Prometheus Fuel Guide

Ventimore Ltd (UK)

1 Copyright

2 Fuel

Modern fuels are a complex mixture of compounds that provide power without damaging your engine while meeting emission standards. It is also probably the most variable element in carburettor jetting. This guide will only discuss technical information that relates directly to karting.

3 Compression ratios and Power

The Rotax FR125 kart engine has a very modest compression ratio of 7.9:1. It is a simple fact that the higher the compression ratio, the more of the energy in the fuel is extracted as kinetic engine. I.e. the more efficient the engine is. The reason is buried in the science of Thermodynamics. All petrol and diesel engines are heat engines. The heat from burning fuel heats up the fuel/air mixture which pushes against a piston. The longer the piston moves, the more work is done by the gases and the more mechanical energy is extracted. The engine cannot allow the gas to expand for ever since the piston will come to the end of it's travel. At that point, the energy left in the gas is lost and the piston begins the next part of the combustion cycle. Modern petrol engines have an efficiency of around 25+%.

4 Octane rating

High compression engines are subject to pre-detonation, also known as "knock" or "pinking". Fuel additives are used to prevent knock, and fuels are graded on an Octane scale to indicate how resistant they are to knock. Pure Octane has a 100 rating. Racing fuel may have a rating of more than 100 Octane. Road fuels typically have a rating of less than 100.

Modern road cars have knock sensors which retards the ignition timing if knock if detected. BP supplies "Unleaded 95" and "Premium 98" fuels in the UK where the 95 and 98 indicate the octane rating. The premium fuel will generate more power that the standard fuel only if your engine cannot operate normally with the standard fuel. In many cases, the premium fuel is a waste of money. The low compression ratio of the FR125 engine means that there is no reason to purchase premium fuels to avoid knock.

5 Density and Viscosity

The density and viscosity vary with temperature and it is that variation which means that the jetting is much more sensitive to temperature than it would be if only air density was considered. To get the best from Prometheus, you should ideally always use the same fuel when karting. If you can afford it, use racing fuel.

The supply chain in the UK and many other countries is such that there can no guarantee that fuel purchased from the same petrol station at different times will be consistent. The best that can be said is that petrol in the UK should comply with the BSEN 228 standard, however that leaves considerable scope for variation. It is probably best to purchase fuel from a petrol station owned by a big-name pertoleum company like BP, Shell or Esso which has a high turnover. The composition of fuel also changes to minimise emissions at different times of the year [1] - Winter fuel, for example, will contain more short chained hydrocarbons such as pentanes which are removed in Summer.

Racing fuels are more consistent. They are mixed in large batches for consistency to a known formula. They are however very expensive, typically £4+ per litre. The cost in fuel for a kart over a weekend of testing can be more than £80 (20 litres), which is prohibitive for Lad and Dad. It is not really practical to buy a large quantity of petrol and store it at home. It would be a disaster is a fire broke out. It is also illegal in the UK to store more than 30 litres of fuel at home, and more than 10 litres in any single container.

WP Racing supply racing fuel to Super One in the UK. The details of their fuel can be found in the Appendix.

6 Petrol care

Petrol goes off very quickly. Make sure that the petrol you purchase is kept in an air tight container and throw it away after the weekend of use. It is good practice to fill the fuel tank in a kart to minimise the escape of volatiles. The ridiculous weight limits in karting however make this impractical in many situations. The author is aware of reports of karters re-jetting during the day as a result of petrol "going off", the atmospheric conditions remaining the same.

Temperature (C)	Density (kg/m^3)	Viscosity (Pa·s)
0	719	0.719
25	703	0.516

Table 1: Variation of density and viscosity with temperature

7 Fuel properties

Which fuel properties are required to calculate the jetting? They are

- The variation of density with temperature. ρ(T).
- The variation of viscosity with temperature. η(T).
- The EFR are maximum power. EFR_{max}

It is feasible to determine the first two by direct measurement. If the first two are known, it is then possible to pin the third down by testing (listen for popping down the straight and adjust Prometheus' recommendations accordingly)

Fuel density can be measured by a hydrometer, fuel viscosity measured by a viscometer.

It is now possible to purchase electronic meters which measure both. Not surprisingly, they are expensive (hundreds of pounds).

A single measurement of fuel's density or viscosity is not enough. You need to cool down or heat up the fuel and re-measure the density and viscosity again. Table [1] shows measurements for nOctane.

The measurement temperatures should be between about 0C and 35C. The more viscosity measurements you make the more accurate the model should be.

Note that you should NEVER USE A NAKED FLAME to heat petrol. It is much better to cool down a sample with an ice bucket. Wait till the fuel is at the same temperature as the ice water before making a measurement. If the ambient temperature is close to freezing, then a small fuel sample can be heated up a SMALL AMOUNT in a container USING A BACKET OF WARM WATER.

You can setup a fuel is the Prometheus' XML configuration file. Copy and repeat the fuel section as below. Give the fuel a unique name ("Local garage" in the example below). Add the details from above. Leave the maximum AFR at 12.6

```
<Fuel name="n-Octane" T1="323.15" density1="667.78"
                      T2="348.15" density2="665.7"
                      AFR_max="12.6">
        <viscosity T="223.15" value="1.837"/>
        <viscosity T="273.15" value="0.719"/>
        <viscosity T="298.15" value="0.516"/>
        <viscosity T="303.15" value="0.486"/>
        <viscosity T="323.15" value="0.39"/>
        <viscosity T="348.15" value="0.306"/>
        <viscosity T="373.15" value="0.247"/>
</Fuel>
```

8 Which fuel?

The best fuel is the one that produces the most power. Theoretical calculations are of less use that simply putting an engine on a dyno, tuning it and seeing which fuel works the best.

Even that is somewhat academic. Most karters will have to go with fuel from the local petrol station. They will not have access to sophisticated measuring equipment. So how can they compete with those that do? The answer is that if you stick to the same type of fuel (say Unleaded 95) you should be able to judge over time how Prometheus' recommendations vary from reality. For example, you may come to the conclusion that the recommendation is half a jet too high/low in winter. Or that above 25C, it is half a jet too high/low. You should always use the Saturday before race day to check recommendations and make adjustments to Prometheus if necessary. Once Prometheus is in the right "ball park" it should be able to accurately tell you if you need to change a jet when the weather changes, say, between heats.

9 Final word

Jetting does not have to be perfect. The kart on the back row of the grid may have an engine that is tuned ever bit as well as the guy on the front row. Relax and have fun.

References

[1] http://www.tds.bp.com.au/pdf/10457_REGULAR%20UNLEADED.pdf