AIRCRAFT ACCIDENT SHORT REPORT

CA18/2/3/9769, Unsuccessful forced landing after an engine failure while turning crosswind for Runway 17 at Hoedspruit Aerodrome (FAHT).

Date and time	**:** 8 February 2019 at 0530Z
Location	**:** Zandspruit River, near Hoedspruit
Aircraft registration	**:** ZU-DOG
Aircraft manufacturer and model	**:** Micro Aviation New Zealand Ltd, Bantam B22J
Last point of departure	**:** Hoedspruit Aerodrome (FAHT)
Next point of intended landing	**:** Hoedspruit Aerodrome (FAHT)
Location of accident site with reference to easily defined geographical points (GPS readings if possible)	**:** Zandspruit River, 24°37'20.47" South 030°59'31.87" East
Meteorological information	**:** Surface wind: 170°/5kt, temperature: 25°C, CAVOK
Type of operation	**:** Training (Part 141)
Persons on board	**:** 1 + 1
Injuries	**:** None
Damage to aircraft	**:** Substantial

All times given in this report are Co-ordinated Universal Time (UTC) and will be denoted by (Z). South African Standard Time is UTC plus 2 hours.

Purpose of the Investigation:

In terms of Regulation 12.03.1 of the Civil Aviation Regulations (CARs) (2011), this report was compiled in the interests of the promotion of aviation safety and the reduction of the risk of aviation accidents and incidents and ***not to apportion blame or liability****.*

Disclaimer:

This report is produced without prejudice to the rights of the South Africa Civil Aviation Authority (SACAA), which are reserved.

1. SYNOPSIS

1.1 On 8 February 2019 at approximately 0530Z, a flight instructor and a student pilot were conducting circuit training at Hoedspruit Aerodrome (FAHT) under the provisions of Part 141 of the Civil Aviation Regulation (CAR) 2011 as amended. While turning onto the crosswind leg for Runway 17, the engine stopped. The instructor took control of the aircraft and performed a forced landing in a dry riverbed. During the landing roll, the aircraft nosed over and came to rest in an inverted position.

1.2 Neither of the occupants on-board the aircraft sustained any injuries. The aircraft was substantially damaged during the accident sequence.

1.3 The investigation revealed that the in-flight engine failure occurred because of a worn valve guide, which led to the failure of the inlet valve due to fatigue. The pilot executed a forced landing on a dry riverbed and, during the ground roll, the nose gear dug into the soft soil and the aircraft nosed over.

2. FACTUAL INFORMATION

2.1 History of flight

2.1.1 On 8 February 2019 at approximately 0530Z, a flight instructor pilot (instructor) and a student pilot were conducting circuit training at Hoedspruit Aerodrome (FAHT) under the provisions of Part 141 of the CAR 2011 as amended. Whilst turning crosswind for landing on Runway 17, the engine made a loud bang, which was followed by a sound of broken metal.

2.1.2 The flight instructor took control of the aircraft and lowered the nose to achieve best glide speed. She identified an open area for a forced landing on a dry riverbed (Zandspruit River) straight ahead. She then broadcasted a MAYDAY call, stating that the aircraft had an engine failure and that she was going to perform a forced landing. On landing, the right main wheel collided with a rock while the aircraft was still travelling at approximately 20 knots (kt), the nose gear dug into the soft soil and it nosed over, coming to rest in an inverted position. After switching off the electrical system, they loosened their safety belts and vacated the aircraft. The aircraft sustained substantial damage and neither of the two occupants reported any injuries.

2.1.3 The accident occurred during daylight at a geographical position determined to be 24°37’20.47” South 030°59’31.87” East at an elevation of 1 850 ft above mean sea level (AMSL).

2.1.4 The aircraft touched down in a southerly direction in a dry riverbed (Figure 1). During the landing roll, the right main wheel collided with a rock and the aircraft nosed over, coming to rest in an inverted attitude (Figures 2 and 3). The nose gear bent backwards, but the cockpit/cabin area remained intact.

