2019

Gasoline Fuel Systems, Engines and Related Systems For Recreational Boats

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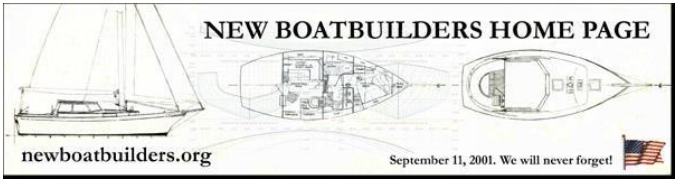
Newboatbuilders.com

3/30/2019



Gasoline Fuel Systems Engines and Related Sytems For Recreational Boats

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All photographs and diagrams were created by the author unless otherwise noted.

Original Edition 2019

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Introduction To Fuel Systems

Why are there so many requirements for fuel systems?

Gasoline is extremely dangerous and volatile. It can go boom at the worst moments ruining your whole day! But it's no joke.

Fuel system regulations have been developed over many years, mainly by the Society of Automotive Engineers (SAE) and the National Fire Protection Association (NFPA). These have been incorporated into the ABYC standards and the US Coast Guard regulations.

Most fuel leaks occur at a fitting. So standards were developed to prevent this. Things such as double clamping a hose and using swaged fittings were made primarily to prevent leaking connections.

Hoses that were used in autos were found to be inadequate in boats. Fuel in cars does not stay in the hose very long, but in boats it can sit for months at a time. This gives the additives and the components of the gasoline itself time to attack the compound of the hose. So hoses have to be able to resist this. Alcohol in the fuel leaches out the parafins that make the hose pliable and flexible. So hose was developed that was alcohol resistant. Even so, hose should be checked periodically for cracks, stiffening, becoming very soft and mushy, and replaced.

Hoses that are exposed to sunlight have to be UV resistant as well. Hoses used for outboard engines in particular have to be UV resistant because they often are outside exposed to the sun.

Hoses used in some areas on the boat also need to be fire resistant. If a fire gets started the last thing you need is a fuel hose burning through and dumping fuel into the boat, feeding the fire. So hoses have to resist a fire for 2 1/2 minutes. Why 2 1/2 minutes? Because if your fire fighting system doesn't put out the fire in that amount of time, you probably won't put it out. It gives you time to get off the boat.

Fuel hose clamps are usually metal, although plastic ones are being used occasionally. The metal has to be corrosion resistant. So stainless clamps should be used, but all stainless! Many supposed stainless clamps are not. The little screw that tightens them is not always SS. The clamps corrode and lose their tension, loosening the connection. One of the most common causes of fires is fuel dumped in the boat when fueling up. This is because the clamps on the fuel fill hose have loosened and fuel leaks at the fitting, or the hose falls off.

Metal fuel lines also have problems. Copper in a marine environment deteriorates rather rapidly. Plus that it is subject to galvanic corrosion. So metal fuel lines have to be certain materials such as copper-nickel or nickel copper. Steel lines are also allowed. A big problem with metal fuel lines is vibration. Vibration loosens fittings, and fatigues the metal, resulting in cracks, usually at the fittings. So metal fuel lines are usually kept short, and there are short flexible lines between the metal fuel line and the engine inlet.

Other fuel system components have the same sorts of problems. Fuel pumps and filters have to be fire resistant and not leak. Fuel filters used in cars don't meet these requirements. If you get a fuel leak in a car the gas goes on the ground. In a boat it goes into the bilge. So components have to meet the same requirements as hoses and tanks.

Fuel tanks need to be of a material that doesn't easily corrode, is fire resistant, and strong enough to last with all the forces that they are subjected to. Tern plate (a lead tin compound), used to be common on cars. Unfortunately, it corrodes rapidly on boats. So tern plate is not allowed. Steel needs to be properly prepared and coated to resist corrosion. Aluminum corrodes if it is constantly wet. It also is subject to corrosion from the inside of the tank due to phase separation of the gasoline and alcohol, and alcohol's tendency to attract water. So it needs to be mounted properly to avoid corrosion. The same goes for any metal tanks. Stainless is a special problem. It too will corrode if wet, so it needs to be mounted where it can be kept dry. It is also subject to crevice corrosion, particularly at the welds. So welds need to be kept to a minimum. All of these materials have to be able to resist shock and vibration, sloshing of fuel in the tanks, and sudden accelerations in all three directions.

