Australian Government
Australian Transport Safety Bureau

Engine failure involving Gippsland Aeronautics GA-8, VH-AJZ

135 km NNE of Marree, South Australia | 29 September 2011

Investigation

ATSB Transport Safety Report
Aviation Occurrence Investigation
AO-2011-125
Final – 18 March 2013

Australian Government

Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY REPORT

Aviation Occurrence Investigation

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SAFETY SUMMARY

What happened

On 29 September 2011 at 1240 Central Standard Time, a Gippsland Aeronautics GA-8 Airvan, registered VH-AJZ, departed Marree, South Australia with one pilot and six passengers for a scenic charter flight over Lake Eyre and surrounding regions. About 45 minutes after takeoff and while flying at a height of about 500 ft above ground level the pilot felt a shudder through the airframe, then heard a loud pop and the propeller stopped. The pilot carried out a successful forced landing on the Birdsville Track, approximately 135 km north-north-east of Marree.

What the ATSB found

The No. 5 piston of the aircraft's single engine sustained a fatigue failure, resulting in severe mechanical damage that stopped the engine. The engine's oil system was contaminated by metal chipping (spalling) from the bodies of two tappets because of contact fatigue to the tappets. This increased the risk of abnormal wear and failure of pistons and other engine components. The ATSB could not conclusively establish that this led to the piston failure, although similar failures in comparable engines had been attributed to that mechanism.

Although there was little warning to the pilot during flight of the impending engine failure, the operator had recently noted an abnormally high consumption of engine oil, which could have indicated poor engine condition. The oil consumption in fact exceeded the manufacturer's limits for continued operation, but was misinterpreted, when referred to the maintenance organisation, as falling within those limits.

Finally, there was severe spline wear on the engine-driven fuel pump (EDFP) drive which could, if undetected, have led to EDFP drive failure and sudden loss of fuel flow to the engine, although this did not contribute to the occurrence.

What has been done as a result

The engine manufacturer had previously introduced a factory-fitted roller tappet to reduce spalling. Subsequently, for engines not yet incorporating that modification, the manufacturer introduced a flat tappet with an improved bonded coating, providing a more resilient sliding surface.

The aircraft operator reviewed the circumstances of this occurrence and has improved their monitoring of engine operating data, including oil consumption.

Accelerated and abnormal EDFP spline wear in this engine type has been subject to ongoing study by the Civil Aviation Safety Authority (CASA). A number of failed EDFP shafts were examined by the ATSB in support of the CASA study.

Safety message

The investigation highlights the importance of operators monitoring and using engine oil consumption data as a diagnostic tool and of immediately investigating oil consumption figures that fall outside the manufacturer's acceptable limits. Also highlighted are the importance of the engine manufacturer's recommended oil filter inspections during scheduled maintenance and the associated guidance material when assessing any debris or contamination found.

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Engine failure involving Gippsland Aeronautics GA-8, VH-AJZ, 135 km NNE of Marree, South Australia, 29 September 2011

Prepared By

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THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The Bureau is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated. The terms the ATSB uses to refer to key safety and risk concepts are set out in the next section: Terminology Used in this Report.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB’s investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes appropriate, or to raise general awareness of important safety information in the industry. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

TERMINOLOGY USED IN THIS REPORT

Occurrence: accident or incident.

Safety factor: an event or condition that increases safety risk. In other words, it is something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence. Safety factors include the occurrence events (e.g. engine failure, signal passed at danger, grounding), individual actions (e.g. errors and violations), local conditions, current risk controls and organisational influences.

Contributing safety factor: a safety factor that, had it not occurred or existed at the time of an occurrence, then either: (a) the occurrence would probably not have occurred; or (b) the adverse consequences associated with the occurrence would probably not have occurred or have been as serious, or (c) another contributing safety factor would probably not have occurred or existed.

