Living with E-10 Gasoline: The Quest for Truth

By
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By now, just about every recreational boater and professional fisherman knows that E-10 gasoline, (10% ethanol) is bad news for them. But just how bad is it, really? First: the facts. Ethanol is here to stay. It's a homegrown alternative and renewable fuel, and as manufacturing plants modernize and become a "closed-loop system", meaning the refinery is run on the ethanol they produce, it will eventually require no imported oil to produce. It is important to our national energy security, and that's the fact. So if you own an older boat, (pre-1985) and it has a fiberglass fuel tank, consider it your donation to the fight against oil imports, because you probably have to replace it. Ethanol can dissolve many old fiberglass resins, it will harden into black deposits on your valves, and then you may blow your engine. Much has already been written on the actual mechanism of these resin failures in journals such as Boat US, so we won't address it technically in this article.

For the rest of you, while E-10 isn't the best fuel choice for marine use, it isn't the end of the world. Here are the facts, along with the Do's and Don'ts of how to handle E-10 safely in your boat.

Ethanol is alcohol. Alcohol loves water. It mixes infinitely with water. Once mixed, they stay mixed. This is because both alcohol and water are "polar", which means they have electric charges, in this case, charges that cause attraction to each other. (Picture the static "cling" that draws dust to your TV screen). The technical term for something that loves water enough to suck it right out of the air is "hygroscopic". You will hear that a lot in conversation if you talk to either science nerds or fuel additive salespeople.

Gas (and diesel), are pretty much electrically neutral, or "non-polar". Left to themselves, they won't hold much water in suspension. Nor does gas like ethanol all that much. Small amounts of ethanol can be dissolved into gas to make E-10, but it is not tightly, chemically bound into the fuel. As your boat (or car) sits around water, especially in warm, high humidity climates, the gasoline literally absorbs moisture from the air. This is not just the condensation on fuel tank walls that has plagued boat owners forever. This is really a sponge-like effect. As the ethanol draws moisture into the fuel the water attaches itself to the ethanol, and the mix separates from the gas. The gas becomes hazy. This haze is caused by suspended water droplet's de-fraction of light. The performance of the fuel may start to degrade at this point, with fuel economy and cold starts becoming noticeable. Once the fuel's total water level exceeds about .5%, (that's a half gallon of water in 100 gallons of fuel) and water being heavier than gas, the water/ethanol mix separates from the gas. Get used to another catchy buzzword, "phase separation". That means your ethanol just sank to the bottom. This is where the problems really begin. Ethanol is about 111 octane, and the refinery uses it to build the octane ratings in their gas. After phase separation,

the octane rating of your gas drops along with the ethanol. The engine becomes hard to start, it idles poorly, runs rough, and gets bad fuel economy. Without the proper octane, the engine will ping and knock under acceleration, and given a severe drop, the knock can literally destroy an engine. Picture a tiny hammer on the top of your pistons, slamming them 1,000 times a minute.

Problem number two is that the ethanol/water mixture makes a good paint stripper, and as it settles, it breaks off old varnish, gums, and resin that have been deposited by years of gasoline sitting around in the tanks. This sticky goo plugs filters and sticks up carburetors and fuel injectors, causing everything from mild drops in performance, to complete engine shutdown. There has been a lot of talk about E-10 "gelling" when it mixes with gas using the older MTBE additives. This is not really the picture. MTBE which is an "ether", and unlike ethanol, it is not particularly miscible with water. It is a clear solvent, and chemically similar enough to alcohol to mix along with it in fuel. It is not the source of the brown and milky haze and chunks of solid matter plugging your fuel filter. Some California oil refiners have used either ethanol or MTBE in their fuel for many years, and have had no problems with their brands intermixing. Cars were not stranded across the state from "gelled" fuel. What you are seeing is contaminated E-10 with broken down pieces of varnish and gums, hardened deposits now mixed with water and ethanol. It will not happen in a new, or clean fuel tank, with or without MTBE gas present. It will happen if you have old and dirty fuel tanks, where either through years of sitting unused, or from evaporated gas having left deposits throughout the fuel system, there is built up varnish, gum, and resin. Unfortunately for hundreds of thousands of boaters, that is exactly what they have.

