K-STATE Research and Extension

Ethanol and Small Nonroad Engines

BioEnergy Solutions

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Introduction

Many articles have been written about ethanol fuel use in cars, vans, and pickup trucks. These high quality fuels provide many advantages to motorists. Ethanol is now a common additive to gasoline. It is so common that 70 percent of all gasoline sold contains some ethanol. Engines in late model road vehicles can use varying blends of ethanol fuels, depending on their design. Small nonroad engines (SNRE) are another class of engine that also uses fuel blended with ethanol. SNREs are defined as engines of less than 25 horsepower used in household or commercial applications such as lawn mowers, utility vehicles, chain saws, line trimmers, and portable generators.

The Energy Independence and Security Act of 2007 (EISA) established the Renewable Fuel Standard (RFS), requiring the use of 36 billion gallons of renewable fuel by 2022. Ethanol is one of the renewable fuels covered by the RFS, and use of this fuel will increase. As part of the RFS, the EPA has granted a waiver to allow more ethanol in gasoline blends for general-use vehicles than was previously allowed. Specific blends of fuel will be discussed later in this publication.

What is ethanol?

Ethyl alcohol, or ethanol, is an alcohol that is fermented from sugars or starches found in most plants and then distilled to a nearly pure form. It is commonly fermented from field corn and grain sorghum grown throughout the central part of the United States, though almost any form of plant material can be processed into ethyl alcohol. Fuel ethanol is a blend of petroleum fuel and ethyl alcohol. Fuel ethanol is commonly named ethanol and this is the terminology used in this paper.

Availability of ethanol

Most ethanol available for use as a vehicle fuel is blended with gasoline. Since 1995, ethanol can be found in small percentages of gasoline as a replacement for MTBE, a fuel oxygenate that reduces air pollution. The two most common ethanol blends are E10 and E85. E10 is a mixture of 10 percent ethyl alcohol and 90 percent gasoline (the E stands for ethanol and the 10 for 10 percent alcohol). E85 is a mixture of 85 percent alcohol and 15 percent gasoline. E85 fuel can only be used in engines designed and labeled by the manufacturer specifically for it. These engines are found in flex-fuel vehicles and are designed to run on gasoline blends up to 85 percent ethanol. Most of these vehicles also have a yellow gas cap or labels in the fuel door to indicate the required fuel.

Fuel blended with ethanol is becoming more common. You may have already used ethanol blended fuel without realizing it.

While you may not have decided to start using ethanol blends in your vehicle or other gasoline engines, you may already have E10 in your tank. Depending on the state you are in, it is possible that all gasoline fuels at a filling station may contain up to 10 percent ethanol without any label indicating ethanol presence. Depend-

ing on pricing conditions and state tax incentives, fuel wholesalers have the legal leeway to provide retailers with variations of blended fuel. The ethanol blend gasoline improves air pollution from engine exhaust by replacing previously used fuel additives.

The mandate within the RFS to use 36 billion gallons of renewable fuel by 2022 may not be achievable with the current allowable blends of ethanol on the market. One way to meet this mandate is to allow the usage of ethanol blends in more vehicles or increase the ethanol content in gasoline. In late 2010, the Environmental Protection Agency (EPA) approved the use of E15 in road vehicles manufactured since 2001. It is believed that a blend of E20 could be used as easily as E15 in these same road vehicles and could receive EPA approval at some point in the future. SNRE did not receive EPA approval to use E15 fuels. It is currently **illegal** to use E15 in an SNRE. It is possible that E15 could accidently be used to fill the tank of an SNRE. This paper is intended to consider the use of the standard E10 blend in an SNRE and what the inadvertent use of E15 blend would be on an SNRE.

Ethanol blended fuels are very good fuels. They are used daily in all types of engines, including small engines, without difficulty; however, some features of small engines deserve some consideration when using ethanol.

SNREs, ethanol, and water

One of the first considerations of ethanol and small engines is the usage cycles of most small engines. Many small engines are used seasonally or sporadically throughout the year with long intervals between engine starts. Any engine that is not regularly started and used is more likely to develop starting and running problems. Ethanol fuels can add to or lessen these problems because of the properties of the fuel.

