octane number (MON) method, which uses higher engine temperatures and high load conditions in the test.

As the MON test is more demanding, typical fuels have lower MON than RON values. Unleaded Mogas fuels tend to be controlled in the range 95 - 98 RON but can range anywhere from 82 - 90 MON. Avgas is measured on lean mixture (similar to MON). The lean mixture rating has a specification minimum of 99.5 octane (15 octane higher than the comparable 85 MON typical of unleaded Mogas), but in practice has actual production values around 104, so has considerably better detonation resistance than Mogas.

But for low-octane demand engines, surely it is acceptable to use a lower octane fuel? This is the thought behind the Mogas supplementary type certificates. For low-powered aircraft, Petersen Aviation Inc in the USA and others, such as the Experimental Aircraft Association, have a test program agreed with the Federal Aviation Authority that qualifies a given engine or aircraft combination to run on unleaded Mogas. These approval methods have also been accepted by other aviation authorities, such as those in Europe and Australia and involve running the engine in the aircraft and looking for fuel flow and detonation problems whilst burning a typical Mogas.

Research and Development

Significantly, these tests accept the engine conditions seen during the testing and do not look at the engine's whole operating envelope. This is the problem. As part of our own Research and Development programs, Shell Aviation has a low-octane demand Lycoming engine – one apparently suitable for use with unleaded Mogas – on a test stand. During some related combustion study work, Shell conducted some tests within this engine's operating envelope, but with higher than normal cylinder head temperatures (CHTs). In spite of using a high octane, 98 RON Mogas, rather than the normal 95 RON unleaded fuel covered by the typical supplementary type certificates, the engine suffered severe detonation under moderate load at only 1,200 rpm, somewhere close to what most people would use as a ground idle condition. Reducing the CHTs to a more typical level allowed the fuel to work throughout the power curve, which is why many of the aircraft do not experience problems under the Mogas approval program, but it is proof that even high-octane Mogas does not give an adequate detonation boundary throughout the operating envelope of the engine.

Aircraft fuel for aircraft engines

It is not too hard to imagine a scenario: a hot day with a quick stop for fuel, a long hold on the ground, or a rapid turn-around – all would allow the engine to heat up to higher than average CHTs. Our engine bench testing work shows that having Mogas in the tanks at this point represents a much greater risk than choosing to use Avgas and adds weight to the position by the oil companies and engine manufacturers that aircraft engines should use aircraft fuel.

What do I fly with? Avgas 100LL.

Happy flying.

No matter how reliable the fuel supplier, road fuels are designed only to be used in road vehicles

Shell Aviation

Dear Aviators

I trust you all had a peaceful and relaxing Christmas and New Year. I am sure this will be another exciting and prosperous year for all those out there in the Aviation Industry in Australia.

In this the first edition for 2008 - Tech Talk issue 20, our good friend Rob Midgley discusses why many in the Aviation Industry prefer to use Aviation Gasoline (AVGAS) as opposed to Motor Gasoline (MOGAS). Rob's discussion covers aspects around the constituents, composition, properties, storage, quality, handling and Octane rating of the two fuel types. Rob highlights aspects that are often overlooked e.g. the shelf-life. I trust you find the article interesting and beneficial for the future.

I once again throw it out to you the reader, if you would like any aspects of this issue's topic explained further or there are points you need clarification from past articles, please drop me an email and I will happily get our Technical experts to respond to you. Similar if there are topics you want cover in future issues, my details are below – please drop me a note with the topic.

Happy Flying

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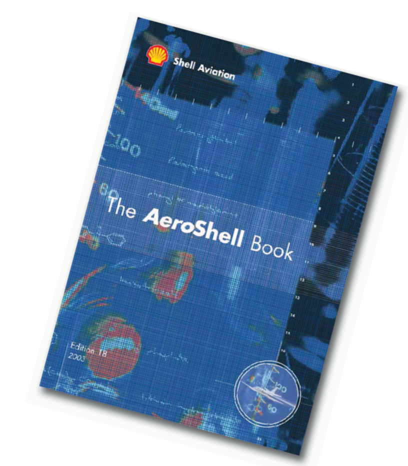

AVGAS: THE RIGHT CHOICE

DESPITE THE FACT THAT SUPPLEMENTARY TYPE CERTIFICATES ARE IN PLACE TO ALLOW SOME LIGHT AIRCRAFT OR ENGINE COMBINATIONS TO USE MOTOR GASOLINE (MOGAS), MANY IN THE AVIATION INDUSTRY PREFER TO USE AVIATION GASOLINE (AVGAS).

Even where the use of Mogas is allowed by the aviation authorities, Shell Aviation, other major oil companies and the engine manufacturers have always taken the position that Mogas should not be used in aircraft applications - in particular the common air-cooled Textron Lycoming and Teledyne Continental engines. The cynical may think that this is due to an effort to sell more Avgas, but in fact it is more to do with the safety and suitability of the fuel.

There are several areas where the composition and control of Mogas differs from Avgas and this can result in safety concerns with Mogas even if the rules and restrictions are observed.

