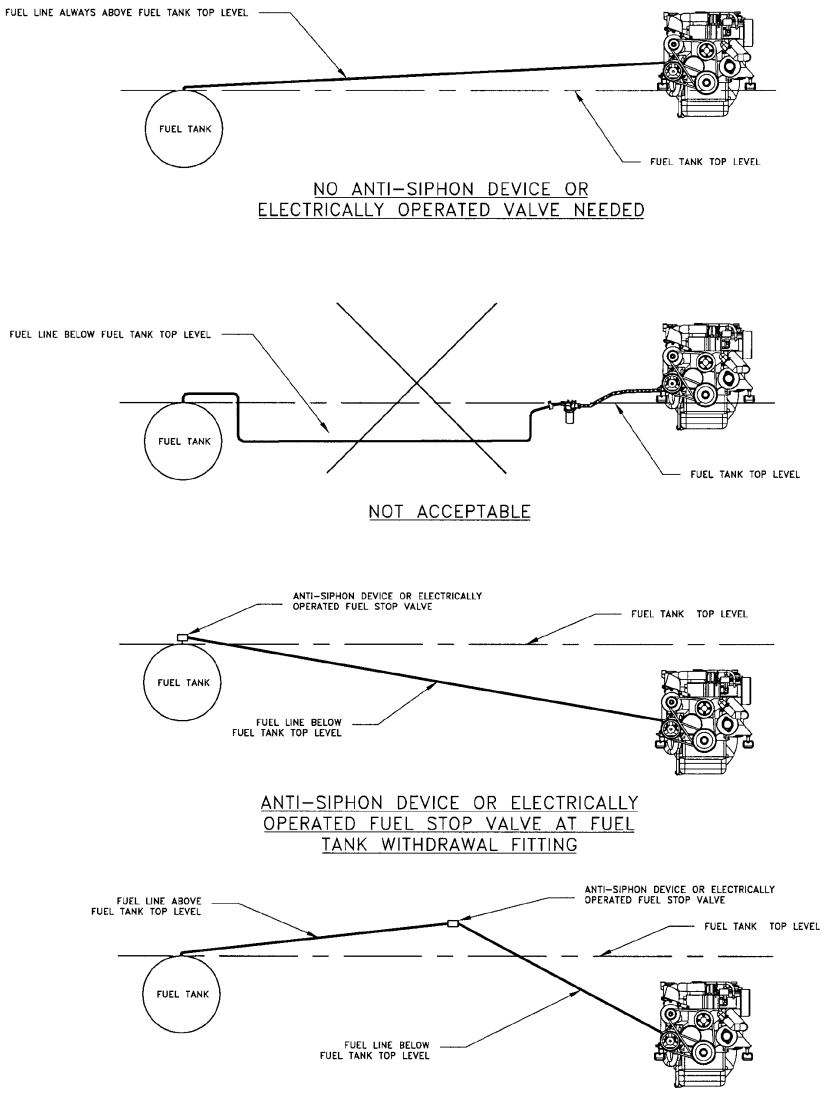
Some anti-siphon devices are spring-loaded check valves. These valves have a specific cracking pressure and provide protection up to a specific head. Therefore, the anti-siphon valve must be selected or ordered to protect against the siphon head for a particular installation. Too high a cracking pressure may cause vapor lock. Be sure to select the correct cracking pressure.

Some anti-siphon devices involve a bleed hole in the fuel pick-up tube, near the top of the fuel tank. The size of the hose is critical for a particular application. Each installation using this type of protection must be evaluated to assure its effectiveness. Too large a hole will bleed excessive air into the fuel flow affecting engine operation. Too small a hole may not stop fuel flow in the event of a fuel leak. This installation is used very infrequently because of inherent problems that may result.

Fuel stop valves used in the fuel system, whether electrically operated or manually operated, must be directly at the fuel tank connection by 183.568(c)(1) and must be installed so that it can be operated from outside the compartment. This can be accomplished with a reach rod or a long valve stem. The installation of an access panel over the valve is also permitted. However, once open, the valve must be immediately accessible inside the panel so that the operator does not have to reach through fire to shut off the fuel.

FIGURE 25 Anti-Siphon Protection

4.8 FUEL FILTERS AND STRAINERS



Fuel filters and strainers may not use the attached fuel lines for their primary means of support. Many

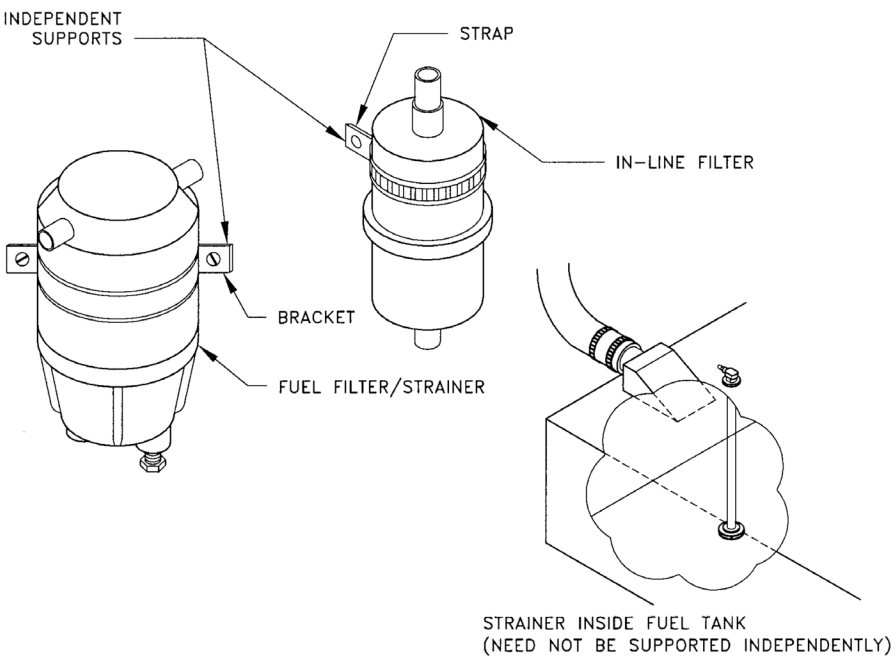
> Per 183.570 Each fuel filter and strainer must not be supported by its fuel line connections.

