

The Compatibility of Reformulated and Oxygenated Gasoline with Fuel System Materials

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Introduction

The recent introduction of reformulated gasoline has drawn some media attention to these fuels and often to the oxygenates they contain. Some of these media reports regarding the compatibility of these fuels with fuel system materials have been inaccurate or incomplete. This has caused undue alarm among some consumers.

It is important to understand that the components in reformulated gasoline are not something new or novel. The reformulation of gasoline is simply the raising or lowering of various components to achieve a reduced level of exhaust and evaporative emissions as well as a reduction of certain toxic components. In addition, oxygenates are added to achieve more complete combustion and to aid in reducing the level of toxic emissions. The most commonly used oxygenates are methyl tertiary butyl ether (MTBE) and ethanol. Both of these oxygenates have been used in gasoline for nearly twenty years and often at higher levels than those used in reformulated gasoline or other oxygenated fuels. Until the late 1980s, oxygenates were used primarily to raise the octane quality of gasoline. While their use as an octane enhancer continues, the focus today is to add oxygen to gasoline to comply with environmental needs. Although both MTBE and ethanol have been used in gasoline for years, they seem to be the focus of various media reports. Some media reports have alleged that ethanol or MTBE may not be compatible with all materials found in the fuel systems of automobiles and other gasoline powered equipment. Since both oxygenates have been extensively tested, it is worthwhile to review the information that is available.

Automotive Fuel Systems

A variety of plastics and elastomers (rubber-like components) are used in automotive fuel sys-

tems. Selection of specific materials depends on where and how the component will be used. Obviously a carburetor needle tip will be of a different material than a fuel line or fuel injector O-ring. It is important to note that regardless of the materials selected, fuel system components do not last forever and will eventually deteriorate to the point where replacement is required. The life cycle of these components is affected by far more than just the amount and type of fuel that flows through them. Some of the factors that influence life cycle of these parts include driving cycle, heating and cooling cycles, weather conditions, road salt, and ambient ozone levels, all of which can contribute to accelerated deterioration.

A number of metals are also used for various fuel system applications. Again, the specific metal selected for a given use is based upon its location and use in the fuel system. As with the elastomers, there are various factors that affect the life cycle of fuel system metals. Depending on the application, these factors include moisture in the fuel system, and frequency of fuel turnover, and wear of moving parts. There are seldom any reports of compatibility problems with the metals used in fuel systems.

Over the past thirty or so years, there have been a number of test programs and field demonstration projects on gasolines containing both ethanol and MTBE. In addition to tests by the oxygenate manufacturers, tests have also been conducted by both the petroleum and automotive industries. While some of these tests, such as those used by auto manufacturers for materials selection, are proprietary, some studies have been published. Before MTBE was ever allowed to be introduced into gasoline, the EPA had to review its affect on fuel system and emission system components to determine there were no adverse effects. This was done in 1979 to permit the use of MTBE at levels

up to 7%. In the 1980s the permitted level was raised to 11% and in 1988 to 15%. Each time data on materials compatibility was reviewed.

In information submitted to EPA in March 1988,¹ studies indicated, "In summary, there were no large differences in swell of plastics and elastomer parts soaked in gasoline and gasoline with 15% MTBE... For some materials, there was less swell with fuels containing MTBE." This same test reported that "15% MTBE does not contribute to fuel injector plugging. Further, inspection of the fuel delivery systems indicate no sign of corrosion deterioration."

Similar data² was submitted to EPA in 1990 to allow for the use of mixtures of oxygenates and again there was no indication of materials compatibility problems. Indeed, some studies³ have concluded that, "MTBE may actually prolong the useful life of elastomeric materials as compared with the life of such materials if the same octane quality of the fuel were obtained by adding aromatics"³ This and other studies also point out the important role that aromatics play in elastomer swell and deterioration. Aromatics such as benzene, toluene, and xylene contribute to elastomer swell. The level of these components increased markedly during the 1980s. Likewise various studies have indicated that "sour gasoline", or gasoline high in peroxide (due to extended storage periods), can accelerate deterioration of elastomers.