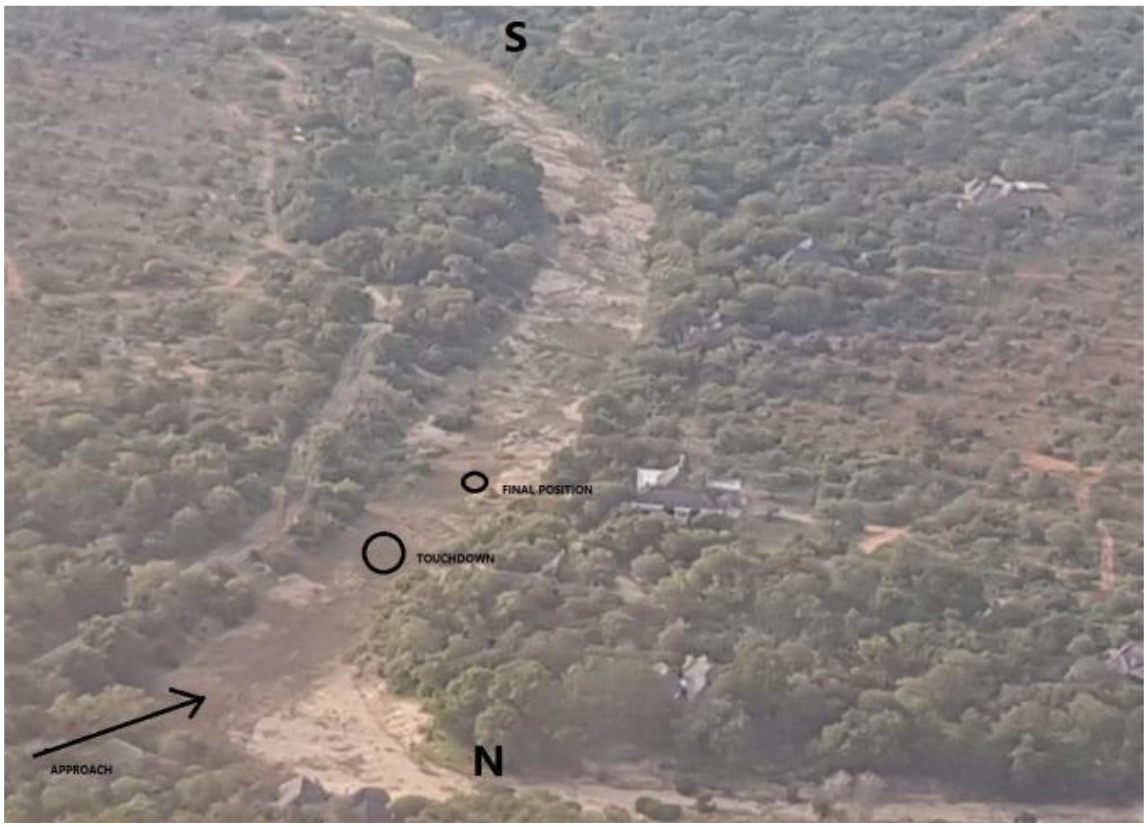


Figure 1: Aerial photograph of the approach and the terrain (Photograph courtesy of the ATO)

Figure 2: The aircraft as it came to rest

Figure 3: Ground marks showing that the nose wheel dug in before the aircraft nosed over (Photograph courtesy of the ATO)

2.1.5 Test and Research:

The engine, a Jabiru 2200A with serial number 22A1878 was removed from the wreckage after it was recovered and was subjected to an engine teardown inspection at an approved aircraft maintenance organisation (AMO). It was found that the inlet valve on the number 4 cylinder had failed, which resulted in extensive internal engine damage. The engine had been in operation for 898.0 hours since new.

