Australian Government
Civil Aviation Safety Authority

AIRWORTHINESS BULLETIN

AWB 85-024 Issue 1 – 2 August 2018

Piston Engine Exhaust Valve and Valve Guide Distress

1. Effectivity

All spark ignited aviation gasoline (AVGAS) reciprocating engines. The condition identified in this AWB may exist or could develop in any aircraft exposed to the described operational conditions.

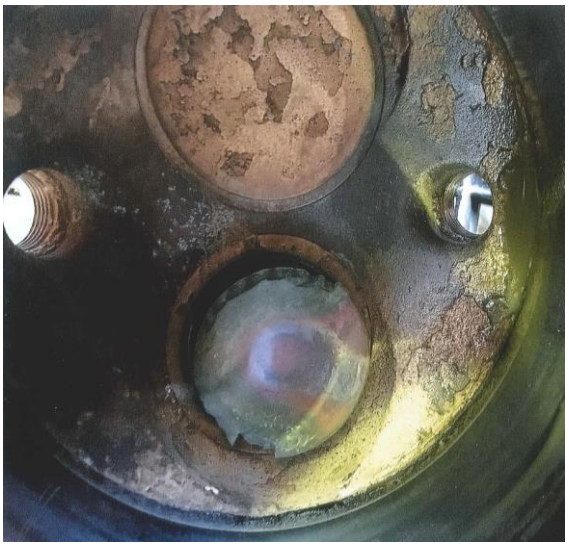
Direct Population - Lycoming O-320, O-360 and O-540 series engines or their fuel injected variants installed in Robinson R22 and R44 Helicopter Models located in the northern regions of Australia, conducting Heli Mustering operations.

2. Purpose

To advise owners, registered operators, pilots, maintenance organisations and Licensed Aircraft Maintenance Engineers of the increasing incidence of premature exhaust valve and valve guide wear, due to elevated combustion temperatures that will lead to degraded engine performance.

A failure to observe or ignoring adverse indications or unusual behaviour of the engine may result in the situation developing to a point where cracks or large chips can form around the edge of the valve face or cause the valve head to separate from the stem with sudden and complete loss of cylinder compression and partial or complete engine failure.

The content and scope of this document is based on preliminary investigation findings and may be updated as additional information becomes available.



Images of Exhaust Valve Seat Degradation and Valve Chipping

3. Background

Industry participants are seeing a significant increase in incidence of premature engine cylinder removals due to exhaust valve and valve guide wear, predominantly affecting Heli Mustering operations across the northern regions of Australia.

In several cases cylinder changes have occurred within the first 100 hourly inspection due to failed compression testing.

It has been widely theorised that changes in AVGAS grade, has caused the described problem when aircraft operations are conducted in high Outside Air Temperature (OAT) environments. However, at this time it has not been conclusively determined that changes in the fuel composition is the source of the engine problems.

A clear understanding of all potential causative factors needs to be established before any solutions can be recommended.

An investigative stakeholder group has been formed with representation from Lycoming as the primary affected engine manufacturer, Viva Energy Australia as the primary fuel supplier and the Australian Helicopter Industry Association, together with a number of prominent affected operators and maintainers in QLD and NT.

It should be noted at this point that the described problem is not limited to Lycoming products, as cylinders fitted with PMA parts have also failed in similar circumstances, with Continental engines installed in fixed wing aircraft also having similar occurrences.

4. References

CASA AWB 85-023 Issue 2 - Piston Engine Spark Plug Insulator Cracking - provides related information regarding engine maintenance and combustion chamber deterioration.

5. Recommendations

Air cooling alone, may be insufficient to adequately cool all cylinder components in some elevated temperature operating environments.

Exhaust valve longevity is predicated on having precise contact between the valve seat and face, and a good fit between the valve stem and guide. Exhaust valves that do not seat properly are unable to dissipate heat effectively, leading to premature guide wear, with the first indication usually being an asymmetric pattern of deposits on the valve face.

The durability of the exhaust valve and guide may be influenced by the following;

A. Use of an inappropriate or non-qualified fuel

The risk to the integrity of AVGAS in relation to being fit for purpose can occur at any point in the supply chain from the point of manufacture to final delivery to the aircraft, thus creating the potential to adversely affect aircraft systems and components.

Fuel suppliers need to verify that all product supplied to the market complies with Defence Standard 91-090 AVGAS and has been manufactured, stored and handled in compliance with Energy Institute 1530 aviation fuel quality system compliant supply chains to control contamination risks. Once the product leaves oil industry bulk storage locations and managed supply chains, testing for potential degradation or contamination is dependent on locally adopted standards and knowledge.

It is therefore of fundamental importance that every responsible organisation involved in AVGAS manufacture, supply, storage, transport, uplift and use has such systems in place in order to assure that the fuel is fully traceable, and is preserved such that it continues to meet the requirements of the appropriate specification and end user purpose, whilst in its custody and/or its control.