Other safety factor: a safety factor identified during an occurrence investigation which did not meet the definition of contributing safety factor but was still considered to be important to communicate in an investigation report in the interests of improved transport safety.

Other key finding: any finding, other than that associated with safety factors, considered important to include in an investigation report. Such findings may resolve ambiguity or controversy, describe possible scenarios or safety factors when firm safety factor findings were not able to be made, or note events or conditions which 'saved the day' or played an important role in reducing the risk associated with an occurrence.

Safety issue: a safety factor that (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operational environment at a specific point in time.

Risk level: the ATSB's assessment of the risk level associated with a safety issue is noted in the Findings section of the investigation report. It reflects the risk level as it existed at the time of the occurrence. That risk level may subsequently have been reduced as a result of safety actions taken by individuals or organisations during the course of an investigation.

Safety issues are broadly classified in terms of their level of risk as follows:

- **Critical** safety issue: associated with an intolerable level of risk and generally leading to the immediate issue of a safety recommendation unless corrective safety action has already been taken.
- **Significant** safety issue: associated with a risk level regarded as acceptable only if it is kept as low as reasonably practicable. The ATSB may issue a safety recommendation or a safety advisory notice if it assesses that further safety action may be practicable.
- **Minor** safety issue: associated with a broadly acceptable level of risk, although the ATSB may sometimes issue a safety advisory notice.

Safety action: the steps taken or proposed to be taken by a person, organisation or agency in response to a safety issue.

FACTUAL INFORMATION

History of the flight

On 29 September 2011 at 1240 Central Standard Time[1], a Gippsland Aeronautics GA-8 Airvan, registered VH-AJZ (AJZ), departed Marree, South Australia on a scenic charter flight over Lake Eyre and surrounding regions. One pilot and six passengers were on board the aircraft. The pilot climbed the aircraft to 3,500 ft above mean sea level (AMSL) and followed the standard company route. All engine indications and power settings were normal. About 55 NM (102 km) north-west of Marree, the pilot descended the aircraft to 500 ft above ground level (AGL) and flew the scenic route for a further 20 NM (37 km) before turning west towards Lake Eyre.

About 45 minutes after takeoff and at a height of about 500 ft AGL, the pilot felt a shudder through the airframe, heard a loud pop and the propeller stopped suddenly. The pilot carried out a forced landing on the Birdsville Track (Figure 1), approximately 135 km north-north-east of Marree.

Figure 1: VH-AJZ on the Birdsville Track

Photograph courtesy of the pilot in command

The pilot and passengers were not injured and the aircraft sustained no damage as a result of the forced landing. Inspection of the aircraft revealed engine oil pooling inside the lower engine cowls and covering the underside of the fuselage. Large cracks in the engine crankcase could be seen through the cowling and the propeller could not be rotated by hand (Figure 2).

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[1] Central Standard Time (CST) was Coordinated Universal Time +9.5 hours.

Figure 2: Cracks in the engine crankcase

The pilot made contact with Flightwatch[2] using high frequency (HF) radio and was instructed to activate the personal locator beacon[3] that was being carried on board the aircraft. The passengers were driven back to Marree that afternoon.

Aircraft information

The aircraft was manufactured in Australia in May 2006 and placed on the Australian aircraft register. Maintenance documentation indicated that, at the time of the occurrence, the aircraft's total time in service (TTIS) was 1,764.7 hours.

The aircraft was fitted with a fuel injected, horizontally-opposed, six-cylinder Textron Lycoming IO-540 K series engine. The engine was installed at aircraft manufacture and also had a TTIS of 1,764.7 hours.

The aircraft was maintained in accordance with the requirements of the manufacturer's maintenance data. The last 100-hourly inspection was completed on 5 September 2011 at 1,721.4 hours TTIS and a maintenance release[4] was issued in the charter operational category.

