

### **What are ethanol and ethanol-blended fuels?**

Ethanol for fuel is highly refined beverage (grain) alcohol, approximately 200 proof, that can be produced from natural products such as corn, sugar cane and wheat. New technology will allow ethanol to be made from "cellulosic" feedstocks including corn stalks, grain straw, paper, pulp, wood chips, municipal waste, switchgrass and other sources. Ethanol used for fuel has been "denatured," or rendered unsafe to drink by the addition of a hydrocarbon (usually gasoline). The ethanol-blended fuel E-10 refers to fuel that contains 10 percent ethanol and 90 percent gasoline. Similarly, E-85 refers to fuel that contains 85 percent ethanol and 15 percent gasoline. E-85 is intended only for engines specially designed to accept high-ethanol content fuel blends, such as the Flexible Fuel Vehicles (FFV) made by some car companies.

### **How is ethanol made?**

In the U.S., ethanol is typically produced by removing the starch or sugar portion of corn and fermenting it. The fermented starch is then distilled into alcohol. Excess water is removed, resulting in very pure - 200 proof - ethyl alcohol (ethanol).

In some parts of the world, ethanol is made from a variety of raw materials. For example, sugar cane is used to produce ethanol in Brazil, while sugar beets and wheat straw are commonly used in Europe.

### **What are the characteristics of ethanol?**

Ethanol is an oxygenated hydrocarbon compound that has a high octane rating and therefore is useful in increasing the octane level of unleaded gasoline. The EPA, the agency responsible for setting some of the requirements for all gasoline used in the U.S., has allowed the use of ethanol in gasoline at levels up to 10 percent as an octane enhancer and to provide beneficial clean-burning combustion characteristics that help improve some emissions.

Ethanol is hygroscopic (it has an attraction for water) and will more readily mix with water than with gasoline. It has different solvency behaviors than does gasoline, which allows it to loosen rust and debris that might lay undisturbed in fuel systems. And it can more readily remove plasticizers and resins from certain plastic materials that might not be affected by gasoline alone. Loose debris will plug filters and can interfere with engine operation. Additionally, ethanol is corrosive to some metals, especially in combination with water. Although gasoline does not conduct electricity well, ethanol has an appreciable capability to conduct electricity and therefore can promote galvanic corrosion.

### **What is MTBE and why is it being replaced?**

MTBE is the chemical shorthand description for methyl tertiary-butyl ether. MTBE is another oxygenated hydrocarbon compound that has a high octane rating. It was initially a preferred compound widely used for octane enhancement as a replacement for leaded compounds in gasoline. When the EPA developed regulations requiring oxygenated gasoline to help reduce smog in several areas of the country, MTBE was the most commonly used compound to supply the additional oxygen, while ethanol was chosen for this purpose in the Midwest region of the country. Recently, most states have banned the use of MTBE because of its tendency to work its way into ground water systems, usually from leaks and spills, as an undesirable contaminant. Ethanol is being used as a replacement.

### **Does ethanol affect horsepower or fuel-efficiency?**

Ethanol has a heating value of 76,000 BTU per gallon, which is approximately 30 percent less than gasoline's heating value (which is approximately 109,000 to 119,000 BTU/gal). The result is E-10 gasoline which should yield slightly lower mileage - a decrease of approximately 3 percent. Fuels containing higher levels of ethanol will have a corresponding reduction in mileage. For example, E85 fuels produce mileage approximately 30 percent less than gasoline.

The octane rating of pure ethanol (200 proof) is about 100 and is therefore useful in elevating the octane value of gasoline. In E-10 blends the presence of ethanol provides about 2.5 to 3 percent of the overall octane rating. The effect on engine horsepower is determined by the octane result of the blended fuel. Care should be taken to select fuels having the octane rating recommended for the engine as indicated in the owner's manual for proper operation.

### **Are Mercury engines compatible with ethanol fuels?**

The fuel-system components of Mercury engines will withstand up to 10 percent ethanol in gasoline - the maximum level currently allowed by the EPA in the U.S. There are some efforts to establish E-20 (20 percent ethanol mixed

with 80 gasoline) for use in some areas, but that will require agreement from EPA to grant a waiver. Part of the EPA waiver process will require verification from studies that demonstrate that higher levels of ethanol do not create problems with fuel-system materials or operation of hardware. E-20 has not been extensively studied by Mercury and is not acceptable for use in Mercury products. E-85 fuels must not be used in any Mercury engines and could seriously damage current Mercury products. It is not legal in the U.S. to market any ethanol fuel as gasoline if it contains more than 10 percent ethanol.