The following elements need to be considered and addressed accordingly:

1. The fuel product being received is from an organisation that can demonstrate that all product supplied is compliant with the above referenced Standards.
2. Documents provided by fuel suppliers show the product traceability and integrity of each batch and that these documents are maintained.
3. The design, construction and condition of customer storage and delivery tanks are verified as appropriate. Tanks are effectively identified, segregated and dedicated to maintaining fuel integrity and preventing cross-contamination. Tanks also need to be water drained on a regular basis to maintain fuel integrity and reduce risk of water carryover to aircraft.
4. Ancillary equipment (filter systems etc.) meet appropriate specifications and are adequately checked and maintained to assure the delivery of clean uncontaminated fuel.
5. Fuel turnover is such that evaporative losses or heat induced degradation is kept to a minimum. Fuel held in tank storage for over 180 days without a receipt or drums over 12 months from fill date should be retested by a recognised laboratory accredited to ISO 17025 for aviation fuel testing.

B. Uneven or insufficient cylinder cooling

A 500°F red line Cylinder Head Temperature (CHT) is meaningless if the exhaust valve and guide can be destroyed at a lower temperature. The

current experience demonstrates that it is, in fact, possible to operate the cylinder within the allowable CHT range and yet have destructive heat loads imposed on the exhaust valve and guide.

Heat is the enemy of valve guides. Unfortunately, even a cylinder displaying a moderate CHT, can be suffering accelerated valve guide wear. It may also be that the exhaust valve guide is potentially operating much hotter than the indicated CHT. Be mindful that a single probe CHT may not be indicative of all cylinders nor even and consistent cooling of the entire cylinder.

1. During high ambient air temperature operations ensure that the engine cool-down period is adequate and provides a positive indication of a drop in the CHT with an appropriate margin to prevent thermal runaway, if flight operations are to continue. Be aware that there is a cumulative effect of high CHT's on cylinder assembly materials.
2. If we accept that the thermal design of the cylinder head is fine, then the cooling system may not be providing sufficient air through the normal flow paths to adequately carry away excess heat. An assessment of the cylinder and oil cooling system should be undertaken to optimise performance and cooling efficiency. Check integrity of inter-cylinder baffles, perimeter baffles, cowl and shroud seals, cooling ducts, and any other seals or areas that direct or control airflow, as applicable.

C. Instrument Calibration

To ensure the engine is operating within recommended limits for normal operation, check the accuracy of the aircraft engine gauges, including the tachometer, manifold pressure, fuel flow, fuel pressure, oil pressure, oil temperature, CHT, exhaust gas temperature (EGT) and turbine inlet temperature (TIT), as applicable.

D. Fuel Flow

Ensure proper fuel system setup and operation in accordance with the aircraft maintenance manual and engine manufacturers service instructions. Check that the fuel flow rate (lbs/hr) is appropriate. As a guide fuel flow is in an acceptable range at approximately 0.55-0.58 lbs/hp/hr.

E. Maintenance Regime

Strict adherence to aircraft operational limitations, the aircraft and engine manufacturer's maintenance schedule together with associated instructions for continuing airworthiness is essential for optimum performance and longevity of the engine.

1. Assess engine air induction system for properly sealed filters and air ducts in addition to an appropriate clean and replacement regime, based on operating environment.

2. Ensure oil type and grade is appropriate for the operating environment. Approved higher viscosity oils should be considered during periods of elevated ambient air temperatures.
3. Engine Condition Monitoring
    a) Regular Borescope Inspection - Enables timely and direct visual inspection of the combustion chamber, including the valves, cylinder head, cylinder barrel, and piston crown. The borescope permits a quick, inexpensive, unambiguous determination of whether the exhaust valve is healthy.
    b) Spectrographic Oil Analysis - can provide a line of defence and an early warning of exhaust valve seat degradation caused by accelerated valve guide wear. Exhaust valve guides are made of a high-nickel alloy, so accelerated guide wear will show up in oil analysis as increased nickel.
    c) Enhanced Engine Monitoring - Digital engine monitoring provides a further line of defence against exhaust valve failures by displaying and recording per-cylinder EGT and CHT data and often numerous other parameters. The engine monitor's compelling advantage is that it monitors the engine continuously and doesn't need to be scheduled unlike interrogative maintenance activities.

6. Reporting

Report all instances of premature exhaust valve and guide wear to CASA via the DRS system available on the CASA website. Details of the maintenance history for the engine should be provided in addition to information concerning the method of failure detection, the location and condition of the defective parts.

Where possible, flight ops. parameters should also be reported i.e. OAT, RPM, MAP, CHT, Oil Temp, Est. Fuel Burn (lbs/hr) together with any other information on possible triggers for the reported event. This information will facilitate a detailed review of potential failure causes and contributing factors.

7. Enquiries

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

AirworthinessBulletin@casa.gov.au

or in writing, to:

Airworthiness and Engineering Branch
Aviation Group
Civil Aviation Safety Authority
GPO Box 2005, Canberra, ACT, 2601