Maintenance records indicated the engine's oil, oil system suction screen and the paper element from the 'spin-on' type oil filter were inspected during that maintenance and 'nil contamination found'. The inspection was specified by the engine manufacturer as a mandatory service bulletin[5], for the purpose of identifying abnormal metal contamination of the lubrication system and to be used as a diagnostic tool.

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2 Flightwatch is a generic radio call-sign for the flight information service provided by Airservices Australia, providing pilots with on-request operational information.

3 A Personal Locator Beacon is a small, portable emergency locator beacon which can be carried on the person and manually activated.

4 Official document, issued by an authorised person, that is required to be carried on an aircraft as an ongoing record of its time in service (TIS) and airworthiness status. Subject to conditions, a maintenance release is valid for a set period, nominally 100 hours TIS or 12 months from issue.

5 Refer Lycoming Mandatory Service Bulletin 480E.

The operator had recently dry-leased AJZ and the aircraft was flown to Marree on 18 September 2011. On arrival, the aircraft's maintenance release recorded 26 hours operation and 8 quarts (qt)[6] of oil added to the engine since the 100-hourly inspection.

The engine manufacturer's maximum oil consumption for the IO-540 K series engine was 0.6 qt per engine operating hour (qt/hr) at 60%[7] power, 0.75 qt/hr at 75%[8] power and 1 qt/hr at 100% normal rated power. The operator typically operated the engine during cruise at 24 inches (in.) manifold pressure and 2,400 RPM and 25 in. manifold pressure and 2,500 RPM during the climb (the maximum continuous power as listed in the aircraft flight manual). The operator reported being unaware of the manufacturer's oil consumption limits.

Following its removal from the airframe, the engine was shipped to a Civil Aviation Safety Authority-approved engine overhaul facility for disassembly and examination under supervision of the Australian Transport Safety Bureau (ATSB). Additional technical examination was conducted by the ATSB in Canberra.

Engine examination

Examination of the engine found significant internal mechanical damage in the vicinity of the No. 5 and No. 6 cylinders, which were located at the rear of the engine. The No. 5 piston had separated from its connecting rod and was fractured in several places around the piston skirt and at the piston pin bore (Figures 3 and 4). Examination of the fracture surfaces found evidence of fatigue cracking originating at the pin bore and separately, through the piston adjacent to the groove of the oil control ring. The remaining damage to the piston was attributed to repeated impacts from the connecting rod and other circulating debris.

Figure 3: No. 5 piston within the cylinder barrel

6 One US qt equals 0.946 L.

7 60% power was listed by the engine manufacturer as 180 horsepower (hp) at 2,350 engine RPM.

8 75% power was listed by the engine manufacturer as 225 hp at 2,450 engine RPM.

Figure 4: No. 5 piston and cylinder, fatigue cracking arrowed

The No. 5 piston oil control ring and compression rings were fractured in several places and held in place by deformation to the ring grooves. Of these rings, impact damage to a number of the fracture surfaces precluded their examination. There was no evidence of progressive cracking or other defect on the undamaged fracture surfaces of the rings.

The camshaft had sustained impact damage and was fractured between the No. 5 inlet and exhaust camshaft lobes. Damage to the camshaft likely resulted from continued engine operation after separation of the connecting rod from the piston.

The installed tappets were the original cast iron tappet design (see the discussion in the section of this report titled *Engine tappet (cam follower) information*). Examination of the engine components found evidence of metal chipping (spalling) to two of the cast iron flat tappets (cam followers). The No. 3 exhaust tappet had fractured through the sliding contact surface (Figure 5). Significant amounts of hard facing material had been spalled from the camshaft lobe contact surface (Figure 6) and there was associated cracking and surface pitting. Spalling of the tappet surface was therefore likely the result of contact fatigue and the wear surface had then been rolled over the adjacent fracture surface by continued operation after the fracture. The No. 6 inlet tappet exhibited similar spalling damage to the hard facing of the sliding contact surface (Figure 7). There was no significant material difference between the tappets exhibiting spalling damage and others from the same engine. Microscopic examination of the undamaged tappets found minor surface pitting that was uniform across the surface, but with no significant loss of material.