Figure 4: The failed valve stem on number 4 cylinder (Photograph courtesy of AMO)

2.1.6 All valves from this engine were inspected and the following observations were made from the inspection report:

1. The failed inlet valve separated from the stem and the nature of the failure was metal fatigue. The stem of the valve shows two distinct areas of wear, indicating that the valve was moving side-to-side in the valve guide. See Figure 5 and 6 below.

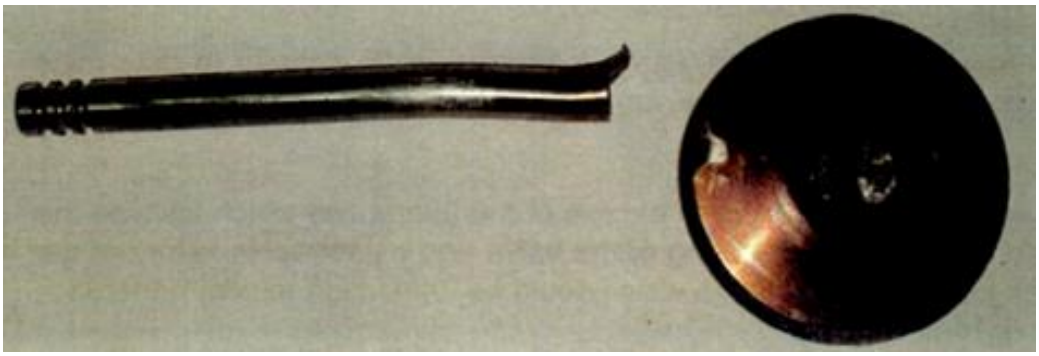


Figure 5: Showing the failed valve on number 4 cylinder

Figure 6: Shows the wear on the failed valve stem on cylinder number 4

2. The report concludes that, the valve guide for the failed valve was worn in excess of its tolerance/limits. That allowed the valve to operate at unusual angles, which led to the valve failing due to fatigue. Other valves, which were also inspected, had signs of scuffing which is attributed to the lack of lubrication or overheating or dirt in the oil. See Annexure A.

2.1.7 In 2014, the Australian Civil Aviation Safety Authority (CASA) responded to the high and increasing rate of engine failures among aircraft powered by engines manufactured by, or under licence from Jabiru Aircraft Ltd and issuing the following document attached as annexure B to this accident report.

3. FINDINGS

3.1 The instructor was issued with a National Pilot Licence on 19 February 2009, with an expiry date of 7 July 2020. She had the aircraft type endorsed on her licence.

3.2 The instructor was issued with an aviation medical certificate (Class 4) on 24 April 2018, with an expiry date of 30 April 2021.

3.3 The instructor had accumulated a total of 2 112.0 flying hours at the time of the accident, of which 1 580.0 were on the aircraft type.

3.4 The student pilot had been issued with a recreational Student Pilot Licence on 15 June 2017, with an expiry date of 7 November 2019. He was also in possession of valid aviation medical certificate (Class 4) which was issued on 7 February 2017 with an expiry date of 28 February 2020.

3.5 The aircraft was issued with an Authority to Fly on 9 October 2018 with an expiry date of 2 October 2019.

3.6 The Certificate of Release to Service for this aircraft was issued on 3 October 2018, with an expiry date of 2 October 2019 or 920.8 airframe hours, whichever came first.

3.7 The last annual inspection carried out on the aircraft prior to the accident flight was certified on 3 October 2018 at 822.1 airframe hours. A further 75.9 hours had been flown with the microlight aircraft since the inspection.

3.8 The inlet valve on the number 4 cylinder was found to have failed due to fatigue, which resulted in a catastrophic engine failure with extensive internal engine damage.

3.9 Nobody was injured in the accident sequence and the aircraft was substantially damaged.

3.10 The prevailing wind at the time of the flight was from the south at 5 knots (kt), and the temperature was 25°C.

3.11 The investigation revealed the in-flight engine failure was because of a worn valve guide, which led to the failure of the inlet valve due to fatigue. The pilot executed a forced landing on a dry riverbed and, during the ground roll, the nose gear dug into the soft soil and the aircraft nosed over.

