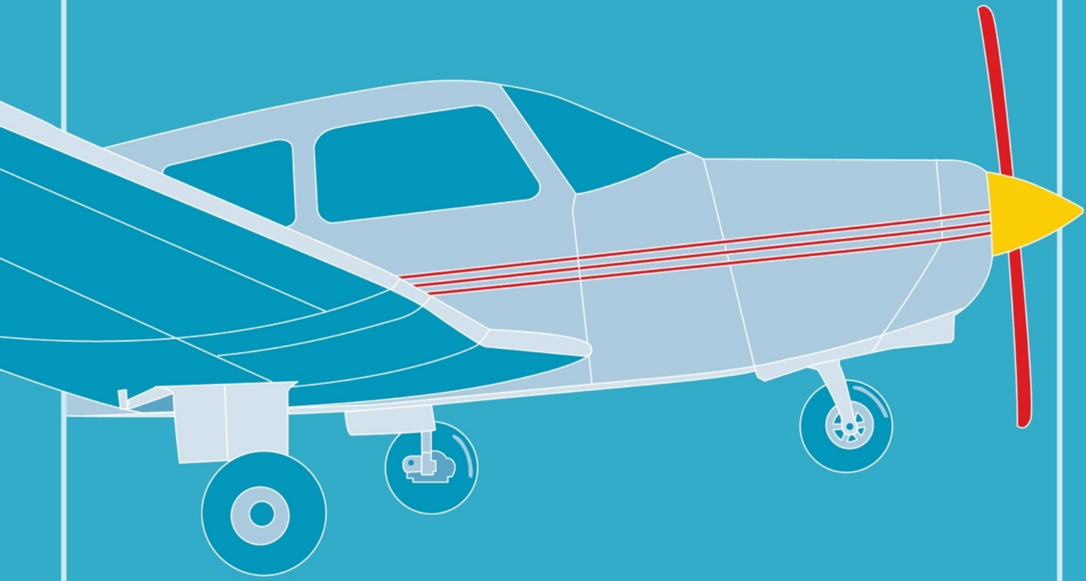
AEROSHELL PISTON ENGINE OILS



3. AEROSHELL PISTON ENGINE OILS

For many years the performance of aircraft piston engines was such that they could be lubricated satisfactorily by means of straight mineral oils, blended from specially selected petroleum base stocks. However, growing demand for oils to reduce sludge formation necessitated 'fortifying' them with the addition of small quantities of non-petroleum materials. The first additives incorporated in straight mineral piston engine oils were based on the metallic salts of calcium. In highly-rated engines the dispersant performance of these oils was excellent, but the combustion chambers of the majority of engines could not tolerate the presence of the ash deposits derived from these metal-containing additives.

To overcome the disadvantages of harmful combustion chamber deposits, a non-metallic, i.e. non-ash forming, polymeric additive was developed which was incorporated in blends of selected mineral oil base stocks, to give the range of AeroShell W Oils. Following extensive operational success in a wide range of civil engines, military specifications based on the general characteristics of AeroShell W Oils were prepared and issued.

AeroShell W Oils were in service with the world's airlines and aircraft operators for many years when they operated big transport piston-engined aircraft, during which time these oils became virtually the standard for all aircraft piston engines. Nevertheless, supplies of straight AeroShell Oils remained available primarily for running-in the aircraft piston engine and for the few operators who required them. Today these oils (both AeroShell W Oils and AeroShell Oils) are still required for the smaller piston-engined aircraft flying in air taxi operations, flying clubs or flown by private pilots. W is just a model designator to differentiate between AeroShell ashless dispersant AeroShell W oils and straight mineral AeroShell oils, which have no letter designator.

In the early 1980s a semi-synthetic multigrade W oil for piston engines (AeroShell Oil W 15W-50) was added to the range. This grade has become very popular amongst engine manufacturers and operators alike. In order to cater for those Lycoming engines which need improved load-carrying (i.e. those engine models which require the addition of Lycoming Additive LW 16702) AeroShell Oil W 15W-50 was upgraded in 1986 to include an antiwear additive.

In recent years utilisation of piston engine aircraft has decreased, resulting in the aircraft spending more time on the ground. This led to an increase in corrosion being seen inside the engine. In order to combat this, AeroShell Oil W 15W-50 was further upgraded in 1993 to include a very effective anti-corrosion additive package.

For those operators who prefer a single grade but still want the anti-wear and anti-corrosion benefits of the multigrade oil, AeroShell Oil W80 Plus and AeroShell Oil W100 Plus have been added to the range of ashless dispersant oils.

To cater for the demands of operators of light sport aviation piston engines, AeroShell Oil Sport Plus 2 (for 2-stroke engines, now discontinued) and AeroShell Oil Sport Plus 4 (for 4-stroke engines) were introduced in the 2000s.

With the development of compression ignition (Diesel) piston engines specifically for the aviation market, Shell Aviation worked closely with the OEMs to develop appropriate lubricants for this engine type. The result of these co-operative efforts was the development of AeroShell Oil Diesel 10W-40 (now discontinued), and AeroShell Oil Diesel Ultra.

SPECIFICATIONS

Since the 1940s, piston engine operators have relied on two U.S. Military Specifications for defining piston engine lubrication requirements. Beginning with the non-dispersant MIL-L-6082 oils and continuing through the MIL-L-22851 Ashless Dispersant products, the U.S. Military Specifications were the standards for oil performance worldwide. In military circles Grades 1065 and 1100 as well as Type II and III were familiar grade identifications, whilst in civil use Grades 65, 80, 100 and 120 were common. However, that has all changed.

The SAE Fuels and Lubricants Technical Committee 8 – Aviation Piston Engine Fuels and Lubricant Committee worked very closely with the U.S. Navy to convert these Military Specifications into SAE Standards. Also involved were oil manufacturers, engine builders, test laboratories and the American FAA. In due course agreement was reached on a new set of performance standards for piston engine oils. These current SAE Standards are J1966 Lubricating Oil, Aircraft Piston Engine (Non-Dispersant) and J1899 Lubricating Oil, Aircraft Piston Engine (Ashless Dispersant), both of which have now been adopted for use. The adoption of these new SAE

Standards means that the two Military Specifications (MIL-L-6082 and MIL-L-22851) are now obsolete.

These new specifications include upgraded and improved tests and have been designed to meet current technology, and include the latest test methods and precision limits.

The most obvious change for users is the move from the old Grade or Type Number system to the more common SAE viscosity classification. Thus products in both SAE specifications are defined as SAE Grades 30, 40, 50 or 60. In addition, for the first time, multigrade aviation oils are included in the new specifications.

The U.K. has now cancelled DERD 2450 and DERD 2472 and adopted the SAE specifications.

FUNCTION OF PISTON ENGINE OIL

A piston engine oil's function inside a piston engine is to:

- reduce friction between moving parts
- provide necessary cooling to internal areas
- cushion moving parts against shock and help seal piston rings to cylinder walls
- protect highly finished internal parts of the engine from rust and corrosion
- keep interior of engine clean and free of dirt, sludge, varnish and other harmful contaminants

APPLICATION

AeroShell Oils and AeroShell W Oils are intended for use in four-stroke (four-cycle) aircraft reciprocating piston engines. They are not recommended for use in automotive engines converted for use in aircraft, and in these cases the conversion shop should be consulted for proper oil recommendations.

The term "ashless dispersant" was given to aviation oils to distinguish them from straight mineral aircraft piston engine oils. Automotive and heavy duty truck engine oils contain ashless dispersants and ash-containing detergents. They were traditionally called detergent oils (some aircraft operators incorrectly refer to ashless dispersant oils as "detergent oils").

Because of the negative effect of ash on aircraft engine performance, it is very important that ash-containing oils are NOT used in an aircraft piston engine.

Due to differences in metallurgy, operating conditions and fuel specifications, an aircraft oil will not meet all of the automobile/heavy-duty engine's requirements. In addition, the aviation oils are not qualified for this application and their use could result in voiding the warranty and/or reduction in engine life.

Thus automobile oils MUST NOT be used in aircraft engines which use or specify SAE J1899 or J1966 oils. Similarly aviation oils MUST NOT be used in automobile engines.

Selection of Right Grade of Oil

For the majority of aircraft piston engines the selection of the right grade is important to maximise engine performance and engine life.

Running-in	use	AeroShell Oils
Normal operation	use	AeroShell W or W Plus Oils

Selection of Correct Viscosity Grade

AeroShell Oils and AeroShell W Oils are each available in four grades. The grades differ only by viscosity and thus cover the needs of all reciprocating engines now in airline and general aviation operation. There is no general rule by which the correct grade for every engine type can be chosen, but the following table, based on recommendations from Lycoming, provides approximate guidance for selecting the most suitable grade, based on the average ambient outside air temperature at engine start-up.

AeroShell Oil (Single Grade)	65	80, W80 and W80 Plus	100, W100 and W100 Plus	120 and W120
Ambient air temperature °C (°F)	Below –12 (+10)	–17 to 21 (1 to 69)	16 to 32 (60 to 89)	Above 26 (78)
Corresponding SAE No.	30	40	50	60

AeroShell Oil (Multigrade)	W 15W-50
Ambient air temperature °C (°F)	All Temperatures
SAE Grade	SAE J1899 Grade Multigrade

N.B. For large engines the choice depends greatly upon the operator's preference and past experience. Traditionally the choice seems to be associated with climatic zones: AeroShell Oil W100 or W100 Plus is preferred for temperate regions and AeroShell Oil W120 for warmer climates.

UNDERSTANDING MULTIGRADES

Oil has many functions to perform in the engine, but the primary one is to reduce friction between moving parts by separating moving surfaces with a layer of oil. This oil must not only separate the two surfaces, but must also support any load that is being applied between them, so that the load can be transferred from one surface to the other.

If the oil did not support this applied load, then the two surfaces would force through the oil film until they came into contact, potentially causing significant and irreparable damage.

An important indication of how much load an oil can carry is the measurement of the oil's viscosity.

Viscosity is the resistance to flow of a particular fluid. Under the same conditions, a liquid with a low viscosity, such as water, will flow more quickly than a liquid with a

This is the concept of the multigrade oil and there are two principle ways of achieving these objectives:

Mineral Multigrades

Mineral multigrades use a lightweight mineral oil (the same as a lightweight monograde oil), but include an additive called a Viscosity Index Improver. The best way to visualise this viscosity index improver is as a long chain molecule which curls up like a ball of string when cold, but then uncurls as the temperature increases.

Thus, when an oil is cold, the presence of the viscosity index improver has very little effect and the oil flows well as the base oil is a low viscosity oil. As the oil heats up, the viscosity index improver uncurls with the effect that it tends to restrict the motion of the oil, or 'thickens' it, which to some extent counteracts the decrease in viscosity of the base oil. This enables the oil to support more load than would otherwise be possible.

