FUELING INTEREST IN HOW OCTANE WORKS

If you're like most people, when you go to fill up your tank at the gas station, you select regular, mid-grade or premium by rote and then go on your merry way, secure in the knowledge that you have what you need to get you to where you want to go, without ever thinking about the science behind those quotidian digits on the pump.

The fact is, few things in the automotive sector are more unclear than what octane actually means and how it affects an engine. Many don't know that octane is a hydrocarbon chain with eight carbon atoms. The numbers featured on the fuel pump are typically 87, 89, 91, 92 or 93. There are, however, a variety of diverse components and supplemental additives which comprise our fuel; thus, the numbers stand for the performance of the different fuel grades and not their actual content. Most engines use either premium grade or lower grade fuel, with the mid-grade being the forgotten middle child of the octane milieu. Gasoline consists of, perhaps 300 components, beginning with minor amounts of C_3 and going up to about C_{13}.This is critical since in order to create an explosive charge in the cylinder, the engine needs to compress the fuel-air admixture considerably.

Octane numbers are assigned using the single cylinder Waukesha engine under specified conditions. Primary reference fuels are used , consisting of mixtures of 2,2,4-trimethylpentane, which was the best fuel tested and assigned an octane number of 100, and normal heptane, which was the worst fuel tested and assigned an octane number of zero. The octane number is the percent of 2,2,4-trimethylpentane in a mixture with normal heptane.

A modern fuel pump at a gas station on Jacksonville's Westside. Photo by Anthony M. Inswasty

A gas station featuring five en:Octane ratings. Photo taken by Bobak Ha'Eri.

Many people may not realize what determines which grade of fuel to use: The primary factor in determining this is the compression ratio (or CR). This refers to the delineation between volume of the combustion chamber, when the piston is at the bottom of the stroke, to the volume when it reaches the apex of top-dead-center. How high the compression ratio is depends on how great the difference is, and the more power an engine can generate for a specific size.

Typical car engines run CRs of approximately 10:1. That number has been steadily ascending, though, in recent years, as manufacturers strive for higher levels of performance and fuel economy. Today, some cars boast compression ratios greater than 13:1, although the tendency today is to have CR's of about 7:1 to prevent knock. Diesel engines use very high CR's, which can range from about 14 to 25:1 to cause combustion. This leads to the greater levels of efficiency diesel offers compared to gasoline engines. Diesel engines do not require a spark to ignite the fuel/air mixture, but use high compression for spontaneous combustion.

In the proper operation of the gasoline internal combustion engine, the piston moves down in the combustion chamber and draws in a combination of air and gasoline vapors. At the bottom, dead center, the piston moves up and compresses the mixture. Prior to top dead center, the spark plug fires, exploding the mixture and propelling the piston through the cylinder, thus providing power. As the spark plug continues its firing, a series of combustion waves are propelled through the cylinder. Behind each wave is an area of low pressure and high temperature. In front of the wave, is an area of high pressure and high temperature. so all the waves form a single combustion wave.

The high temperature and high pressure in front of the combustion wave may cause heating of engine deposits in other parts of the cylinder and they will spontaneously combust, resulting in their own combustion waves. It is the interaction of these waves that causes the knocking in the engine. There is no metal-to-metal contact

This all boils down to the fact that the tighter your car's engine squeezes its fuel, the higher the fuel grade necessary to stave off annoying pinging or knocking caused by early detonation. So, if you happen to drive a car that is designed for high performance or maximum efficiency, don't try to skimp, and fill up your tank with regular; it will require at least mid-grade, if not premium. In fact,

Most car engines use the same basic principle: The combustion of air and fuel creates rotational force which is used to move a car. See more car engine pictures.

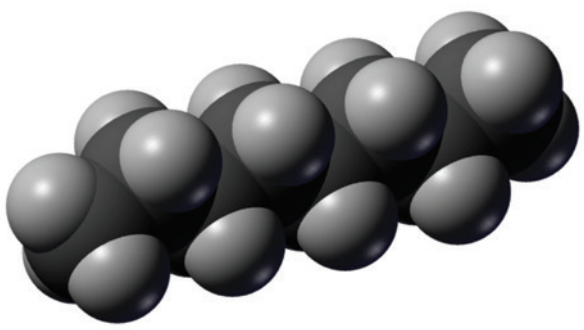
Classic Car Engine

getting other than what is recommended by your owner's manual is a very bad idea and that foolish frugality can even potentially nullify your vehicle's warranty. On the flipside, if you have a car where regular is specified, don't think you're doing your car any special favors by treating it to higher octane gas. Instead, do your wallet a favour, and remember that if the cheapest gas is indicated for your car, there may not be much benefit to giving it higher than 87 octane.