One question that comes up often is "why can't I put the fuel pump in or on the tank"? This is commonly done with fuel injected systems on cars . It helps to eliminate vapor lock and insures a steady supply of fuel. However, this means that the fuel line running from the tank to the engine is under pressure. In some fuel injected systems this can be as much as 30 psi. Think what would happen if a leak developed! In a pressurized system this would result in all of the fuel in the system being sprayed into the boat. I mean all! It would empty the tank. This is one of the basic laws of physics. So, the fuel pump on a boat is required to be on or within twelve inches of the engine. That way the only line under pressure is the one from the fuel pump to the carburetor or fuel injection system. This line is usually very short, generally about a foot or maybe two on larger engines. The fuel from the tank is sucked to the engine rather than pushed. If a leak develops, the fuel just stops flowing and the engine

quits. Pressurized lines and fuel systems are not allowed on boats, except for that one short line.

Why not a closed fuel system? Why does it have to be vented to the atmosphere? Doesn't this add to air pollution? Yes it does. But for the reasons cited above you don't want a pressurized system. A leak would dump all the fuel into the boat. However, the new EPA Fuel system rules do allow for up to 1 psi in the tank, fill and vent.

So the main purpose behind fuel system regulations is to prevent leaks, thereby preventing fires and explosions.

To add a complication, the US Environmental Protection Agency (EPA) and the California Air Resources Board (CARB) have recently (since about 2001) proposed a series of regulations that would control evaporative emissions from permanently installed fuel systems, and exhaust emissions from inboard gasoline engines. The regulations would limit evaporative emissions to 15 grams per square meter of surface per 24 hour period. This is far less than the current 100 for A1 or B1 hose and 300 for A2 and B2 hose. The same requirement would apply to tanks and vent systems which have always been open to the atmosphere. Because of the safety issues surrounding pressurized systems, the EPA and CARB have agreed not to require closed systems, as are used on cars, but to require a charcoal canister in the vent that would not create back pressure and would absorb fuel vapors. Plastic tanks would also have to limit the amount of vapor permeated through the tank wall. The engine exhaust will have a catalytic converter, similar to cars but much smaller in size. Some of these regulations go into effect in 2009, and all go fully into effect in 2010. As of July 2012 all of these EPA regulations are in effect. See http://newboatbuilders.com/pages/environment_epa.html

Chapter 1. GASOLINE FUEL SYSTEMS

Safety standards for gasoline fuel systems on recreational boats.

Warning: I am only going to very briefly cover the basics here. There are requirements in the Federal Regulations and in ABYC standards that are not included here! I will only hit the high points. Contact ABYC at www.abycinc.org, and the Coast Guard www.uscgboating.org to get the latest standards for fuel systems.

Read the Federal Regulation; 33 CFR 183.501-183.590 ; See Appendix A (page 45)

Federal regulations for recreational boats apply only to gasoline, but I have included notes when the rules for gasoline differ from the ABYC standards for diesel. ABYC has standards for both permanently installed gasoline fuel systems. and portable fuel systems.

Diesel Fuel Systems: The USCG does not regulate diesel fuel systems for recreational boats. However, ABYC does have a standard for Diesel Fuel Systems in ABYC H-33. Contact ABYC (https://www.abycinc.org) for a current copy. There are also ISO (ISO 10088 can be obtained through ABYC) and Canadian Standards http://www.tc.gc.ca/publications/en/tp1332/pdf/hr/tp1332e.pdf) for Diesel Fuel Systems.

Scope:

The Federal fuel system safety regulations in 33 CFR 183.501-183.590 apply to:

Recreational Boats with permanently installed inboard gasoline engines for:

Propulsion
Generators
Auxiliary Equipment

This does not apply to:

Outboards:
Portable Equipment: (portable means it can be removed without using tools)

Although you aren't required to follow the Federal fuel system regulations on outboard powered boats, you should use them anyway. Better yet, use the ABYC standard which is more comprehensive than the Federal regulation. ABYC standard **H-24 Gasoline Fuel Systems** applies to both inboard and outboard powered boats with permanently installed fuel systems. If you ever get dragged into court, the complainants attorney will ask you. "Do you meet ABYC standards?" If you decide to use portable fuel tanks, ABYC has a standard, **H-25 Portable Gasoline Fuel Systems,** for boats with portable fuel tanks. They also have a standard for diesel fuel; **H-33 Diesel Fuel Systems.**

FUEL TANKS

I strongly recommend that anyone building boats with permanently installed gasoline tanks not build their own tanks. The reason is simple. You have to certify that whatever you put in this boat meets Federal Regulations. Fuel tanks have to meet a whole raft of rules, both USCG and US EPA, and unless you are setup to test them it's better to just buy them from someone who has already tested and certified the tank.