However, the viscosity of an oil which contains a viscosity index improver depends on the rate it is made to flow (or sheared). It may decrease rapidly if the oil is sheared rapidly, and this decrease can be temporary or permanent.

A temporary loss in viscosity develops when high shear rates (which frequently occurs in engines when one surface moves quickly past another) force the large viscosity index improver molecules to align themselves in the direction of flow. More seriously, a permanent loss of viscosity may occur if the shear rate is sufficient to physically break the large molecules into smaller units. This can happen in oil pumps and the like. Both of these scenarios reduce the oil's viscosity and therefore the load carrying ability.

The vast majority of 20W-50 aviation multigrades on the market are mineral multigrades.

One advantage of using the multigrade AeroShell W 15W-50 is that, not only does it pump quicker at low temperatures than the single grades – and even the 20W-50 multigrades on the market; it is also unusual in being a semi synthetic rather than a pure mineral oil.

Semi-Synthetic Multigrades

When Shell first started evaluating multigrade aviation piston-engine oils over 30 years ago, testing proved that multigrade oils formulated only with mineral base oils did not have adequate base oil viscosity (thickness) to properly lubricate all the high load points in the engine. Then we tested and flight evaluated a formulation made with all-synthetic base oils. This formulation had excellent anti-wear characteristics in all tests run. However, in the flight evaluations, some engines would reach 600 to 900 hours then lose oil consumption control and/or compression. When the engines were disassembled, we found that the piston rings were covered with a grey tacky substance that was primarily made up of the lead by-products of combustion (from the use of leaded aviation gasoline). Although synthetic oils are excellent lubricants with good high-temperature stability and very good low-temperature flow characteristics, they are relatively poor solvents. In an aircraft engine, the lead by-products of combustion must capacity to do this. This is why a fully synthetic oil is not feasible for aviation piston engines.

Are multigrade and single-grade AeroShell oils compatible?

The compatibility question covers two issues: mixing one grade of AeroShell oil with another, and the effects on the engine of changing from one AeroShell grade to another. If you typically run on AeroShell multigrade and find yourself in a place where only AeroShell single grades are available, you can safely add the AeroShell single grade to your engine. They are completely compatible.

If you run on an AeroShell single grade during the summer, but want to switch over to AeroShell Oil W 15W-50 Multigrade for the winter, you can safely replace the straight weight with the multigrade oil at your regular oil-drain interval. The idea that you have to stick with the type of oil you started with comes from the days of unusual chemistry when the resultant oils were incompatible. All approved SAE J1899 (former MIL-L-22851) and SAE J1966 (former MIL-L-6082) AeroShell oils are compatible. For example, if you have a high-run-time engine using ashless dispersant oils and need to replace a cylinder, you can switch to a mineral oil for 50 hours or so to break in the new cylinder. The only time Shell recommends against switching is in a high-run-time engine using straight mineral oil exclusively. Here, a switch to ashless dispersant oil can loosen the deposits left behind by the mineral oil.

UNDERSTANDING ADDITIVES

There are some aftermarket additives that claim to benefit engines and can be used in aviation piston engine oil. The general rule is that, unless they have been properly tested and approved for use in aircraft engines, they should not be used. Often these additives at best give no benefit at all, or can even cause the engine harm.

Most of the additives on the market have been developed for the automotive market, where conditions are much different to those found in aircraft engines. In automotive engines, cylinder head temperatures are much lower, the fuel is unleaded, the piston diameter to length ratio is much smaller, the mean power setting is much lower, etc.

These and other factors put different demands on the oil and have led to aviation engine oils being much different to their automotive cousins. If we take the cylinder head temperature for instance, aviation engines typically run around 100°C (212°F) hotter than automotive engines, and this leads to aviation oils needing to have specialised additives which do not form ash - hence the name ashless dispersant oils.

If an additive which has been developed for the automotive market is used, then it is likely to be an ash-forming compound which can cause combustion chamber deposits, leading to pre-ignition which can rapidly lead to a hole being burnt through the piston and you looking at a stationary propeller looking for somewhere to land.

Load Carrying/Anti-Wear Additives

Other additives, such as the Teflon type "anti-wear" additives, are sold as being able to improve engine lubrication. This type of additive is of dubious benefit and just coat the whole engine with a layer of Teflon, regardless of where it is needed. This can, at worst, restrict oil ways and limit lubricant flow, and at best is an expensive way of putting an unnecessary coating on the oil filter. These additives are not approved for use in aircraft engines, so using them is not only potentially dangerous, but also invalidates any warranty on the engine.

Using the additives present in the AeroShell range of Plus Oil (AeroShell Oil W 15W-50, AeroShell Oil W100 Plus and AeroShell Oil W80 Plus) to illustrate, the load these oils would not meet the demands put on them. This has also been recognised by Lycoming; they have adopted the additive under the name LW16702, and is mandated for use in their O-320H, O-360E's and TIO-541 series engines. Therefore, using AeroShell range of Plus Oil means that no additional additive needs to be used if you operate one of these engines.

Metal Passivators

Metals such as copper are normally a problem for oils as they cause oil to degrade quicker than they would otherwise. This can be a problem as many General Aviation engines contain copper – the largest area is normally found on cam shafts which is left over from the manufacturing process.

When cams are manufactured, the cam face is often hardened using a process called nitriding. This leaves a hard, but brittle surface – ideal for the cam face, but not for the rest of the shaft.

The rest of the shaft does not need to be hardened and it performs better if the surface is not brittle from the nitriding process. So to protect the rest of the shaft, a thin layer of copper plating is used to cover all the areas which do not need to be hardened.

Once the cam has been manufactured this copper serves no useful purpose, but it is not removed. This can be a problem for the oil in an engine because the copper acts as a catalyst to make the oil degrade faster than normal – and a degraded oil does not make a good lubricant.

This is where the "metal passivator" additive reacts with the surface of copper components forming a protective layer which separates them from the oil, thus preventing the copper from degrading the oil.

Corrosion Inhibitors

One more additive used in AeroShell range of Plus Oil (AeroShell Oil W 15W-50, AeroShell Oil W100 Plus and AeroShell Oil W80 Plus) is a corrosion inhibitor. This inhibits the formation of rust in the engine – a common root cause of engines not reaching TBO (Time Between Overhaul). Rust is often found in engines as used oil is acidic and, combined with dissolved water from the atmosphere, causes corrosion.

The reason why this problem is more pronounced in aviation piston engines than in automotive engines, is all due to how often they are used. The average General Aviation aircraft flies for around 100 hours per year, compared to your car, which is probably 4 times that figure.

OIL SERVICING

The pilot or mechanic should always review the manual for the proper procedures. An oil change may not only include draining the hot oil, changing and inspecting the filter and refilling the crankcase with the proper oil. For example, an inspection of the oil pan's suction screen is recommended at each oil change for most engines.

Converting from Straight Oils to 'W' Oils

Elaborate precautions are not needed when changing from straight mineral oil to AeroShell W Oils, since both types of oil are compatible with each other.

Experience has shown that AeroShell W Oils do not loosen or affect the hard carbonaceous material already deposited in high-time engines, and may therefore be introduced at any time during the operational life of an engine.

Many single- grade customers try AeroShell Oil W 15W-50 during the colder part of the year and then convert to using it year round. Others, however, alternate between single grade and multigrade, depending on the time of year. Either system works well because AeroShell oils are entirely compatible and can be interchanged as desired. In addition, if you need to replace a cylinder on a mid-time engine, you can switch from AeroShell Oil W single grade or AeroShell Oil W 15W-50 to a straight AeroShell mineral oil for one or two changes to break in the new cylinder. Then you can switch back to the ashless dispersant oil after the rings are properly seated.

The easiest and possibly the best way of converting a fleet of engines to an AeroShell W Oil is to 'top-up' with the oil commencing from a given date. The majority of operators use this method following procedures recommended by the engine's manufacturer.

However, other operators have drained engines and refilled them with AeroShell W Oil. If this procedure is adopted, the oil filters should be checked after a ground run and at short intervals during initial operation, because the fresh charge of AeroShell W Oil may disperse 'pockets' of partly oxidised straight mineral oil which may have bound together and retained flaky carbonaceous material during previous operation.

Similarly, if you have a mid-time engine that has been run exclusively on a straight mineral oil and wish to try an ashless dispersant oil, use caution. The introduction of an ashless dispersant oil into your engine could loosen some of the carbon deposits. So check your oil screens and filters often to guard against oil starvation and/or oil screen collapse.

Oil Draining

When draining oil, the engine should be hot. This can be very difficult on some aircraft, but it is recommended. The reason for changing oil when the engine is hot is to avoid the settling of dirt and water in a cold engine. When the engine is fully warm when it is drained, a higher percentage of contaminants is drained away with the old oil. When the engine is drained cold, more of these contaminants remain in the oil in the bottom of the pan, which results in more contaminants mixing with the new oil.

Oil Change Interval

Almost all oil change recommendations specify not only an engine hour time limit, but also a calendar time limit; typically 4 or 6 months depending upon engine manufacturer. On low usage aircraft the calendar time limit is usually more critical than the engine hour limit. The need for frequent oil changes in aircraft is not caused by the oil wearing out, but rather by the oil becoming contaminated with by-products of combustion, dirt, water both atmospheric as well as from condensation inside an engine) and unburnt fuel. This contamination can cause corrosion in the oil wetted areas of an engine and thus changing the oil removes these contaminants and helps to minimise corrosion. In order to minimise this corrosion inside low usage engines, calendar time changes are important.

Oil Change Extension

Many operators are interested in extending oil change intervals. As a general rule extensions are not recommended for the following reasons:

- many engine manufacturers do not approve extended intervals
- possibility of losing engine manufacturers' warranty on the engine
- possibility that extended intervals will shorten engine life

The initial enthusiasm in the U.S. for extended intervals has declined due to problems associated with lead sludge found in engines. Many operators have now reverted back to the engine manufacturers' oil change recommendations and found that these problems disappear. Operators are urged to follow the engine manufacturers' or rebuilders' recommendation for oil change interval.

Break-in Procedure

Most aircraft engine manufacturers and rebuilders/overhaul agencies suggest in their service bulletins the use of straight mineral oil in new or newly overhauled engines for break-in. These straight mineral oils are usually recommended for the first 25 to 50 or even 100 hours of operation, or until the oil consumption stabilises. Other rebuilders or manufacturers, especially for such engines as the Lycoming O-320H and O/LO-360E, allow either ashless dispersant or straight mineral oil for break-in, whereas ashless dispersant oils are mandated for break-in for all turbocharged Lycoming engines. Operators should check with engine manufacturers or rebuilders for the correct recommendation for the specific engine and application.