fuel filters and strainers have brackets designed to provide support. If brackets are not provided as part of the fuel filter or strainer, clips, straps or other means must be employed to support the fuel filter or strainer independent of its connected fuel lines.

Fuel filters or strainers used inside a fuel tank, such as might be attached to the fuel tank withdrawal fitting, are not required to be independently supported.

FIGURE 26 Fuel Filter or Strainer Support

4.9 GROUNDING



The resistance between the fuel system metallic components and ground must be less than 100 ohms.

> Per 183.572: Each metallic component of the fuel fill system and fuel tank must be grounded.

Fuel flowing from the dispensing nozzle into a fuel tank is a potential source of a static electric charge that could cause a spark between the dispensing nozzle and metal component of the fuel tank fill system. To prevent such a spark from occurring, metallic components of the fuel tank fill system and metallic fuel tanks must be grounded.

Grounding or bonding may be accomplished by connecting the metallic components electrically by running a wire from one component to the next, and so forth to the boat's ground. Grounding can usually be accomplished by a connection to the common bonding conductor or the engine negative terminal.

Bonding wires put under the end of a hose could cause a fuel leak. The bonding wire should be a "bolted connection" on the tank's ground tab. At the deck plate the bonding wire may be securely connected to a ground fitting provided on the deck plate, or securely connected to a deck fill plate bolt. If the fuel tank deck fill fitting is nonmetallic, and nonconductive hose is used as a fill pipe, there is no

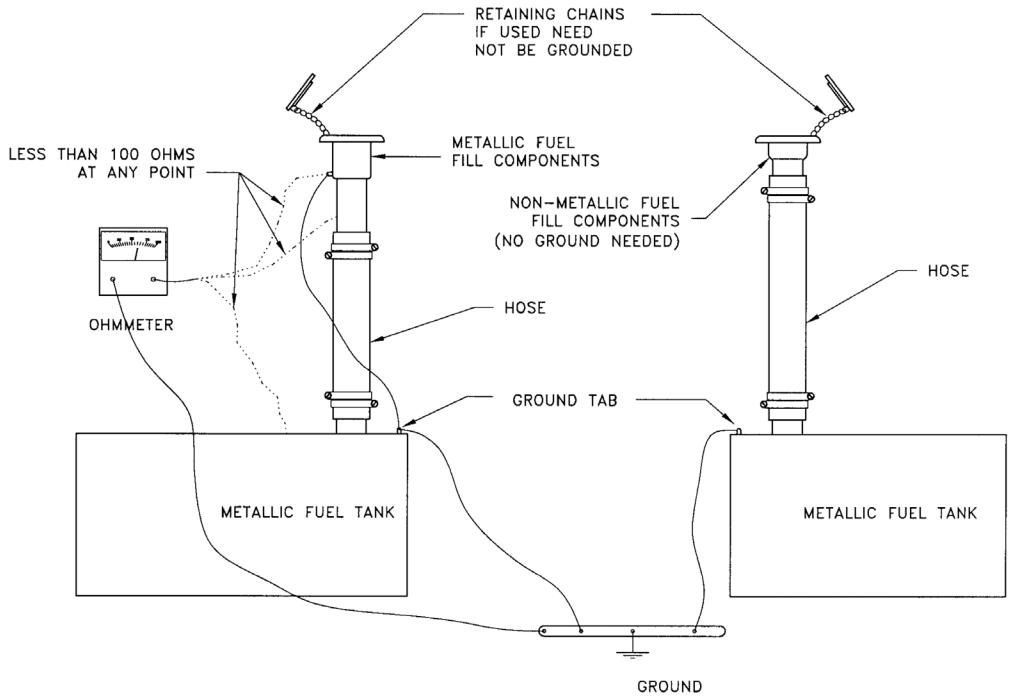
need for grounding the fill fitting.

Chrome-plated plastic fill fittings are treated the same as metallic fittings.

If a metal hose attachment fitting is used, it must be grounded.

Fill cap retaining chains need not be grounded.

FIGURE 27 Fuel Fill System Grounding



CAUTION:

BONDING WIRES PUT UNDER THE END OF A HOSE COULD CAUSE A FUEL LEAK. The bonding wire should be a "bolted connection" on the tank's ground tab. At the deck plate the bonding wire may be securely connected to a ground fitting provided on the deck plate, or securely connected to a deck fill plate bolt.

4.10 FUEL SYSTEM TESTS

Boatbuilders are not expected to complete the fuel system tests described in CFR Section 183.580. But – they are listed in the CFR – and included in this guideline – to give boatbuilders a basic understanding of the various tests with respect to the purpose of the tests. As noted before, only the static pressure test is required. The other tests discussed are 'IF" tested (as may be required by the USCG).

