AeroShell TECH TALK

BASE OILS

	Group 1	Group 2	Group 3	Group 4	Group 5
Saturates	<90%	≥90%	>90%		
	AND / OR	AND	AND	Synthetic	All Other
Sulphur	>0.03%	≤0.03%	≤0.03%	PAO*	Basestocks**
	AND	AND	AND		
Viscosity Index	≥80 < 120	≥80 < 120	>120		

* Poly Alpha Olefin – synthetic oil of the type used in AeroShell Oil W 15W-50

** e.g. Esters used in aviation turbine oils, or low V.I. Napthenics used in refrigerator oils.

As most people know the additives used in aviation piston engine oils make them different to automotive engine oils, but not many people appreciate that the base oil also needs to be somewhat different to that found in most car oils.

Base oil selection is very important in piston engine formulations – after all it represents about 95% of what is in the bottle – and choosing not only the type of base oil used but where it is from and how it is refined can be significant in its performance.

Base oils are generally classified by the oil industry into different classes, or Groups, which are used to define how much their viscosity changes with temperature and how 'pure' the oil is.

So what is significant about these categories of Saturates, Sulphur and Viscosity Index?

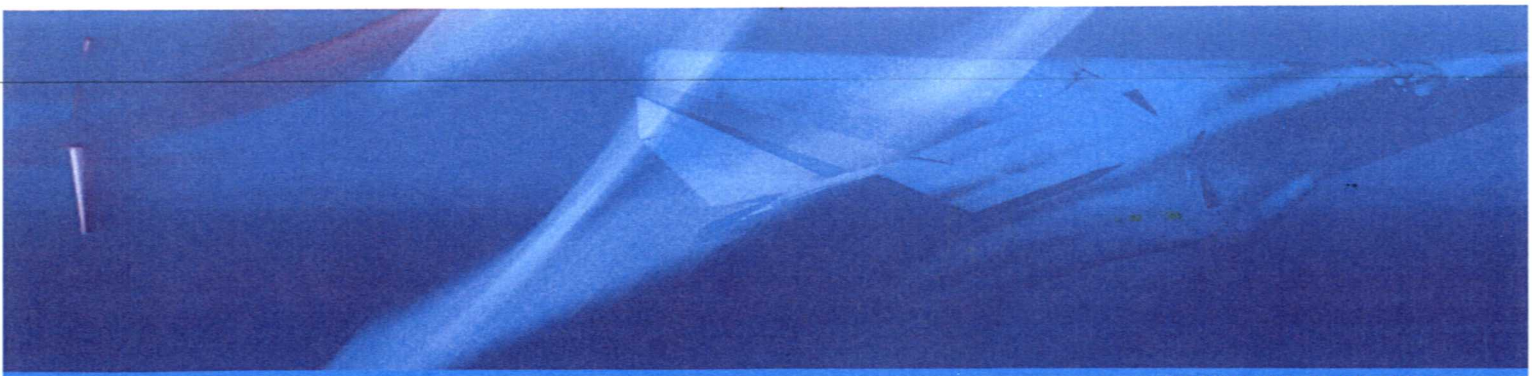
All crude oils are essentially a 'soup' of molecules. This soup consists of a range of hydrogen and carbon molecules (Hydrocarbons) that are the building blocks of the lubricant. Each crude oil source will have a different mixture of shapes and sizes of molecules that can significantly affect the properties of oils that are made from it. For example, straight chain molecules (referred to as paraffinic molecules) tend to produce oils whose viscosity changes slowly with changes in temperature, whereas oils containing a lot ring structures (napthenic oils) vary their viscosity a large amount with temperature.

Having a small change in viscosity with varying temperature, referred to as having a high Viscosity Index, is generally preferred for engine oils as it means that the oil has a wider useful temperature range. Although paraffinic oils do offer this advantage, they can have problems at low temperatures as they tend to form waxes more easily than napthenic oils, which is why napthenics are commonly used as low temperature refrigerator oils.