One of the most recent and comprehensive testing programs was covered in California's "CaRFG Performance and Test Compatibility Program"¹⁰. This program conducted by the State of California and supplemented by industry sponsored test programs found no materials compatibility problems with California Reformulated Gasoline containing MTBE. This test encompassed numerous vehicle models both old and new.

In addition to the numerous studies on gasoline containing MTBE, gasolines containing ethanol have also been extensively studied. A fleet study and lab testing dating to 1986 indicated, "Materials compatibility of fuel system components of the late model automobiles tested using ethanol-extended unleaded fuel does not appear to be a problem"⁴ A technical report issued by EPA⁵

concluded that 10% ethanol blends "Appear to present few if any materials compatibility problems...". These conclusions are further supported by work completed by Texaco,⁶ as well as examination, by Chevron⁷, of a late model vehicle with over 100,000 miles which was operated exclusively on gasoline ethanol blends, and which found that in this instance the ethanol "does not contribute to corrosion or deterioration of fuel system components."

There is no question these numerous studies indicate that oxygenates are acceptable gasoline components. Moreover trillions of miles have already been driven on gasolines containing both MTBE and ethanol.

Perhaps more important is the position of the auto manufacturers themselves. All automobile manufacturers permit the use of reformulated gasoline and other gasolines containing oxygenates⁸. In fact several, including Chrysler, Ford, General Motors, Nissan, and Suzuki recommend the use of these fuels⁸. GM has said that reformulated gasoline can be used "In any GM car or light-duty truck. Any model, Any year."⁹ Clearly, if the auto manufacturers thought fuel oxygenates would have negative effects on the fuel system in their products they would recommend against their use.

Vintage Vehicle Fuel Systems

Obviously the fuel system materials used in late model vehicles are dramatically improved compared to the original equipment used in vintage/classic vehicles.

Most testing on oxygenates has been done on vehicles that are post mid-1970s. This leaves somewhat of an informational void on vehicles predating those model years.

Older fuel systems could contain natural rubber or synthetic rubber much less compatible with today's fuels than the Viton® and fluoroelastomers used in modern fuel systems. Usually, however, older cars have already had most fuel system components replaced. Components provided by the aftermarket since the early 1980s are compatible with today's fuel formulations.¹¹

While most questions on materials compatibility are usually related to the oxygenates, they

are not the only gasoline ingredients to consider. As refiners decreased the use of lead, something else had to be increased or added to maintain octane quality. This is often done by increasing the aromatic level of gasoline. On an octane equivalent basis, some of the aromatics are more aggressive to certain elastomers than are the oxygenates. Whether octane is achieved by oxygenate addition or increases in aromatics, today's gasolines are generally more aggressive to elastomers than those of the sixties and seventies. Where can one obtain a gasoline comparable to those sold in bygone years? You can't unless you have mastered time travel.

It should be kept in mind that extended storage periods, common for vintage vehicles, without proper treatment of gasoline can also increase elastomer deterioration. Overuse (beyond recommended treat rate or excessive frequency) of certain over-the-counter additives may also contribute to accelerated deterioration of fuel system components.

If it becomes necessary to replace fuel lines and other fuel system components, preferred materials are Viton® and fluoroelastomers such as 3M Fluorel®

Oxygenates have now been used in gasoline for nearly twenty years. Some areas have used them exclusively in the winter since 1992 and year round since the beginning of 1995. Despite this widespread use there is no evidence that oxygenates are causing any problems with the fuel systems of vintage vehicles.

Furthermore, there are ASTM specifications and guidelines for corrosion properties of gasoline that apply to all gasoline, whether oxygenated or not. Additionally, petroleum companies add corrosion inhibitors to gasoline when needed. Consequently, there should be no major concerns about fuel system corrosion.