The discussion does not give sufficient information for builders to fully understand the tests. One of the references listed in Appendix 1 is the "USCG Compliance Test Procedure – Fuel Standard Test Procedure".

4.10.1 STATIC PRESSURE TEST FOR FUEL TANKS

This general topic has been discussed in this guideline previously:

- The requirement that each fuel tank be pressure tested was covered in the Equipment Standards discussion of fuel tanks per CFR Section 183.510.
- The determination of fuel system pressure was also covered in the discussion of CFR Section 183.510.
- The fuel tank pressure to be marked on the tank was covered in the discussion of CFR Section 183.514.

In most installations, it is almost impossible to completely inspect all surfaces of a tank. Therefore, this

> Per 183.580: Gives the procedure for the (required) static pressure test of fuel tanks.

test should be performed before the tank is installed. Testing the tank before installation should result in the discovery of defects in the tank that could result in drastic disassembly of the boat, if such test was performed after installation.

The CFR basically says to pressurize the tank and look for leaks. The referenced USCG 'Fuel System Standard Test Procedure' explains the 'Static pressure test for fuel tanks' in greater detail – as follows:

The tank should be empty for this test. Testing pressure can be supplied by pressurized air or compressed inert gas. The tank's rated testing pressure is marked on the tank, but in no case will it be below 3 psig.

During the test, the sides, top and bottom of the tank should be accessible. All openings except the one used to admit the pressure should be sealed.
A regulated source of pressure, a gauge or manometer, a pop-off or relief valve and a shut-off valve will

be needed. The gauge should have a range of less than three times the test pressure. The relief valve should be set for less than the maximum gauge pressure to prevent harm to the gauge and as a safety measure for testing personnel.

When the tank has been pressurized to its rating, it should be isolated from the pressure source by closing the shut-off valve.

The static pressure test must be supplemented with another method to check for leaks. Soapy water or a detergent solution, both of which should be non-corrosive and non-toxic, can be used as well as total immersion of the tank in water. Most small leaks do not produce an immediately detectable drop on the face of the pressure gauge, but soap solutions or immersion will reveal very small leaks by bubbling.

If immersion of the tank is used, remember that immersion increases the pressure on the outside of the tank above normal atmospheric pressure. The testing pressure in this case must be the differential in actual pressures. For example, if the head of water over a tank will produce 1 pound of pressure and the tank is to be tested to a label pressure of 3 pounds of pressure, then, when underwater, the pressure inside the tank must be 4 psi. For every foot of head, the pressure correction is 0.433 psi.

Inspect all seams and attachments — fill, vent, fuel lines, fuel level indicator, etc. for leakage.

4.10.2 THE OTHER 'IF' FUEL SYSTEM TESTS

There is no CER requirement that these 'IF' tests be completed. The USCG may direct that specific tests be completed for specific fuel system components. The shock test, pressure impulse test, and slosh test apply to fuel tanks. The fire test might involve a variety of fuel system components.

> Per 183.584 – Shock Test / 183.586 Pressure Impulse Test/183.588 Slosh Test/183.590 Fire Test – procedures are covered for fuel system components 'IF' tested.

4.10.2.1 SHOCK TEST

The shock test is completed to see how a fuel tank can handle accelerations. This test is completed on fuel tanks of less than 25 gallons.

In simple terms:

- First complete static pressure test (as above).
- Precondition a non-metallic tank by filling with gasoline for 30 days – then drain and clean.
- Mount tank on impact test machine.
- Fill tank with water.
- Apply accelerations (per listed number of cycles at listed vertical acceleration at listed rate) – depending on planned tank location in boat.
- Complete another static pressure test to check for pass/fail.

Clearly the fuel tank manufacturer or a testing lab would conduct this test.

A key determination of the shock test is whether a fuel tank can be mounted for installation aft of the half-length of the boat.

4.10.2.2 PRESSURE IMPULSE TEST

This test is completed to see how a fuel tank can handle pressure fluctuations. The test is completed on tanks of 25 gallons or more.

In simple terms:

- First complete a static pressure test
- Pretreat non-metallic fuel tank by filling with gasoline for 30 days – then drain and clean.
- Mount tank on test platform.
- Fill the tank with water.
- Seal each opening
- Apply (3.0 psi / 0.0 psi cycle) pressure impulses for listed number of cycles at listed rate.
- Perform static pressure test to determine pass/fail.

Again – this test would be completed by the fuel tank manufacturer or by a testing lab.

4.10.2.3 SLOSH TEST

This test is completed to see how a fuel tank can handle repeated rocking motion. This test is completed only on tanks of 200 gallons or more.

In simple terms:

- First complete both the static pressure test and the pressure impulse test.
- Secure tank on the test platform rocking structure.
- Fill the tank half way with water.
- Seal each opening.
- Apply the required number of cycles of rocking motion to 15 degrees each side at the specified rate.
- Perform static pressure test to determine pass/fail.

Again – this test would be completed by the fuel tank manufacturer or by a testing lab.

4.10.2.4 FIRE TEST

Obviously, fire tests are potentially dangerous – and will only be completed by the fuel system component manufacturer or by a testing lab.

This test covers more than just fuel tanks. Table 5 shows the potential applicability of additional fuel system components – and the manner in which they are to be tested.