Next on the E-10 Quest For Truth is fuel economy. Ethanol does have less potential energy (measured in BTU's) than gasoline. SAE (Society of Automotive Engineers) data indicates gasoline has about 18,500 BTU's per pound, where ethanol has only 11,500 BTU's per pound. Being 9 parts gas and 1 part ethanol, E-10's formula reads like this: 90% of 18,500 =16,650, and 10% of 11,500 = 1,150. Add 16,650 + 1,150 = 17,800. Therefore, a gallon of E-10 gas has 17,800 BTU's per pound, versus gasoline's 18,500 BTU's, which is a tad over a 3% loss of potential energy.

Therefore, engines running clean and fresh E-10 under lab conditions will experience about 3% to 4% loss in fuel economy. Measuring fuel economy in the lab never matches what happens in the real world.

You may have noticed that E-10 affects the "drivability" of your boat, but not so much your car. Ethanol, before it was being used to supplant our gasoline supply, was first introduced as an additive to lower carbon monoxide emissions. Ethanol is called an "oxygenate". Ethanol readily provides an extra oxygen atom into the combustion reaction, helping convert deadly carbon monoxide (CO) to the safer carbon dioxide (CO2). *Yes, CO2 is the greenhouse gas causing global*

warming, but at least it won't kill you on the spot. CO, especially in the salon of a boat, can be deadly in a matter of minutes. E-10 lowers CO significantly. So in spite of all the apparent problems surrounding ethanol in boating, the fact is, it might actually save your life.

Along with ethanol entraining water in the fuel, which ruins engine performance, the drivability issue comes from the oxygen in ethanol leaning out the combustion. In a car, the computer-controlled fuel system adjusts and optimizes the engine's fuel/air mix ratio using feedback systems. Many boats on the water today are without these feedback systems, and they run lean on E-10. "Lean" means less fuel and more air, as opposed to "rich" which is more fuel and less air. Lean mixes have less power. Fine for a car that has momentum rolling down the highway, but not so good in a boat, which has to push water out of the way at all times. The lean fuel mixture costs boaters power, which they compensate for by using more throttle, which in turn is the cause of the much larger increase in fuel consumption reported by boaters. In the lab, E-10 may only produce a 3% drop if fuel economy, but in the boater's world, that can be 5%, or even higher, if you are heavy on the throttle.

Lean mixes also tend to make engines hard to start when cold, and some engines will run poorly, especially two-strokes. Oxygenates such as ethanol, when combusted without retuning the air/fuel mixture, burn cooler. This can result in incomplete combustion, and in some engines, can increase soot and the buildup of carbon deposits, which can lead to fouling of spark plugs, causing misfiring, especially noticeable in older two-stroke engines. That in turn, can lead to engines running hot, even with a cooler flame temperature. Generally, most engines can handle E-10, as long as it is dry and clean, and all engines manufactured today are rated for 10% ethanol.

The next issue is corrosion. Yes, pure ethanol is corrosive to aluminum, and if water is present, which is just about a given in boat's fuel, it can increase corrosion in steel tanks as well. However, the refinery puts an anti-corrosion additive in the fuel, so as long as you don't mess up their blend by adding chemical fuel additives that mess with the fuel's anti-corrosive chemistry, corrosion is not generally a serious issue.

Ethanol will swell and damage elastomers, which are your rubber hoses, gaskets and o-rings. Most vessels made over the past five years have ethanol-resistant components. It is critical to check with your mechanic or marine supply vendor if you don't know what you have. You can usually squeeze a fuel line, and if it feels soft or mushy, it is breaking down. But you can't simply check a gasket or o-ring, and a fuel leak in a boat is nothing to ignore.

Studies by the SAE have indicated that E-10 can cause intake system deposits, especially in the valve and manifold area. Gas requires a significantly stronger dose of anti-deposit additives to protect against these deposits in the presence of

ethanol. Fuel injectors must also be kept clean. Unfortunately, many of the chemicals that are effective fuel injector cleaners tend to increase valve deposits. The refinery strikes a careful balance in its anti-deposit additive package, providing a blend of detergents, as well as a host of unpronounceable chemicals like polybuteneamines and the tongue-twisting polybutenesuccinimides. These additive packages are fine for most cars, but the heavy workload and harsh environment of the marine engine can leave these fuels lacking in the anti-deposit department. Marine engines running E-10 are more likely to require aftermarket fuel injector cleaners or valve deposit cleaners than cars, but care must be taken in selecting the product. Many aftermarket fuel additives rely on the same detergents or chemicals that the refinery uses, and worse, they may also include more alcohols or ethers, and should be avoided with E-10. Too much of a good thing does not work in the E-10 fuel business.

