

BESTCHEM Racing Fuel additive - Toluene (114 octane)

Meets military specs: TT-T-548E

Toluene is a pure hydrocarbon (C₇H₈). I.e. it contains only hydrogen and carbon atoms. It belongs to a particular category of hydrocarbons called aromatic hydrocarbons. Complete combustion of toluene yields CO₂ and H₂O. This fact ensures that the entire emission control system such as the catalyst and oxygen sensor of your car is unaffected. There are no metallic compounds (lead, magnesium etc), no nitro compounds and no oxygen atoms in toluene. It is made up of exactly the same ingredients as ordinary gasoline. In fact it is one of the main ingredients of gasoline.

Toluene has a RON octane rating of 121 and a MON rating of 107, leading to a (R+M)/2 rating of 114. (R+M)/2 is how ordinary fuels are rated in the US. Note that toluene has a sensitivity rating of 121-107=14. This compares favourably with alcohols, which have sensitivities in the 20-30 range. The more sensitive a fuel is the more its performance degrades under load. Toluene's low sensitivity means that it is an excellent fuel for a heavily loaded engine.

Toluene is denser than ordinary gasoline (0.87 g/mL vs. 0.72-0.74) and contains more energy per unit volume. Thus combustion of toluene leads to more energy being liberated and thus more power generated. This is in contrast to oxygenated octane boosters like ethanol or MTBE, which contain less energy per unit volume compared to gasoline. The higher heating value of toluene also means that the exhaust gases contain more kinetic energy, which in turn means that there is more energy to drive turbocharger vanes. In practical terms this is experienced as a faster onset of turbo boost.

Toluene has a (R+M)/2 rating of 114 octane

Modern vehicles now use computerized engine management systems that can react to engine knock and retard ignition timing if low octane fuel is being used. Consequently cars are now being manufactured with very high compression ratios that appear to give good fuel economy and at the same time good performance. This combination does assume that fuel of adequate octane is being used.

For a high compression engine to run on low octane fuel, the engine management system will need to retard the ignition timing to prevent pre-ignition or pinging. Retarding the ignition timing means that the firing of the spark plug is delayed until a later moment in the compression stroke. It does not take much to see that a later onset of combustion means that the combustion is less complete, which in turn mean less power and poorer fuel economy. It is possible that the casual driver will still come out ahead in terms of saving money by using low octane fuel, but the retarded ignition advance also means a rougher running engine and a much duller throttle response. Thus octane boosting is not necessarily of interest to all motorists but rather the enthusiasts. For turbocharged or supercharged engines, insufficient octane will also lead the engine management system to

curtail the amount of boost which in turn defeats the purpose of these engines. Toluene is such an effective anti knock fuel that it takes a smaller quantity to achieve the same octane boost compared to 100 octane racing gas.

Aviation fuel verses Toluene?

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Aviation gas is less dense than most racing gasoline. Instead of weighing about 6.1 to 6.3 pounds per gallon like racing gasoline, it weighs 5.8 to 5.9 pounds per gallon. The racer must compensate for this by changing to richer (larger) jets in the carburettor when changing from racing gasoline to avgas. Most types of aviation fuel have very high lead content, which would rule out cars equipped with catalytic converters. Most piston-engined aircraft burn leaded fuel. Also aviation fuel has a very different hydrocarbon mix to optimize volatility properties at high altitude. Avgas sometimes has a high level of aromatics, which can contribute to lazy throttle response.

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The other major difference is octane quality. Avgas is short on octane compared to most racing gasolines. Many racing engines with "quick" spark advance curves or with no centrifugal advance have more spark advance at low rpm than avgas and some racing gasoline's can handle. The result is detonation, especially during caution periods in circle track racing because all of the spark advance is "in", rpm is low, and part throttle air fuel ratios are too lean for the operating conditions.

If the driver does not "work" the throttle back and forth, pistons can be "burned" which melts away part of the aluminium piston material. Inadequate octane quality is one of the quickest ways to destroy an engine. Pistons can be severely damaged during acceleration where detonation is present and the racer may not know what is happening until it is too late.

How much toluene should I use per tank of gasoline?

[00] A 5 or 10% increase in the aromatic content of gas will most likely be well within the refining specifications of gasoline defined by ASTM D4814, which specifies an aromatic content of between 20% and 45%. What this means is that if the 92 octane gas that you started off with had an aromatic content of say 30% and you increased it by 10% to 40% you would still be left with a mix that meets the industry definition of gasoline.

Because toluene is such an effective anti knock fuel it also means that it is more difficult to ignite at low temperatures. The Formula 1 cars that ran on 84% toluene needed to have hot radiator air diverted to heat its fuel tank to 70C to assist its vaporization. Thus too strong a concentration of toluene will lead to poor cold start and running characteristics. It's recommended that the concentration of toluene used not to exceed 30% or what the engine is capable of utilizing. I.e. Experiment with small increases in concentration until you can no longer detect an improvement.

Octane ratings can be very easily calculated by simple averaging

Toluene has octane rating of 114. So use this formula to figure what octane you get when u mix toluene with gasoline:

Litres of gasoline x Octane (eg.95 or 98) + (Litres of toluene x 114)
Total Litres of Gasoline & Toluene

example The fuel tank capacity of an EVO 8MR is 55 litres. Based on a 30% toluene mixture, filling it with

16.5 litres of toluene and 38.5 litres of 98-octane gasoline will yield a fuel mix of:

$(38.5 \text{ litres} \times 98) + (16.5 \text{ litres} \times 114)$
55 litres
= 102.8 octane

Notes: Common ingredient in Octane Boosters in a 12-16 ounces bottle will only raise octane by 0.2 - 0.3, i.e. from 98 to 98.3 octane.

MAKE YOUR OWN OCTANE BOOSTER

To make your own octane booster, it is easiest to make up a large batch, and then bottle it up in "dosage-size" uses. Below is the basic formula of one of the popular octane booster products. To make eight 16 ounce bottles (128 oz = 1 gal):

100 oz of toluene for octane boost

25 oz of mineral spirits (cleaning agent)

3 oz of transmission fluid (lubricating agent)

The above formula is an "octane booster with cleaning agent and lubricating agent". Diesel fuel or kerosene can be substituted for mineral spirits and light turbine oil can be substituted for transmission fluid. Colour can be added with petroleum dyes.