Metallic material was found embedded in the engine’s bearings and there was evidence of heat distress on the corresponding crankshaft journals. Some gear teeth in the accessory gear train also exhibited hard facing damage, likely as a result of the circulating contaminants interfering in the gear mesh. The oil filter paper element contained a significant amount of small ferrous particles. There was evidence of overheating of the pistons and smearing of piston metal on the piston skirts. Several small, metallic particles of around 100 microns in diameter were found embedded in the surface of the piston pin bore and piston skirt. Analysis of these particles found that they were consistent with material from the spalled tappets.

Figure 5: Tappets, No. 3 cylinder (inlet left; exhaust right)

Figure 6: Exhaust camshaft lobe smearing, No. 3 cylinder

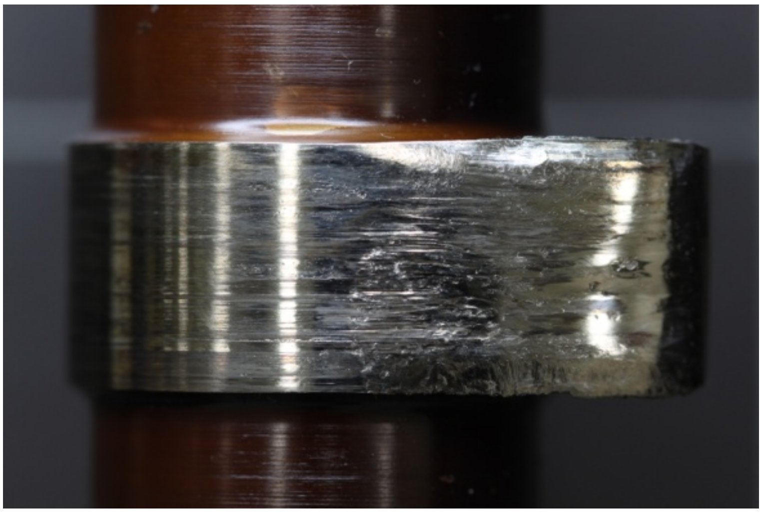

Figure 7: Inlet tappet's sliding contact surface, No. 6 cylinder

Organisational and management information

About 10 days after AJZ arrived in Marree, and in response to concern about the engine's high consumption of oil, the contracted maintenance organisation recommended the operator conduct a 1-hour evaluation flight at cruise power. That flight established the engine used about 0.75 qt/hr. The maintenance organisation was reported to have reviewed the results from that flight and assessed that the oil consumption was within the engine manufacturer's recommended limits and that additional investigation was not required at that time. The engine's oil consumption was attributed to the age of the engine, which was close to the engine manufacturer's recommended overhaul limit of 2,000 hours.

Pilots reported that all other engine operating parameters, such as oil temperature and pressure, cylinder head temperature and magneto drops[9] were normal. With this in mind, the operator and pilots continued to operate the aircraft while monitoring the engine oil consumption.

The operator used a computer spreadsheet to record the aircraft's flight hours and the quantity of fuel and oil used. The Chief Pilot was also the Head of Aircraft Airworthiness and Maintenance Control (HAAMC) and was based in Geelong, Victoria. The HAAMC was one of the key personnel required within a company in order to hold an Air Operator's Certificate (AOC). Amongst his other duties, the HAAMC was responsible for entering data from remotely-based pilots into the spreadsheet. The operator reported this data could be up to 1 week old when entered. The spreadsheet did not have any mechanism to alert the HAAMC of trending data exceeding any set limits, instead relying on that person's knowledge and ad hoc interpretation of the data. The September spreadsheet[10] recorded an average oil consumption of 0.93 qt/hr between 25 and 29 September 2011, which was outside the manufacturer's recommended limits for continued engine operation.