An important note regarding fuel additives: If E-10 has phase separated, and lost octane, adding an octane booster or a combustion catalyst to restore ignition quality it critical to engine safety. However, aftermarket octane boosters are made of ethanol. If the tank is still filled with water, they will not fix the problem for more than a few minutes. Once the boat is out to sea, and the water bottoms are shaken up, it will pull the new ethanol out of the gas as well, and all you have done is added another twenty or thirty cents per gallon to your bad fuel. Either remove the water before using ethanol octane boosters, or use a non-ethanol combustion catalyst to enhance the fuel's ignition characteristics.

Finally, in our Quest For Truth about E-10, let's address fuel storage. First, ethanol evaporates faster than gas. Always keep your fuel system in tip-top shape. Replace worn hoses, check fittings, and keep the boat covered or protected from the sun if it is stored on a trailer. Second, E-10 goes stale faster than standard gasoline, and tends to form gums quickly. Using fuel additives that prevent gum formation is key to preventing your fuel from aging rapidly.

By now, you should have a pretty good picture of the problem. Ethanol likes water, and fuel systems and engines don't. This has been the rule of law in the fuel business forever. When you read any fuel specification, it calls for "color" and "clarity". The term the fuel industry uses for good fuel is "Clear and Bright", or C&B. You should be able to read 10-point type on a newspaper through a quart jar of fuel. When water and fuel are mixed, it is called "emulsification". It becomes dirty white or milky, and more viscous (thicker) that regular fuel. Emulsified water in fuel can cause wear and corrosion in the fuel system, damaging carburetors, fuel injectors, and fuel pumps. In some engines, most notably, two-strokes and diesels, emulsified water will break down the fuel's lubricity, and can cause catastrophic engine failure.

Water is non-compressible. In the combustion chamber, water reduces the volume of air space, which raises the compression ratio. While this produces more horsepower, and injecting water into the combustion chamber (from a

separate tank, never in the fuel) was an interesting experiment in racing and aircraft engines many decades ago, water corrodes every piece of metal it touches. Additionally, higher compression ratios require higher octane, and in E-10, the higher compression from water entrained in the fuel comes as the octane is typically being reduced by ethanol loss. Without sufficient octane, engine knock will damage the engine, and unless the valve springs are rated for the higher horsepower, the excessive explosive pressures can cause valve damage. So unless you want to rebuild your engine on a regular basis to gain some extra horsepower, you'd best not let water enter your engine.

Water is not a component of fuel. If you added water to your engine intentionally, you would void any warranty. The use of an additive that intentionally causes emulsification could be construed as intentionally adding water. You may void your engine warranty. Ask you dealer before using any hygroscopic fuel additive.

Aftermarket fuel additives should be used only if they have no impact on emulsification, or if they can improve de-emulsification. Most commercial or refinery-grade additives will not emulsify water. However, many aftermarket additives contain certain types of detergents, alcohol, including ethanol, or any number of coalescing agents such as mono-butyl glycol ether, butyl cellosolve, TBA, and butoxyethanol. These chemicals will cause emulsification, and should be avoided. These are the same chemicals used in paints to mix latex in water, industrial or household cleaning chemicals to hold cleaning solvents and water together, and where they may have some cleaning benefits in conventional gas or diesel fuel systems, they are not useful in controlling water, as they suspend water in the fuel. You want water out of the fuel.

CONCLUSION:

With all of these problems, how do you keep your engine safe and your fuel system clean, using E-10 fuel? The trick really is found within the use of the fuel itself. Simply keep using more E-10, use good housekeeping practices to keeping the fuel tank as dry as possible, and always use a top quality (non-alcohol, non-emulsifying) fuel additive: one that prevents water emulsification, eliminates old varnish contamination, stops fuel deterioration and loss of octane, and keeps the fuel system and combustion chamber carbon deposits under control.

This excerpt is from the SAE's "Automotive Fuels Reference Book (ISBN 1-56091-589-7, Owen and Coley), the "Bible" of fuel design and performance, and is also the source of much of the data in this paper.

"*Water bottoms growth is a feature of alcohol blends in storage tanks. The water in the bottom of a gasoline tank is normally left behind every time gasoline is discharged, so that if alcohol is present in the gasoline, the level of water bottoms will increase as alcohol enters the water phase from successive batches of*

gasoline. Eventually, the aqueous phase will contain so much alcohol that it becomes soluble in the gasoline so that the water bottoms will gradually disappear."