3.12 The Australian CASA published a document in November 2014 seeking to limit the operation of all aircraft fitted with Jabiru engines to visual flight rules (VFR) by day in areas that were not populated, had no carriage of passengers, had no solo operations by students with less experience, and had warning placards which indicate restriction for passengers and students.

4. PROBABLE CAUSE

4.1 An in-flight engine failure was caused by a worn valve guide which led to the failure of the inlet valve due to fatigue. The pilot executed a forced landing on a dry riverbed and, during the ground roll, the nose gear dug into the soft soil and the aircraft nosed over.

5. CONTRIBUTING FACTOR

5.1 None.

6. REFERENCES USED IN THE REPORT

6.1 Engine teardown report from the AMO.
6.2 Inlet valve failure report on Jabiru A2200 engine.
6.3 https://www.casa.gov.au/files/consult-draft-cd1425sspdf.

7. SAFETY RECOMMENDATION

7.1 The Regulator, SACAA, should consider the adoption of the Australian CASA document published in November 2014 and mandate its implementation.

8. ORGANISATION

8.1 This was a training flight, which was conducted under the provisions of Part 141 of the CARs of 2011 as amended. The aviation training organisation (ATO) was in possession of a valid ATO approval certificate, which had been issued by the South African Civil Aviation Authority (SACAA) on 7 July 2017 and which was valid until 31 May 2022.

9. Appendices

9.1 Annexure A (Inlet valve failure report on Jabiru A2200 engine)
9.2 Annexure B (CASA documents on limitations of the use of aircraft fitted with Jabiru engines)

This report is issued by:

Accident and Incident Investigation Division (AIID)
South African Civil Aviation Authority
Republic of South Africa

Compiled by: Jacques Grobbelaar

_____

For: Executive Accident and Incident Investigations Division

ANNEXURE A

AMO 909 Report:
Aircraft reg: Not Confirmed
Engine Model: Jabiru 2200

Date: 31 May 2019
Airframe Serial Number:
Engine Serial Number: Not Confirmed

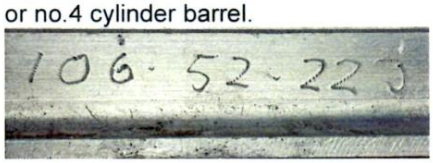
Prepared By: Mr. Len Alford

This Report
This report has been compiled in the interest of Safety. In an effort to fully explain the investigative findings this report contains photographs which may contain imbedded notes with explanations. Attached to this report will be more comprehensive copies of documents referred to.

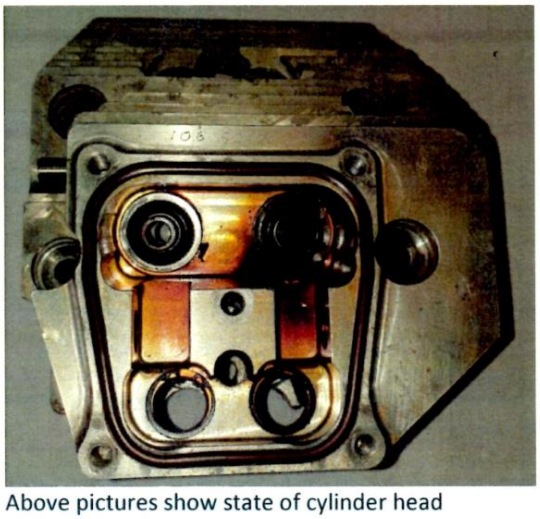
INTRODUCTION:
At the request of the SACAA accident investigation section an inspection of a Jabiru Cylinder head from a Jabiru 2200 engine was sent to our facility to inspect and report back on the cylinder head serial number 106-52-22J and broken valve to determine the cause.

On opening the package contents found - 1 cylinder head, 4 exhaust valves of which one was bent, 4 inlet valves of which one was broken, 5 valve retaining collets.