Non-Automotive Gasoline Engines

Initially, during the early 1980s, the predominant oxygenate used was ethanol. During this time frame, gasoline ethanol blends comprised only a few percent of the gasoline marketplace and were viewed as somewhat of a novelty. Small engine/equipment manufacturers were slow to conduct

tests on a fuel with limited marketshare and an uncertain future. Little technical data about the use of gasoline ethanol blends was available and, of course, there was little field experience upon which to base decisions regarding its use in such applications. These factors led to the majority of manufacturers initially recommending that gasoline ethanol blends not be used in their products.

By the mid 1980s manufacturers began to indicate that gasoline ethanol blends could be used in their products provided certain storage precautions were followed. The degree of approval often varied with some simply stating ethanol blends could be used while others stated such use was permitted but not recommended.

By the late 1980s, some manufacturers also began to mention MTBE in their equipment owners manuals, indicating gasolines containing MTBE were acceptable for use.^{12,13}

Ethanol and MTBE, have been extensively tested for their effects on various metals, plastics, and elastomers. Such tests have included both controlled laboratory testing as well as field demonstration projects.^{10, 14, 15, 16, 17} Some equipment manufacturers have also conducted tests on their specific equipment. In the early to mid 1980s, some manufacturers did find it necessary to upgrade a few of the materials used in their fuel systems. Whether or not this was necessitated solely by the use of alcohols and ethers is sometimes uncertain because the aromatic content of gasoline was also increased during the same time frame. Since aromatics also effect elastomer durability, this may have also contributed to isolated problems. In any event, manufacturers now use upgraded materials that are largely unaffected by properly formulated oxygenated fuels. This is evidenced by their fuel recommendation comments which now permit the use of such fuels.¹² Further, responsible aftermarket suppliers provide only replacement parts that are designed for use with oxygenated fuels. As an example, Walbro Engine Management Corp., a major supplier of carburetor rebuild kits and other parts, has indicated that Walbro parts are resistant to alcohol-related decomposition as long as the volume of alcohol is within legal limits.¹⁸

Numerous manufacturers of power equipment,

boats, and motorcycles have indicated that gasolines containing ethanol and MTBE can be used in their products. These include Bolens/Troybilt, Briggs & Stratton, Dixon, Echo, Homelite, Honda, Kawasaki, Kohler, McColloch, MTD, Onan, Ryobi, Sears, Tecumseh, Toro/Lawnboy, Harley Davidson, Suzuki, Yamaha, ArcticCat, Polaris, Ski-Doo, Mercury Marine, OMC (Johnson/Evinrude), and Pleasurecraft, as well as others.

In addition to the guidance in the equipment owners manual, several manufacturers have issued technical bulletins and advisories indicating that the use of gasolines containing MTBE and ethanol is acceptable^{19, 20, 21, 22}. Some of these bulletins do advise consumers to inspect their fuel systems more frequently in older equipment, i.e. older than 10-15 years. This is because, as with automobiles, the durability of older fuel system parts is more difficult to predict because of all the variables that affect the life cycle of fuel system components.

Lastly, a word on aviation use of oxygenated fuels. Some small piston engine aircraft have undergone extensive testing and certification to permit them to operate on automotive gasoline. These aircraft have been designated by a Supplemental Type Certificate or STC. These gasolines must meet specification ASTM D 4814. The Federal Aviation Administration (FAA) has indicated that their testing has included gasolines containing MTBE. However, information on gasolines containing ethanol is considered insufficient. Consequently, STCs for automotive gasoline include gasolines containing MTBE, but not ethanol. The FAA has stated that research tests indicate "No materials compatibility problems or safety issues associated with gasolines containing MTBE"²³. Consequently if you are using oxygenated gasoline for one of these aircraft applications, you should use one containing MTBE.

As demonstrated by the numerous tests and information listed, there are no unique materials compatibility concerns about the use of oxygenated or reformulated gasolines. Consumers who keep their vehicles and gasoline powered equipment properly maintained should not experience any problems unique to these fuels.

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