K-STATE Research and Extension

Ethanol Fundamentals

BioEnergy Solutions

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Introduction

The Energy Independence and Security Act of 2007 (EISA) was passed to increase the use of renewable fuels. This law established the Renewable Fuel Standard (RFS), which requires the use of 36 billion gallons of renewable fuel in vehicles by 2022. Ethanol is one renewable fuel covered by the RFS. As a result, the production, availability, and use of ethanol will increase.

For consumers, this means a variety of ethanol blended fuels are, or soon will be, available at filling stations. Fuel ethanol blends E10, E15, E20, and E85 are some of the combinations that are either available or may soon be available at the pump. While ethanol as a fuel or fuel additive has been around as long as Americans have been driving cars, the driving public has little knowledge and may have misunderstandings about the fuel. This publication provides basic information about these ethanol blended fuels.

What is Ethanol?

Ethyl alcohol or ethanol is an alcohol 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 United States, though most forms of plant material can be processed into ethyl alcohol. Fuel ethanol is a blend of petroleum fuel and ethyl alcohol. It is common to refer to fuel ethanol as ethanol and this is the terminology that is used in this fact sheet.

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 in certain large cities 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. Other formulations such as E20 or E40 are possible, but may not be currently available due to various regulations. "Blender fuel pumps," which allow consumers to blend their desired ethanol percentage within limits, are starting to appear in some states. These pumps are another way consumers can purchase ethanol.

Corn is one crop used for ethanol production.

While you may not have decided to start using ethanol blends in your vehicle, 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. Depending on pricing conditions and state tax incentives, fuel wholesalers have the legal leeway to provide retailers with variations of blended fuel in order to provide consumers with a price-competitive product. This is a more common practice when gasoline prices are high and ethanol prices are low.

The current blending limit for non-flex fuel vehicles, with or without a label, is 10 percent; however, this limit may be changing. In late 2010 and early 2011, the EPA waived a number of regulations to allow E15 to be used by the fuel buying public. The waived regulations allow vehicles built after model year 2001 to be fueled with E15 fuel. An estimated 60 percent of all vehicles on the road today are now eligible to use E15. While this action removed the direct regulatory barriers to the use of E15, there are economic and practical barriers that must be overcome before E15 is readily available at your local

filling station. Further, there is an ongoing regulatory discussion of the merit of making an E20 fuel blend as readily available as E10.

As these new blends become available, consumers need a greater understanding of ethanol when fueling their vehicles.

Using E10

E10 is the most common ethanol blended fuel. Automobiles built since the mid 1980s are designed and warranted to run on E10. When ethanol blends were first made available in the late 1970s, some consumers had problems using ethanol blended fuel. This was mostly related to materials used in the fuel supply chain, vehicle fuel system components at that time, and the cleaning nature of ethanol. Automobile manufactures and fuel dealers recognized that ethanol blended fuel was here to stay and have adjusted. Fuel dealers upgraded equipment to accommodate ethanol blends and most filling stations have the capability to handle E10 fuels. Automobile manufactures also responded and now design and build cars that run on alcohol blends. Generally speaking, any vehicle built since 1985 has a fuel system that can operate on a blend of E10. Vehicles built since 1996 are generally thought to be capable of running on blends up to E20, although manufacturers' warranties and recommendations do not recommend fuel blends above E10.

Using E85

A Flex Fuel Vehicle (FFV) is necessary to use E85 fuel. An FFV can operate on any ethanol blend mixture of fuel from E0 (100 percent gasoline) to E85 (15 percent gasoline). Two aspects of a FFV allow usage of such a wide range of ethanol blends. First, the fuel system components (fuel lines, pump, tank, gaskets, and O-rings) are all compatible with long-term, high-concentration exposure to ethanol. Second, the computerized injector control system, exhaust sensors, and fuel injectors found in a FFV are designed for variable ethanol concentrations.

