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PISTON ENGINES – BEYOND TBO

Does AD/Eng/4 suggest that the application of Appendix 'A' is all that is needed to enable a piston engine, when fitted to an aeroplane, to safely go beyond TBO? Experienced LAMEs will tell you that applying the Appendix 'A' criterion alone will not assure that the engine will safely operate past TBO. Maybe it is time to take a step back and look at what should be considered before carrying out the AD Appendix 'A' checks to enable continued operation beyond TBO. This paper will also review whether there really is a need for this AD?

There comes a time in the life of every piston engine when it must be overhauled. There is no exception to this rule; therefore the AD Appendix A does not eliminate the need for an engine overhaul. These requirements are a means to extend the useful life of an engine without compromising safety to the point where routine maintenance can no longer ensure the continued safe operation of the engine and overhaul becomes necessary. These requirements consist of repetitive inspections to determine the engine condition so that it can be removed from service prior to failure. The concept of allowing engines to go beyond manufacturer's 'recommended' TBO is not to operate the engine till it fails.

There are many factors that affect the wear of a piston engine including the utilisation per month, the efficiency of the air filter, the techniques used by the pilot in engine management particularly during start up & shut down, the atmospheric operational conditions, the types of operations – e.g. lengths of flights, the types of oil and fuel used, maintenance, the storage condition of the aircraft during low utilisation periods, etc.

Manufacturer's "recommended" overhaul periods are not mandatory hard time Airworthiness Limitation. Reviewing the manufacturer's "recommended" periods that they have promulgated find that they are obviously based on an analytic annual utilisation rate. Utilising a common engine manufacturer's 12 year calendar 'recommended' overhaul period and a 2000 hour 'recommended' overhaul period, whichever comes first, provides the foundation of a basic utilisation rate. The manufacturer is basing these "recommendations" on the engine being operated for around 15 hours per month. This monthly utilisation rate is important in keeping any piston engine operating safely and if met, would help justify putting an engine on an "on-condition" maintenance program to go beyond TBO. Under some regulatory systems, figures up to 40 hours a month are recommended before an engine can be operated under an on-condition maintenance program to extend beyond manufacturer's recommended TBO.

The manufacturers "recommend" the overhaul periods simply because it is a safe guide that they know their engines will meet if operated correctly. If the aircraft is being commercially operated on a weekly basis, they should be able to be operated under an approved "on-condition" program beyond TBO as they are in North America and many other countries. These programs are all based on a higher monthly utilisation rate than 15 hours.

Using US data to support the 'on-condition' debate from the private operator's point of view is a problem as US private aircraft utilisation is still just over 100 hours per annum whilst Australia's private aircraft utilisation rate is now below 30 hours per annum. Any privately owned aircraft with such a low utilisation should not exceed the overhaul periods (hours or calendar) unless it has been stored correctly, had long monthly engine runs or having the engine properly inhibited and regularly inspected during the inhibited period, or being internally inspected. This low utilisation rate raises the risks as aircraft, in general, need to be regularly flown to remain reliable. Many engines have successfully exceeded the recommended hours but few go beyond the calendar period due to low utilisation unless they have an internal inspection (old top overhaul) at around 75% of the overhaul period.

Although it is possible to identify engine degradation in many areas of the engine, there are some potential failure modes (e.g. crankshaft cracking, counterweight wear) for which predictive checks would not be effective without engine disassembly. For these reasons, the overhaul period extensions should not be applied unless adequate in-service reliability has been demonstrated, particularly in relation to failures which cannot be prevented by on-wing inspection.

It is also correct that you may place yourself in legal jeopardy with respect to liability if you operate beyond TBO. Engines may be operated well beyond TBO safely, but if you do have a failure and damage the aircraft, or hurt yourself or passengers or persons or property on the ground, you're going to have to defend your decision to operate beyond TBO. When an opposing barrister or prosecutor holds you against the standard of a manufacturer overhaul recommendation and paints you as one who elected to operate beyond that threshold, you may find yourself in an unwinnable situation. You may find yourself held criminally negligent, civilly liable, and without insurance coverage. It's a very real concern.

So what are some of the things that should be considered so the engine can go beyond TBO? Let's take into consideration some of the information that is available on the **www** promulgated by those that support 'on-condition' engine maintenance beyond TBO as long as the engine meets certain criterion.

Is the aircraft flown often?

- When piston engines sit idle for more than a week, much of the oil film that coats internal parts drains back into the sump.
- The thin film that remains does not provide enough of a barrier to stop rust formation on the ferrous parts of your engine.
- On highly polished surfaces like cam lobes, followers and lifter bodies, the oil film thins out even faster.
- Once rust starts, pitting soon follows and polished parts are the least able to withstand pitting.
- The microscopic pitting causes spalling and that always results in expensive repairs.
- Engines that do not operate for more than a month should be put in long term storage (inhibited)

How many oil changes?

- Oil that sits without regular engine runs never gets a chance to boil off the moisture it absorbs during our humid months of the year. This moisture, combined with combustion by-products, forms very corrosive acids. High time engines or engines with low compression are especially prone to the accumulation of these acids because of blow-by.
- Over time, these acids eat away at critical surfaces, especially cam lobes and lifter bodies causing pitting and spalling. Once those surfaces are pitted they lose their ability to withstand the intense compressive loads placed on them when the engine is running and they fail long before you make TBO.
- Every engine manufacturer publishes Service Bulletins which require oil changes be based not only on hours, but on calendar time as well. Oil should never sit in your engine for more than 4 months (120 days), even if it's clean looking and has very few hours on it.
- Change oil at a minimum 50 hours if your engine has a filter, 25 hours if it doesn't and if you fly less than 100 hours a year, make sure that you do at least 3 oil changes in that year, irrespective of hours.

