Australian Government
Civil Aviation Safety Authority

AIRWORTHINESS BULLETIN

Piston Engine Oil & Filter Element - Inspection

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1. Applicability

All aircraft piston engines - particularly those equipped with “disposable” or “spin-on” oil filtration “paper” element cartridges.

2. Purpose

Advise all aircraft owners, operators and maintenance personnel to cut open the canister of disposable oil filters and examine the element and to emphasise the importance of thorough oil filter element inspections and proper evaluation of filter debris to assist in the determination of engine serviceability and need for corrective action.

3. Background

Clean engine oil is fundamental to engine durability and reliability in operation. The engine oil system cools, reduces friction between moving parts and flushes potentially harmful wear particles away from contacting surfaces as it circulates through the engine. As it does so, the oil becomes increasingly contaminated. The engine oil filters help reduce wear by collecting these harmful particles from the oil.

Many light aircraft piston engines are equipped with simple oil screens – usually a fairly coarse mesh screen on the suction side of the oil pump and a much larger and finer screen on the pressure side of the oil pump. Micronic paper “spin-on” filter elements have proved quite effective in maintaining cleaner oil via much improved oil filtration and the increased ability to provide early clues to the internal health of the engine - and of impending failure.

Many SDRs received by CASA demonstrate that a potential in-flight engine failure has been avoided by early detection of adverse internal wear or damage by careful examination of the oil and oil filter contents. Recent reports, however, indicate that some operators/maintainers may be either failing to look for metal debris in the screens and filter, or failing to properly evaluate what was found at the oil filter inspection immediately prior to catastrophic engine failure.

In addition to regular oil filter analysis, some manufacturers recommend that operators use spectrographic means to analyse the oil to monitor trends in minute levels of brass, bronze, aluminium, steel and silicone, etc. Whilst particulate in the sub-microscopic to microscopic range is undetectable during a visual inspection of the filter element contents, this analysis method is a valuable tool for monitoring the health of piston engines where available.

1. Check the Draining Oil

Run the engine to ensure the oil is warm enough to permit rapid draining. When the sump plug is first opened, note if any water comes out first. Condensation in any engine promotes corrosion. Any inspection of the lubrication system during periodic oil and filter changes should include a basic visual check of the oil colour as it drains from the engine. If the oil colour is “black” it may indicate that the engine is overheating, has worn valve guides, worn rings allowing blow by, or that the oil change frequency is inadequate for the type of operation. Black looking oil may be accompanied by many flakes of carbon in the filters, particularly during the latter stages of engine life. Ideally the oil should have a light brown appearance.

Not all the metal debris that an engine may produce during operation is caught by the filter. Large metal parts, such as a gear tooth, are screened out of the oil at the inlet screen of the oil pump and may remain at the filter screen and/or in the sump or oil tank. When hot oil is drained, metal and other fragments in the sump can be carried to the drain plug as the oil drains from the engine sump. It is good practice to drain the oil through a mesh or screen as it comes from the engine to find any lumps that might otherwise pass un-noticed into the bucket and into the re-cycling drum.

2. Inspecting filters

Both the suction and pressure filters should be inspected. Due to the pleated design of micronic paper cartridge pressure filters, most of the contaminants are deposited on the surface and deep within the folds of the element. The oil filter container housing the element should be cut open so that the element can be withdrawn and the pleats unfolded and closely examined. The inside of the canister should also be examined for metal particles, using a strong light source, preferably sunlight.

Volume of debris

Probably the most important factor to consider, besides finding something like a gear tooth or other identifiable engine fragment in the oil, is the volume of metallic debris found in the filters. A satisfactory evaluation of the volume of metallic debris can only be completed when the contents of the suction and pressure filters, plus anything caught during the oil drain, has all been carefully collected and combined.