The corollary to this, however, is that if your car has a label that states "premium fuel required" it is compulsory that you always purchase the higher grade fuel. While, the devil's advocate may say your car's knock sensor should prevent problems regardless, it is far better to be safe than sorry, especially when considering the investment involved in a car requiring premium fuel. On the other hand, if your car only admonishes "premium fuel recommended", you have a choice since your car can run safely on regular or mid-grade, but there will be the benefit of better performance, and even possibly improved fuel economy if you splurge on premium.

If you're unsure if it's worth the extra expenditure to put in premium at the pump, you can conduct your own experiment using a simple technique: Begin by charting your fuel economy in relation to various fuel grades. You can fill the tank and reset the trip odometer, use up what's in the tank and then refill and divide the number of miles driven by the number of gallons needed to refuel. This simple math will yield you an accurate MPG or miles-per-gallon. Your results of this do-it-yourself experiment will either confirm or refute your original hypothesis and show you, beyond a shadow of a doubt, what type of gasoline will avail your vehicle optimal performance and economy, in other words, bring you the most bang for your buck.

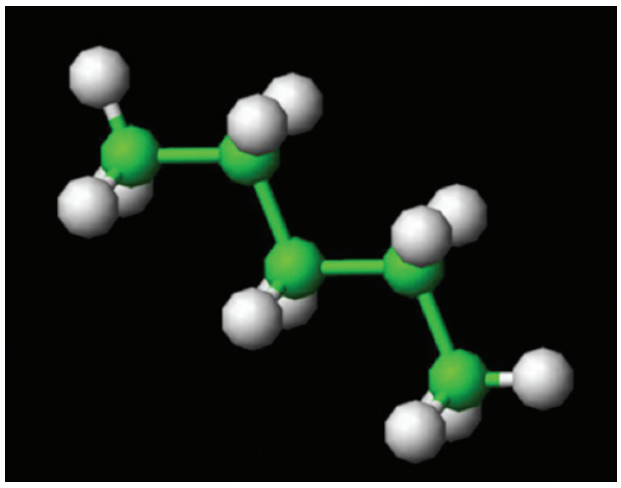
One special case, where the car label may not be much help in determining fuel grade, is if you have a classic or very old car (1970s or prior). In this instance, it may behoove you to use 89 octane or higher, as well as remaining vigilant to listening for pre-ignition knock. Although, hearing that unwelcome sound means your car needs a tune-up and not higher-grade gas. Cars made in the late 1980s or after should still follow the credo of using whatever fuel grade is specified in the owner's manual. Many people may think that if an older car is not running as well as it used to that more expensive gas may solve the problem, but it is more likely a sign that the fuel or ignition system needs cleaning or adjustment; therefore, you're much better off putting your money into that amelioration and sticking with your tried and true regular at the pump.



Octane

Another special case to consider, where fuel grade is concerned, is if you're traversing steep terrain: For instance, if you're trekking through the mountains, you may be surprised to see gas with lower-octane than you're used to seeing. For instance, regular may be 85 octane instead of the usual 87 octane. This is due to the air density being reduced at high altitudes. This affects how the fuel burns in the engine. Keep in mind, if you're spending the week then go ahead and fuel up on the octane that you would typically use, but if you're just passing through then plan for lower altitudes and go by the numbers indicated on the pump.

Most stations in the U.S. and Canada offer a sole grade of diesel fuel, which may be labeled ULSD or Ultra Low Sulfur Diesel, and the pump is usually green so it is easily recognizable. When it comes to diesel, remember to not put regular gas in a diesel automobile's fuel tank or you will regret it when the engine won't run on gasoline and the repairs are costly.



The Octane Molecule

Finally, biodiesel blends, notated by a BD label, such as BD5 or BD20 are available at select stations. Biodiesel is derived from vegetable oil, and the number denotes the percentage; for instance, BD20 is comprised of 20% biodiesel with the 80% remainder being petroleum-based diesel. If you're wondering if biodiesel is an option for you, check your owner's manual to find out if your engine is BD-capable. If it is, also find out what percentage it needs. The majority of new vehicles are limited to BD5. Biodiesel contains methanol; this can be deleterious to pliable rubber parts in the car's fuel system, and could be too heavy to flow through the thinner orifices of today's streamlined fuel injectors.

Now that you understand a bit more about what is driving the octane fueling your vehicle, you're ready to make an informed decision the next time you head to the pump. Basically, the bottom line is to always use what your manufacturer specifies: Using higher octane when only regular is indicated is not worth the added expenditure and won't boost fuel economy or performance. On the other hand, skimping on premium when it is indicated and using regular instead will result in performance reduction, knocking, pinging and potentially even engine damage. Although, rest assured, today's cars are very hearty and forgiving of an occasional fuel switch that is less than optimal. However, if your car manual allows for some leeway when it comes to fuel, it may be in your best interest to do some experimentation to determine which grade gives you the best performance for the price.

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The authors wish to thanks Dr. Sal Rand for his useful comments and help in the preparation of this article.

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1958 MG Magnette
Credit: Mike Casey, Reminisce Extra March 2017

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