Racing Fuel Characteristics

The Four Primary Characteristics of Racing Fuels

OCTANE is a measure of a fuel's resistance to pre-ignition, pinging, and detonation. There are three octane ratings for motor fuels; Research Octane Number (RON), Motor Octane Number (MON), and the average of the two (R+M/2). Of these three ratings, MON is the most useful to race engine builders because it is tested under load and higher RPM conditions. High MON ratings allow the use of higher compression ratios and more advanced spark timing. However, there are other fuel characteristics that influence the ability of a particular fuel to resist knocking.

BURNING RATE is the speed at which a fuel burns and releases its heat energy. At higher RPM's there is less time for fuel to burn, so racing fuels tend to work better if they have a rapid burning rate. If a fuel can be almost completely burned by the time the crankshaft is 20 degrees after TDC (Top Dead Center) on the engine power stroke, peak horsepower and engine efficiency are realized.

LATENT HEAT of VAPORIZATION is the ability of a fuel to cool the intake charge and the combustion chamber. It is often expressed as BTU's/gal (British Thermal Units per gallon). A fuel with a high latent heat value will do a better job of removing heat. This makes the intake charge more dense and packs more energy per volume into the engine. The cooling effect also helps control detonation and reduces the temperatures of engine and oiling system components.

ENERGY VALUE is an expression of the total heat energy contained in a given amount of a fuel, expressed as British Thermal Units per pound (BTU/lb). The total amount of heat energy that is available to make horsepower depends on the Net Energy Value of the fuel. This is found by taking the raw energy value of the fuel and then multiplying that by the amount of fuel that can be burned. The ideal air/fuel ratio for a fuel is called its stoichiometric. The lower the stoichiometric, the more fuel is burned and the more power can be produced.

Fuel	Octane (R+M/2)	Octane (MON)	Burning Rate (ms @ stoich.)	Latent Heat (Btu/gal)	Energy Value BTU/Lb	Power Stoichio-metric	Net Energy Mj/kg	Boiling Point (°F)
Pure Ethanol	113	102	.39	396	12,800	6.5/1	3.00	149
Pure Methanol	N/A	103	.43	503	9,750	5/1	3.08	172
Pump Gasoline	86-93	80-90	.34	150 *ave.	18,700-19,100	12.5/1	2.92	130-430
Racing Gasoline, Sunoco 260 GTX	N/A	99	N/A	N/A Est.160	N/A Est. 18,500	12.5/1	N/A Est.2.90	247
E-30	91-94	87-94	.36	337 (approx)	17,178 (approx)	10.7/1	2.94	218
E-85	103-109	99-100	.38	359 (approx)	14,021 (approx)	7.4/1	2.99	164

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Fuel Characteristics Rankings

The chart below reflects how various fuels rank in each of the four previously discussed categories. Remember that the last column, Net Energy Value is the most important with regard to power making capabilities:

Fuel	Octane (MON)	Burning Rate	Latent Heat of Vaporization	Net Energy Value
Pure Ethanol	2	5	2	2
Pure Methanol	1	6	1	1
Pump Gasoline	6	2	6	5
Racing Gasoline, Sunoco 260 GTX	4	1 (estimated)	5	6
E-30	5	3	4	4
E-85	3	4	3	3

Advantages of Ethanol-Enriched Racing Fuels

HORSEPOWER: Because Ethanol contains oxygen, it has a very low power stoichiometric when compared to gasoline fuels (6.5 compared to 12.5). Ethanol must be run at much richer mixtures than gasoline, more than offsetting the lower energy per unit volume. The net energy released per cycle is higher and this results in more horsepower.

For example, if a pound of gasoline is burned at its preferred max power air fuel mixture of 12.5/1, it will release approximately 19,000 BTU's of energy, where ethanol run at its preferred power stoichiometric of 6.5/1 will release approximately 24,400 BTU's. By comparison, methanol releases slightly more, about 27,650 BTU's. The more ethanol there is in gasoline, the more powerful it is as a motor fuel. Typically, you can expect at least 5% more horsepower at the rear wheels of a vehicle running on E-85 than one burning gasoline only.