Ethanol has hydroscopic properties, which means it attracts moisture. Fuel tanks that contain ethanol for an extended time and are exposed to humidity or operated near water are more likely to collect water. An empty fuel tank exposed to humidity and rapid temperature changes may also collect moisture. Water in fuels can cause starting difficulties, poor engine performance, and in some cases engine damage. In addition, water can cause corrosion in the fuel system components and foul small orifices in carburetors. In extreme situations, metal fuel tanks and fuel lines can rust through, causing fuel leaks and a possible a fire hazard.

These problems can be avoided with a little awareness and a few simple precautions. Small quantities of water accumulate in the fuel system during regular use of an SNRE, and ethanol blends will actually absorb the water and safely pass it through the engine. But if storing an SNRE for an extended period of time, engine manufactures generally recommend draining the fuel tank, tightly closing the gas cap, and storing the engine in a dry location. By limiting air access to the tank, the collection of water because of the ethanol attraction to water or normal condensation can be mitigated. Alternatively, drain the tank of fuel containing ethanol and refill with pure gasoline. If pure gasoline is unavailable, filling the tank completely full, screwing the gas cap on tightly, and adding a fuel stabilizer to the tank can limit water collection within the fuel tank.

Another aspect of ethanol is the cleaning nature of the fuel. Ethanol is an effective solvent. Small engines used sporadically can collect deposits in the fuel systems. Contaminants may be sludge in the bottom of tanks or films of varnishes on the walls of the tank and fuel lines. Regular gas, without ethanol, may leave these deposits in place as the SNRE is used. An ethanol blended fuel added to the tank may dissolve these deposits and then transport them to the fuel filter, carburetor, or into the cylinder, causing clogging or wear problems. It is possible that an engine that has been running fine will start to run rough and lose power after an ethanol-blended fuel is used for the first time. Often, changing the inline fuel filter will improve or completely alleviate these problems. As previously noted, much of the available gasoline may contain ethanol. The presence of ethanol may prevent the collection of contaminants and will keep fuel systems clean in the first place.

Another consideration for stored ethanol blends is shelf life. The typical shelf life of ethanol is 90 to 100 days versus several years for regular gasoline, because of the hydroscopic nature of ethanol. Ethanol fuel blends have the tendency to separate over time as water is absorbed into the fuel from the atmosphere. Regular gasoline, on the other hand, is hydrophobic and does not combine easily with water; it will separate above the water. Consequently, homeowners and businesses that keep a small container of fuel around for use in their SNREs should dispose of unused fuel at the end of the usage season. (For example, it is not wise to store your lawn mower fuel over winter.) This is a good practice regardless of whether the fuel contains ethanol or not.

SNRE component resistance to ethanol

Like cars, many recently manufactured small engines contain components rated for ethanol-blended fuels. Engine manufacturers understand that fuels avail-

able to consumers are likely to contain some amount of ethanol and have manufactured their engines with ethanol-tolerant components. Most SNRE manufacturers currently rate their engines for E10 blends. Components in recently manufactured SNREs may tolerate higher blends of ethanol. Therefore, an SNRE accidently fueled once with an E15 blend will likely not be harmed. These engines will NOT tolerate fueling with E85, which is not an acceptable fuel for small engines. Reasons for this will be discussed in the section on SNRE operation and ethanol blends.

Material wear and compatibility are a concern of many SNRE manufacturers regarding the use of ethanol fuel. Certain materials corrode when in contact with ethanol fuels. The most vulnerable materials are natural rubber, fiberglass, and some metal alloys. Most small engines manufactured since 1996 have alcohol-tolerant parts. Replacement parts offered in auto parts stores today are generally tolerant of ethanol. The effect of ethanol on certain metallic materials is difficult to judge because metals corrode instead of dissolve.

Depending on ethanol concentrations and exposure time, it may be a long time before an incompatibility problem is identified. Rubber and plastic parts that dissolve, swell, or harden tend to be more immediate and apparent. Fuel tanks made of fiberglass materials are of particular concern with ethanol. First, the ethanol can react with the resins in the fiberglass and form sludge on the bottom of the tank that can clog the fuel system. Secondly, ethanol can dissolve the tank over time and cause fuel leaks, creating fire hazards, and wasting money. If you have an older SNRE, you may need to check for compatibility of the engine components and ethanol. The following website has more information on materials directly affected by ethanol:
http://www.eere.energy.gov/afdc/e85toolkit/specs.html

SNRE operation and ethanol blends

The ideal ratio of air to fuel mixture in the combustion chamber of an engine using pure gasoline is 14.7 (14.7 parts air to 1 part gasoline). This ratio provides enough oxygen to, in ideal conditions, completely combust the gasoline. Variations of this ideal ratio are either "lean" or "rich." A "lean" air fuel ratio is above 14.7. A "rich" ratio is below 14.7. Because an ethanol molecule contains oxygen, the addition of ethanol containing gasoline to a fixed air-fuel mixture tends to "enlean" the air fuel ratio. The greater the percentage of ethanol in the gasoline, the larger the resulting effective air fuel ratio becomes.