TABLE 5 Fire Test Selection

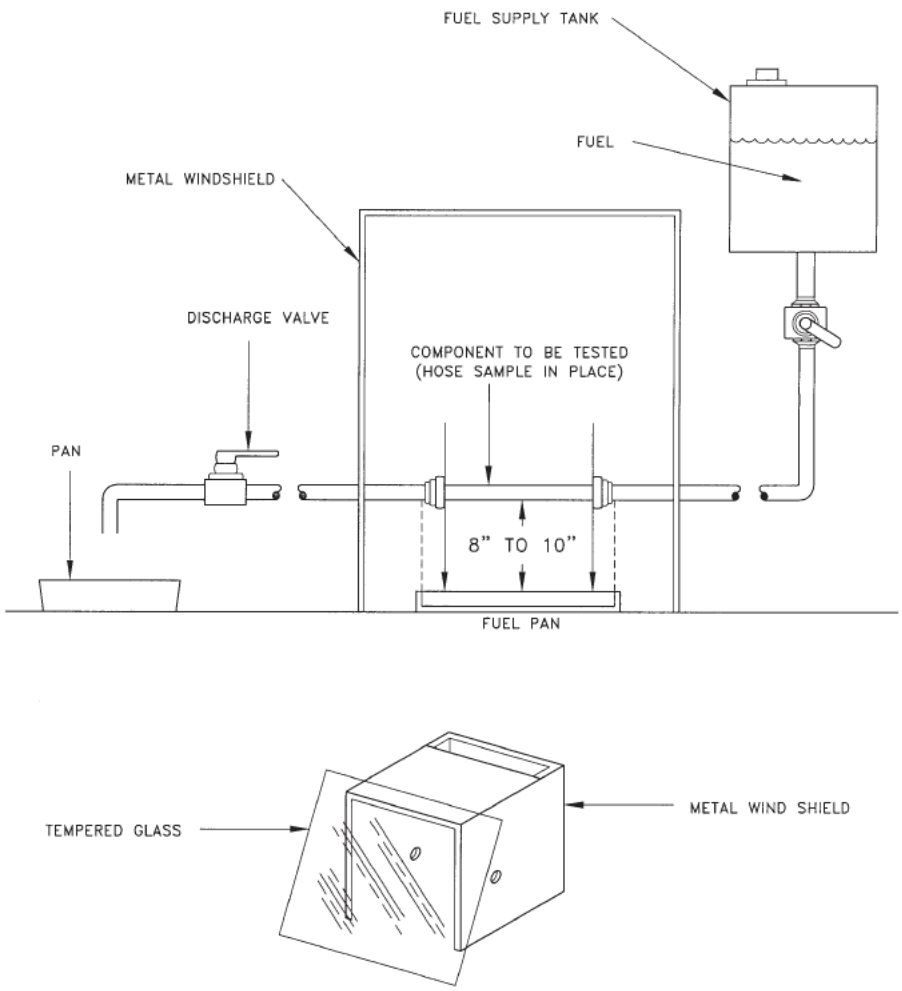
ITEM	FIRE CHAMBER	ON ENGINE	HULL SECTION
Fuel Tank	•		•
Fuel Stop Valves	•		
USCG Type A Hose	•		
Fuel Filters	•	•	
Strainers	•	•	
Fuel Pumps	•	•	

Each fire test is completed with free burning heptane with the test component exposed to the flame for 2 ½ minutes. For an accurate test the flame must be extinguished at the 2 ½ minute mark.

Figure 29 shows a typical fire chamber arrangement. The fire test procedures specify chamber temperature and heptane fuel location.

FIGURE 28 Fire Test in a Typical Fire Chamber

For components installed on an engine placed in the test chamber, sufficient heptane to burn for



2 ½ minutes is poured over the component to collect in a flat-bottomed pan below and near the component.

As noted in Table 4, fuel tanks may be tested separately or as a part of a hull section. Fuel tanks are tested when filled with fuel to one-fourth the capacity marked on the tank. If tested as a part of a hull section the quantity of heptane to burn for 2 ½ minutes needs to collect in the hull section around the bottom of the fuel tank.

If the component being tested is a hose clamp, it must be subjected to a tensile test after the fire test. It must withstand a 1-pound (0.5 kg.) pull in any direction in which it might be subjected in any use. It must not separate, break, crack or noticeably deform as a result of the application of the weight used for the test.

"USCG Type A1" and "USCG Type A2" fuel hoses and stop valves must not leak fuel after the fire test

when subjected to a 3-foot head of fuel. (See 183.528 and 183.532).

Fuel filters, fuel strainers and fuel pumps must not leak more than 5 ounces of fuel in 2-1/2 minutes after the fire test, in accordance with 183.524 and 183.534.

Appendix 1. Fuel Systems References and Resources

The following standards are referenced in this regulation:

ASTM D 471	"Test Method for Rubber Property — Effect of Liquids". Applies to section 183.516.
ASTM D 1621	"Test Method for Compressive Properties of Rigid Cellular Plastics". Applies to section 183.516.
ASTM D 1622	"Standard Test Method for Apparent Density of Rigid Cellular Plastics". Applies to section 183.516
MIL P-21929B	"Plastic Material, Cellular, Polyurethane, Foam in Place (2 pounds per cubic foot)". Applies to section 183.516.
SAE J1527	"Marine Fuel Hose". Applies to section 183.540.
SAE J536	"Hose Clamps". Applies to section 183.564
UL 1114	"Marine Flexible Fuel-line Hose". Applies to section 183.540.
USCG	Fuel System Standard Test Procedure (January 1978). Applies to sections 183.580 – 590.

ASTM standards are available from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, (610) 832-9585.

MIL standards are available from Document Automation and Production Service, 700 Robins Ave, Bldg 4, Section D, Philadelphia, PA 19111-5094, (215) 697-2179.