The previous operator of AJZ provided oil consumption data to the ATSB that had not been available to the occurrence operator. That data indicated an average consumption between:

- 16 March and 17 June 2011 of 0.509 qt/hr (99.6 hours total flight time)
- 30 June and 26 July 2011 of 0.519 qt/hr (93.7 hours total flight time)
- 3 August and 31 August 2011 of 0.584 qt/hr (99.5 hours total flight time)
- 7 September and 16 September 2011 of 0.356 qt/hr (17.8 hours total flight time).

Those recorded consumption figures fell within the engine manufacturer's acceptable limit.

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9 The pilot checked the operation of the magnetos during completion of the pre-take-off checklist. This check will detect faults in the aircraft's ignition system, including a faulty magneto, faulty magneto lead or a fouled spark plug.

10 This spreadsheet did not include the previous operator's figures for 7 to 16 September 2011, or the 8.2 flight hours accrued prior to the aircraft arriving in Marree.

Additional information

Engine tappet (cam follower) information

In an engine such as the IO-540, the tappet maintains contact with the corresponding camshaft lobe so that movement is transmitted through the tappet to the pushrod. In/out movement of the pushrod articulates the rocker arm about the rocker shaft such that the inlet and exhaust valves open or close in the cylinder head according to the particular stroke of the four-stroke engine. An hydraulic apparatus within each tappet body maintains continuity of the valve train. Tappets are subject to high contact stresses and repetitive stress cycles. Identified failure modes for these components include spalling as the consequence of inadequate lubrication and spalling as a consequence of corrosion of the ferrous tappet material.

As part of the engine manufacturer's continuous product improvement program, the original cast iron tappet was replaced by a tappet incorporating an improved hardened and bonded sliding surface. That enhancement was to reduce susceptibility to spalling of the hardened sliding surface, but in-service experience demonstrated that the tappet was still subject to spalling.

In October 2006 the manufacturer replaced the flat tappet bodies with 'roller' tappets, which were not vulnerable to spalling. Since that time, all factory new, rebuilt and overhauled engines have been upgraded to incorporate the roller tappet bodies. This did not include some turbocharged engines and other engines fitted with solid valve lifters.[11] The roller tappet modification was only available at the engine manufacturer's factory in the United States (US) and necessitated the return of an engine's core to the manufacturer. The engine manufacturer has reported significantly improved in-service reliability for the roller tappet design.

Also, as a continuing product improvement initiative for engines not equipped with roller tappets, in February 2012 the engine manufacturer introduced a further-enhanced flat tappet design that used a more resilient body material for improved wear qualities and an improved bonded coating on the flat sliding surface. That product addressed the spalling issues found with earlier flat tappet designs.

Other power loss occurrences

Engine manufacturer report of occurrences

The engine manufacturer reported conducting in-house examinations and technical inspections on damaged engines for the US National Transportation Safety Board and US Federal Aviation Administration. Those examinations were reported to have identified a typical mode for piston failure, which included metal particles from spalling tappets becoming embedded in the piston skirt and lodging between the piston pin end plugs. This contributed to accelerated wear and the development of 'slop' between the piston and piston pin. Those mechanisms could increase localised stresses and contribute to fatigue cracking, leading to rapid failure of the piston.

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11 Such as the Textron Lycoming '76' series engines.

The manufacturer also reported that an engine fitted to an Australian-registered Robinson R44 helicopter sustained a similar failure.

Australian occurrences

The ATSB occurrence database was reviewed for GA-8 Airvan engine-related (mechanical failure) occurrences between 1999 and 2012. The review identified a total of 7 forced landings as a consequence of total engine failure and 13 instances of abnormal engine operation that resulted in a precautionary landing/diversion during that period. In respect of the 13 reported instances of abnormal engine operation, nine involved failure of the engine-driven fuel pump (EDFP). Of those nine failures, eight occurred during 2011 and 2012 and six of these involved the same aircraft operator.

