From Shell Oil Company

Engine Break In

This article is on the Shell website here- https://www.shell.com/business-customers/aviation/aeroshell/knowledge-centre /technical-talk/techart08-30071255.html

All of this advice is equally applicable to Lycoming or Continental horizontally opposed engines, but pilots should also ensure that they refer to Lycoming Service Instruction 1014 and TCM Service Information Letter 99-2 respectively for specific information about oil selection specific to your engine.

If your engine has recently been overhauled, or is new, then you should "Break-In" your engine using straight mineral oils.

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 obviously 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 groves 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 groves 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.

So what does this mean for the pilot?

Use a good quality Straight Oil, such as AeroShell Oil 80 or AeroShell Oil 100, 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 480D

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 CHT's 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 perfectly 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 - 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 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.

I normally advise therefore, that there is less risk carrying on with a straight oil for more that 50 hours if you're 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.