SAE standards are available from the Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096, (412) 776-4841, www.sae.org.

UL (Underwriter Laboratories) standards are available from COMM 2000, Inc., 1414 Brook Drive, Downers Grove, IL 60515, (888) 853-3503., www.ul.com.

The United States Coast Guard Compliance Test Procedure — "Fuel System Standard Test Procedure" is available from: American Boat & Yacht Council Inc., 3069 Solomons Island Road Edgewater, MD 21037-1416' (410) 956-1050, www.abycinc.org, email: info@abycinc.org.

Appendix 2. 33 CFR 183 Subpart J – Fuel Systems

§ 183.501 APPLICABILITY

(a) This subpart applies to all boats that have gasoline engines, except outboard engines, for electrical generation, mechanical power, or propulsion.

§ 183.505 DEFINITIONS

As used in this subpart:

Flame arrestor means a device or assembly that prevents passage of flame through a fuel vent.

Fuel system means the entire assembly of the fuel fill, vent, tank, and distribution components, including pumps, valves, strainers, carburetors, and filters.

Static floating position means the attitude in which a boat floats in calm water, with each fuel tank filled to its rated capacity, but with no person or item of portable equipment on board.

§ 183.507 GENERAL

Each fuel system component on a boat to which this subpart applies must meet the requirements of this subpart unless the component is part of an outboard engine or is part of portable equipment.

§ 183.510 Fuel TANKS

(a) Each fuel tank in a boat must have been tested by its manufacturer under § 183.580 and not leak when subjected to the pressure marked on the tank label under § 183.514(b)(5).

(b) Each fuel tank must not leak if subjected to the fire test under § 183.590. Leakage is determined by the static pressure test under § 183.580, except that the test pressure must be at least one-fourth PSIG.

(c) Each fuel tank of less than 25 gallons capacity must not leak if tested under § 183.584.

(d) Each fuel tank with a capacity of 25 to 199 gallons must not leak if tested under § 183.586.

(e) Each fuel tank of 200 gallons capacity or more must not leak if tested under §§ 183.586 and 183.588.

§ 183.512 Fuel TANKS: PROHIBITED MATERIALS

(a) A fuel tank must not be constructed from terneplate.

(b) Unless it has an inorganic sacrificial galvanic coating on the inside and outside of the tank, a fuel tank must not be constructed from black iron or carbon steel.

(c) A fuel tank encased in cellular plastic or in fiber reinforced plastic must not be constructed from a ferrous alloy.

§ 183.514 FUEL TANKS: LABELS

(a) Each fuel tank must have a label that meets the requirements of paragraphs (b) through (d) of this section.

(b) Each label required by paragraph (a) of this section must contain the following information:

(1) Fuel tank manufacturer's name (or logo) and address.

(2) Month (or lot number) and year of manufacture.

(3) Capacity in U.S. gallons.

(4) Material of construction.

(5) The pressure the tank is designed to withstand without leaking.

(6) Model number, if applicable.

(7) The statement, "This tank has been tested under 33 CFR 183.510(a)."

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

(c) Each letter and each number on a label must:

(1) Be at least 1/16 inch high and

(2) Contrast with the basic color of the label or be embossed on the label.

(d) Each label must:

(1) Withstand the combined effects of exposure to water, oil, salt spray, direct sunlight, heat, cold, and wear expected in normal operation of the boat, without loss of legibility; and

(2) Resist efforts to remove or alter the information on the label without leaving some obvious sign of such efforts.

§ 183.516 CELLULAR PLASTIC USED TO ENCASE fuel TANKS

(a) Cellular plastic used to encase metallic fuel tanks must:

(1) Not change volume by more than five percent or dissolve after being immersed in any of the following liquids for 24 hours at 29 °C:

(i) Reference fuel B ASTM D 471 (incorporated by reference, see § 183.5).

(ii) No. 2 reference oil of ASTM D 471 (incorporated by reference, see § 183.5).

(iii) Five percent solution of trisodium phosphate in water; and

(2) Not absorb more than 0.12 pound of water per square foot of cut surface, measure under Military Specification MIL P-21929B.

(b) Non-polyurethane cellular plastic used to encase metallic fuel tanks must have a compressive strength of at least 60 pounds per square inch at ten percent deflection measured under ASTM D 1621 (incorporated by reference, see § 183.5), "Compressive Strength of Rigid Cellular Plastics".

(c) Polyurethane cellular plastic used to encase metallic fuel tanks must have a density of at least 2.0 pounds per cubic foot, measured under ASTM D 1622 (incorporated by reference, see § 183.5), "Apparent Density of Rigid Cellular Plastics."

§ 183.516 CELLULAR PLASTIC USED TO ENCASE fuel TANKS

(a) Cellular plastic used to encase metallic fuel tanks must:

(1) Not change volume by more than five percent or dissolve after being immersed in any of the following liquids for 24 hours at 29 °C:

(i) Reference fuel B ASTM D 471 (incorporated by reference, see § 183.5).

(ii) No. 2 reference oil of ASTM D 471 (incorporated by reference, see § 183.5).

(iii) Five percent solution of trisodium phosphate in water; and

(2) Not absorb more than 0.12 pound of water per square foot of cut surface, measure under Military Specification MIL P-21929B.

(b) Non-polyurethane cellular plastic used to encase metallic fuel tanks must have a compressive strength of at least 60 pounds per square inch at ten percent deflection measured under ASTM D 1621 (incorporated by reference, see § 183.5), "Compressive Strength of Rigid Cellular Plastics".

