A Comparison of California Reformulated Gasoline to Federal Reformulated Gasoline

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Downstream Alternatives, Inc.

Introduction

In the spring of 1996, the State of California required the introduction and sale of California Reformulated Gasoline (CaRFG), often referred to in California simply as "cleaner-burning gasoline". As is often the case with anything perceived as new, some consumers expressed concern about the use of this new gasoline in their vehicles or other gasoline powered equipment. These concerns were in some cases fed and nurtured by inaccurate and incomplete media reports. In particular, one television station, under the guise of investigative reporting, continually presented reports that were at best inaccurate, and in some cases, complete misrepresentations of the facts.

Gasoline reformulation has been studied for a number of years. In an effort to minimize the environmental impact of automobiles and the fuels they use, both government and industry worked to develop fuel formulations that, while providing the same level of performance, would result in lower evaporative and exhaust emissions.

The 1990 Clean Air Act Amendments required the introduction of reformulated gasoline in the worst ozone non-attainment areas beginning on January 1, 1995. This also included certain areas of California.

Due to California's more severe pollution problems, the original Clean Air Act contained provisions whereby the state could implement their own more stringent pollution control programs. In fact, California has often implemented automotive pollution control strategies in advance of the rest of the nation. California's 24 million gasoline vehicles use approximately 13.5 billion gallons of gasoline per year. Despite the lower emission levels of newer vehicles, the increasing number of vehicles, and the miles they travel, result in their still being a significant source of emissions of carbon monoxide (CO), hydrocarbons (HC), and oxides of nitrogen (NOx). In an effort to address their more severe air pollution, California, in 1996, required the statewide introduction of a reformulated gasoline that undergoes slightly more changes, and provides greater pollution reduction, than the federally required RFG.

The federal version of RFG has been thoroughly studied and found to provide performance comparable to that of conventional gasolines. These topics have been thoroughly covered in other informational documents published by Downstream Alternatives Inc. (DAI) as well as various publications by others. The purpose of this paper is to compare CaRFG to federal RFG and discuss various myths that have arisen concerning California's "Clean Burning Gasoline" program.

Gasoline Reformulation

Gasoline reformulation is not a new concept. In fact, gasoline has been "reformulated" on an ongoing basis to reflect changes in refinery technology and the characteristics of changing crude supplies. However, the reformulation of gasoline required under the Clean Air Act and under California regulations is done to provide reduced emissions.

There is nothing present in CaRFG that cannot be found in federal RFG or, for that matter, conventional gasoline. Nor is there anything absent. The formula has simply been fixed at a point in the traditional range of composition that has been shown to reduce emissions. In the simplest terms, it could be compared to baking a cake. There are many recipes to bake a cake. Some, by substituting skim milk for whole and reducing the amount of butter, may be lower in fat. Much like this, reformulated gasoline is designed to provide the traditional performance expected but with lower emissions.

California RFG versus Federal RFG

There are some minor differences between CaRFG and federal RFG. The table below compares the typical properties and environmental benefits of conventional gasoline, federal RFG, and CaRFG. These are typical properties. Due to some refiners using averaging techniques, some gasolines may vary slightly from the values in the table.

As can be seen from the table, CaRFG will typically have a lower sulfur and olefin content and slightly lower aromatic and benzene content. Additionally, the vapor pressure of CaRFG is reduced slightly from the federal RFG requirement of 7.2 psi for southern areas. However distillation properties are very near those of federal RFG. This, combined with comparable oxygen content and octane levels results in near identical performance. More importantly you can see that reductions in NOx and sulfur dioxide are greater for CaRFG than for federal RFG. Additionally there is a greater reduction in cancer risk for CaRFG.

Comparison of Conventional Gasoline, Federal RFG, & California RFG
(Typical Properties)

Property	Conventional Gasoline Range	Feberal RFG	California RFG
SummerVapor Pressure (psi)	7.8-10.0	7.2 - 8.1	7.0
T50 (˚F)	141 - 251	202	200
T90 (˚F)	286 - 364	316	290
Aromatic (vol %)	6.1 - 52.2	23.4	22.0
Olefins (vol %)	0.4 - 29.9	8.2	4.0
Benzene (vol %)	0.1 - 5.18	1.0	.80
Sulfur (ppm)	10 - 1170	302	30
MTBE (vol %)	0 - 15.0	11.0	11.0
Ethanol (vol %)	0 - 10.4	5.7	5.7
Oxygen content (wt %)	0 - 3.6	2.0	2.0
Octane ([R+M]/2)	87 - 93	87 - 93	87-93
% Projected emissions reduction of NOx	--	4.0	11.0
% Projected emissions reduction of CO	--	11.0	11.0
% Projected emissions reduction of Sulfur Dioxide	--	--	80.0
% Reduced cancer risk	--	20-30	30-40

Source U.S. EPA, CARB, DAI

Performance and Compatibility

While the minor property changes would result in no prediction of performance or compatibility problems it may assure readers to know that satisfactory performance and compatibility has also been demonstrated through controlled tests. In addition to the numerous tests that have been done on automobiles and gasoline powered equipment operating on federal RFG, there has also been extensive testing of CaRFG.