There was one accident as a consequence of an engine-related mechanical failure during the period 1999-2012, with minor injuries sustained by the pilot. In addition, there was one fatal accident during this period for which the wreckage was not located. This precluded the identification of any factors that may have contributed to the accident.[12]

Statistical data from the Bureau of Infrastructure, Transport and Regional Economics indicated a total of 117,171 hours were flown by the Australian GA-8 Airvan fleet during the period 1999-2010. At the time of publishing this report, statistical data was not available for 2011 and 2012.

Fuel pump anomaly

The engine logbooks recorded the following service history for the EDFP fitted to AJZ at the time of the occurrence:

- The pump was removed from the engine on 30 May 2011 and replaced with a different EDFP.
- On 3 August 2011, the pump was repaired and refitted to AJZ (about 99.5 operating hours prior to the incident). That repair did not include an assessment of the pump's drive spline wear.

Examination of the shaft and spline gear on the EDFP showed excessive and abnormal wear of the gear teeth but no evidence of cracking or other major defects. Witness marks from the mating gear were also present on the reverse (opposite to drive) side of its splines. The amount of material lost from the drive spline was evident by the rust-coloured dust covering the spline, shaft and surrounding surfaces. Those patterns were likely the result of fretting wear over an extended period of time, both pre and post the EDFP repair.

Figure 7 shows the spline gear removed from the pump and the additional wear/fracture on the load bearing surfaces.

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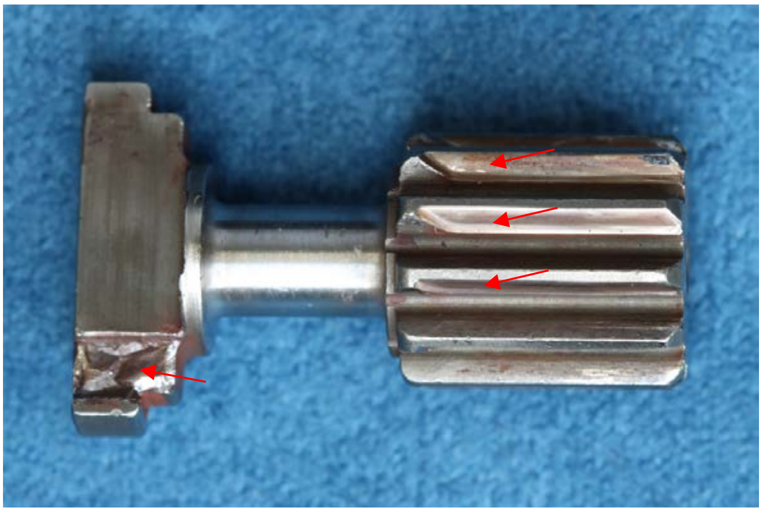
12 See http://www.atsb.gov.au/publications/investigation_reports/2008/aair/ao-2008-072.aspx.

Figure 7: Drive spline as removed from the EDFP – note abnormal wear (arrowed)



The Civil Aviation Safety Authority (CASA) has been monitoring the reliability of the EDFPs fitted to engines in the GA-8 Airvan. In addition, CASA provided three failed spline shafts to the ATSB for independent technical analysis. The results of that analysis were provided to CASA in November 2011 and were incorporated in CASA's ongoing work in respect of EDFP reliability in engines installed in the GA-8 Airvan.

At the time of writing this report, CASA was continuing to monitor EDFP failure rates in this series of engine model, including in those fitted to the GA-8 Airvan.

ANALYSIS

Introduction

The aircraft lost engine power as a consequence of significant internal mechanical damage that prevented the continued operation of the engine. This analysis will examine factors associated with that failure and the associated risk controls.

Engine failure

The sequence of internal engine damage began some time before the engine failure.

The spalling of the tappets was consistent with a progressive failure that resulted from contact fatigue. Given the similar metallurgy of the spalled and unspalled tappets, and the number of operating variables such as lubrication and applied stress to each tappet, no underlying condition was identified.