Modern road engines are equipped with computer controlled fuel injection systems and many sensors that allow the engines to adjust air-fuel ratios under various horsepower requirements and blends of fuel. Regular automotive engines are able to adjust across a narrow band of ratios and fuel blends, E0 to E10. Flex-fuel vehicles can operate across a wider range of fuel blend ratios, anything between E0 and E85. Small engines are generally less sophisticated than automotive engines and tend to have simple fueling systems without computer processors and sensors. Generally, they are designed to run on a fixed or very narrow air-fuel ratio. As a result, some SNREs may not respond well to ethanol blends. Remember that small engine manufacturers have designed and rated their engines for E10. The concern is what happens if E15 is accidently added to the tank of an SNRE.

SNREs are generally open loop engines operating with a carburetor. Open loop engines are commonly air cooled and operated in a fuel-rich air-fuel mixture. A rich fuel mixture will suppress combustion and cause cooler combustion temperatures, which helps keep the engine running at a cooler temperature. Using an ethanol mixture in a fixed air-fuel ratio essentially enleans the air-fuel ratio and may cause the engine to run hot. The higher the percentage of ethanol, the leaner the air-fuel ratio will be, and the greater likelihood of the engine running hot.

The first likely symptom of an SNRE fueled with a higher than allowable percentage blend of ethanol might be running hot. The higher operating temperature will not necessarily cause immediate harm to an engine, but it will likely reduce the life of the engine. Body components and shields near the engine may not be able to withstand the higher operation temperature. Also, depending on engine and exhaust locations, operators of SNRE machinery may be exposed to higher temperatures.

A second concern develops with the leaner air-fuel mixture in a small engine caused by a higher-than-allowed blend. A lean mixture in a fixed-ratio engine can also increase the idle speed of the engine. If the machine is equipped with a centrifugal clutch, an unexpected engagement of the centrifugal clutch can occur with a higher idle speed. Line trimmers in particular are susceptible to this, but any device that couples a centrifugal clutch with an SNRE could have similar problems.

Two other concerns with ethanol-blend fuels in SNREs are cold starts and vapor lock. Ethanol has a lower vaporization temperature than gasoline. For combustion to occur within a spark-ignition engine, the fuel must first vaporize to properly mix with the air and then combust when a spark is introduced into the

combustion chamber. With ethanol's lower vaporization temperature, less of the blended fuel will vaporize at low temperatures during cold starts, making it harder for the SNRE to start. Manifold heaters, storage of these engines in warm buildings, or use of smaller ethanol blends of fuel during cold weather can reduce cold starting problems. During operation in hot temperatures, vapor lock can be a problem. The vapor pressure of ethanol in hot conditions can cause starting and running problems.

SNREs, ethanol, and emissions

SNRE are designed to provide as much power as possible. Engine manufacturers set the air-fuel ratio, engine compression, and spark timing for optimum power output, not for optimum fuel combustion. As a result, SNREs tend to produce more negative exhaust emissions than their on-road counterparts. SNREs will produce higher hydrocarbon (HC), carbon monoxide (CO), and nitrogen oxide (NOX) emissions that are harmful to humans and the environment than on-road engines. Use of oxygenates, such as ethanol, reduces these emissions. Accidentally filling an SNRE with a higher blend of ethanol will not increase emissions.

Conclusion

Ethanol-blended fuels are quality fuels available to consumers. E10 blends that are currently available to consumers will not cause problems with late-model SNREs. Higher blends of ethanol may soon be available for road engine use. Misfueling an SNRE with a higher ethanol blend will not cause immediate harm to the engine. It may make a noticeable change in the operational characteristic of an SNRE. Care must be taken to not accidently fuel an SNRE with these higher blends of ethanol. Understanding the effect of a higher blend of ethanol in an SNRE will help consumers identify an improperly fueled engine.

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