These tests included an extensive study by the California Air Resource Board (CARB) which was supplemented by numerous industry studies. This study included an on-road test program of 829 vehicles operating on CaRFG driving over 5 million miles. The fleet included vehicles ranging from automobiles to heavy trucks and included vehicles ranging in age from pre-1981 to 1995 model years and odometer readings in some cases exceeding 220,000 miles.

The test vehicles were periodically inspected for signs of fuel related problems (fuel tanks/lines, hoses, gaskets, fuel pumps, carburetors, etc.). Fleet records were reviewed for any fuel related complaints or repairs. This study found that CaRFG provided driveability, starting, idling, acceleration power, and safety comparable to conventional gasoline. Additionally there was no meaningful difference between fuel system repairs of the test and control vehicles. The test vehicles did not require any additional maintenance or special adjustments

as a result of using CaRFG. The study did note that fuel economy was reduced by an average of 1% compared to conventional oxygenated gasoline.

In conjunction with California's efforts various studies were also conducted by industry. These included the following:

- Nissan Motor Company: Tested for any adverse effect on valve or combustion chamber deposits and found none.

- General Motors & Ford Motor Company: Conducted tests on fuel system elastomers/plastics and metal wear on CaRFG and found no adverse effects.

- Harley Davidson: Found no fuel related problems with CaRFG in their tests.

CARB and industry participants also examined the use of CaRFG in various off-road applications such as boats, snowmobiles, and lawn mowers/power equipment. Industry participants in these tests included Briggs & Stratton, Tecumseh, Mercury marine, the Portable Power Equipment Manufacturers Association, and Arctco (maker of Arctic Cat snowmobiles and TigerShark personal water craft). These tests also indicated no adverse results from using CaRFG.

The above tests are, of course, in addition to tests conducted on federal RFG and the trillions of miles that have now been driven on reformulated gasoline since its introduction over two years ago. Finally, it is important to note that the three U.S. auto manufacturers as well as several foreign manufacturers all recommend the use of RFG.

Performance Change-Myth or Reality

Since the characteristics of CaRFG are so near to federal RFG, as well as conventional gasoline, there is no reason why performance should be noticeably different. The two minor exceptions to this would be fuel economy and cold start/warm up performance on unseasonably cool days. Tests have shown that the fuel economy of CaRFG is about 1% below conventional oxygenated gasoline or federal RFG which in turn is about 2% lower than non-oxygenated conventional gasoline. Therefore a fuel economy reduction of 1% to 3% should be anticipated. For most modern vehicles this would equate to 1/4 to 3/4 miles per gallon lower fuel economy. Older carbureted vehicles may actually show a slight improvement in fuel economy because the oxygen in the fuel will enlean the air/fuel charge resulting in more complete combustion of the fuel. However, computerized cars, once reaching operating temperature, will compensate for the oxygen content by increasing fuel flow, hence the 1% to 3% fuel economy reduction.

CaRFG is less volatile than conventional gasoline in order to reduce evaporative emissions. This means the fuel does not vaporize as easily at lower temperatures. During unseasonably cool weather (below 50˚F) this may increase cranking time slightly on older carbureted vehicles. Likewise, warm up performance on these days may deteriorate modestly. However such incidents are limited largely to carbureted vehicles. Conversely, less volatile CaRFG will help minimize any incidence of vapor lock or hot start/hot driveability problems on unseasonably hot days.

With the minor exceptions noted above, no noticeable differences should be experienced when operating a vehicle or gasoline powered equipment on CaRFG. For those interested in more detailed information, a list of key references is provided.

References

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7. *Performance Features of 15% MTBE/Gasoline Blends, W. Douthit, et.al., Sun Refining, SAE Paper # 881667, October 1988*

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9. *Auto Manufacturer Fuel Recommendations-Downstream Alternatives Inc., 1990 through 1997 Data Base*
10. *Lundberg Fleet Managers Survey, 1995*
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12. *Comparison of the Lubricity of Gasoline and Diesel Fuels, Wei Dan Ping, et.al., SAE Paper # 962010*
13. *Development of a Benchtop Fuel Lubricity Assessment Method, J.G. Eleftherakis, et.al., SAE Paper # 941915*

The information contained in this document is based on a number of technical papers, test reports, and information sources. While presented in a condensed form, Downstream Alternatives Inc. has made every attempt to represent the information as accurately as possible, and it is believed to be accurate as of the date of printing.