AeroShell TECH TALK

MULTIGRADE OILS

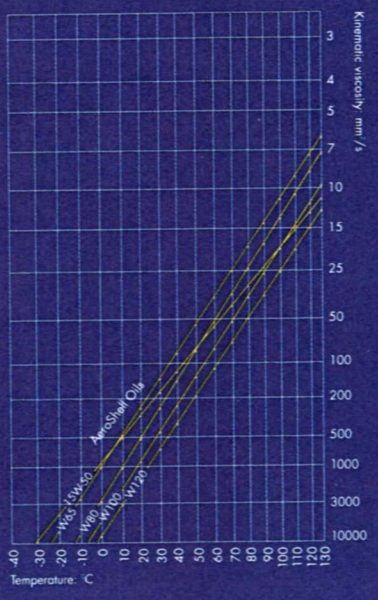
I often get asked questions about multigrade oils and what the differences are between these and other oils. Let's start by explaining what a multigrade oil is.

All oils change their viscosity with temperature - the higher the temperature, the more the viscosity reduces. This relationship between viscosity and temperature is known as the Viscosity Index (V.I.) of an oil; low VI oils change their viscosity a great deal with temperature and high VI oils undergo a much reduced change in viscosity. The compromise is that at low temperature we need an oil to be fluid enough to be able to flow rapidly when the engine is first started, and yet viscous enough at high temperature to keep parts separated and also have a thick enough oil film to cushion the load transferred between parts when the engine is running at normal operating temperature. If an oil's viscosity is optimised for high temperature use, then it may suffer from poor oil circulation when the engine is started in cold temperatures. An engine running with a very limited oil supply immediately after start up can result in engine damage such as scuffing as moving parts touch one another, but it can also significantly contribute to fatigue pitting (which often seen on cam followers) as the limited oil film left of the parts increases the load transfer between the them.

This compromise is evident with single grade oils which still predominate in the light aircraft market. If there is a significant variation in ambient temperature between seasons then the oil grade needs to be selected to suit the conditions. Lycoming's Service Instruction 1014, covering oil grade selection, recommends that SAE 50 grades (such as AeroShell Oil W100) should be used in ambient temperatures above 60 degrees Fahrenheit (16 degrees C) and SAE 40 oils (such as AeroShell Oil W80) can be used between temperature of 30 to 90 deg F (-1 to +32 deg C). There is no temperature limitations for Multigrade oils. Other engine manufacturer's recommendations may differ, but this illustrates the general idea that single grade oils should be selected to suit the conditions. This is precisely why multigrade oils were developed.

Multigrade oils have a high Viscosity Index, and so are able to be used in any temperature - from Alaska to the Sahara. The grade classification of the oil indicates the viscosity range of the oil. Let me use the example of AeroShell Oil W 15W-50 to explain the classification system.

Typical Temperature/Viscosity Curves of Aeroshell W Oils



In the case of AeroShell Oil W 15W-50, the oil is cooled to minus 15 degrees Celsius and the viscosity is measured. In the example used, the oil's viscosity at this temperature is the same an SAE 15 grade single grade oil, hence the "15" part of the name. As an aside, the lightest single grade oil available for aviation use, AeroShell Oil W65, is an SAE 30 oil - so at low temperature the multigrade is much more fluid than even the lightest available single grade oil. The oil is then heated to 100 degrees Celsius, which is representative of the oil temperature inside an operating engine, and the viscosity is again measured. At this temperature AeroShell Oil W 15W-50 has the same viscosity as an SAE 50 oil (the same as AeroShell Oil W 100), and results in the "50" part of the 15W-50 name.

AeroShell Oil W 15W-50 has the best low temperature pumping performance of any aviation piston engine oil available on the market and it is easy to see from the

classification that the low temperature flow will be better than a 20W-50 oil for example, whilst maintaining the required viscosity at high temperature. This is significant, as much of the wear in an engine comes from the period initially after start up - the quicker the engine can develop full oil flow, the more this wear will be limited. Advantages can also be gained by how the engine is operated during the first few seconds after start up.