The following details the engine break-in concept for further understanding:

When a cylinder is new, the inner wall surface is not smooth as might be imagined. The objective of the break-in procedure is to rub off any high spots, both on the cylinder wall and the piston rings, so that the rings can create a tight gas seal for normal operation. This requires the piston ring to break through the oil film and allow a certain amount of metal-to-metal contact between the components. Once this matching has occurred, the break-in is considered to be complete and very little contact will occur thereafter.

The anomaly is that the lubricating oil is there to prevent metal-to-metal contact, but the process described requires that we rupture the oil film. Two actions by the pilot can critically impair this film rupture and therefore prevent adequate break-in – low power settings and the use of improper lubricating oils.

There are two main classifications of aviation piston engine oil on the market, Straight Oils and Ashless Dispersant (or 'W') oils. Ashless Dispersant oils contain additives, which becomes significant during break-in of most engines.

With the exception of some turbocharged engines (check the documents mentioned above), break-in should be conducted using straight oils. The first risk with using Ashless Dispersant oils used during break-in is that the higher film-strength will prevent the piston ring from rupturing the oil film and therefore the necessary abrasion on the cylinder wall will not occur.

Secondly, the frictional process creates unusually high surface temperatures on the cylinder wall and this can cause the additives in the Ashless Dispersant oils to form a glaze in the honing grooves on the surface of the cylinder wall. When a cylinder is manufactured, a cross-hatch hone is used to score a diamond pattern into the surface of the liner; this is necessary to allow an oil film to be held on the surface of the cylinder wall and lubricate the piston during operation.

If this glazing of these honing grooves occurs before the break-in period is complete then the piston ring will not seal properly, and the cylinder wall will no longer have the surface grooves necessary to carry lubricant, and the combination will result in a poor gas seal and high oil consumption. The only way to remove such a glaze is by re-honing the cylinder wall – meaning expensive and avoidable additional maintenance.

However, successful break-in not only means the use of a straight oil of the correct grade but also the use of high power settings. High power settings mean high combustion pressures which, due to the piston ring design, forces the piston ring out to rupture the oil film. This is the key to the break-in process.

Use a good quality Straight Oil, such as AeroShell Oil 65/80/100/120, and stay with it right through the break-in period (typically 50 hours but check your engine manual). Be sure to check the oil level frequently as oil consumption will be higher than under normal operation.

You should be aware that the engine will produce wear metal particles during the break-in process and the oil and filter should be changed more frequently to remove these particles so that they don't act as a grinding paste and cause additional, unwanted wear.

The oil and filter should be changed:

- Within the first 10 hours operation after overhaul
- Within 25 hours of the first oil change
- Within 50 hours of the 25-hour oil change for engines with full flow oil filters, or 25 hours for engines with pressure screen filters
- After 4 months since the last oil change regardless of engine hours

This is in line with the manufacturer's recommendations such as those found in Lycoming's Service Bulletin 480F.

As for engine operation, it is all about generating high cylinder pressure and maximising the engine cooling. Use full rated power and RPM for every take off and maintain these settings until at least 500 feet above the departed runway; at this point you can reduce power to 75% and continue the climb to your cruising altitude. Maintain 65% - 75% power for all cruise operations during the break-in period.

Avoid high altitude operation with non turbo- or supercharged engines as altitudes in excess of 8,000 feet will not permit sufficient cylinder pressure to be developed to overcome the spring force of the piston rings, preventing them from bedding in. Interrupt cruise power every 30 minutes or so with a smooth advance to full power for 30 seconds and then return to the original cruise settings. This allows the rings to flex and move in the piston groves.

Avoid long, low power descents as, again, there will be insufficient cylinder pressure force the piston rings out to form a gas seal and you will suffer from large amounts of combustion blow-by past the rings and also large amounts oil not being scraped from the cylinder wall. This combination can lead to excessive oil burn that can inhibit ring seating.

When descending, carry enough power to keep the cylinder head temperature (CHT) at least in the bottom of the green. For similar reasons, ground running should be kept to a minimum, particularly during hot weather. During break-in, it would be better to delay departure than to sit at the end of the runway for 15 minutes or so running in high ambient temperatures.

Be careful with engine cooling as the increased friction from the wear process will increase the cylinder wall and piston temperatures and so particular attention should be given to providing adequate engine cooling.

When climbing, keep the airspeed up, decreasing the angle of climb so that increased ram air is available for cooling. Be generous with the fuel mixture. Keeping a rich mixture will provide charge cooling of the combustion chamber and so all take offs should be made with fully rich mixture and at altitudes in excess of 5,000 ft.

The mixture should only be leaned sufficiently to restore power loss from an overly rich mixture. These procedures will help to hasten the break-in and ensure a good match of rings and bore.

To summarise, don't handle your engine gently, remember to check your oil level frequently and top up with only the correct oil during the break-in period and observe the oil change periods. Particularly with group-owned or rental aircraft, be sure that all those that fly the aircraft during the break-in period are aware of these 2 points.

How do you know when you have broken the engine in?

There are several clues that the engine will give you, and one key one is oil consumption, so you should really start to take note what the consumption is from the start. What you will find is that the consumption will probably be quite high initially, will reduce rapidly and then plateau at a certain value.

What this value is, is not really too important - it can be anywhere in the range of 1 litre every 4 to 20 hours - an indication of stabilisation is more the key. Too high an oil consumption indicates that the engine has not broken in yet (or has possibly glazed if it is over 100 hours operation).

Second indication to look out for is the exhaust stack. This will normally start being black and wet (due to the high level of oil burned during the initial stages of break-in). It will then turn to black soot and finally produce a tan / grey deposit, indicating that there is little oil being burned and the mixture setting is correct.

Another indication is that of crankcase pressurisation. If you fill the engine up to the maximum oil level indication and it rapidly loses the first half litre down the breather pipe, then many people just fill the engine with less oil next time. This is fine if it is an old, worn engine, but during break-in it is actually telling you something.

Assuming that it is not an aerobatic engine, the reason that the oil is being pushed down the breather is that the crankcase is being over-pressurised by exhaust gas getting past the ring pack. In other words, the engine is not effectively sealing itself and has not achieved a good gas seal between rings and bore – so the break-in process is not yet complete.

It is best to top oil up to the maximum and monitor whether it rapidly loses the first half litre or so.

Chrome Bores vs. Steel Bores

Most engines have nitrided steel cylinder liners and chrome-faced piston rings. Whilst this combination will often break-in quite easily, it would be good advice to fly as often as you can in the initial break-in period if your engine is fitted with steel liners rather than Channel Chrome bores.

The steel liners are particularly susceptible to surface corrosion in the early life of the engine, surface rust being quite common after only a few days of inactivity if the conditions are right. The straight oil is used for 50 hours in these engines more to create a thin protective film of lacquer on the bore rather than to hasten break-in; the break-in process tends to happen quite quickly with steel bores, but the potential for corrosion remains.

The Channel Chrome cylinders obviously do not suffer with the same corrosion problem, but the hard chrome surface is much more difficult to break-in – sometimes taking over 100 hours to break-in. Therefore it is very important to be patient to ensure proper ring matching with corrosion-resistant cylinders, as the hard surface of chrome bore engines is much more prone to cylinder glazing following improper break-in.

Long Term Operation on Straight Mineral Oils

It is possible to run engines permanently on straight mineral oils but, as straight mineral oils do not contain any additives, they tend to cause deposits to form in the engine. The "W" ashless dispersant oils contain an additive that is designed to keep particles separated so that they do not congregate to form a large mass.

If these particles are kept separated, then they are less likely to block an oil passage and deposit inside the engine. If the filter is of the relatively efficient cartridge type, then the small, dispersed debris will be removed by the filter element. It is these particles in suspension that makes an oil appear black.

If straight mineral oils are used, then the oil tends to appear relatively clean but carbon and other particulates deposit inside the engine on casings etc. This is not too much of a problem unless you later encourage these deposits to loosen.

Changing onto an ashless dispersant oil after a significant build-up of this deposit has occurred can cause this to happen. The dispersant additive can act like a detergent and clean out the inside of the engine. This normally results in an abnormally high level of filter deposits after the period of change over, so care should be taken to monitor this.

The critical time period for a significant deposit to occur inside an engine running on straight mineral oil depends on the individual engine type, operating temperature, flight profiles etc. but is normally around the 300 to 400 hour mark.

If your engine has run for this length of time on straight oil and you convert onto "W" (or ashless dispersant) oil, then take care to monitor your filter more frequently for signs of blockage. If your engine has not done this number of hours then you are reasonably free to choose whichever oil you see fit and don't worry too much.

There is therefore less risk carrying on with a straight oil for more than 50 hours if you are unsure whether or not the break-in is complete, than there is from having the cylinders glaze from changing to an ashless dispersant oil too early.

Oil Analysis

Routine oil analysis is now seen as a valuable part of a good maintenance programme. Increasingly, operators are adopting oil analysis programmes in order to help discover problems before they turn into major failures. Typically these programmes consist of spectrometric wear metal check, together with a few simple oil tests such as viscosity and acidity. Shell Companies can offer this service to operators.

As engines are used, small amounts of wear occurs all the time. This wear metal appears as minuscule amounts of metal held in suspension in the oil. These particles are much too small to be removed by the oil filter - and will do no abrasive damage to the engine - but by analysing the level of these particles in used oil, the operator has a means of assessing the condition of the engine.

The used oil sample can be analysed by a laboratory using a very sensitive technique known as spectrographic analysis, and particles can be detected down to levels of less than one part in every million of oil. It is not just wear metals that can be detected; water content, fuel dilution, acid content of the oil and other characteristics can be measured.

All engines produce a certain amount of wear metal - this is normal. The significant point about oil analysis is that the level of microscopic wear metal present in used oil will normally increase if a component starts to wear excessively. This will normally occur prior to any particles being present in the filter and is a good way of predicting a failure. The data can also can be an indication that the engine is not set up correctly, or a clue that the engine is being operated incorrectly. Here are some examples:

- High Aluminium content is usually from Gudgeon Pin end caps and is often an indication that the engine is not being properly warmed up prior to take off.
- High Silicon content is normally from the ingestion of dirt and dust, so the inlet filters should be checked.
- High Chrome content can be an indication of excessive piston ring or cylinder bore wear. This can be due to overloading the rings due to incorrect magneto timing.

- High Fuel dilution combined with high water content shows that the engine is being operated for too long on the ground at low idle speeds and the idling speed should be increased.
- Fuel dilution with high Lead content can be due to either worn piston rings which should be checked with a compression check, or poor fuel mixture adjustment (which should be checked and adjusted).

It is not only the engine that we can analyse by sampling used oil, we can also look at the condition of the oil.