The main areas of difference between Avgas and Mogas are:

- Less regulation of which constituents are allowed when making the fuel;
- Mogas routinely changes composition and properties between winter and summer;
- Mogas is not designed to be stored for long periods;
- Mogas does not have the same quality and handling restrictions.

Constituents

Mogas is allowed to contain a number of components which are known to be a problem with aircraft systems, or can even reduce power. One such item is alcohol, which can be aggressive to seals, carburettor components, fuel tank linings. This can lead to leaks, engine failure due to poor mixture control and it has even been the documented cause of in-flight fires. There is also no assurance that one supply source of fuel will have a consistent composition, so always buying from one forecourt is no guarantee that the fuel's composition is always the same.

"Refueling with Mogas - it's not just the process that is less controlled, so is the product".

Composition and properties

Winter grade Mogas is more volatile, which is intended to assist with engine starting in cold weather. This means that it has a lower initial boiling point and will form a vapour more easily; a problem with aircraft fuel systems as a bubble of vapour in the fuel line will prevent fuel from flowing and cause engine failure. Why is this a problem for aircraft and not cars? The significant difference here is that cars don't get up to flight levels. The reduction in pressure with altitude causes vapours to form more easily even at moderate temperatures. This can be compounded by the fact that aircraft tend to be used less frequently, meaning that there is a greater risk of winter grade Mogas still being in the tank on hot spring and summer days, making the problem of vapour lock more of a risk.

Storage

Within the automotive world Mogas is generally burned within a few weeks of production so storage stability is not a concern. However, kept for longer periods, it can form sticky lacquers and gums that have the potential to result in fuel injector or carburettor malfunctions. Avgas's composition is much more tightly controlled, allowing fuel to be kept for months without deterioration. This is significant in aviation as it is not uncommon for an aircraft to be in the hangar for several months with fuel remaining in the tank.

Continued on page four

Restrictions on quality and handling

Avgas's quality is guaranteed by the use of dedicated manufacturing and storage vessels, road tankers that are only used for Avgas transportation and dedicated airfield storage. Furthermore, water is removed and the fuel tested throughout the delivery system, almost totally eliminating the risk of contamination. Upon delivery to the aircraft Avgas is cleaned using filters so fine that they would be capable of separating red and white cells from blood – the result is that you receive very clean, dry, on specification fuel.

None of these quality restrictions are in place for the Mogas supply chain, which involves numerous areas where there is a chance of cross-contamination. These range from the obvious, such as non-dedicated vehicles, to the less obvious, such as distributing Mogas large distances by pumping it down multi-product pipelines along with other products, ranging from diesel fuel to heating oil are also being moved. Remember there is equivalent to the edge of the road at 3,000 feet.

Octane rating

There is one more fundamental difference where Avgas out-performs Mogas – that of octane rating. Octane is the measurement of a fuel's detonation resistance. All fuels will automatically combust before the flame reaches them if the temperatures and pressures are high enough in the yet-unburned gas. This leads to explosive combustion of the remaining fuel in a phenomenon known as detonation. Severe detonation can destroy an engine in a few seconds. Octane rating measures how resistant a fuel is to detonation; the higher the octane rating, the more the fuel or air mixture can be compressed without detonation happening. To make this clear, octane rating is not a measure of the amount energy in the fuel but measures its resistance to detonation. The advantage of higher octane fuels is that a higher compression ratio or supercharging ratio can be used, which then leads to a higher engine cycle efficiency, which in turn means more power output for a given fuel burn.

Engine Test Cell: There's a Lycoming 360 in there somewhere!

There are several things that determine an engine's octane demand of an engine (in other words things that encourage the fuel to detonate in a given engine). They include compression ratio, supercharger pressure, inlet temperature, cylinder wall temperature, ignition timing, load (or power setting), engine speed and cylinder bore. In aviation, we generally have engines which do pretty much everything badly from an octane demand viewpoint: low engine speed, air-cooled (high cylinder wall temperature), large cylinder bore, supercharged with no intercooler (high pressure and high temperature inlet air), fixed ignition timing with magnetos and relatively high average power setting.

Once we know the engine's octane demand, how do we measure the fuel's performance? A fuel's octane performance is measured in the lab using single cylinder test engines in which the compression ratio can be altered by screwing down the cylinder head, therefore increasing the compression ratio. However, the way in which this engine is operated – with varying temperature, load and speed – results in different types of responses, leading to differing octane numbers for a given fuel.

Road fuels tend to be measured on a research octane number (RON) scale, in which the test engine is run at low cylinder temperature and low load. This is intended to replicate a liquid-cooled car engine on the open road and so is commonly used as a reference point for Mogas fuels. Aviation fuels are measured using the more demanding motor

Light aircraft

The aircraft referred to in this article are principally the common category A light aircraft, which include Pipers and Cessnas, rather than aircraft in the microlight and ULM categories, such as Rotax, which seem to operate well on unleaded fuel. However, while this prevents the problem of lead fouling, some of the compositional concerns outlined in this article still apply and should be considered if deciding to use Mogas.