Fatigue damage of cam followers, characterised by surface pitting, is not uncommon in General Aviation engines which suffer premature failure (see image above). Fatigue damage affects metal parts, and is the result of a cycling load being

applied to the surface; an increase in either the load or the number of cycles will reduce the length of time that the parts will last before failure. There are typically two causes of this - either the wrong grade of monograde oil has been used for the ambient temperature conditions, or high power levels have been used immediately upon start up.

The period immediately after start up of an engine can be critical, as the moving parts are relying upon any residual oil left on them from the last time the engine was run. Unless the engine is used frequently, this often means that there will only be a thin oil film present, and a thin oil film will mean a higher load transfer between moving parts - an increase in the fatigue cycling. As soon as a full oil supply reaches the parts, a full oil film separation occurs and the load transfer drops, so using an oil with a good low temperature flow is of real benefit here, and is why I would be more inclined to use a multigrade oil if the aircraft is to be used in cold climates.

There is also something the pilot can do to help. I often see pilots using high engine speeds as soon as the engine starts and it makes me flinch. The high engine speed both increases the load and number of cycles on the moving parts before a full oil supply is available. It is better to use a throttle stop idle (around 700 rpm on most engines) if possible from start up, watch the oil pressure, and then allow about 15 seconds after full oil pressure is reached before going to the normally recommended 1000 - 1200 rpm ground idle speed. Allowing the engine to race as soon as it fires is not to be recommended.

Back to the oils. Not all multigrades are born equal; AeroShell's multigrade, unlike most other multigrades on the market, is a semi synthetic. This is a great advantage as the synthetic portion of the oil does not degrade as quickly as mineral based oils, it is able to withstand higher temperatures, and it naturally improves the Viscosity Index of the oil so that it does not have to rely purely upon additives to impart multigrade performance to the oil.

A concern with the oils which rely upon high levels of additives to improve the V.I. is that the type of additive used can be unstable when high shear rates are encountered. This is when thin oil films are forced to flow at high speed, such as in large diameter plain bearings where the surface speeds are high. This can make the Viscosity Index Improving molecules align and so the viscosity drops - the oil film thickness reduces, which then increases the load transfer between the parts. This takes us back to the increased fatigue problems.

One further problem with using large amounts of these additives is that they are not known to burn cleanly and can form combustion chamber deposits. Not good news if your engine has high oil consumption, as is the case for some old engines or if breaking in a new engine.

In addition to the low temperature flow, and semi synthetic composition, AeroShell Oil W 15W-50 also contains similar additional performance additives to those used in AeroShell Oil W100 Plus. This includes a corrosion inhibitor, to help prevent rust from forming in the engine during periods of inactivity, and also an anti scuffing additive, which is recommended by Lycoming under the name of LW16702. This second additive reacts with the surface of moving parts if they come into contact so that a layer of additive prevents "scuffing" damage; when metal is torn from the surface by direct contact with another part. This is useful on engine which have stood idle for some time and there is an absolute minimum of oil remaining on the engine parts. This scuffing damage is subtly different from fatigue damage, but using an oil which allows rapid circulation combined with an anti scuffing additive will help with both forms of engine wear.

As you will appreciate, there is a lot of work that goes into formulating oil and Shell has tried to look at the requirements of engine operators and offer products which meet the demands of real world operations. Shell was the first to introduce this combination of modern technology into aviation oils and recent testing carried out by the independent Aviation Consumer Magazine* AeroShell Oil W 15W-50 was shown to out perform all of the competing multigrade oils. The testing compared both the anti wear and anti corrosion properties of AeroShell Oil W 15W-50, Phillips 20W-50 and the new Exxon Elite 20W-50. The AeroShell Oil exceeded the performance of the other oils in every test category. It can be argued that bench testing only counts for so much though - so AeroShell's multigrade has also been tested under the most demanding of conditions - more than 15 years of successful operational service.

HAPPY FLYING.

*Aviation Consumer Magazine covered the aviation oils testing in their October and November 2002 issues. Back issues can be ordered from their web site www.aviationconsumer.com

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