In addition to the molecule shape, the saturation of the molecules can also have an effect. A saturated hydrocarbon is one in which all the possible hydrogen atoms that can be included on the carbon skeleton are present. Carbon will always try to make 4 bonds with other atoms, but if one of these bonds is not used then the molecule is left with some overall electrical charge and is more reactive, or unstable, than one that is fully saturated. This normally means that the oil will oxidise more easily, but leaving some un-saturated molecules in the oil can also have some secondary benefits as we shall see later.

Hetero Molecules

We have looked at the types of hydrocarbons that can appear in the oil, but that is not the whole story with crude oil in its raw form; all crude oils also contain impurities. Referred to as 'hetero' molecules (hetero is of Greek origin, meaning different) these are commonly nitrogen or sulphur containing molecules and in general it is preferable to remove these molecules from a finished lubricant. Most of these hetero species are generally bad news as they can increase engine wear rates and promote oxidation in the oil and so should be removed. However certain hetero molecules can be of benefit,



for example Sulphide Sulphurs can act as natural anti-oxidants.

A common link between these hetero molecules and the non-saturated hydrocarbons is that they both have a residual electrical charge on the molecule and are collectively referred to as 'polar' molecules.

Polar Molecules

Generally, in automotive engine oils, polar molecules are not wanted in the finished lubricant and the process of refining crude oil is intended to remove them. There are various processes available ranging in severity and effectiveness.

Solvent extraction ranges in severity and uses a solvent to remove the undesirable species but this process tends to be selective, preferentially removing the higher polarity species. Other more modern methods use hydrogen to convert the undesirables, rather than remove them, and these processes are usually referred to as hydro-processing and hydro-finishing.

The advantage of using some of the more modern severe hydro-processing techniques is that very poor quality crude oils (referred to as sour crudes) can be converted into very pure hydrocarbon finished oils containing very few polars or impurities. This is a great advantage for a refinery as it can buy cheap, poor quality crude oils and still convert them into high quality, Group 3 type lubricants, ideal for the automotive sector. Unfortunately this option is not open to aviation engine oils as they have other demands upon them.

Aviation Engine Oil Requirements

In aviation engines we still use a fuel that contains a large amount of lead. Avgas 100LL contains about 8 times the lead content of even the old leaded road fuels and this poses a problem for the oil. Lead by-products - found in the exhaust blow-by gas and in raw fuel, both of which find their way into the oil - do not naturally dissolve in saturated hydrocarbon oils and so quickly form sludge deposits in synthetic and severely processed oils. What we need is some of those polar species to be left in the oil, as it is their polarity that gives a base oil the ability to dissolve the lead compounds and prevent the unwanted deposits. This being the case we need to keep enough of the polar species in the base oil, but we need to make sure we maximise the quantity of helpful impurities (such as the natural anti-oxidants) and remove as many of the undesirable ones as possible. Now you start to appreciate that selection of the right crude oil 'soup' is very important. As well as choosing highly paraffinic crude oil sources to minimise viscosity changes, we also need to select sweet crude sources and closely control how we refine the oil so that we leave behind enough solvency to deal with the lead, but don't include undesirable impurities in the finished oil. This means that a successful aviation lubricant needs a lot more care and attention lavished on how it is selected and made when compared to the 'brute force' methods that can be employed to make relatively poor starting ingredients into high quality, finished automotive oils.

Shell's Advantage

This is where Shell has an advantage over many other aviation piston engine oil suppliers. Shell Aviation is an integrated supplier, meaning that it controls the whole process from crude oil selection, extraction from the ground, refining, blending and bottling. Most of the piston engine oil suppliers in the market, including many of the competing oil majors, are not integrated suppliers: many suppliers buy their base oils from third parties and most don't even blend and bottle their own oils. By being and integrated supplier Shell Aviation can carefully control the whole process which, combined with over 80 years of experience in supplying piston engine oils to this market, ensures that you, the customer, can rely on the fact that the oil in the bottle is ideally suited for the job in hand.