Cylinder head 106-52-22J on the Jabiru 2200 4 cylinder engine this cylinder head would be either on no.1 or no.4 cylinder barrel.

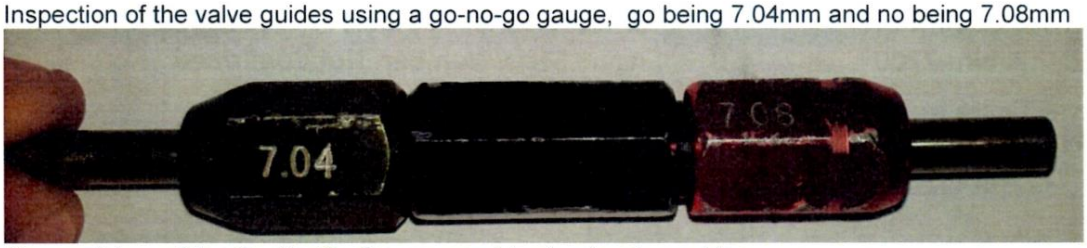


CYLINDER INSPECTION:
The cylinder head is a Generation 2 type (course Fin)
The head condition prior to valve failing is in good condition, with no signs of recession, cylinder head leak. Inlet and exhaust ports show no evidence of leaks in the system

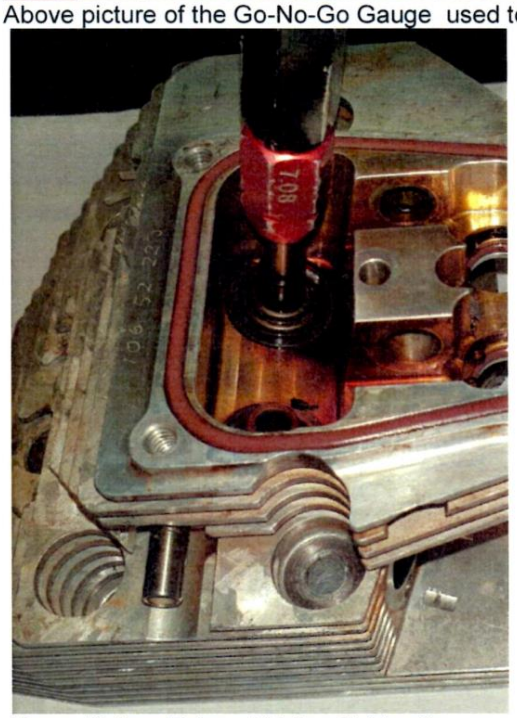


Above pictures show state of cylinder head

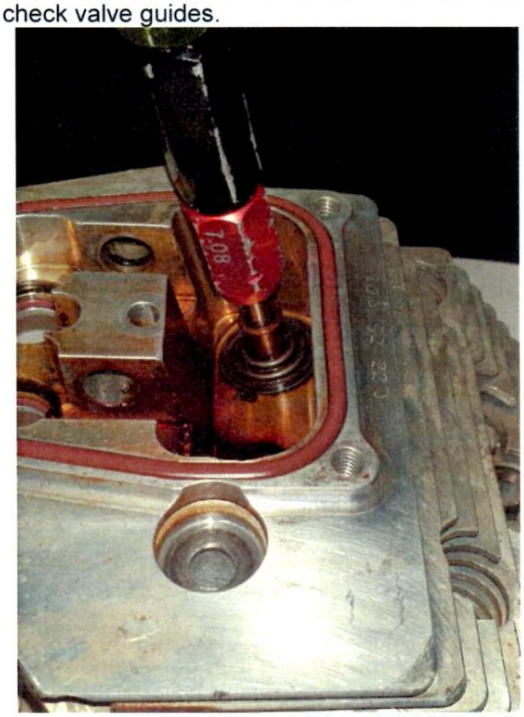
Inspection of the valve guides using a go-no-go gauge, go being 7.04mm and no being 7.08mm