As oil is used in an engine, several things happen to it to cause it to degrade. The best measure of the condition of the oil is what is known as the Total Acid Number, or TAN. When an oil is in contact with the air, especially at high temperature, it will degrade and a by-product of that process is the formation of organic acids. This is prevented to a certain extent by having anti-oxidant additives in the oil, but these additives are depleted over time and is one reason why oil changes are necessary.

Once the anti-oxidants have been consumed, the oil itself will start to oxidise, resulting in poorer lubricating properties. If the Total Acid Number of the oil is measured, then an assessment can be made as to whether the anti-oxidant has been used up and if the oil has started to degrade significantly in use. These are good clues as to whether the correct oil choice has been made, whether the oil has been thermally stressed in use, and may even be a sign that the oil change period needs to be reduced.

The viscosity characteristics of an oil can also give some indication of how effective it is in an engine. The viscosity of an oil is related to the size of the oil molecules - the bigger the molecules, the higher the viscosity and vice versa. If the oil has undergone severe shear stress, as can happen in gearboxes for example, then the molecules can be broken into smaller pieces with the result that the viscosity of the oil can reduce over time.

However, exposure to high heat can also make the molecules join together, or polymerise, to make large structures which can increase the viscosity. If both these processes happen at the same time, then the overall result may be no change in the viscosity, so measurement of viscosity alone does not give a complete picture - it must be considered in conjunction with TAN which should also increase with polymerisation.

There is a lot of practical information that can come out of oil analysis and it is an excellent way of limiting wear and preventing failures which increases aircraft safety and reduces the amount of expensive repair bills.

It is important to note that the information gained is only as good as the sampling procedure. A single test is not enough to reveal trends and significant changes, it can only tell an operator if there is already a serious problem, such as a scuffed piston. Operators should therefore:-

- **Take samples properly**
  For best results, take the sample about midway through the draining of hot oil from the sump. A sample pulled off the bottom may be dirtier than normal. The sample should be taken the same way every time. An improperly taken sample can lead to mistaken conclusions about engine problems.

- **Rely on a series of consistent tests over time**
  Operators should look for significant changes or trends over time, not just absolute values. Do not rely on just one very good result from just one report; it could have come from a 5- or a 10-hour sample. Relatively constant numbers from the last six oil changes are a far better indicator that the engine is in good condition. Your record of regular oil changes and analyses is also helpful when selling an aircraft.

- **Take samples consistently**
  Always take the sample the same way at the same time interval. If you change your oil after 50 hours and then after 25 hours the next time, the first sample may show twice the wear metals. (Expect higher wear metals during break-in or after some maintenance procedures, such as a cylinder replacement.) Always properly label the sample so that its identity is known.

Finally, always remember that oil analysis should be part of a good maintenance programme, not a replacement for one.

Understanding Your Oil Filters

Many people also throw a lot of useful information into the bin when they dispose of oil filters. These filters normally contain a lot of carbon deposits, but they will also hold any larger pieces of metallic debris that has come from the engine internals.

An engine may produce a small amount of metal which will be seen in the filter element, and this can be classed as normal. There is no defined level which is normal for an engine – each engine is different – but there will be a quantity which is usual for your engine.

This will vary not just from engine to engine, but will also depend on whether the engine has recently been overhauled. Engines which are still being broken in after overhaul will produce more wear metal than at other times. This is nothing to worry about as wear metals are inevitably produced as part of the abrasive break in process and is one of the reasons why the oil drain period is shorter during these times.

These filter deposits can be sent off to a qualified laboratory for analysis where the filter deposit weight and composition can be accurately assessed. Any metal deposits, even very small ones, can be analysed to see not only what the deposit is made of, but also what the exact alloy composition is. This means that not only can the laboratory tell that a particle is steel, for example, but also which steel alloy it is.

This is significant as different alloys are chosen by the engine manufacturers to perform different functions in the engine – so the steel alloy used in the cam shaft is different to that used in the valves and so on. This means that a small particle found in a filter can often be identified as coming from a particular component – so both you and your aircraft's engineer could know which component is wearing and you have the opportunity to work out why, or have the chance to replace it before complete failure occurs.

Again, this is a very powerful tool in preventing an in-flight engine failure and for reducing maintenance costs. Imagine that you know that a valve is worn and needs replacing. Your engineer knows which part he needs to replace before he dismantles the engine, so the labour costs are reduced, and he also needs to replace just one part rather than the whole engine, as might be the case if it failed. You also have the satisfaction of knowing that you have a reliable engine which is less likely to stop working when you need it most.

Even if you do not go to the extent of sending your filter off to a laboratory for analysis, there is some basic analysis that you can do yourself, instead of throwing the old oil filter away (or just cleaning it if you have a screen filter).

This will not be as accurate a technique as sending it off for analysis, but if you know what is the normal level of deposition is for your engine, and what types of particles are normally there when the oil is changed, then you may notice a change when things start to go wrong.

If you are going to analyse your own filters, use the proper tool to open the filter. Do not cut it open using a saw as the metal produced by sawing will contaminate the filter and give a false indication of deposits. There are tools available from aviation suppliers that work like a can opener and do not produce any metal swarf.

When looking at the results of either oil or filter analysis, the absolute values or quantity of deposit is less important than how the values have changed from previous samples - every engine will have a different level of what is normal and how this changes over time is the important factor. For this reason, the analysis of individual samples is of limited use; a long-term program of sampling is much more valuable.

Always wear protective clothing and gloves when dealing with used oil, as it can be carcinogenic and therefore represents a health hazard.

Changing of Oil Filters

It is necessary to change the oil filter at every oil change. If you do not change the filter each time, the new oil will automatically start with a retained amount of contaminated used oil. (Remember, the primary purpose for changing oil is to remove contaminants.) Old filters can serve as an excellent indicator of engine condition. An old filter that has been removed and cut open can indicate the engine’s condition by the amount and size of the particles in the filter. If your engine is not equipped with an oil filter, the pressure screen should be monitored.

Oil Colour

When a straight mineral oil turns dark or black, it usually means that the oil is starting to oxidise and needs to be changed. Because mineral oil does not absorb much of the dirt and sludge in your engine, the oil stays clean and the inside of your engine gets dirty. Ashless dispersant oils, however, are designed to get dirty so that the engine will stay clean. Just how quickly the oil turns black depends on several factors, including the condition of the engine, the dirt load, the oil temperature, the normal air/fuel mixture, the type of fuel, the time since the last service and the frequency and duration of your flights.

The important thing to remember is to change your ashless dispersant oil based on the recommended oil servicing requirement, not according to its colour. In addition, oil analysis can help ensure that the oil is still in good condition, even though it may have turned black.

Oil Consumption Rate

Oil can be consumed or lost by three different routes in an engine: the rings, leaks and the valve guides. In a good, tight engine, there should be very little oil consumption or loss via the guides and none through leaks. That leaves the rings as your primary concern. The amount of oil going past the rings will depend on the cylinder type and the break-in process. Assuming that the cylinders were broken in properly, the oil consumption may still vary according to the type of service and how the aircraft is flown.

Even two identical engines (such on a twin-engine aircraft) operated in the same way may have different oil consumption rates. Engine manufacturers state that oil consumption of up to a 0.26 gal/h (1 L/h) is acceptable on some models. (Some manuals for large radial engines say that anything over 6 gal/h (23 L/h) is excessive.) The best answer is that oil consumption will be at a certain level for each engine. Consumption changes should not be compared with an absolute level, but rather with the level that your engine sets historically.

Lower oil consumption is not necessarily better. Oil consumption due to leaks and loose guides is certainly bad. However, some oil consumption past the rings is beneficial. When the piston moves down on the intake stroke, the ring leaves a very thin layer of oil on the cylinder wall. This film helps the compression rings to seal properly. If the oil consumption is too low, the seal may be inadequate, which leads to increased blow-by, higher cylinder wall temperatures and accelerated cylinder bore wear. If you have a large or turbocharged engine, you will probably be better off if your engine uses a little oil past the rings.

LOW OIL TEMPERATURE

Low oil temperature can lead to excessive rusting and corrosion of critical engine parts. When an aircraft sits on the ramp or in a hangar, the engine heats up during the day and cools down at night. While the engine is cooling, some of the moisture in the air condenses on the engine walls and drops into the oil. This can form rust on internal engine components. The moisture can also react with by-products of combustion in the oil to form acids that may cause corrosion. The best way to remove this water is for the engine to boil it off during flight. Studies have shown that the temperature of your engine oil increases by about 33°C (50°F) as it circulates through the engine.

Therefore, unless the oil temperature reaches 77–82°C (170–180°F) during flight, the engine will not boil off the water that has accumulated in the crankcase. The result is rust and corrosion. Note that an excessively high oil temperature will also cause problems. Here are some tips to help avoid oil temperature problems:

- Check your oil temperature gauge for accuracy. It should read about 100°C (212°F) when the sensor is placed in boiling water.
- Monitor the oil temperature during flight. It should be about 82°C (180°F), even in winter. If it is lower, you may need a winterisation kit. Otherwise, check with your mechanic to see what is causing the excessively low oil temperature.
- The unique additive feature in anti-corrosion/anti-wear AeroShell Oil W 15W-50 can also help to control problems caused by rust and corrosion.

Why does my engine rust even though I fly often and with the gauges showing the correct temperature?

Pilots are always taught to “trust your gauges,” which is a critical lesson especially when flying instrument flight rules. Most of us apply this lesson to our engine as well.

However, another part of this lesson should be to check the calibration of all instruments periodically, including the oil temperature, tachometer and pressure gauges. Remember that quite a few general aviation aircraft are over 20 years old. So it is not surprising to hear numerous report of tachometers being off by several hundred revolutions per minute and temperature gauges being off by 5, 10, even 15 degrees. It is important to have you gauges checked and calibrated periodically.

One method used is to put marks on the oil temperature gauge so that the "preferred" range can be easily seen. (The "green" band on many oil temperature gauges starts at just over 38°C (100°F), which is okay for taking off but too low for normal cruising.) Remember, oil temperature is one of the most critical parameters to be measured and controlled.

As a rule, many naturally aspirated engines will run even at an oil temperature that is too low. This can lead to excess moisture in the crankcase and rusting or corrosion of critical engine parts. Conversely, many turbocharged engines run too hot and care must be taken to keep the cylinder and oil temperatures down. In most cases, a cruising oil temperature of 82–93°C (180–200°F) is preferred. Temperatures below 77°C (170°F) usually do not provide proper boiling off of water, which can lead to rusting. At the other extreme, cruising oil temperatures significantly above 100°C (220°F) can be an indication of inadequate cooling.