The same logic applies in other countries that use the Recreational Craft Directive, or the ISO standards. It is much easier for a boat manufacturer to buy tanks from a tank manufacturer who certifies that the tanks meet the regulations that apply in that country, than it is to build your own and go through the lengthy and expensive certification process.

Here's a list of the USCG tests that tanks have to meet. See 33 CFR 183.501-183.590 in Appendix A: (page 44)

Tests

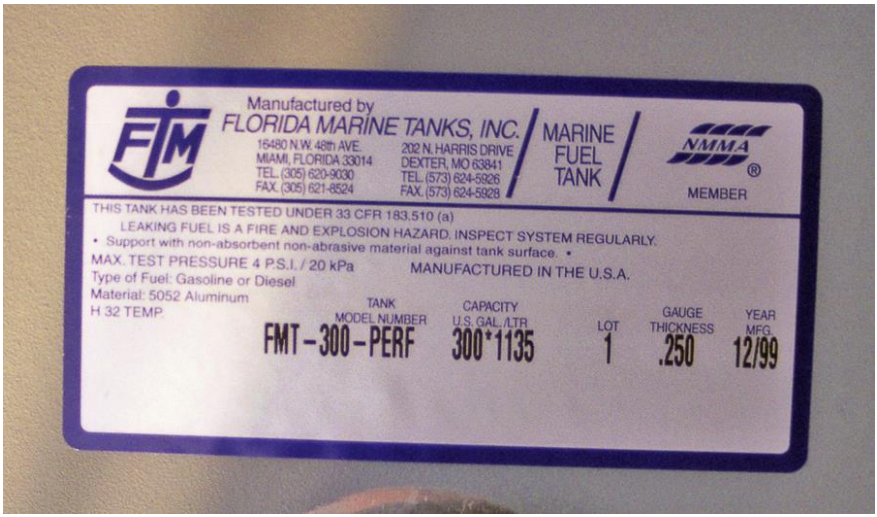
The 2 ½ minute fire test: Under very specific conditions the tank has to survive a fire for 2 ½ minutes. The test setup for this is not cheap and only a few test labs have one and know how to perform the test.

Slosh Test:

Pressure Impulse Test:

Static Pressure Test:

The tank must be capable of passing all of these tests. If it passes the Static Pressure test it must have a label that says; "This tank has been tested under 33 CFR 183.580" which means it has passed the static pressure test. There is more information that needs to be on this label.



Also, if you are planning to put the tank in the forward half of the boat it has to meet additional requirements. Tanks that don't meet those requirements have to have a label saying "Must be installed aft of the boat's half length."

Gasoline tanks cannot be integral with the hull. That means that the hull cannot form one side (or more) of the tank. Tanks must be separate from the boat structure. and cannot support a structure or deck. Some boat builders do use integral tanks but only on diesel powered boats. Diesel fuel tanks may be integral with the hull.

Additionally, plastic (cross-linked polyethyelene, roto molded) tanks have to meet EPA requirements for evaporative emissions

and be labeled by the tank manufacturer. See http://www.nmma.org/assets/cabinets/Cabinet103/Evaporative_Emission_FAQs.doc

So, go buy a tank from a tank supplier.

Some other considerations. Basically there are two kinds of tanks commonly used in recreational boats, aluminum and plastic. Both have distinct advantages. Some people swear by aluminum, others swear at it. The same is true for plastic. I prefer plastic. Plastic tanks don't corrode. But the choice is yours to make. Tanks are occasionally made out of other materials such as steel, stainless steel, monel and so forth. If you want to use materials other than aluminum or plastic, you will probably have to have the tank specially made. ***No matter what material they are made out of they all have to meet the same requirements for strength and fire resistance.***

Some builders want to build tanks out of fiberglass reinforced plastic (FRP). This is common practice for diesel tanks but not advisable for gasoline tanks. It is not prohibited, if they meet all the other requirements for gasoline tanks. But, there have been serious problems with FRP gasoline tanks leaking, primarily due to high levels of ethanol (ethyl alcohol) in the fuel. I would strongly recommend you do not make gasoline tanks out of FRP.

Prohibited Materials:

Ternplate: (Sheet steel, coated with a lead-tin alloy. An alloy of lead containing tin (10-20 per cent) and antimony (1.5-2 per cent.)

Black Iron or Carbon Steel: Unless galvanized on the inside and outside.

Ferrous materials encased in foam: If you want enclose a tank in foam the tank cannot be a tank made of a ferrous (iron or steel) material.

To see all of the ABYC standards for tanks call the American Boat and Yacht Council **www.abycinc.org , (410-990-4460)** and get a copy of **H-24 Gasoline Fuel Systems,** or **H-33 Diesel Fuel Systems**.