For example, a typical four or six cylinder engine; one manufacturer stipulates that if one quarter (¼) of a teaspoon or more of non-magnetic plating material which may have copperish tint, being 1/16th of an inch in diameter; or one quarter (¼) of a teaspoon non-magnetic metal with a brass or copperish colour resembling coarse sand in consistency - is discovered during any single oil and filter inspection, it is reason to ground the aircraft and investigate the engine further. In fact, anytime 1/2 teaspoonful or more of metal is found in the filter, it is justification for engine removal.

In order to collect as much debris as practicable, some maintainers place the paper element in a container with a quantity of solvent in order to gently agitate and flush contamination from the filter. This technique helps retrieve both large and small particles - down to the size of very fine grains and fretting debris - from the element, which then collects as sludge in the bottom of the container.

Once the volume has been established, determine if the volume of debris (from all filters and screens) is increasing or decreasing. Such trends can only be established by knowing what the filters had in them at the last inspection. Any increase is a good reason to investigate further.

Types of debris

Filters trap a wide range of debris, not just metal and carbon. Examples of debris include:

Lint - from rag, as well as plastic, rubber or other particles which can quickly block internal engine oil passages and cooling jets and lead to engine failure.

Carbon - is brittle and usually breaks easily when pressed between your fingers. Carbon flakes are generated by oil breaking down under exposure to high heat or combustion flame and may indicate high cylinder head temperatures, worn valve guides or stuck or worn rings. Carbon flakes together with black oil and high oil consumption can be indications of an engine requiring overhaul.

Metal - Metallic particles are basically either magnetic or non-magnetic. Knowledge of the materials used in the construction of the engine and the way in which each of the various components interact with each other during engine operation is essential.

Magnetic metal particles typically come from piston rings, valve springs, gear teeth, cylinder walls, valve lifters, cam shaft and cam followers, the crankshaft and connecting rods.

Non-magnetic metallic materials (apart from carbon) are usually shed by pistons, various metals used in main crankshaft bearings, connecting rod big-end bearings and small end bushes, back gear bushes, valve guides and crank-case material and may be bronze, brass aluminium, or copper coatings.

Appearance, shape and size of the metallic fragments can be another key to understanding if the filters hold normal wear particles or some other trauma has - and is - producing the debris. Typical terms used to describe the debris include “Flakes”- flat or slightly curved pieces of metal, often looking as if they have been hammered flat. “Fragments” - broken pieces of metal. “Grains”- contamination having the appearance similar to grains of sand. “Slivers” - Long thin needle-like pieces of metal. “Shavings” – appearance of drilling or machining swarf “Paste” – some modes of wear between sliding surfaces or fretting between crankcase halves produces particles so fine that when the filter is gently agitated in the solvent the very fine particles collect as sediment in the container and appears as a “paste” on the fingers.

3. Typical Filter assessments

In the absence of any other data, the following could act as a general guideline. However, each engine type must be considered and assessed on its individual merit. There are many factors that should be considered when inspecting the engine oil filters.

In the case of a newly installed engine, the filter may contain debris from a previous engine failure. Inadequate flushing of oil lines, cooler and supply tanks may result in debris appearing in the filter of a serviceable engine.

New or newly overhauled engines

Small amounts of shiny non-magnetic flakes or small amounts of short hair-like fragments of magnetic material are not uncommon in the oil screens or filters of a new or newly overhauled engine. If there are no other signs of engine distress or history of RPM exceedance, etc. and the volume of debris is low, then it is likely that after about 25 hours of operating time, the metal content should decrease rapidly to a level essentially consistent with normal wear patterns.

Engines in Service

Normal engine operation will continually produce wear particulate from bearings, rings, gears and camshaft etc. When the appearance of the debris changes or the volume of metallic filter debris increases, but remains well below that which would require further investigation or engine removal, consider reducing the oil and filter change intervals in order to more closely monitor the serviceability of the engine.