LEAD FOULING

Avgas 100LL contains a compound known as Tetra Ethyl Lead (TEL) which acts as an octane booster for the fuel. This results in a fuel which is commonly known as a 100 Octane lean mixture and 130 rich mixture Performance Number fuel.

In practice it is even better than this, with ratings more like 106 lean mixture & 130 rich mixture which are far in excess of the comparable 85 - 87 octane of road fuels. To achieve this, a lot of TEL is used – around 5 times the quantity that was used in the old Leaded automotive fuels.

This increase in octane allows aviation engines to produce more power through increased compression ratios or alternatively by increasing the inlet pressure by using a turbo or a supercharger. The problem with using Leaded fuels is that they will always burn with more deposits than unleaded fuels.

The Tetra Ethyl Lead used for octane boost in the fuel naturally degrades to form Lead Oxide when it is burned. In reality it is this oxide which gives the octane boost. The problem is that Lead Oxide is a solid up to about 900°C (1652°F), which is well within the wall temperatures inside a piston engine.

In order to prevent these deposits from forming, a Lead scavenging compound is added to Avgas 100LL – this compound is Ethylene Dibromide. This scavenger is designed to react with the Lead Oxide to form Lead Bromide which is more volatile – becoming a gas at around 200°C to 250°C (392°F to 482°F). This is a low enough temperature to ensure that the Lead is removed from the engine as a gas and it subsequently goes back to the solid phase as the exhaust gas cools in the atmosphere.

As a point of interest, the pale brown / ash coloured staining that is often seen leading from the exhausts of high-powered engines, such as those found on the warbirds, is in fact Lead Bromide.

To enable this reaction between the Lead Oxide and the scavenger to work, there needs to be a relatively high combustion temperature.

What a lot of people do is conduct the warm-up with the engine power lever on the idle stop, and this is inappropriate. The technique for the common Continental Motors and Textron Lycoming General Aviation engines is as follows.

After start-up, the engine should be operated at 1000 to 1200 rpm for the initial warm-up period and not at the 600 to 650 rpm idle speed. This serves a number of purposes.

The higher cylinder pressure encourages the rings to seal properly, not only limiting oil egress into the combustion chamber, but also reducing the amount of corrosive combustion by-products going the other way into the sump oil. This technique thus also helps reduce the risk of corrosion problems in the long term by reducing the amount of acids and Lead being pumped into the oil.

Meanwhile in the combustion chamber, Lead Oxides tend to form deposits because of the low combustion temperatures. The temperature for Lead deposits to form tends to be favourable around the spark plugs (as the whole mixture is quite cool before the flame starts to propagate) and on the exhaust valve stem (as the mixture cools after combustion).

The problem is that the deposits are electrically conductive, which shorts out the spark plug - and corrosive, which can start to attack the metal of the valve stems.

Temperature is a key factor in preventing Lead fouling and it is not just at start up, but also the correct shut down procedure should be carried out.

Engines that have been involved with long, low power descents, or have taxied for some distance, can have quite low cylinder temperatures and this - as we now know - can lead to lead fouling. Again the advice from Textron Lycoming and Continental Motors to remedy this is: once on the aircraft is on the stand, the engine speed should be kept between 1000 and 1200 rpm until the engine temperatures have stabilised.

Once the temperatures are stable, the engine speed should be increased to 1800 rpm for a period of 15 to 20 seconds, which should generate enough temperature to burn off any deposits. Once this period is past, the engine speed should be reduced to 1000 - 1200 rpm once again and then immediately shut down using the mixture control.

WATER INGESTION IN ENGINE OIL

When an engine is running, acids form in the oil from a combination of combustion gases dissolving in the oil and the oil's own natural degradation. The combustion gases enter the crankcase by 'blowing' past the piston rings and, once in the crank, they dissolve in the oil. Oil degradation is the inevitable and unavoidable oxidation process which occurs when an oil is at high temperature and in contact with air.

These by-products do not cause any problems until you also have water present in the oil, which then 'activates' them by hydrolysing them to form, predominantly, Formic and Nitric acids. It is these acids, along with any free water which may be present, which cause corrosion in an engine.

Water inevitably appears within the engine by condensing out of the atmosphere in much the same way as moisture condensing on the outside of the aircraft structure; the air getting into the engine internals though the crankcase breather. This is a continual process and occurs if the aircraft is in use or not.

The usual and most effective way of eradicating problems arising from this acid and water attack is to fly the aircraft. This heats up the oil and drives off any moisture in the oil, thus eliminating the water problem and deactivating the acids. The only way to get the oil hot enough to do this is to fly the aircraft; ground running will not get the oil hot enough to drive off the moisture. We usually suggest a minimum of 30 minutes cruising flight every 2 weeks.

One of the advantages of using AeroShell range of Plus Oil (AeroShell Oil W 15W-50, AeroShell Oil W100 Plus and AeroShell Oil W80 Plus) comes when the aircraft is not flown this frequently as the oil contains both a corrosion inhibitor and an anti-scuffing additive to help the occasional flyer.

If the aircraft cannot be flown with the frequency required to keep the oil 'dry' (a minimum of ½ hour cruise every 2 weeks), the corrosion inhibitor will suppress the formation of any corrosion during periods of inactivity, which would otherwise form due to the action of acids and water.

Furthermore, once the aircraft engine is started up after being inactive, the anti-scuffing additive will have coated all the internal metallic surfaces with a molecular layer so that metal to metal contact is prevented if there is no oil present. This is particularly important during the first few seconds after startup as the oil pump will not pump oil to all the extremities of the engine immediately.

PREPARATION FOR AIRCRAFT STORAGE

It is important that an aircraft be properly prepared if it is going to be inactive for an extended length of time, whether during winter storage, or in the middle of a major restoration or repair project. This extends to the oil you use.

When an aircraft sits unused, especially in humid conditions, it rusts. Rust forms in the engine on cams, lifters and cylinder bores. Rusting can cause pitting and the rust particles may act as a very fine grinding compound in your oil. This can lead to increased wear and reduced engine life.

Winterizing Your Aircraft

The best solution is to hangar your aircraft where it can be protected from winter elements and kept in a reasonably stable temperature environment. But even so, some precautions should be taken.

Many operators tend to fly their aircraft during summer, store over winter and then consider having the annual and routine maintenance carried out during spring, so that the aircraft is in perfect order for the new season.

This is fine to a certain extent, but we would recommend that if you do no other maintenance in autumn, then the old oil from your engine should be drained and have it filled with the appropriate grade.

The problem of leaving old used oil in the engine is that this used oil can be quite acidic which, when combined with water from the atmosphere, causes corrosion. This can lead to pitting of components like cam lobes, bearings etc. if left in the engine over a period of time.

This problem is then compounded when the rust particles that are formed get into the oil and act like a grinding paste when the engine is next started, causing further wear and damage. This all leads to increased maintenance bills and reduced reliability, all for the cost of an oil change.

The old oil, once drained, can be replaced by your normal grade if you intend to carry on flying for a minimum of half an hour cruise every fortnight. If however, like many, you fly less than this over the winter, then you have two choices.

AeroShell range of Plus Oil (AeroShell Oil W 15W-50, AeroShell Oil W100 Plus and AeroShell Oil W80 Plus) with its corrosion inhibitor and anti-wear additives is ideally suited for pilots who intend to fly through the winter, but do not manage to fly every 2 weeks. Alternatively, a mixture of 1 part of AeroShell Fluid 2XN to 3 parts of AeroShell Oil 100 can be used as an inhibiting oil (formerly AeroShell Fluid 2F) if the aircraft is to be stored for the winter period. Simply change the oil and the filter, then run the engine for approximately 15 minutes to circulate the product through the system. During this time, make sure the engine does not exceed its normal operating temperature.

This combination of AeroShell 2XN and AeroShell Oil 100 can be used in any certified aircraft engine, including Lycoming, Continental, Pratt & Whitney and most other radial, opposed or in-line engines, and can also be used as a flyaway oil for up to 50 hours during the time between overhaul of opposed engines. However, it is not recommended for two-cycle or adapted automotive engines.

Things to consider doing even if the aircraft is hangared are:

- **Change the Oil**.
- **Chock the wheels front and back, and release the parking brake**. This will prevent the brake seizing on, whilst keeping the aircraft static.
- **Blank the inlets exhaust and vents**. Pitot and static vent covers are essential to ensure that the orifices do not become blocked with insects or dirt, so as to prevent your ASI or altimeter from being inoperative. Blanking engine intakes and exhausts will also significantly reduce the amount of moisture from getting into the engine, which can cause the onset of corrosion.
- **Apply a canopy cover or at least tie a dust sheet over the cockpit area**. Not only does sunlight effect perspex, but bird droppings can be quite corrosive and etch the surface if not removed for a period of time.
- **Apply airframe grease**. Whilst doing storage checks, it is prudent to re-lubricate hinges and linkages. Most light aircraft use AeroShell Grease 6 as a general-purpose airframe grease, but do check with your maintenance engineer.
- **Check that the fuel cocks are closed and master switches off**. Also consider removing the battery to prevent any leakage current from draining it.
- **Fill the fuel tanks**. Ensuring that the fuel tanks are full prevents the build-up of condensation in the tanks over winter. This condensation is inevitable if air is present in the tank and will in turn will lead to the build-up of water in the bottom of the tank. This will again mean corrosion and potentially expensive tank repairs. This is particularly important if your aircraft is stored outside. If your aircraft is hangared, ensure that you have permission to

store your aircraft with full tanks – some hangar managers consider it to be a potential fire hazard and frown on such practice.

If your aircraft is metal skinned and your only option is to store it outside, the above suggestions still apply, but you should also consider the following:

- **Picket your aircraft down**. Ideally find a sheltered spot where the aircraft is not exposed to too much wind. The aircraft should be secured, using the correct tie down points, nose into the prevailing wind direction for that site. The tie down points should be secured to concrete blocks, screws, spikes or ideally dedicated hard points set into the ground. Ensure that the straps used are not too tight as they may alter in length in dry or damp conditions.
- **Apply control locks**. Use either external flying control surface locks or internal control braces to prevent the control surfaces from damaging themselves by crashing from one lock stop to the other whilst unattended.

No matter what you have added (control locks, engine blanks, pitot covers), or removed (battery), it is always good practice to placard the cockpit to remind you or others of the condition of the aircraft. In this way, when spring does finally come, the pre-flight walk around will be easier and you will take to the air with the peace of mind that you have done all you can for your aircraft.

Preparing Your Aircraft After Winter Storage

Activities that can be carried out to ensure that the first flight after storage will be a safe one:

- **First ensure that the battery is in good condition and fully charged**. It is not only the first start after a period of inactivity that may put a heavy demand upon the battery, but also it would be beneficial to have some enough battery power to help with some additional engine cranking as we shall see in later. The best way to ensure battery charge is to remove the battery from the aircraft and use a slow "trickle" charger rather than a rapid charger. This has less risk of damaging the battery. Slow charging of the battery has more chance of recovering a discharged battery and also rapid charging of a battery can sometimes cause damage by delaminating the cell plates.

