



Fuel Properties and Examples

The exothermic reactions, heat generation, and thermal decomposition are different from fuel to fuel. As a general rule, having more oxygen available makes more power by virtue of burning more fuel. Every fuel has a specific heat value. Every fuel has an optimum point of ignition. Maximum power for conventional piston engines will occur when peak cylinder pressure is observed at approximately fourteen degrees after top dead center. Combustion chamber size, fuel type, and percent nitrogen in the mixture are important factors that determine the optimized point of ignition.

One of the most over-looked areas involving nitrous oxide is excessive fuel volumes. We normally have a rich condition to begin with before the nitrous comes on. We also know that many systems have a fuel lag issue when the system is activated, but once the fuel gets there, these same systems normally flow far more fuel than necessary so our overall fuel curve is going up and down. As we have consistently pointed out at O2 Technology, it is impossible to run a chemically correct ratio, so it is important to run toward the rich side, but we must do this with much caution. An excessively lean or overly rich gasoline mixture actually burns faster. It is paramount to keep our mixtures where the engine is efficient and burning the majority of the fuel and at the same time making power. When lean or rich mixtures occur, we simply pull back timing and think the problem is fixed, but when this is done we suffer a power loss. The typical way of thinking is that if we adjust to a richer mixture, we cool the engine, but in reality, this is not necessarily true. The non-vaporized fuel does not have enough oxygen present to burn it and is basically taking up space and increasing compression.

The latent heat values for different liquids are as follows: Gas-350 kJ/kg; Water-2256 kJ/kg; Methanol-1109 kJ/kg; Ethanol-904 kJ/kg. We can easily see the kilojoules of heat energy required for a particular latent heat value.

In an article by *Klaus Allmendinger, VP of Engineering, Innovate Motorsports*, he reports: If we use gasoline at a 12.5/1 ratio, each kg of air (1divided by 12.8) equals .08kg of fuel which is mixed and vaporized. This vaporization extracts 28kJ of energy from the air charge (350 x .08). Yet if we use a rich mixture of 11.0/1, we extract 31.8kJ. This is a difference of 3.8kJ. This small difference has little effect on knock or power. If instead, we put water in place of the excess fuel, the intake tract would be cooled by 18 degrees, which is 4 times the cooling effect of the richer mixture. The extra fuel cannot burn because there simply is not enough oxygen available.

It does not matter if we add fuel or water, but with water we get added cooling which helps to add power. Klaus's article was written in respect to turbo applications, but the same physics and chemistry apply to nitrous applications. With lean or rich conditions, we aggravate cylinder temperature and pressure which causes detonation.



These destructive situations are not as problematic with an alternative fuel like ethanol. We already have a larger amount of fuel going into the engine (30-32%), with much cooler inlet air temperatures. Due to this super-cooled environment, when running nitrous oxide, our nitrous/fuel curve can be run closer to a chemically correct ratio. We all know how hot a blown gas engine runs compared to a blown methanol engine. An optimum mixture with a “later” ignition can produce more power because more energy is released from the process.

In the case of gasoline (hydrocarbons), we have multiple stages of combustion. First the molecules are broken into hydrogen and carbon, then combine with the oxygen from the air to form water (H₂O) and CO. This process is fast and then during the 2nd stage, CO is converted to CO₂ (carbon dioxide) which is a slower process that requires water from the 1st stage. If all of the oxygen is already consumed, the 2nd stage cannot happen, so about 2/3 of the energy released from the burning of carbon is released during the 2nd stage. This creates a very hot environment and a very fast burn rate. Therefore, a rich mixture releases less energy. As we pull back ignition timing we are lowering peak pressures and temperatures, but also lowering power. Rich mixtures without the oxygen available to burn the fuel will always cost power. We walk a fine line with hydrocarbon fuels (gas, C₈H₁₈).

Physical Properties of Various Fuels

	Fuel Type	Specific Gravity	Boiling Point	Vapor Pressure 68F	Thermal Decomp.	Oxygen Content	Dielectric Constant	Freeze Point
C ₈ H ₁₈	Gasoline Iso-octane	.69-.78	100-400F (244F)	10.44		0	1.0-2.0	-10 to -80F (-224F)
CH ₃ OH	Methanol	0.796	148F	97.48	867F	50%	32.6	-137F
C ₂ H ₅ OH	Ethanol	0.794	172F	43.89	685F	35%	24.3	-104F
CH ₃ NO ₂	Nitro-methane	1.14	214F	27.80	890F	52.50%	39.4	-83F
C ₂ H ₅ NO ₂	Nitro-ethane	1.045	255F	15.60	690F	42.70%	19.7	-131F