Everything you may or may not want to know about Gasoline and Octane Rating

When teaching about hydrocarbons in chemistry classes, I sometimes get questions about Octane. I also hear of people using higher octane in their car than recommended by the manufacturer. That is not always good, and can cause other problems in the long run. Some of the following information may help you understand the octane levels in the gasoline used in our Corvettes and other vehicles. Text was compiled from various sources, including class notes and from my personal experience in the lab.

Almost all of our vehicles use four stroke engines. One of those "strokes" of the piston is called a compression stroke, where the engine compresses a cylinder full of air and gasoline into a much smaller volume before igniting it with a spark. The amount of compression is called the "compression ratio" of the engine, and is typically around 8-to-1 (more in a high performance engine).

The Octane Rating of gasoline (a hydrocarbon) tells you how much the fuel can be compressed before it spontaneously ignites. When gasoline ignites by compression rather than because of spark from the spark plug, it causes knocking in the engine. Knocking can damage the engine since it puts undue stress on the piston as it is still going up into the cylinder. Lower octane gasoline like 87-octane, can handle the least amount of compression before igniting. Diesel engines use only compression to ignite a different formulation of hydrocarbon fuel.That's a different story.

The compression ratio of your engine determines the octane rating of the gas you must use in the car. One way to increase horsepower of an engine of a given displacement is to increase its compression ratio. So a "high-performance engine" has a higher compression ratio and requires higher octane fuel. The advantage of a high compression ratio is that it gives your engine a higher horsepower rating for a given engine weight. It costs more to run, though.

A bit of history: The name "octane" comes from the following fact: When you take crude oil and "crack" it in a refinery, you end up getting hydrocarbon chains of different lengths. These different chain lengths can then be separated from each other and blended to form different fuels. For example, you may have heard of methane, propane and butane. All three of them are hydrocarbons. Methane has just a single carbon atom. Propane has three carbon atoms chained together. Butane has four. Pentane has five, hexane has six, heptane has seven, and Octane has eight carbons chained together.

It turns out that heptane handles compression very poorly. Compress it just a little and it ignites spontaneously. Octane handles compression very well - - you can compress it a lot and nothing happens. Eighty-Seven-Octane gasoline is gasoline that contains 87 percent octane and 13 percent heptane (or some other combination of fuels that has the same performance of the 87/13 combination octane/heptane). It spontaneously ignites at a given compression level, and can only be used in engines that do not exceed that compression ratio.

During World War One, it was discovered that you can add a chemical called tetraethyl lead (TEL) to gasoline and significantly improve its octane rating above the octane/heptane combination. Cheaper grades of gasoline could be made usable by adding TEL. This led to the widespread use of “ethyl” or “leaded” gasoline. Unfortunately, the side effects of adding lead to gasoline are: Lead clogs a catalytic converter and renders it inoperable within minutes; and worse, the Earth became covered in a thin layer of toxic lead.

When lead was banned, gasoline became more expensive because refineries could not boost the octane ratings of cheaper grades any more. Only airplanes are still allowed to use leaded gasoline, known as AvGas, and octane ratings of 100 or more are commonly used in super-high-performance piston airplane engines. In the case of AvGas, 100 is the gasoline’s performance rating, not the percentage of actual octane in the gas. The addition of TEL boosts the compression level of the gasoline - - it doesn’t add more octane. Engineers are currently working on the development of airplane piston engines that can use unleaded gasoline.

Use of higher octane gasoline in lower compression engines does not improve performance, and can actually cause carbon buildup and other problems over the long run. The term “Premium” has long been used to describe higher octane gasoline, thereby causing some people to think it is better for their car, no matter what the compression ration or manufacturer recommendations. This is really a waste of money. Some manufacturers note octane levels that are “recommended” or “required”. If your manual says “required”, it’s best to use the octane specified. If it says “recommended”, you can try a lower octane rating in cooler, easier driving conditions and monitor performance and mileage. The computers in modern cars can adjust the spark and valve settings a bit to compensate for variations in octane. If you notice performance degradation or spark “knock” when trying lower octane gasoline, move back to the next higher octane rating.

Submitted by Craig Iansiti