Happy flying.

Shell Aviation

What Is Black Oil?

There has been quite a bit of discussion around the hangars recently about "Black Oil".
What is "Black Oil" and what can it mean? Is it always bad, or can it be OK to discover that your engine oil is black? What causes it and should we act if we find it? Many questions to answer.

There are a few key differences between an oil for a large piston diameter, spark ignition, air cooled engine running on leaded fuel - typically found in most general aviation aircraft, and a small piston diameter, spark ignition, liquid cooled engine running on unleaded fuel - typically found in automotive applications. These differences can contribute to what we see in the quality of used oils.

Base Oil

These differences also impact which base oil is most appropriate for each particular use, aviation or automotive. In aviation applications, Shell's experience over 80 years is that a select number of Group 1 base oils perform best, with lead solvency properties being a big concern as explained inside this edition of Tech Talk. In effect, the "impurities" of Group 1 base oils give them a desirable performance advantage in aviation engines running leaded fuel.

Causes of Black Oil

Getting back to the topic at hand though, what makes oil become black with use? Basically there are two causes for oil to be dark or black - oxidation or contamination. Of the two, contamination is the least serious to the ongoing performance of the oil for its intended purpose within the engine. Contamination is in fact one of the things we want to see in an engine oil...but only once it is in service and then only with the 'appropriate' contaminants. Normally the contaminants produced by a healthy engine will cause the engine oil to assume a medium to dark brown colour, and there is no pungent burnt smell present. This oil is not normally the intense black colour such as we associate with diesel engine oil.

The reason for the brownish discolouration is the presence of normal combustion by-products – things such as light carbonaceous material, some lead oxides and bromides, organic acids, and various compounds containing nitrogen and sulphur atoms. The purpose of the Ashless Dispersant additive included in Shell's "W" range of aviation oils is to keep these contaminants in suspension in the oil so that they find their way into the oil filter, or, if they are smaller than the filter pore size, so that they stay separated and small enough not to cause a problem inside the engine. We all know what can happen when important capillary lines and controllers, and other galleries become blocked with particulate contamination. Of course, small carbon particles being held in suspension in the oil will tend to make the oil seem dark-coloured.

So we can see that oil appearing 'dirty' may actually be evidence that the oil is doing its job.

Oxidation

Now what about the other reason oil can become black? One of the worst things that can happen with oil is oxidation. Oxidation describes the process whereby an oil undergoes a chemical reaction with oxygen (usually under heat); the result being an acidic by-product, with little lubricating value, that can encourage corrosion.

The prime reason that oxidation is harmful to your engines life is that the change in the molecular structure that takes place during the oxidation process causes the formation of compounds that DO NOT have the ability to provide proper lubrication under high stress. The result of oxidised oil pumping through the oil system of your engine is accelerated engine wear.

Another unfortunate by-product of oxidised oil is its tendency to form very long chain polymeric molecules that will ultimately become a sticky mess inside the engine. Finally oxidised oil can rapidly lead to a large range of other problems inside an engine including but not limited to, sticky valves, accelerated cylinder wear and sticking rings. When piston rings start to stick, there is also the potential for the rings to overheat due to an increase in blow-by gas, leading to a massive increase in the contamination of the lubricating oil with hot exhaust gasses. This leads to a further degradation in lubrication performance, making the problem rapidly worse.

Summary

Shell blends an anti-oxidant into its piston engine oils to help protect the oil from oxidation and is blended in sufficient quantity to protect your oil under normal operation for the full 50 hours between oil changes.

Different oils will have different oxidation profiles; something that is considered carefully by Shell when formulating oils. Even well formulated oils containing anti-oxidants will oxidise if exposed to aggressive environments. If you experience heavily oxidised, black oil after a period of 50 hours operation or less, it is a warning that either the oil is not up to the job, or there is a problem with the engine that is causing premature oxidation. Either way we would advise you seek professional advice.

Shell Aviation