- **Next check the fuel for water**. Condensation will form on the inside walls of a fuel tank and on the fuel surface, if the fuel temperature is below that of the dew point. This can cause some water to become suspended in the fuel as well as water to form in the bottom of the tank. What we need to think of when checking fuel drains is that as the temperature of fuel decreases, so does its ability to hold water in suspension. Hence the fuel will contain less water after being exposed to cold ambient temperatures – which tends to be overnight. It would also help if the aircraft has been stood still without any movement as agitation will encourage the mixing of water and fuel at the boundary where the two meets. This all means that the best time to check fuel drains is first thing in the morning before the aircraft is moved.
- **A full walk around.** This should also include the condition of the brakes. It is possible that the brakes could be seized if the aircraft has been left unused for a period, so care should be taken to make sure that the brakes are free. This is especially important if the brakes are seized off. It is best not to find out that the park brake is on in the cockpit, but the brakes are not actually on, after you have started the engine - this could be an expensive oversight. During the walk around, remove all the control locks, pitot and static blanks, and any engine blanks that you may have applied to exhaust, inlet etc. Once the blanks are removed, have a thorough check for any stowaways that you might have. Birds, animals and insects all find dormant aircraft a good place to make their home so have a good look in the engine bay, in accessible areas of the airframe and especially pitot and static vents. If there is any evidence of insect debris in the pitot and static vents do not be tempted to remove only the visible blockage, think what may be happening inside. Some insects use these vents as homes and use the pipe runs as small breeding areas. So what you found as a blockage at the vent opening may only be an indication that there is a further obstruction of insect larvae further down the line. If you find evidence of insect infestation at the vent opening, have an engineer check the whole line for obstructions. This is often not too complicated and better to find nothing on the ground than to be left in the air without pressure instruments.

- **Check on the engine**. If the engine has been stored for several months, it should have been inhibited with a storage oil and desiccant plugs put in place of one set of spark plugs to keep moisture out of the combustion chamber. We need to remove the desiccant plugs. If we do this and then leave the plug out, then the engine will not have any compression. With the cowling removed, the engine can then be turned over on the starter motor with the fuel turned off and the mixture lever in the idle cut off position, and magnetos in the "off" position. Without engine compression offering any resistance, the engine will turn over quite rapidly. This should allow the oil pump to rotate quickly enough to supply some oil to the oil gallery thus limiting the time that the engine will run without full lubrication after engine start. Now replace the spark plugs and start the engine for a brief ground run, just enough to warm the oil enough to make it more fluid to aid the drain.
- **Drain the preservative oil**, replacing the filter if necessary, and refill with an operating oil. If your aircraft is normally underutilised – perhaps you have periods of more than 2 weeks when the aircraft is not used – then consider using an oil with a corrosion inhibitor and anti-scuffing additive to reduce wear on start up. Oils such as the multigrade AeroShell Oil W 15W-50 or the monograde AeroShell Oil W100 Plus are two such oils.
- **Other areas of the aircraft that might need lubrication**: Light aircraft joints, such as flap and control surface operating linkages and other general-purpose applications are normally lubricated by AeroShell Grease 6. Often these grease application points go for long periods without adequate grease reapplication. The old grease appears dark and hard in nature and should be replaced. Some applications can be made by the pilot or operator, but perhaps it may be safer to ask your engineer to recharge these points with fresh grease. With applications that have grease nipples, fresh grease should be applied so that it flushes out the old product and fresh grease is seen emerging from the part being lubricated. With wiping applications, then the old grease should be cleaned off as far as possible and fresh grease applied and the joint cycled to help the grease to penetrate.
- **Perspex of the cockpit canopy**. Have any new surface marks developed over the winter period – scratches, abrasion marks or even

surface damage from bird droppings? These surface marks can be removed by using specialised Perspex blending and polishing kits which can significantly improve visibility especially when flying into a low sun, something that happens quite frequently in the early and late parts of the season.

- **Ensure full and thorough pre-flight run ups are completed**. If the aircraft has been in extended storage and not run for some months, then gums and lacquers could have formed in the fuel system which could restrict fuel flow – especially if Mogas has been used. So ensure that full power is available when doing the magneto checks and also check the throttle stop idle speed.
- **Pay attention to variable pitch propellers**. These are normally operated by engine oil pressure being fed to the propeller hub and, with the engine having had the oil changed, make sure that the propeller has full oil supply by cycling the pitch properly during the ground run.

RADIAL ENGINES

Radial engines utilise special parts and, depending upon the type of aircraft, application and climate are often subject to specific problems not seen in other types of piston engines.

In a radial engine each bank of cylinders has all of the cylinders in the same plane and transmits power through a single master rod bearing to the crankshaft. This master rod bearing is subjected to high loading and absorbs the shock and vibration from the cylinders and thus requires very good protection from the lubricant. Generally radial engines have greater piston and bearing clearances and thus require a higher viscosity oil.

As a result of all this heavy duty stress, it is recommended that for radial engines used in normal operation (all operations except agricultural spraying), an oil such as AeroShell Oil W 120 is used in moderate to temperate climates and AeroShell Oil W 100 in cooler climates (if breaking-in, then AeroShell Oil 120 and 100 respectively). Alternatively AeroShell Oil W 15W-50 could be used in those radial engines for which it is approved. None of these oils contain zinc additives which if used would quickly destroy the master rod bearing.

Agricultural operations represent a special problem for an oil used in radial engines. This is because of problems with high dirt and overspray ingestion into the oil. The best way to combat this is proper maintenance, good flying procedures and frequent oil changes.

VINTAGE AIRCRAFT

Vintage aircraft piston engines, including vintage radial engines, were approved on oils produced at the time the engine was originally manufactured. Many of these oils are no longer available. If the engine was approved on an aviation oil other than a MIL-L-6082 or a MIL-L-22851 oil then operators should consult with either the engine rebuilder or oil supplier. On no account assume that present oils are direct replacements for old vintage aircraft applications.

NON-AVIATION USE OF AEROSHELL PISTON ENGINE OILS

In selecting an AeroShell piston engine oil for a non-aviation application the properties of the oil must be examined. This will only give an approximate indication as to the expected performance in the specific application. However, such data must be regarded as guidance only. There is no laboratory test that can give a complete prediction of performance in actual use, and the final stage in any decision must involve performance tests in either the actual equipment or in the laboratory/test house under conditions expected in service.

STABILITY IN STORAGE

AeroShell W Oils are inherently stable and, providing they have been stored and handled correctly, prolonged storage does not have any effect on their quality, properties or performance.

AEROSHELL OILS 65, 80, 100 and 120

AeroShell straight mineral oils are blended from selected high viscosity index base stocks. These oils do not contain additives except for a small quantity of pourpoint depressant (which is added when improved fluidity at very low temperature is required) and an antioxidant.

APPLICATIONS

AeroShell Oils are available in four different viscosity grades:
AeroShell Oil 65 – AeroShell Oil 80 – AeroShell Oil 100 – AeroShell Oil 120

The suffix for each grade corresponds to the viscosity of the oil at 99°C (210°F) in Saybolt Universal Seconds.

The appropriate grades of these AeroShell Oils are approved for use in four-stroke (four-cycle) certified aircraft reciprocating piston engines (except Porsche) and other aircraft radial engines which use oil to specification SAE J1966 (MIL-L-6082) and which do not require use of an oil containing a dispersant additive. AeroShell Oils are used primarily during break-in of most new or recently overhauled four-stroke aviation piston engines. The duration and lubrication recommendations for break-in vary, so operators should refer to the original engine manufacturer and/or overhaul facility for specific recommendations.

SPECIFICATIONS

The U.S. Specification SAE J1966 replaces MIL-L-6082E.

Although it was planned to replace the British Specification DERD 2472 with a DEF STAN specification this has now been put into suspension and instead the SAE specification has been adopted.

AeroShell Oil	65	80	100	120
U.S.	Approved SAE J1966 Grade 30	Approved SAE J1966 Grade 40	Approved SAE J1966 Grade 50	Approved SAE J1966 Grade 60
British	-	Approved SAE J1966 Grade 40	Approved SAE J1966 Grade 50	-

Table continued

Table continued

AeroShell Oil	65	80	100	120
French	-	-	RO-117	-
Russian	-	MS-14	MS-20	-
NATO Code	-	-	-	-
Joint Service Designation	-	OM-170	OM-270	-

Typical Properties	65	80	100	120
SAE viscosity grade	30	40	50	60
Density @ 15 °C (59 °F) kg/m^3	882	884	888	890
API Gravity	28.8	28.3	27.8	27.2
Kinematic viscosity mm^2/s @ 100 °C (212 °F)	11	14	20.5	23.3
Viscosity index	> 94	> 95	> 94	> 96
Pourpoint °C (°F)	< –27 (–16)	< –21 (–5)	< –21 (–5)	< –12 (+10)
Flashpoint °C (°F)	> 250 (482)	> 250 (482)	> 250 (482)	> 250 (482)
Total acidity mgKOH/g	< 0.1	< 0.1	< 0.1	< 0.1
Sulphur %m	0.25	0.35	0.38	0.42
Copper corrosion 3hrs @ 100 °C (212 °F)	Passes	Passes	Passes	Passes
Ash content %m	< 0.005	< 0.005	< 0.005	< 0.005
Trace sediment ml/100ml	Passes	Passes	Passes	Passes
Foaming tendency	Passes	Passes	Passes	Passes

AEROSHELL OILS W80, W100 and W120

AeroShell W Oils were the first non-ash dispersant oils to be used in aircraft piston engines. They combine non-metallic additives with selected high viscosity index base stocks to give exceptional stability, dispersancy and anti-foaming performance. These additives leave no metallic ash residues that can lead to deposit formation in combustion chambers and on spark plugs, which can cause pre-ignition and possible engine failure.

APPLICATIONS

AeroShell W Oils are available in four different viscosity grades:

AeroShell Oil W80 – AeroShell Oil W100 – AeroShell Oil W120

The suffix for each grade corresponds to the viscosity of the oil at 99°C (210°F) in Saybolt Universal Seconds.

AeroShell W Oils are intended for use in four-stroke (four-cycle) certified reciprocating piston engines, including fuel-injected and turbocharged engines. AeroShell W Oils are not recommended for use in automotive engines. For automotive engines converted for use in aircraft, the specific engine manufacturer or the conversion agency should be consulted for proper oil recommendation.

Most radial engine operators use AeroShell Oil W120 in warm weather operations with AeroShell Oil W100 or AeroShell Oil W 15W-50 being used in cooler ambient temperatures.