### **Will the use of fuels containing ethanol void my engine warranty?**

Fuels containing up to 10 percent ethanol are considered acceptable for use in Mercury engines. Fuels containing higher levels of ethanol are not considered acceptable for use, and the use of fuels containing ethanol higher than 10 percent can void the warranty.

### **What about the fuel-system components on the boat?**

It is important to follow boat manufacturers' recommendations when selecting appropriate fuels. Use of an inappropriate fuel can result in damage to the engine and boat components that may require repair or replacement. Fuels with ethanol can attack some fuel-system components, such as tanks and lines, if they are not made from acceptable ethanol-compatible materials. This can lead to operational problems or safety issues such as clogged filters, leaks or engine damage.

### **Can ethanol-blended fuels affect the performance of traditional carbureted two-stroke outboards?**

Two-stroke outboards should experience little or no decrease in performance due to gasoline fuels containing up to 10-percent ethanol when operated according to Mercury's standard recommendations. When gasoline with ethanol is used for the first time after a fuel changeover from MTBE, the tank must be completely free of water prior to introduction of gasoline with ethanol. Otherwise, phase separation could occur that could cause filter plugging or damage to the engine. (It is probably better for a boat owner to fill the fuel tanks with ethanol fuel for the first time when the tank is low on fuel, but that is not critical. There should be no difficulties if the tank is clean and free from water. If the tank is not free from water, a partial load of fuel will more easily phase separate because with less ethanol in place it takes less water to cause phase separation. The important thing for boaters to concern themselves with is the presence of water in their tanks.)

If an engine is a 1990 or older model, frequent inspections of all fuel-system components are advised to identify any signs of leakage, softening, hardening, swelling or corrosion. If any sign of leakage or deterioration is observed, replacement of the affected components is required before further operation.

### **How does ethanol affect my fiberglass fuel tank?**

Fiberglass tanks manufactured prior to 1991 may not be compatible with gasoline containing ethanol. It has been reported that, in the presence of ethanol, some resins may be drawn out of fiberglass and carried into the engine where severe damage could occur. If an older fiberglass tank is used, check with the manufacturer to determine if gasoline with ethanol can be safely used.

### **Are older fuel lines prone to failure? What about gaskets?**

During the 1980s, many rubber components for use in fuel systems were developed to withstand exposure to fuels containing ethanol. If rubber components in a fuel system are suspected to be of this vintage or older it may be advisable to replace them with newer ethanol-safe components before using fuels containing ethanol. Check with the manufacturer for advice or frequently inspect these fuel-system components for signs of swelling or deterioration and replace if problems are noted.

### **Ethanol is replacing MTBE in my region? What should I do?**

Before gasoline with ethanol is introduced to your fuel tank, ask your boat manufacturer if any special precautions should be considered with the use of fuel containing ethanol. Check for the presence of water in the fuel tank. If any is found, remove all water and dry the tank completely. As a precaution, it is advisable to carry a few extra filters in case filter plugging becomes a problem during boating.

### **Should I add an additional fine-micron filter to the system to prevent debris from entering the engine?**

The addition of another filter to the system will create another possible flow restriction that can starve the engine of fuel. Mercury already provides the appropriate level of filtration to protect the engine from debris.

### **How can a marina prepare for the change from MTBE to ethanol as the fuel oxygenate?**

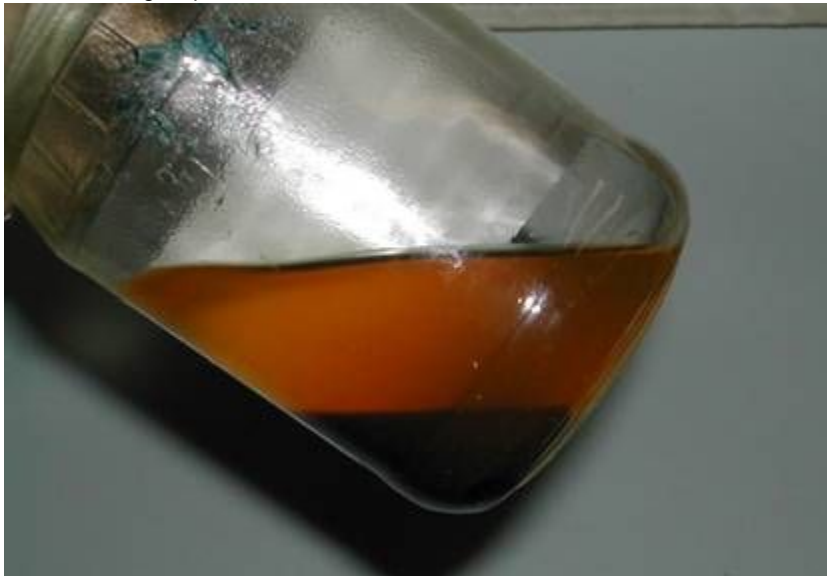
Check with the manufacturer to make certain the tank and lines won't experience problems with ethanol. Inspect the tank for water and, if present, pump out all water and thoroughly clean the tank. Install ethanol-compatible filters. The tank should be less than 20 percent full before adding the first load of fuel with ethanol.