(c) Polyurethane cellular plastic used to encase metallic fuel tanks must have a density of at least 2.0 pounds per cubic foot, measured under ASTM D 1622 (incorporated by reference, see § 183.5), "Apparent Density of Rigid Cellular Plastics."

§ 183.520 Fuel TANK VENT SYSTEMS

(a) Each fuel tank must have a vent system that prevents pressure in the tank from exceeding 80 percent of the pressure marked on the tank label under § 183.514(b)(5).

(b) Each vent must:

(1) Have a flame arrester that can be cleaned unless the vent is itself a flame arrestor; and

(2) Not allow a fuel overflow at the rate of up to two gallons per minute to enter the boat.

§ 183.524 Fuel PUMPS

(a) Each diaphragm pump must not leak fuel from the pump if the primary diaphragm fails.

(b) Each electrically operated fuel pump must not operate except when the engine is operating or when the engine is started.

(c) If tested under § 183.590, each fuel pump, as installed in the boat, must not leak more than five ounces of fuel in 2 1/2 minutes, inclusive of leaks from fuel line, fuel filter and strainer.

§ 183.526 CARBURETORS

(a) [Reserved]

(b) Each carburetor must not leak more than five cubic centimeters of fuel in 30 seconds when:

(1) The float valve is open;

(2) The carburetor is at half throttle; and

(3) The engine is cranked without starting; or

(4) The fuel pump is delivering the maximum pressure specified by its manufacturer.

(c) Each updraft and horizontal draft carburetor must have a device that:

(1) Collects and holds fuel that flows out of the carburetor venturi section toward the air intake;

(2) Prevents collected fuel from being carried out of the carburetor assembly by the shock wave of a backfire or by reverse air flow; and

(3) Returns collected fuel to the engine induction system after the engine starts,

§ 183.528 Fuel STOP VALVES

(a) Each electrically operated fuel stop valve in a fuel line between the fuel tank and the engine must:

(1) Open electrically only when the ignition switch is on; and

(2) Operate manually.

(b) If tested in accordance with the fire test under § 183.590, a fuel stop valve installed in a fuel line system requiring metallic fuel lines or "USCG Type A1" hose must not leak fuel.

§ 183.530 SPUD, PIPE, AND HOSE FITTING CONFIGURATION

Except when used for a tank fill line, each spud, pipe, or hose fitting used with hose clamps must have:

(a) A bead;

(b) A flare; or

(c) A series of annular grooves or serrations no less than 0.015 inches deep, except a continuous helical thread, knurl, or groove.

§ 183.532 CLIPS, STRAPS, AND HOSE CLAMPS

(a) Each clip, strap, and hose clamp must:

(1) Be made from a corrosion resistant material; and

(2) Not cut or abrade the fuel line.

(b) If tested in accordance with the fire test under § 183.590, a hose clamp installed on a fuel line system requiring metallic fuel lines or "USCG Type A1" hose must not separate under a one pound tensile force.

§ 183.534 Fuel FILTERS AND STRAINERS

If tested under § 183.590, each fuel filter and strainer, as installed in the boat, must not leak more than five ounces of fuel in 2 1/2 minutes inclusive of leaks from the fuel pump and fuel line.

§ 183.536 SEALS AND GASKETS IN fuel FILTERS AND STRAINERS

(a) [Reserved]

(b) Each gasket and each sealed joint in a fuel filter and strainer must not leak when subjected for 24 hours to a gasoline that has at least a 50 percent aromatic content at the test pressure marked on the fuel tank label.

§ 183.538 METALLIC fuel LINE MATERIALS

Each metallic fuel line connecting the fuel tank with the fuel inlet connection on the engine must:

(a) Be made of seamless annealed copper, nickel copper, or copper-nickel; and

(b) Except for corrugated flexible fuel line, have a minimum wall thickness of 0.029 inches.

§ 183.540 HOSES: STANDARDS AND MARKINGS

(a) "USCG Type A1" hose means hose that meets the performance requirements of:

(1) SAE Standard J1527DEC85, Class 1 and the fire test in § 183.590; or

(2) Underwriters' Laboratories, Inc. (UL) Standard 1114.

(b) "USCG Type A2" hose means hose that meets the performance requirements of SAE Standard J1527DEC85, Class 2 and the fire test in § 183.590;

(c) "USCG Type B1" hose means hose that meets the performance requirements of SAE Standard J1527DEC85, Class 1.

(d) "USCG Type B2" hose means hose that meets the performance requirements of SAE Standard J1527DEC85, Class 2.

NOTE:
SAE Class 1 hose has a permeation rating of 100 grams or less fuel loss per square meter of interior surface in 24 hours.
SAE Class 2 hose has a permeation rating of 300 grams or less fuel loss per square meter of interior surface in 24 hours.

(e) Each "USCG Type A1," "USCG Type A2," "USCG Type B1," and "USCG Type B2" hose must be identified by the manufacturer by a marking on the hose.

(f) Each marking must contain the following information in English:

(1) The statement "USCG TYPE (insert A1 or A2 or B1 or B2)."

(2) The year in which the hose was manufactured.

(3) The manufacturer's name or registered trademark.

(g) Each character must be block capital letters and numerals that are at least one eighth-inch high.

(h) Each marking must be permanent, legible, and on the outside of the hose at intervals of 12 inches or less.

§ 183.542 Fuel SYSTEMS

(a) Each fuel system in a boat must have been tested by the boat manufacturer and not leak when subjected to the greater of the following pressures:

(1) Three pounds per square inch; or

(2) One and one-half times the pressure created in the lowest part of the fuel system when it is filled to the level of overflow with fuel.