This tells us that the problem of gathering water in a boat's fuel tank is a repeating cycle, and will be rectified by successive loads of alcohol-based gasoline. You can't cure the problem just by adding pure alcohol. There is no place to "absorb" the water and alcohol. However, fresh gasoline has the ability to absorb up to .5% water, (again, that is a half gallon per 100 gallons) and therefore, you can "dry" out a fuel tank by just using and refilling the tank. The use of a top quality fuel additive will prevent the loss of octane and the formation of gums in the gas phase in between these "wetting" and "drying" cycles.

If you choose the right fuel additive to prevent or repair varnish and gum contamination, and to protect the octane characteristics of the fuel, and keep the injectors and carburetors clean to maximize fuel economy, E-10 is not that hard to work with.

The only boats (or cars) that are really at risk with E-10 are the ones that don't get used. They absorb water, and then just sit. Once the gas has phase-separated, and the ethanol is on the bottom, the remaining fuel is no longer hygroscopic. However, it will deteriorate beyond recovery if it sits for more than a couple of months without a proper additive, and corrosion will begin on metal components of the fuel system.

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Do's and Don'ts for using E-10 fuel in the boating industry.

Do

1. Replace pre-1985 fiberglass tanks. Immediately.
2. Replace old fuel lines, o-rings, and gaskets that are not rated for ethanol.
3. Routinely inspect hose clamps and any metal fittings in the fuel system for signs of corrosion.
4. If the boat is in constant use, keep your tank full as much as possible, to keep down the airspace in the tank, which will reduce the amount of condensation.
5. Install a fuel line water separator to eliminate water that does collect in the tank that can be picked up by the fuel system during rolling seas.
6. Use fuel additives that will stop fuel from aging and oxidation, and will protect octane and other ignition characteristics of the gas.
7. Use fuel additives that clean fuel injectors and do not contribute to carbon deposits on valves and pistons. Vice versa for fuel additives that remove carbon deposits, but do not form fuel injector deposits. (Choose carefully)
8. Use only de-emulsifying additives or additives that are "hydrophobic", or non-reactive with water, to prevent water from homogenizing throughout the fuel and binding to even more ethanol.
9. When feasible, remove excessive water and ethanol bottoms from phase-separated fuel that is not used often and refilled routinely with fresh gas.

Don't

1. Never use a fuel additive that emulsifies water. Water is not a component of fuel, and by intentionally putting water in your fuel, you may void any warranty. Ask your engine dealer.
2. Never buy fuel that is not clear and bright.
3. If E-10 has been contaminated with water, and has phase separated, do not run it without adding a combustion-enhancing additive to restore octane qualities or reduce the engine's octane demand, to prevent engine
4. Do not leave a near-empty fuel tank sitting for long periods of time. Drain it.

THE SOLTRON® ADVANTAGE

Soltron® Enzyme Fuel Treatment is essential for the safe handling and housekeeping issues facing boaters using E-10 (ethanol) gas. Soltron's unique enzyme formula does not contain detergents or harsh cleaning chemicals. Soltron® is pure fuel, and is safe in all engines and all fuels. Soltron® delivers several benefits to the user, and with its dose rate of only 4,000:1, Soltron® is incredibly cost effective.

Soltron® benefits:

1. Prevents the accumulation of moisture from simple condensation in vessels with frequent gas turnover, preventing phase separation.
2. Protects stored gas from forming gum and resin deposits.
3. Restores the combustion characteristics to older, or "stale" gas.*
4. Keeps injectors, carburetors, fuel lines, and fuel tanks clean.
5. Prevents water accumulation on tank bottom, which reduces rust formation.
6. Dissolves gum and varnish pieces dislodged and suspended by ethanol.
7. Keeps filters and injectors from plugging.
8. Removes carbon deposits from combustion chamber.

*Soltron® should be used at a double dose, or 2,000:1, for long-term storage, or when rejuvenating stale gas. Soltron® will not emulsify water, and is not able to eliminate accumulated water/ethanol mix in phase separated fuel. In vessels that are run frequently, simply add a double dose of Soltron® and fresh gas, to rapidly eliminate the phase separated layer. In vessels with phase separation that sit for long periods of time, the best practice is to remove the water by pump or drain, and then double dose the gas with Soltron®, and add fresh gas as soon as possible.