AeroShell Oil W100 or AeroShell Oil W 15W-50 are the common choices for most operators of Lycoming and Continental flat engines but, during colder parts of the year, use of AeroShell Oil W80 in place of AeroShell Oil W100 would be an excellent choice.

Although some aircraft engine manufacturers and rebuilders/overhaul agencies suggest in their service bulletins the use of straight mineral oil in new or newly overhauled engines, other rebuilders or manufacturers, especially for such engines as the Lycoming O-320H and O/LO360E, allow either ashless dispersant or straight mineral oil for break-in, whereas ashless dispersant oils are mandated for break-in for all turbocharged Lycoming engines. Operators should check with engine manufacturers or rebuilders for the correct recommendation for the specific engine and application.

AEROSHELL W OILS

- Promote engine cleanliness
- Help keep engines sludge free
- Help reduce oil consumption
- Help engines reach TBO (Time Between Overhaul)
- Protect highly stressed engine parts against scuffing and wear

SPECIFICATIONS

The U.S. specification SAE J1899 replaces MIL-L-22851D.

Although it was planned to replace the British Specification DERD 2450 with a DEF STAN specification this has now been put into suspension and instead the SAE specification has been adopted.

AeroShell Oil	**W80**	**W100**	**W120**
U.S.	Approved SAE J1899 Grade 40	Approved SAE J1899 Grade 50	Approved SAE J1899 Grade 60
British	Approved SAE J1899 Grade 40	Approved SAE J1899 Grade 50	Approved SAE J1899 Grade 60
French	-	-	-
Russian	MS-14	MS-20	-
NATO Code	-	-	-
Joint Service Designation	OMD-160	OMD-250	OMD-370

EQUIPMENT MANUFACTURERS' APPROVALS

AeroShell W Oils are approved for use by the following engine manufacturers:-

Textron Lycoming	301F
Continental Aerospace Technologies	MHS 24B
Pratt & Whitney	Service Bulletin 1183
Curtiss Wright	Various Service Bulletins – refer to relevant Bulletin
Franklin Engines	Various Service Bulletins – refer to relevant Bulletin

Typical Properties		**W80**	**W100**	**W120**
SAE viscosity grade		40	50	60
Density @ 15°C (59°F)	kg/m^3	883	887	891
API gravity		28.6	27.8	27.2
Kinematic viscosity @ 100°C (212°F) @ 40°C (104°F)	mm^2/s	 14.5 139	 18.1 204	 23.8 306
Viscosity index		102	> 96	> 96
Pour point	°C (°F)	< –24 (–11)	< –21 (–5)	< –21 (–5)
Flash point	°C (°F)	> 240 (464)	> 250 (482)	> 260 (500)
Total acid number	mgKOH/g	< 0.4	< 0.5	< 0.5
Sulphur	%m	0.3	0.38	0.51
Copper corrosion 3 hrs @ 100°C (212°F)		1a	1a	1a
Ash content	%m	< 0.004	< 0.004	< 0.004
Trace sediment	ml/100ml	Passes	Passes	Passes
Trace metal content	ppm	Passes	Passes	Passes
Foaming tendency		Passes	Passes	Passes

A viscosity/temperature chart is shown at the end of this section.

NOTES

AEROSHELL OIL W 15W-50

AeroShell Oil W 15W-50 is a unique blend of high quality mineral oil and over 50% synthetic hydrocarbon base stocks, plus the AeroShell Oil W ashless dispersant additive system. This semi-synthetic blend offers high performance in a wide variety of applications and conditions. The synthetic base stock performance provides for better cold temperature pumping and protection than single grade oils. In addition, the blend of synthetic and high quality mineral base stocks provide high temperature performance superior to that of other fully approved aircraft piston engine oils. The mineral base stocks help disperse lead by-products of combustion, thereby keeping engines free of "grey paint" or lead sludge that can be a problem with some fully synthetic oils.

The anti-wear additive system in AeroShell Oil W 15W-50 provides outstanding wear protection for critical camshafts, lifters and other high wear components.

The anti-corrosion additive package in AeroShell Oil W 15W-50 helps protect low usage engines and engines in high humidity climates against rust and corrosion of critical engine parts such as camshafts and lifters.

AeroShell Oil W 15W-50 provides superior anti-corrosion protection for all types of certified aircraft piston engines. When used with proper maintenance procedures, the product provides maximum protection and improves the likelihood that aircraft engines will reach TBO. In addition, this product provides outstanding high temperature oxidation protection for hot running engines. It is designed to keep engines cleaner with less sludge and varnish build-up in critical ring belt and other areas.

APPLICATIONS

AeroShell Oil W 15W-50 is intended for use in certified four-stroke (four-cycle) aircraft piston engines. AeroShell Oil W 15W-50 is superior to single grade oils in almost every application. It offers easier starting, better lubrication after start-up, reduced wear, reduced corrosion and rusting, and improved cleanliness, with oil pressures and temperatures equal to that of single grade SAE 50 oils at fully warmed up conditions.

The anti-corrosion additive system is designed to prevent rust or corrosion in all types of aircraft piston engines. In comparative testing of camshaft rusting under high humidity conditions, AeroShell Oil W 15W-50 was almost entirely rust free while camshafts conditioned on other oils showed heavy rusting on some cam lobes and bearing surfaces.

These results indicate that AeroShell Oil W 15W-50 can provide maximum anti-corrosion protection for aircraft piston engines, when combined with proper maintenance practices and proper operating conditions.

Because of the improved flow characteristics of AeroShell Oil W 15W-50, operators may observe slightly lower oil temperatures in some aircraft. On larger aircraft, the oil cooler flap will normally compensate for this change. However, in small aircraft, oil temperature could be reduced slightly. Operators should always check the oil temperature to ensure that they are in the range specified by the manufacturer. Most manufacturers recommend cruising oil temperatures between 82 to 93°C (180 to 200°F). Oil temperatures significantly below this range can result in excessive water and fuel contamination in the crankcase.

AEROSHELL OIL W 15W-50

- Provides excellent rust and corrosion protection for aircraft engines
- Promotes engine cleanliness, fights wear, offers excellent anti-foam properties
- Helps reduce oil consumption by up to 50% and provides superior oil flow at low temperatures
- Compatible with other approved aircraft piston engine oils
- Functions as an all season oil, no seasonal changes needed
- Reduces fuel consumption by up to 5% over single grades
- Provides superior high temperature oxidation stability

Refer to General Notes at the front of this section for information on oil change recommendations and engine break-in.

AeroShell Oil W 15W-50 is not recommended for use in automotive engines. For automotive engines converted for use in aircraft, the specific engine manufacturer or the conversion agency should be consulted for proper oil recommendation.

SPECIFICATIONS

AeroShell Oil W 15W-50 was developed in co-operation with Textron Lycoming and Continental Aerospace Technologies (formerly Continental Motors) and conforms to their specifications 301F and MHS-24A respectively. This oil is also approved under Military Specification MIL-L-22851 which is now obsolete and has been replaced by the SAE J1899 specification. AeroShell Oil W 15W-50 is also approved for use in all Pratt & Whitney radial aircraft engines. In addition AeroShell Oil W 15W-50 meets the provisions of Lycoming Service Bulletin 446C and 471, plus Service Instruction 1409A and meets the American FAA Airworthiness Directive 80-04-03 R2 which specifies special anti-wear requirements for certain engine models.

AeroShell Oil W 15W-50 already contains, in the correct proportions, an anti-wear additive equivalent to the Lycoming additive LW 16702; operators who use AeroShell Oil W 15W-50 DO NOT need to add this Lycoming additive to the oil.

AeroShell Oil W 15W-50 is qualified for use in all Continental Aerospace Technologies ’ liquid cooled and air cooled aircraft piston engines.

U.S.	Approved SAE J1899 Grade Multigrade
British	Approved SAE J1899 Grade Multigrade
French	Approved DCSEA 262/A (XO-162)
Russian	-
NATO Code	-
Joint Service Designation	OMD-162

EQUIPMENT MANUFACTURERS’ APPROVALS

AeroShell Oil W 15W-50 is approved for use by the following engine manufacturers:

Textron Lycoming	301F Service Bulletins 446E and 471B Service Instruction 1409C
Continental Aerospace Technologies	MHS 24B SIL 99-2
Pratt & Whitney	Service Bulletin 1183
FAA	AMOC to Airworthiness Directive 80-04-03 R2 p.1b

Typical Properties		SAE J1899 Multigrade	TYPICAL
Oil type		–	Mixed synthetic hydrocarbon and mineral
SAE viscosity grade		Multigrade	Multigrade
Density @ 15°C (59°F)	kg/m^3	Report	857
API gravity		Report	33.4
Kinematic viscosity @ 100°C (212°F) @ 40°C (104°F)	mm^2/s	 – –	 18.2 137
Viscosity index		100 min	148
Viscosity dynamic @ –20°C (–4°F)		-	5561
Pour point	°C (°F)	Report	–36 (–32)
Flash point	°C (°F)	220 (428) min	> 240 (464)
Total acid number	mgKOH/g	1.0 max	< 0.1
Sulphur	%m	0.6 max	0.2
Copper corrosion 3hrs @ 100°C (212°F)		 1 max	 1a
Ash content	%m	0.011 max	< 0.006
Trace sediment	ml/100ml	Must pass	Passes
Foaming tendency		Must pass	Passes
Trace metal content	ppm	Must pass	Passes

A viscosity/temperature chart is shown at the end of this section.

AEROSHELL OILS W80 PLUS and W100 PLUS

AeroShell Oil W80 Plus and AeroShell Oil W100 Plus are new single grade oils that combine the single grade, ashless dispersant performance found in AeroShell Oils W80 and W100 and the anti-wear/anti-corrosion additives of AeroShell Oil W15W-50 Multigrade. They are the oils for pilots who prefer a single grade but who also want the extra protection and performance from the additive package.

APPLICATIONS

The advanced additives in AeroShell Oils W80 Plus and W100 Plus provide better rust and wear protection than conventional single grades. The additives work as a protective barrier to prevent critical parts from being slowly degraded by rust or wear, especially when an aircraft sits idle. This protection helps keep the camshaft and lifters coated, reducing the likelihood of premature damage and helping operators reach TBO.

- Blended from selected high viscosity mineral base oils
- Contains AeroShell's proven W Oils additive package
- Additional anti-wear additives (containing Lycoming additive LW 16702)
- Additional anti-corrosion additives
- Fully compatible with other approved aircraft piston engine oils

SPECIFICATIONS

Approved SAE J1899 Grade 40 (AeroShell Oil W80 Plus)
Approved SAE J1899 Grade 50 (AeroShell Oil W100 Plus)

AeroShell Oils W80 Plus and W100 Plus already contain, in the correct proportions, an anti-wear additive equivalent to the Lycoming additive LW 16702; thus complying with FAA Airworthiness Directive 80-04-03 R2. Operators who use AeroShell Oils W80 Plus and W100 Plus DO NOT need to add this Lycoming additive to the oil.