Have thermal cycles been avoided?

- It's not hours that wear out your engine, it's thermal cycles. If you ran your engine 24x7 on a test stand, it could quite easily go 6000 or 7000 hours. Metal stress induced by thermal cycles is what causes engines to wear prematurely.
- The act of starting, especially when cold, takes more life out of your engine than many hours of running, so avoid starts whenever you can.
- If you need to move your aeroplane only a few feet, use the towbar rather than taxi it. And, since starting a warm engine causes significantly less wear than starting a cold one, consider re-fuelling after your flight, rather than before.
- Full fuel tanks are also less likely to take on water from condensation between flights.
- Too rapid cooling can be a significant factor in valve sticking. Like all aspects of flying, your throttle management should be smooth. Gradually reduce power and plan your descents so you never have to descend with a closed or almost closed throttle.

Are the engine baffles in tip-top shape?

- Air leaks around baffles mean your cylinders aren't getting all the cooling they should, nor are they getting even cooling.
- To check your baffles, shine a strong light in the back side (behind the baffles) of the engine and look through the front for light leaks. Wherever you see light, you're seeing an air leak.
- We know from long experience that cylinders that run hot almost never make TBO. Ask a LAME to check the baffles for you; it only takes a few minutes.
- Cool running cylinders are also less prone to valve wear, valve sticking, detonation and all kinds of other life sucking engine problems.
- Consider installing a modern, all cylinders, engine monitor to really keep track of what your engine is doing. Once you do, you'll wonder how you ever flew without one.

Over priming when starting

- Don't over prime when starting. Lycoming engines are especially prone to problems when over primed.
- Over priming can wash the lubricating film from cylinder walls causing metal to scrape on metal at startup.
- The resulting wear on cylinders and piston rings eventually leads to low compression, which can only be cured by an expensive cylinder replacement or overhaul.

Engines restricted from extensions by some NAAs

Some EASA NAAs have clearly stated the following engine types have yet to accumulate sufficient service experience to demonstrate acceptable reliability when operating at the manufacturer's recommended overhaul period.

The provisions of their requirements are not applicable to:

- Societe de Motorisations Aeronautique — All types
- Rotax — All types
- Thielert Centurion Engines — All types
- Mid-West Engines — All types
- Rotary Engines – All types
- Diesel Engines – All types

Does the engine provide performance power?

In reality, before any engine is considered to operate beyond manufacturer's recommended overhaul period (hours or calendar) **then an engine performance power check should be carried out in accordance with the manufacturer's recommendations or a satisfactory timed power climb against the Aircraft's Flight Manual figures**.

CASA's review of AD/Eng/4?

Why does the AD restrict engine operations beyond manufacturer's recommended TBO to engines fitted in an aeroplane instead, as many other NAAs do, apply the 'on-condition' maintenance requirements to extend beyond the manufacturer's TBO to all engines irrespective to whether the engine is fitted to an aircraft or rotorcraft?

- This is a prerogative of CASA as other NAAs, including the FAA for Part 91 operations, include all aircraft.
- We expect CASA to follow whatever EASA decides under EASA Notice of Proposed Amendment (NPA) No 2011-15, '*Non-binding guidance on TBO limits'* that they promulgated in September 2011. Some EASA NAAs restrict this ability to privately operated aircraft with a MTOW of 2730 Kg or below. EASA states:
    - The lack of harmonisation among different European authorities for the management of TBOs extensions of the components (engine) installed in aircraft not used in commercial air transport.
    - Maintenance organisations overhauling components (engine) will certainly lose revenues derived from components overhauls.
    - Other maintenance organisations, independent certifying staff and CAMOs may be slightly positively impacted since they may gain some activity because of the inspections required for the overhaul extension.
- AMROBA asks, "Why aren't the provisions of FAR Part 91 applied to FAA certified engines?"

Is the AD required?

AMROBA, based on its research does not see why the AD is required – it is not addressing a known safety issue.

- To continue to provide the appropriate guidance, CASA only needs to promulgate guidance in the same manner as many other NAAs.
- CAO100.5 requires Airworthiness Limitations (AWL) to be complied with as do other NAAs.
- Engines included in any AWL as a hard time period (not recommended) cannot be 'on-condition'.
- Like FAR Parts 121 & 135, Air Transport AOC aircraft have an 'approved' maintenance program that can include a documented extension beyond TBO.

The simplest method for CASA is to cancel the AD and treat these engines as they are under the system which they are certified under. CA(S)Rs do not mandate engine overhaul periods but CAO100.5 state that AWLs must be followed.

- Most engine manufacturer service publications that govern overhaul times use the term **recommended.** This is an important term to understand. In the US the term recommended to a FAR part 135 operator means "mandatory" and to the FAR part 91 operators it is more advisory in nature.
- Engines that have been certified under FAR part 33 are required to have instructions for continued airworthiness. Often in these instructions, rather than listing overhaul times, if will list inspection times. In order to keep the engine in compliance of instructions for continued airworthiness, you must do these inspections, they are mandatory under any operation.
- Engines certified before the advent of FAR part 33, may not have specific instructions for continued airworthiness but the listed inspections such as hot section, water immersion or sudden stoppage are considered mandatory. There is really no practical way around the term inspection. Inspections must be done!

The continued operation of piston engines "on-condition" is supported provided that the regulatory guidance provides the clarity for those performing the checks and inspections necessary to keep engine in a safe condition of operation.

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