What's in Your Fuel? A Crash Course on the Various Additives Found in Gasoline

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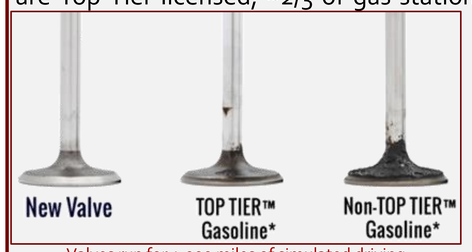
Overview

There are an estimated 150,000 gas stations in the US and about 378 million gallons of gasoline are used daily in the United States. Despite this staggering number, most Americans do not know what's in their gasoline. Modern gasoline is more than just refined oil and contains a complicated concoction of stabilizers, octane boosters, detergents, anti-freezes, and a multitude of other substances tailored to increasing fuel efficiency, decreasing emissions, and maximizing the functionality of the vehicles they fuel.

Fuel Detergents

Combustion engines consistently fall victim to carbon buildup, notably on the fuel injectors since they make the most contact with the gasoline. As fuel injection became more common over carburetors in the 1980s, carbon buildup on fuel injectors became an increased concern. One of the first and most used fuel injector cleaners is polyetheramine (PEA), released under the name Techron in 1995 by Chevron. In 1996, the EPA created the set Lowest Additive Concentration (LAC) standard to enforce a minimum amount of fuel detergent in gasoline. Despite being a new standard, automakers felt that the LAC was insufficient. This inspired the Toyota, Honda, General Motors, and BMW to establish the Top Tier gasoline standard for detergent additives in 2004. The Top Tier designation is a significantly stricter fuel detergent standard than the LAC that requires fuel to use larger amounts of certified detergent additives. In a study conducted by AAA, Top Tier fuel was shown to be **19 times better** at reducing engine deposit build up in engines. There are currently 54 different gasoline retail brands that are Top Tier licensed, ~2/3 of gas stations in the US, including ExxonMobil, BP, Shell, Chevron, Marathon, Sunoco and Conoco.



Valves run for 4,000 miles of simulated driving

Friction Modifiers

Comparison of results from testing Shell V-Power NiTRO+ against LAC premium by ASTM D6079

In most gasoline engines, ~25% of gasoline burned per engine cycle is to overcome friction between the piston and cylinder wall. This is because engine lubrication systems neglect the upper cylinder due to the engine's design. The fuel line is the most practical way to lubricate this part of the cylinder, but the gasoline used to lubricate the cylinder combusts with the rest of the gasoline. Friction modifiers essentially form a "membrane" that contains hydrophilic and hydrophobic molecules that adhere to the metal surfaces to reduce friction. ExxonMobil Synergy cites their friction modifier as a new ingredient currently only available in their premium grade of gasoline that reduces engine wear and tear by up to 30%. Similarly, Shell boasts that their V-Power NiTRO+ (their premium grade) fared significantly better than standard LAC gasoline in a wear test (ASTM D6079).

Corrosion Inhibitors, Demulsifiers, and Solvent Fluids

Corrosion is another issue that plagues automobiles if unaccounted for. Fortunately, corrosion inhibitors are a common additive in gasoline that work to prevent the components from rusting or corroding. Several gasoline brands mention the inclusion of corrosion inhibitors in their additive packages, all of which work similarly to the friction modifiers in that they form a thin coating over the affected components (intake, fuel tank, etc.). Additives such as anti-adhesion compounds, solvent fluids, and demulsifiers also work to keep gasoline in its ideal form to prevent damages to components. These additives work to keep additive ingredients mixed (solvent fluids), while separating unwanted substances, typically water, from gasoline to make removal easier (demulsifiers). Anti-adhesion compounds prevent damage to the fuel system by preventing fuel detergent additives from forming unwanted films in the engine (excluding films formed in the cylinders for lubrication).

Octane Boosters

A typical gasoline engine runs on "regular" gasoline with an AKI octane rating of 87. Despite a rating of 87, the "gasoline" itself does not have a rating of 87, but the additives in the fuel "boost" the octane rating to 87. The first commercially used octane booster was tetraethyl lead (Leaded fuel) in 1921. The use of Tetraethyl lead continued through the 1970s when the EPA was formed to regulate emissions. In 1974, all US fuel stations were required to provide an "unleaded" fuel grade to accommodate vehicles with catalytic converters since lead would damage the components. After the EPA mandated the use of unleaded fuel, many fuel makers turned to alternative compounds such as Methyl Tertiary Butyl Ether (MTBE) and BTEX. MTBE was used to increase oxygenate content in reformulated gasoline and helped boost the octane rating but was phased out of use in 2005 due to water solubility concerns. BTEX is a blend of Benzene, Toluene, Ethyl-Benzene, and Xylene and became more common as an octane booster after lead was phased out. Since the EPA mandated that gasoline cannot contain more than 0.62% Benzene in 2007, Ethanol began to be used as an octane booster and is currently found in ~95% of gasoline sold in the US. The most common Ethanol blend is E10 gasoline, which contains up to 10% Ethanol. The EPA is currently amending laws to allow the sale of E15 gasoline year-round, which would allow up to 15% ethanol in gasoline. Previous EPA restrictions banned the sale of E15 gasoline between June and September, citing increased particle emissions believed to be released into the atmosphere during warmer months. This ban is the main reason most gas stations choose not to sell E15 gasoline at all; switching components and setups to accommodate partial-year sales is not economically favorable.

How Octane is Measured

Octane ratings are calculated a few different ways. In each case, the number is an index for measuring resistance to engine knocking. The scale is from 0 – 100 where 0 is equivalent to pure heptane and 100 is equivalent to pure iso-octane. Numbers over 100 exist but are interpolated since they fall out of scale. The Research Octane Number (RON) is commonly used in most European and Asian countries, and the Anti-Knock Index (AKI) is used in North America. A third rating, the Mechanical Octane Number (MON) also exists, but is way less commonly used than the other two numbers.

Comparison of Octane Tests

Rating	Test	Conditions	
RON	ASTM D2699	600 rpm	52°C
MON	ASTM D2700	900 rpm	152°C
AKI	Average of RON and MON	N/A	N/A

Conclusion

Gasoline is a complicated conglomeration of chemical additives that are engineered to keep engines running cleaner and more efficiently. These additives are designed to keep cars running at peak performance, but are largely ignored by the general population, which remains largely unaware of how much effort goes into fueling their vehicles as efficiently as possible. From developments to produce cleaner and safer fuel, to breakthroughs in keeping engines protected from damages, gasoline additives are a crucial part of the health of our cars and ourselves.

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