For an engine to operate efficiently and smoothly, the ratio of fuel and air in the engine cylinders must be correct. For an engine running on E0, gasoline only, the air/fuel ratio is 14.7:1. For an engine running on E85 the air/fuel ratio is about 9.5:1. Any blend between E0 and E85 requires a different air-fuel ratio. The exhaust sensors, injectors, and computer control system in an FFV can automatically vary the air fuel ratio in the vehicle engine to the optimum ratio for any given fuel blend delivered to the engine. A vehicle owner may initially fuel the FFV with E85 and the next time with E0. The actual blend of ethanol in the fuel being consumed can be anywhere between 0 and 85. Non-FFV vehicles are not capable of compensating for this wide a range of ethanol blends and will not run properly on high-percentage blends of ethanol. Non-FFV vehicles do have some capability to adjust the air-fuel ratio, but not over the wide blend percentage range of an FFV. A non-FFV may run on E85, but it will neither operate properly nor run efficiently on the blend.

Considerations When Using Ethanol Blends

Fuel Economy. Ethanol does not contain the same amount of energy as gasoline. Table 1 illustrates the energy content of various blends of ethanol. Comparing standard grade gasoline to 100 percent ethyl alcohol or ethanol, 100 percent alcohol contains about 65 percent of the BTU energy found in gasoline. For drivers, this translates to lower fuel mileage. A gallon of 100 percent gasoline will move a vehicle farther down the road than a gallon of pure alcohol, simply because it has more energy.

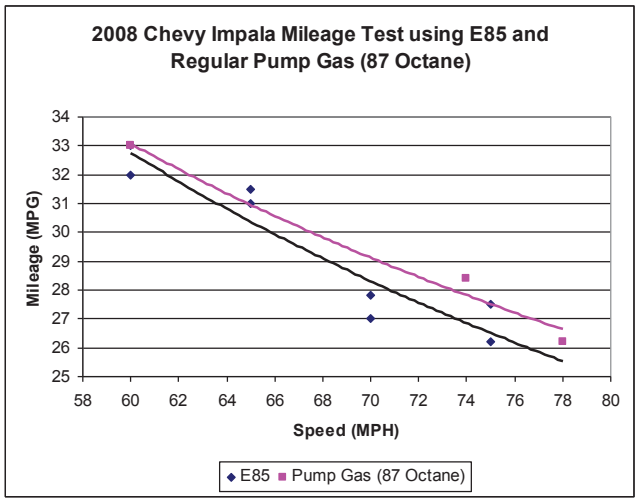
Table 1: Key Fuel Properties

Fuel Blend	Octane	Energy Content (Btu/Gal)
Standard Grade Gasoline (E0)	87	115,000
E10	89	111,000
E15	91	109,000
E20	93	107,000
E85	110	81,700
Pure Ethyl Alcohol (E100)	113	75,700

If you conduct your own mileage tests on the fuel blends shown in Table 1, you should expect to see your fuel economy drop as you progress to greater amounts of ethanol in the fuel. In practice, the fuel mileage differences may not be apparent in the lower percentage blends. Studies indicate that for the lower blends (E10, E15), the affect on mileage may be negligible and will probably be noticeable only on long steady highway trips. Typical day-to-day driving may not be affected as greatly by the reduced energy content of the fuel, because frequent stops and starts have a greater impact on fuel mileage than difference in fuel energy content. For the higher ethanol blends, the drop in mileage should be

more apparent. The graph below illustrates the difference. Note that the tested vehicle results are only applicable to that particular vehicle. Test results from other vehicles may vary.

Figure 1: Car mileage on standard gas (87 octane) and E85.



While fuel mileage, miles per gallon (mpg), may decrease with the higher ethanol blends, the cost per gallon of the blend also may decrease. The net result may be not only lower miles per gallon, but also lower cost per mile. Since both ethanol and gasoline prices fluctuate, a savvy consumer with a flex-fuel vehicle should be able to spot price disparities between fuel blends and be able to save money.