This will help avoid difficulties of dealing with and selling fuel that is a mixture of two different fuel blends to a boater who may have a third blend in the tank. And the marina is dealing with larger stationary tanks that will not allow the two different blends to mix very easily. Ethanol and MTBE should be compatible with each other chemically, but different amounts are used for oxygenation and octane adjustment purposes, and having a tank with two different chemical compounds floating around trying to redistribute could produce unpredictable results. With a tank containing less than 20 percent fuel to begin with, there will be less potential for stratification or other unexpected behavior to enter into the picture. This is consistent with typical practice in the oil and fuel industry and is intended to minimize interaction between blends with different chemical content. It is critical that marinas know their tanks are free from water.

### **What is phase separation, and how do I deal with it?**

If significant amounts of water are present in a fuel tank with gasoline that contains ethanol, the water will be drawn into the fuel until the saturation point is reached for the three-component mixture of water + gasoline + ethanol. Beyond this level of water, phase separation could cause most of the ethanol and water to separate from the bulk fuel and drop to the bottom of the tank, leaving gasoline with a significantly reduced level of ethanol in the upper phase (see Figure 1 below). If the lower phase of water and ethanol is large enough to reach the fuel inlet, it could be pumped directly to the engine and cause significant problems. Even if the ethanol water phase at the bottom of the tank is not drawn into the fuel inlet, the reduced ethanol level of the fuel reduces the octane rating by as much as 3 octane numbers, which could result in engine problems.

The level at which phase separation can occur is determined by a number of variables, including the amount of ethanol, the composition of the fuel, the temperature of the environment and the presence of contaminants. It is very important (A) that the system is inspected for significant quantities of water in the tank before using gasoline with ethanol and (B) to limit exposure of the fuel tank to excess water. If phase separation has occurred, it is necessary to completely remove all free water from the system and replace the fuel before continuing operation. Otherwise, engine problems could occur.



*Figure 1: Sample of fuel from fuel tank in which phase separation has occurred. The upper phase is gasoline with a reduced level of ethanol. The lower level is a mixture of ethanol and water.*

### **Is an additive available that can prevent phase separation?**

There is no practical additive that can prevent phase separation from occurring. The only practical solution is to keep water from accumulating in the tank in the first place.

**Are there any additives that can allow the phase-separated mixture to remix when added to the fuel tank?**

No, the only way to avoid further problems is to remove the water, dispose of the depleted fuel, clean the tank and start with a fresh, dry load of fuel.

**Is there a simple solution to water condensation in the tank as a result of ethanol?**

It is best to maintain a full tank of fuel when the engine is not in use. This will reduce the void space above the fuel and will reduce the flow of air in and out of the tank with changes in temperature. This will reduce condensation on the internal walls of the tank and will limit exposure of the ethanol in the fuel to humidity and condensation.

**What should be done when storing boats with ethanol-blended fuels for extended periods?**

Follow the instructions for normal storage preparation found in the owner's manual or operations guide. When preparing to store a boat for extended periods of two months or more, it is best to completely remove all fuel from the tank. If it is difficult or not possible to remove the fuel, maintaining a full tank of fuel with a fuel stabilizer added to provide fuel stability and corrosion protection is recommended. It is best to add the stabilizer and fuel treatment to the tank at the recommended dosage, running the engine for 10 minutes to allow the system to be cleaned, shutting off the fuel valve to interrupt the fuel supply and allow the engine to run until it stops, topping off the tank until it's full to reduce the amount of exchange with the air that might bring in condensation. Do not cap the tank vent and do not fill with fuel to the point of overflowing. Some extra space should be maintained in the tank to allow for expansion and contraction of the fuel with temperature changes. A partially full tank is not recommended because the void space above the fuel allows air movement that can bring in water through condensation as the air temperature moves up and down. This condensation could potentially become a problem.

Mercury Marine Fuel System Treatment & Stabilizer can help maintain fuel systems in storage. It contains oxidation inhibitors to reduce oxidation and gum formation, metal chelating agents to protect metal components from corrosion, water absorbing agents to reduce the presence of free water, and dispersants to help suspend and disperse debris. When placing the boat back in service, be sure to reopen the fuel valve to the engine.