The introduction of new-specification tappets indicated that the engine manufacturer was aware of the spalling risk to this part number tappet and was managing that risk. It is worth noting, however, that the spalling risk was not treated by replacement until the engine was next overhauled. The aircraft's engine was fitted with the original model of cast iron tappet and had not incorporated the engine manufacturer's subsequent design improvements.

The fatigue cracking initiated in the No. 5 cylinder piston pin boss and had progressed to the extent that the piston fractured and broke away from the connecting rod. The connecting rod, still reciprocated by the crankshaft, further damaged the engine and all power was lost.

Elements of the engine failure, such as the tappet spalling and embedded material in the piston pin bore and skirt, were consistent with the failure mechanism identified during the engine manufacturer's analysis of previous similar engine failures. However, due to the damage sustained by the No. 5 piston, the Australian Transport Safety Bureau (ATSB) was unable to assess the extent to which spalled material from the tappets may have contributed to the fatigue fracture of the piston.

Operational considerations

When the engine failed, a dirt road was within the aircraft's gliding range and the pilot completed a safe forced landing. During this and previous flights the engine had operated normally and there was little warning to the pilot of the impending engine failure.

The pilots who had been operating the aircraft realised the oil consumption was abnormally high, but the maintenance organisation misinterpreted the maximum consumption applicable to the power setting used and did not specify any further action. It was possible that the maintenance organisation interpreted the high engine oil consumption as a symptom of engine wear, associated with the engine's time in service since new. Another factor in the decision making could have been the unavailability of maintenance support at the aircraft's operating base and the otherwise apparently normal engine operation. Had further investigation been carried out prior to the flight, it was likely that metal contamination from the spalling tappets would have been evident in the oil filter.

Engine condition monitoring is primarily carried out at scheduled maintenance inspections, but should not be limited to those inspections. An engine's oil consumption is a useful indicator of engine condition, as is the consumption trend across the life of the engine.

Filter inspection is an additional diagnostic tool in reciprocating engines to ensure continuing airworthiness, and scheduled engine oil filter inspections were noted in the aircraft's logbooks with 'nil defects evident'. It could be expected that in this instance, the spalling tappets would have resulted in some degree of filter contamination, indicating degraded engine condition. The investigation could not determine why metal was not found during the 50-hourly filter inspections immediately preceding the power loss.

Civil Aviation Safety Authority (CASA) Airworthiness Bulletins AWB 85-013[13] and AWB 85-014[14] detail the importance and effectiveness of filter inspection programs and the hazards of undetected camshaft lobe and tappet wear.

Additional observations

Heavy wear patterns were observed on the drive splines from the engine-driven fuel pump (EDFP). These wear patterns were considered abnormal, and are subject to an ongoing study by CASA. If left uncorrected, such wear could have resulted in EDFP failure and a loss of fuel flow to the engine.

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13 See http://www.casa.gov.au/wcmswr/_assets/main/airworth/awb/85/013.pdf, published 14 November 2012.

14 See http://www.casa.gov.au/wcmswr/_assets/main/airworth/awb/85/014.pdf, published 23 November 2012.

FINDINGS

From the evidence available, the following findings are made with respect to the total power loss in Gippsland Aeronautics GA-8 Airvan aircraft, registered VH-AJZ, which occurred 135 km north-north-east of Marree, South Australia on 29 September 2011 and should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing safety factors

- The fatigue failure of the No. 5 piston resulted in severe mechanical damage and engine stoppage.
- The engine's oil consumption exceeded the manufacturer's limits, but was misinterpreted such that it appeared to be within those limits.

Other safety factors

- Contact fatigue of two tappets resulted in spalling that introduced significant metal contamination into the engine, increasing the risk of abnormal wear and failure of pistons and/or other engine components.
- Severe spline wear on the engine-driven fuel pump (EDFP) drive could, if undetected, have led to EDFP drive failure and sudden loss of fuel flow to the engine.