INCREASED ENGINE LIFE: Ethanol has a very high MON octane rating, allowing engine builders to run higher compression ratios without fears of destructive detonation. It also has a very high Latent Heat of Vaporization, so the engine is cooled far better than one running on gasoline. This lowers bottom end and oiling system temperatures substantially.

REDUCED EMISSIONS: Although reducing emissions usually will not directly affect the on-track performance of a race car, engine parts like pistons and valves tend to stay cleaner. More importantly, there are serious health concerns with many of the octane boosting additives that must be added to racing gasoline in order for them to be compatible with higher compression racing engines. Ethanol fumes are also non-toxic.

FIRE SAFETY: While many factors enter into the causes of fuel fires, ethanol does enjoy certain advantages over gasoline fuels. The flame temperature for ethanol is lower, 1920°C compared to 2030°C for gasoline. Because it contains less heat energy than gasoline per volume, less total heat is released with ethanol when burning a given volume of fuel. The auto ignition temperature of ethanol is lower than that of many gasoline, 360° compared to up to 460° for gasoline. Liquid gasoline has vapors present at all temperatures, down to or exceeding -40° C. Ethanol has little or no vapor pressure below 13° C. While pure ethanol fires have little or no color, even slight amounts of gasoline added to denature (poison) the mix create bright colors and dark smoke.

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Why Not Methanol?

ETHANOL IS LESS CORROSIVE: Ethanol is less corrosive to most fuel delivery system components than methanol. This is due in part to the higher oxygen content of methanol. However, certain materials that may be used as sealers or glue in methanol-compatible fuel cells may not be compatible with ethanol. There are solutions to this problem that are being developed for the IRL (Indy Racing League) series that will be running pure ethanol in the 2007 season.

ETHANOL IS NON-TOXIC: Ethanol is really grain alcohol—the kind present in all alcoholic beverages. In order to be legally transported, it must contain a “denaturing agent” (poison) which is usually ordinary gasoline. By comparison, methanol (wood alcohol) is toxic and is harmful or fatal if swallowed. When blended with gasoline, methanol releases formaldehyde in passenger cars until the catalytic converter warms up. No auto manufacturer recommends concentrations of methanol higher than 5% in their cars. However, all car manufacturers have approved ethanol-enhanced gasoline, up to 85% ethanol content in “Flexible Fuel Vehicles”.

What is Required to Run Ethanol Fuels in a Racing Application?

COMPATIBLE FUEL SYSTEM COMPONENTS: Because ethanol contains oxygen, it can form corrosive agents. Any water that enters the system can promote the formation of formic acid. Although this process takes a significant amount of time before damage occurs, the tank, pump, and lines should be either stainless steel or coated with a plastic material that is ethanol-compatible. All natural rubber parts that could be in contact with ethanol must also be replaced with synthetic and other materials. These are all readily available from manufacturers of racing carburetors and racing fuel system components. In some cases it may be desirable to modify the carburetor so that it can handle the required increased liquid fuel flow when converting from a gasoline application.

When considering fuel pump compatibility, it must also be understood that gasoline is an insulator but ethanol does conduct electricity. This should not be an issue for race cars, as they nearly always have a pump that is mounted outside of the tank. However, the pump must be internally ethanol/methanol compatible and must be able to keep up with the increased fuel delivery rates. For information on mechanical pumps, you will have to contact the manufacturer to be sure the pump you plan to run is alcohol/ethanol compatible.

MANAGING FUEL VAPOR PRESSURE: Ethanol does contribute to increased vapor pressures when the underhood temperatures are very high. This issue should be easily resolved if it becomes a problem by adding a cooler to the fuel lines.

STORING ETHANOL-ENHANCED FUELS: All alcohols attract water and should therefore be stored in UL-approved fuel containers that are ethanol-compatible and that limit exposure to outside air. However, it takes a very large amount of water in the fuel (about 4 tsp. per gallon) before “phase separation” between the mixed gasoline and ethanol occur. Water in smaller amounts than that will result in phase separation of pure gasoline.