AeroShell Oils W80 Plus and W100 Plus are qualified for use in all Continental Aerospace Technologies' liquid cooled and air cooled aircraft piston engines.

EQUIPMENT MANUFACTURERS' APPROVALS

AeroShell Oils W80 Plus and W100 Plus are approved for use by the following engine manufacturers:

Textron Lycoming	301F Service Bulletins 446E and 471B Service Instruction 1409C
Continental Aerospace Technologies	SIL 99-2
FAA	AMOC to Airworthiness Directive 80-04-03 R2 p.1b

Typical Properties		W80 Plus	W100 Plus
Density @ 15 °C (59 °F)	kg/m^3	886	891
API gravity		27.9	17.1
Kinematic viscosity	mm^2/s		
@ 100 °C (212 °F)		14.1	18.6
@ 40 °C (104 °F)		135	212
Viscosity index		> 101	> 96
Pour point	°C (°F)	< –24 (–11)	< –21 (–5)
Flashpoint	°C (°F)	> 250 (482)	> 255 (491)
Total acid number	mgKOH/g	< 0.2	< 0.6
Sulphur	%m	0.30	0.35
Copper corrosion 3 hrs @ 100 °C (212 °F)		1a	1a
Ash content	%m	< 0.004	< 0.008
Trace sediment	ml/100ml	Passes	Passes
Foaming tendency		Passes	Passes
Trace metal content	ppm	Passes	Passes

A viscosity/temperature chart is shown at the end of this section.

AEROSHELL OIL SPORT PLUS 4

Developed in conjunction with ROTAX®, AeroShell Oil Sport Plus 4 is the first oil specifically developed for light sport aviation piston engines such as the ROTAX® 912 & 914 series. A combination of low cylinder head temperature (compared with air cooled engines), low oil consumption and the engine internals requires a blend of high quality hydrocarbon base stocks, incorporating synthetic technology, which allows full performance with different fuel types. This oil can be used in all climates.

APPLICATIONS

AeroShell Oil Sport Plus 4 is intended for use in four-stroke (four-cycle) aircraft piston engines that are of an original automotive design and which cannot, therefore, use traditional Ashless Dispersant aircraft engine oil types. These engines include carburetted, fuel-injected and turbocharged types such as the ROTAX® 912 & 914 series.

AeroShell Oil Sport Plus 4 can be used in integrated gearbox and wet clutch systems.

AeroShell Oil Sport Plus 4 can be used in engines which operate on both unleaded gasoline and Avgas 100LL. The correct choice of additives and good solvent properties allow the oil to handle lead by-products that can form a semi solid sludge in the oil which can restrict oil passages and compromise lubrication. AeroShell Oil Sport Plus 4 is superior in this respect to those oil types intended for automotive/motorcycle application.

Please refer to Operators Handbook/Manual for the correct oil drain interval when operating on different fuels.

SPECIFICATIONS

No Aviation specifications yet defined.

Meets or exceeds the requirements of the highest international specifications:
API SL
JASO MA

Fully approved to ROTAX® RON 424 specification, listed in ROTAX® Service Instruction SI-912i-01/SI-912-016/SI-914-019 Selection of suitable operating fluids for ROTAX® engine type 912 & 914 (series).

Please consult Operating Handbook/Manual to confirm the correct lubricant specification before use.

FEATURES AND BENEFITS

- First specific oil for Light Sport and Very Light/Ultra light aircraft engines
- Promotes engine cleanliness
- Helps keep engines sludge and varnish free
- Helps reduce oil consumption
- Helps engines reach TBO (Time Between Overhauls)
- Protects highly stressed engines parts against scuffing and wear
- Anti-foaming additives to maximise lubrication effectiveness – especially for those engines operating an integrated gearbox
- Better cold flow characteristics for easier starts and quicker protection
- High thermal stability for longer-lasting and safer lubrication
- Can be used in any climate
- Advanced anti-rust and anti-wear package

DO NOT use AeroShell Oil Sport Plus 4 in engines that are designed to use Ashless Dispersant aviation piston engines oils such as AeroShell W oils. This includes air-cooled Continental Aerospace Technologies and Textron Lycoming engines.

Typical Properties		**Sport Plus 4**
SAE viscosity grade		10W-40
Density @ 15°C (59°F)	kg/m^3	868
Kinematic viscosity @ 100°C (212°F) @ 40°C (104°F)	mm^2/s	 14.2 94.2
Dynamic viscosity (CCS)@ –25°C (–13°F)	mPa.s	5975
Pourpoint	°C (°F)	–39 (–38)
Flashpoint	°C (°F)	228 (442)
Phosphorus	%m	0.196
Zinc	%m	0.220
Calcium	%m	0.284

A viscosity/temperature chart is shown at the end of this section.

AEROSHELL OIL DIESEL ULTRA

AeroShell Oil Diesel Ultra is a fully synthetic, multigrade engine oil designed for use in the new generation of compression ignition (Diesel) Aviation Piston Engines.

The formulation has been selected to be suitable in piston engines fuelled by Jet A or Jet A-1 and is designed for use in the latest highly rated turbocharged diesel engines under all operating conditions.

APPLICATIONS

AeroShell Oil Diesel Ultra is a fully synthetic engine oil containing a unique additive package to provide superior piston cleanliness, resulting in a clean, efficient and reliable engine. This package includes a powerful surface active additive, which bonds to the surface of highly loaded engine parts, protecting the engine from scuffing damage.

This oil has been developed to provide excellent component wear protection and engine cleanliness, based on substantial engine and component endurance tests with all the major diesel aero-engine manufacturers, and flight experience with diesel aero-engines in the field over recent years.

AeroShell Oil Diesel Ultra has been developed to be suitable for use in engines burning Jet fuel and its performance has been optimised to cope with the demands of this unique type of engine/fuel combination. Its key performance features include the ability to sustain high bearing loads, neutralisation of acid build up from the sulphur present in the fuel, and high dispersancy to allow for the relatively high particle loading produced when burning Jet fuel.

AeroShell Oil Diesel Ultra MUST NOT be used in spark ignition or Avgas powered aircraft engines.

ENGINE MANUFACTURERS’ APPROVALS

AeroShell Oil Diesel Ultra is approved to Mercedes Benz Specification 229.5, recognised and required by the leading Diesel aero engine manufacturers AeroShell Oil Diesel Ultra is approved for use in the following engines. Whilst this is correct at the time of writing, testing is ongoing to extend this approval listing as new engines are produced.

Thielert/Centurion® Engines	1.7 & 2.0 Centurion® (Other models yet to be produced)
SMA	SR305-230E
Austro Engine	AE300

SPECIFICATIONS

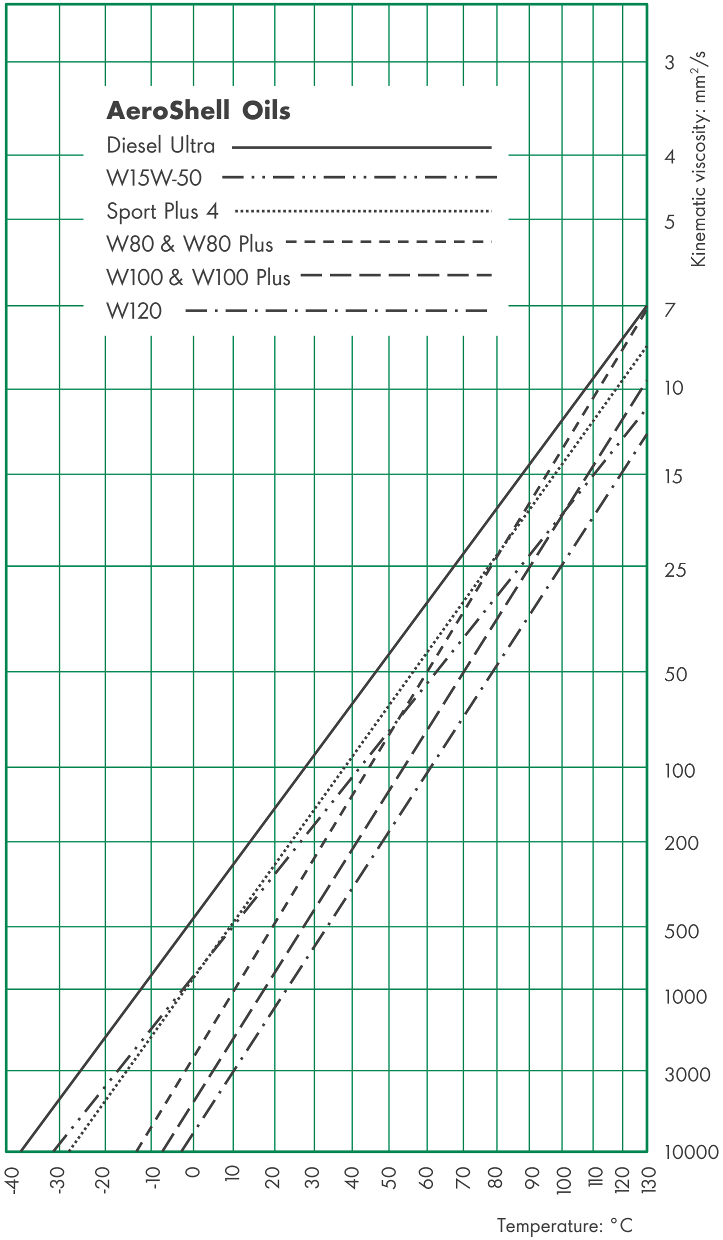
No Aviation specifications yet defined.

U.S.	-
British	-
French	-
Russian	-
NATO Code	-
Joint Service Designation	-
ACEA	Meets the requirements of A3/B4
API	Meets the requirements of SL/CF
Mercedes Benz	MB 229.5
SAE	Viscosity grade 5W-30

Typical Properties		**Diesel Ultra**
SAE viscosity grade		Multigrade 5W-30
Density @ 15 °C (59 °F)	kg/m^3	850
Kinematic viscosity @ 100 °C (212 °F) @ 40 °C (104 °F)	mm^2/s	 12.0 68.2
Pourpoint	°C (°F)	–39 (–38)
Flashpoint	°C (°F)	215 (419)
Dynamic viscosity @ –30 °C (–22 °F)	mPaS	 6043

A viscosity/temperature chart is shown at the end of this section.

TYPICAL TEMPERATURE/VISCOSITY CURVES OF AEROSHELL OILS



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