Fuel Filter Clogging. If an ethanol blended fuel has never been put into your vehicle, you should watch for fuel filter clogging. Ethanol is a good cleaning agent and will dissolve impurities such as carbon, gum, and other residues that may be in the fuel system. These dissolved materials may plug the fuel filter and cause poor vehicle performance, such as engine sputtering, lack of power, or starting problems. If you switch to an ethanol blend and experience problems, fuel filters may need to be replaced. Generally, this problem is rare. Modern fuels either have some amount of ethanol in them already or other detergent additives that keep the fuel systems of regularly driven vehicles clean. A clean fuel system will generally not have problems with ethanol blends.

Shelf Life of Ethanol Blends. Regular gasoline is hydrophobic and does not combine easily with water; it also tends to separate above the water. Alcohol fuels are hydroscopic and have a large affinity for water or water vapor (humidity). Ethanol fuels have the tendency to separate over time as water is absorbed into the fuel from the atmosphere. Typically normal driving and regular use of a vehicle will prevent this, but tractors, lawn mowers, and other engines that are only periodically used may have problems with this. For vehicles that are used only periodically, a regular grade fuel, without ethanol, should be used. The typical shelf life of ethanol is 90 to 100 days versus several years for regular gasoline. To reduce problems, keep the fuel tank lid tight (to reduce the outside air entrance) and drain fuel in times of infrequent use (or replace with regular gasoline filled to the top to avoid dry carburetor seals). This can be especially critical in boats and small lawn mower engines, which are unused for extended times period or operate in high moisture conditions.

Cold Weather Starting. In colder climates, engine starting may be harder when using ethanol blends compared to regular gasoline. Alcohol contains less explosion power (at lower compression ratios), lower spark point, and has a chilling effect when running though the engine's passages. This combination causes the fuel to inhibit starting in cold weather, especially below 15 degrees Fahrenheit. Generally, this is only a problem with the higher percentage alcohol blends, and these blends are seasonally adjusted to mitigate this problem. If you are using an E85 blend regularly in cold weather and experience problems, you might want to consider switching to a lower percentage blend, keeping the vehicle in a garage overnight, or investing in a block heater.

Material Wear and Compatibility. Certain materials corrode when in contact with ethanol fuels. The most vulnerable materials are natural rubber, fiberglass, and some metal alloys. Most vehicles manufactured since the mid 1980s have alcohol-tolerant parts, and 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 or harden tend to be more immediate and apparent. If you have an older car (pre-1985), you may need to check for compatibility of the components. The following website has more information on materials directly affected by ethanol:
http://www.eere.energy.gov/afdc/e85toolkit/specs.html

Small Engines. Small engine operation manuals may or may not address the use of ethanol as a fuel and some do not warranty their engines for use with ethanol. Consequently, it is not advisable to use ethanol blends in chain saws, lawn mowers, motorcycles, and watercraft unless the operation manual has specific instructions for ethanol use. However, non-ethanol use is challenging, as

well, since it is possible that all grades of gasoline available in a given region contain up to 10 percent ethanol. To counter this challenge, fuel-testing kits are available at many auto parts stores that will help consumers identify fuels containing ethanol. Marina and other fuel retailers may provide ethanol-free fuels and can provide that information verbally or on the fuel pumps.

Conclusion

In the near future consumers may have many different fueling options available to them when they go to filling stations. Ethanol blended fuels will be a large share of the options available. Rather than being concerned, consumers need to understand that ethanol fuels are of good quality and safe to use in their vehicles. However, ethanol does have different characteristics than regular gasoline that consumers need to be aware of when they fill their fuel tanks. Learning about the fueling options ensures trouble-free vehicle operations and possibly saves the consumer money.

References

American Coalition for Ethanol: *http://www.ethanol.org/index.php?id=91&parentid=8*

The Alternate Fuels and Advanced Data Base Center: *http://www.eere.energy.gov/afdc/e85toolkit/specs.html*

Energy Independence and Security Act of 2007; Title II— Renewable Fuel Standard

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