Other key finding

- Due to the damage sustained by the No. 5 piston, an assessment of the extent to which spalled material from the tappets may have contributed to the fatigue fracture of the piston was not possible.

SAFETY ACTION

The Australian Transport Safety Bureau (ATSB) expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In addressing those issues, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

The investigation did not identify any organisational or systemic issues that might adversely affect the future safety of aviation operations. However, the following proactive safety action was reported in response to this occurrence.

Aircraft operator

The operator advised that, following this occurrence they conducted a review that resulted in a number of changes to their operation.

In the first instance, it was identified that, due to the remoteness of the operation and manual tabulation of oil usage figures, the actual oil consumption figures analysed by the company's Head of Aircraft Airworthiness and Maintenance Control (HAAMC) were sometimes a week out of date. Since the engine power loss, the operator has introduced a different software management tool and changed the data gathering to daily updates. This has resulted in more meaningful data analysis and increased opportunity for intervention.

The operator also identified that the delay in uplift of this information was likely to be a contributing factor in the engine remaining in service. It was observed that had the figures been up-to-date, the aircraft would most likely have been grounded pending an oil filter inspection.

Finally, the operator's review identified the previous system of trend recording to be inadequate. As a result, the operator has taken action to ensure that aircraft information is more current, that more engine parameters are monitored, and that the person monitoring the information is better informed of the engine manufacturer's limitations.

The operator has advised of the following steps to improve engine monitoring:

- Electronic flight management software has been acquired to enable the daily input of aircraft flight logs. The HAAMC is then able to instantly run a report for a given time period and compare average fuel/oil burn with the engine manufacturer's limitations.
- Engine trend monitoring is now a requirement as per the company operations manual. Data is now sent to the relevant maintenance organisation quarterly.
- The aircraft cross-hire agreement protocol in the operations manual now dictates that an aircraft's fuel/oil use trends must be examined and deemed satisfactory before an aircraft is used by the operator.

Civil Aviation Safety Authority

On 14 November 2012, the Civil Aviation Safety Authority (CASA) published Airworthiness Bulletin (AWB) 85-013 *Piston Engine Oil & Filter*

Element - Inspection. That bulletin advised aircraft owners, operators and maintenance personnel of the importance of thorough inspection of the oil filter element and proper evaluation of filter debris.

Similarly, on 23 November 2012, CASA issued AWB 85-014 *Piston Engine Valve Tappet Body & Camshaft Lobe Wear*. This AWB alerted operators and maintainers to the hazard of possible in-flight engine malfunction or loss of engine power as a result of undetected valve tappet body/lifter and camshaft lobe wear.

APPENDIX A: SOURCES AND SUBMISSIONS

Sources of Information

The sources of information during the investigation included the:

- pilot and operator (current Chief Pilot/Head of Aircraft Airworthiness and Maintenance Control (HAAMC)) of the aircraft
- owner of the aircraft and his specialist engineering adviser
- operator's Chief Pilot/HAAMC at time of occurrence
- Civil Aviation Safety Authority (CASA)
- engine manufacturer
- approved maintenance organisation.

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003* (the Act), the Australian Transport Safety Bureau (ATSB) may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to CASA, the owner, pilot and operator of the aircraft, the engine and aircraft manufacturers and the approved maintenance organisation.

Submissions were received from the operator, the operator's chief pilot (at the time of the occurrence), the aircraft owner's specialist engineering adviser, the engine manufacturer and the approved maintenance organisation. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Australian Transport Safety Bureau

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Investigation

ATSB Transport Safety Report
Aviation Occurrence Investigation

Engine failure involving Gippsland Aeronautics GA-8, VH-AJZ
135 km NNE of Marree, South Australia, 29 September 2011

AO-2011-125

Final – 18 March 2013