(b) The test pressure shall be obtained with air or inert gas.

§ 183.550 Fuel TANKS: INSTALLATION

(a) Each fuel tank must not be integral with any boat structure or mounted on an engine.

(b) Each fuel tank must not move at the mounting surface more than onefourth inch in any direction.

(c) Each fuel tank must not support a deck, bulkhead, or other structural component.

(d) Water must drain from the top surface of each metallic fuel tank when the boat is in its static floating position.

(e) Each fuel tank support, chock, or strap that is not integral with a metallic fuel tank must be insulated from the tank surface by a nonmoisture absorbing material.

(f) Cellular plastic must not be the sole support for a metallic fuel tank.

(g) If cellular plastic is the sole support of a non-metallic fuel tank, the cellular plastic must meet the requirements of § 183.516 (b) or (c).

(h) Each fuel tank labeled under § 183.514(b)(8) for installation aft of the boat's half length must be installed with its center of gravity aft of the boat's half length.

§ 183.552 PLASTIC ENCASED fuel TANKS: INSTALLATION

(a) Each fuel tank encased in cellular plastic foam or in fiber reinforced plastic must have the connections, fittings, and labels accessible for inspection and maintenance.

(b) If a metallic fuel tank is encased in cellular plastic or in fiber reinforced plastic, water must not collect between the plastic and the surface of the tank or be held against the tank by capillary action.

(c) If the plastic is bonded to the surface of a metallic fuel tank, the adhesive strength of the metal to the plastic bond must exceed the cohesive strength of the plastic.

§ 183.554 FITTINGS, JOINTS, AND CONNECTIONS

Each fuel system fitting, joint, and connection must be arranged so that it can be reached for inspection, removal, or maintenance without removal of permanent boat structure.

§ 183.556 PLUGS AND FITTINGS

(a) A fuel system must not have a fitting for draining fuel.

(b) A plug used to service the fuel filter or strainer must have a tapered pipethread or be a screw type fitted with a locking device other than a split lock washer.

§ 183.558 HOSES AND CONNECTIONS

(a) Each hose used between the fuel pump and the carburetor must be "USCG Type A1" hose.

(b) Each hose used -

(1) For a vent line or fill line must be:

(i) "USCG Type A1" or "USCG Type A2"; or

(ii) "USCG Type B1" or "USCG Type B2" if no more than five ounces of fuel is discharged in 2 1/2 minutes when:

(A) The hose is severed at the point where maximum drainage of fuel would occur,

(B) The boat is in its static floating position, and

(C) The fuel system is filled to the capacity market on the tank label under § 183.514(b)(3).

(2) From the fuel tank to the fuel inlet connection on the engine must be:

(i) "USCG Type A1"; or

(ii) "USCG Type B1" if no more than five ounces of fuel is discharged in 2 1/2 minutes when:

(A) The hose is severed at the point where maximum drainage of fuel would occur,

(B) The boat is in its static floating position, and

(C) The fuel system is filled to the capacity marked on the tank label under § 183.514(b)(3).

(c) Each hose must be secured by:

(1) A swaged sleeve;

(2) A sleeve and threaded insert; or

(3) A hose clamp.

(d) The inside diameter of a hose must not exceed the actual minor outside diameter of the connecting spud, pipe, or fitting by more than the distance shown in Table 8.

TABLE 8

IF MINOR OUTSIDE DIAMETER OF THE CONNECTING SPUD, PIPE OR FITTING IS:	THE INSIDE DIAMETER OF THE HOSE MUST NOT EXCEED THE MINOR OUTSIDE DIAMETER OF THE CONNECTING SPUD, PIPE, OR HOSE FITTING BY MORE THAN THE FOLLOWING DISTANCE:
Less than 3/8 in	0.020 in.
3/8 in. to 1 in	0.035 in.
Greater than 1 in	0.065 in.

§ 183.560 HOSE CLAMPS: INSTALLATION

Each hose clamp on a hose from the fuel tank to the fuel inlet connection on the engine, a hose between the fuel pump and the carburetor, or a vent line must:

(a) Be used with hose designed for clamps;

(b) [Reserved]

(c) Be beyond the bead, flare, or over the serrations of the mating spud, pipe, or hose fitting; and

(d) Not depend solely on the spring tension of the clamp for compressive force.

§ 183.562 METALLIC fuel LINES

(a) Each metallic fuel line that is mounted to the boat structure must be connected to the engine by a flexible fuel line.

(b) Each metallic fuel line must be attached to the boat's structure within four inches of its connection to a flexible fuel line.

§ 183.564 Fuel TANK FILL SYSTEM.

(a) Each fuel fill opening must be located so that a gasoline overflow of up to five gallons per minute for at least five seconds will not enter the boat when the boat is in its static floating position.

(b) Each hose in the tank fill system must be secured to a pipe, spud, or hose fitting by:

(1) A swaged sleeve;

(2) A sleeve and threaded insert; or

(3) Two adjacent metallic hose clamps that do not depend solely on the spring tension of the clamps for compressive force.

(c) Each hose clamp in the tank fill system must be used with a hose designed for clamps.

(d) Hose clamps used in the tank fill system must:

(1) Have a minimum nominal band width of at least one-half inch; and

(2) Be over the hose and the spud, pipe, or hose fitting.