Continually monitor manufacturer's information such as Service Bulletins and Airworthiness Directives, because a small amount of a certain or specific type of filter contamination may require immediate removal of the engine. Other options to determine engine serviceability usually include an internal investigation of the engine using a borescope (for example) to inspect cylinders, camshaft, lifters, back gears etc.

If no anomalies are found and in the absence of the evidence of a history, for example, of high oil consumption, operating with low oil quantities, engine RPM exceedance or other trauma such a propeller strike, flight through volcanic ash, etc., consider conducting engine ground-runs and re-inspecting the filters. Based on these results, consider either removing the engine from service or possibly more frequent oil and filter changes and close monitoring of the filter debris to detect any trends.

Clues

A mixture of small chunks of magnetic and non-magnetic material often indicates valve, ring or piston failure. Large amounts of non-magnetic material may indicate bearings spinning in the case or piston pin plugs failing. Magnetic paste may indicate camshaft and/or cam follower wear or rust from corroded cylinder barrels. Non-magnetic "paste" may indicate crankcase or other component fretting.

Many types of contamination raise the possibility of oil passages being blocked leading to oil starvation and possible engine seizure. There are other components such as the propeller governor and turbocharger controls which are particularly susceptible to oil contamination and may malfunction or become jammed, sticky in operation, blocked or wear due to oil contamination.

Disclaimer

It is important to note that the information contained in this AWB is of an advisory nature only. The foregoing should not be used as the sole basis for releasing an engine to service. If in any doubt, contact the technical representative for the engine manufacturer or withdraw the engine from service and conduct an investigation prior to further flight to determine serviceability.

Pilot Maintenance

Assessing engine oil filter contents as a basis for continued operation is a complex process. While CASA Schedule 8 allows a pilot entitled to carry out maintenance under 42ZC(4), which includes oil and oil filter changes, CASA recommends that the assessment of the debris in the engine oil filters to determine the continuing airworthiness of the engine should only be carried out by suitably qualified and trained personnel.

4. References

(a) Teledyne Continental Motors Service Information Letter (SIL) 99-2B or later revision

(b) FAA AD 80-04-03 R2 (or later revision). This AD is applicable to Lycoming 0-320-H and 0-360-E, LO-360-E, TO-360-E and LTO-360-E Series engines. Equivalent information relative to the use of oil additive P/N LW-16702 in other Lycoming series engines, can be found in Service Bulletin (SB) 471B and Service Instruction (SI) 1409C.

(c) Lycoming Special Service Publication SSP-885-1 titled "Engine Mounted Oil Filter Kits and Replacement Filters".

(d) CASA CAAP 42ZC-1(2) Schedule 8 of CAR 1988 – the Pilot Maintenance Schedule – guidance for pilots and Part 66 licence holders.

(e) Teledyne Continental Service Information Directive (SID) 97-2B.

(f) Lycoming Service Bulletin (SB) 480E “Oil filter Change / Oil filter Content Inspection”.

(g) Lycoming Service Instruction No. 1530 Engine Inspection in Particulate laden environments (Volcanic Ash, Sand, Dust, Airborne Debris).

(h) Lycoming Service Instruction No. 1492D (or later revision) Piston Pin Plug Wear inspection.

(i) Lycoming Service Letter No. L171 Spectrometric Oil Analysis

5. Recommendations

CASA recommends that;

1. All piston engine oil filters be examined closely at each oil change to determine engine serviceability.

2. Prior to discarding any used piston engine oil system filter element or spin-on cartridge, it should be opened up and the element inspected to permit examination and assessment of any contamination which may indicate adverse wear.

3. Evidence of excessive metal contamination found in the oil or any filter element justifies immediate further internal examination of the engine to determine the cause before continuing operation.

4. The assessment of the contents of the filter to determine the on-going serviceability of the engine should be carried out by suitably qualified and trained personnel.

6. Enquiries

Enquiries with regard to the content of this Airworthiness Bulletin should be made via the direct link e-mail address:

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or in writing, to:

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