§ 183.568 ANTI-SIPHON PROTECTION

Each fuel line from the fuel tank to the fuel inlet connection on the carburetor must:

(a) Be above the level of the tank top; or

(b) Have an anti-siphon device or an electrically operated fuel stop valve:

(1) At the tank withdrawal fitting; or

(2) Installed so the line from the fuel tank is above the top of the tank; or

(c) Provided that the fuel tank top is below the level of the carburetor inlet, be metallic fuel lines meeting the construction requirements of § 183.538 or "USCG Type A1" hose, with one or two manual shutoff valves installed as follows:

(1) Directly at the fuel tank connection arranged to be readily accessible for operation from outside of the compartment, and

(2) If the length of fuel line from the tank outlet to the engine inlet is greater than 12 feet, a manual shutoff valve shall be installed at the fuel inlet connection to the engine.

§ 183.570 Fuel FILTERS AND STRAINERS: INSTALLATION

Each fuel filter and strainer must be supported on the engine or boat structure independent from its fuel line connections, unless the fuel filter or strainer is inside a fuel tank.

§ 183.572 GROUNDING

Each metallic component of the fuel fill system and fuel tank which is in contact with fuel must be statically grounded so that the resistance between the ground and each metallic component of the fuel fill system and fuel tank is less than 100 ohms.

§ 183.580 STATIC PRESSURE TEST FOR fuel TANKS

A fuel tank is tested by performing the following procedures in the following order:

(a) Fill the tank with air or inert gas to the pressure marked on the tank label under § 183.514(b)(5).

(b) Examine each tank fitting and seam for leaks using a leak detection method other than the pressure drop method.

§ 183.584 SHOCK TEST

A fuel tank is tested by performing the following procedures in the following order:

(a) Perform the static pressure test under § 183.580.

(b) If the tank is non-metallic, fill it to capacity with a gasoline that has at least a 50 percent aromatic content. Keep the fuel in the tank at 21 °C or higher for 30 days prior to testing.

(c) Mount the tank to the platform of an impact test machine.

(d) Fill the tank to capacity with water.

(e) Apply one of the following accelerations within three inches of the center of the horizontal mounting surface of the tank. The duration of each vertical acceleration pulse is measured at the base of the shock envelope.

(1) If the tank is not labeled under § 183.514(b)(8) for installation aft of the half length of the boat, apply 1000 cycles of 25g vertical accelerations at a rate of 80 cycles or less per minute. The duration of the acceleration pulse must be between 6 and 14 milliseconds.

(2) If the tank is manufactured for installation with its center of gravity aft of the half length of the boat, apply 1000 cycles of 15g vertical accelerations at a rate of 80 cycles or less per minute. The duration of the shock pulse must be between 6 and 14 milliseconds.

(f) Perform the static pressure test under § 183.580.

§ 183.586 PRESSURE IMPULSE TEST

A fuel tank is tested by performing the following procedures in the following order:

(a) Perform the static pressure test under § 183.580.

(b) If the tank is non-metallic, fill it to capacity with a gasoline that has at least a 50 percent aromatic content. Keep the fuel in the tank at 21 °C or higher for 30 days prior to testing.

(c) Mount the tank on a test platform.

(d) Fill the tank to capacity with water.

(e) Cap and seal each opening in the tank.

(f) Apply 25,000 cycles of pressure impulse at the rate of no more than 15 impulses per minute varying from zero to three PSIG to zero inside the tank top from a regulated source of air, inert gas, or water.

(g) Perform the static pressure test under § 183.580.

§ 183.588 SLOSH TEST

A fuel tank is tested by performing the following procedures in the following order:

(a) Perform the static pressure test under § 183.580.

(b) Perform the pressure impulse test under § 183.586.

(c) Secure the tank to the platform of a tank rocker assembly.

(d) Fill the tank to one-half capacity with water.

(e) Cap and seal each opening in the tank.

(f) Apply 500,000 cycles or rocking motion 15 degrees to each side of the tank centerline at the rate of 15 to 20 cycles a minute. The axis of rotation of the rocker and fuel tank must be perpendicular to the centerline of the tank length at a level six inches or less above or below the tank's bottom.

(g) Perform the static pressure test under § 183.580.

§ 183.590 FIRE TEST

(a) A piece of equipment is tested under the following conditions and procedures:

(1) Fuel stop valves, "USCG Type A1" or USCG Type A2" hoses and hose clamps are tested in a fire chamber.

(2) Fuel filters, strainers, and pumps are tested in a fire chamber or as installed on the engine in the boat.

(3) Fuel tanks must be tested filled with fuel to one-fourth the capacity marked on the tank in a fire chamber or in an actual or simulated hull section.

(b) Each fire test is conducted with free burning heptane and the component must be subjected to a flame for 2 1/2 minutes.

(c) If the component is tested in a fire chamber:

(1) The temperature within one inch of the component must be at least 648 °C sometime during the 2 1/2 minute test;

(2) The surface of the heptane must be 8 to 10 inches below the component being tested; and

(3) The heptane must be in a container that is large enough to permit the perimeter of the top surface of the heptane to extend beyond the vertical projection of the perimeter of the component being tested.

(d) If the component is being tested as installed on an engine, heptane sufficient to burn 2 1/2 minutes must be poured over the component and allowed to run into a flat bottomed pan under the engine. The pan must be large enough to permit the perimeter of the top surface of the heptane to extend beyond the vertical projection of the perimeter of the engine.

(e) If a fuel tank is being tested in an actual or simulated hull section, the actual or simulated hull section must be of sufficient size to contain enough heptane to burn for 2 1/2 minutes in a place adjacent to the tank.