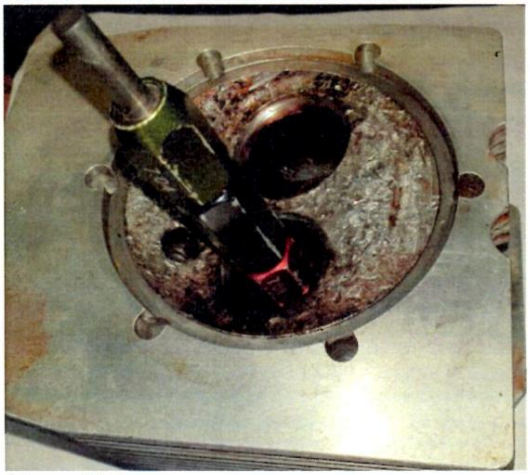
Above picture of the Go-No-Go Gauge used to check valve guides.



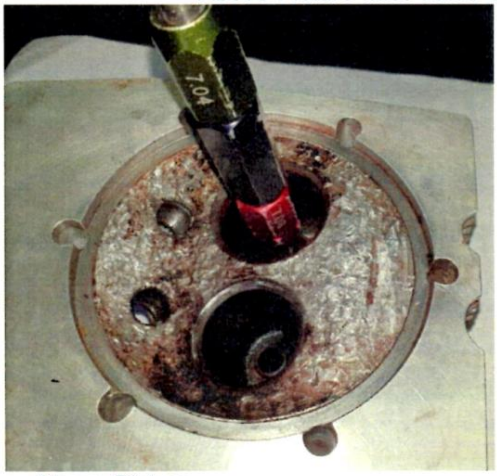
Above Picture Exhaust Valve Guide size



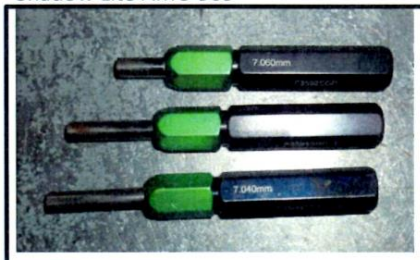
Above Picture Inlet Valve Guide Size



Above Picture
The No go gauge showing same size on the
Other side of the Exhaust valve



Above Picture
The No go gauge showing same size on the
other side of the inlet valve



Go-Nogo gauges are used to quickly and accurately check the inner size of a valve guide. Sizes 7.03 / 7.04 / 7.05 / 7.06 / 7.07 / 7.08. Gauges produced by 'Prittie' (www.prittie.com.au) are used in the factory.

Figure 15 – Valve Guide Size Gauges

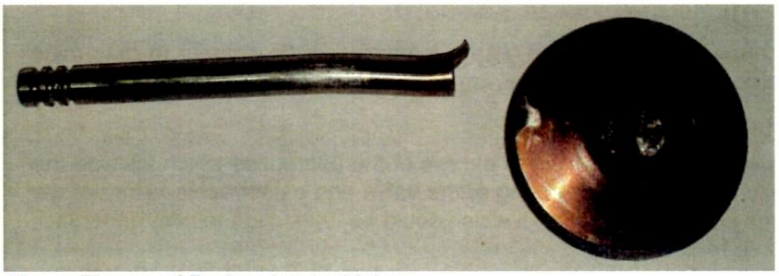
Above Extract from JEM0001-13 Overhaul Manual for Jabiru 2200 and 3300 Engine dated 14-01-2019

Valves Stem diameter Inlet and Exhaust	6.970 - 6.990	Per New Build	Per New Build
Valves Guide ID Inlet and Exhaust	7.040 - 7.050	Per New Build	Per New Build
Valve Spring free length (single spring)	38.000 - 40.000	Per New Build	Per New Build

Above Extract from JEM0001-13 Overhaul Manual of Jabiru 2200 and 3300 Engine dated 14-01-2019 Section 9.2 Build Tolerances Table 10 page 165 Page attached Annexure A

VALVE INSPECTION:

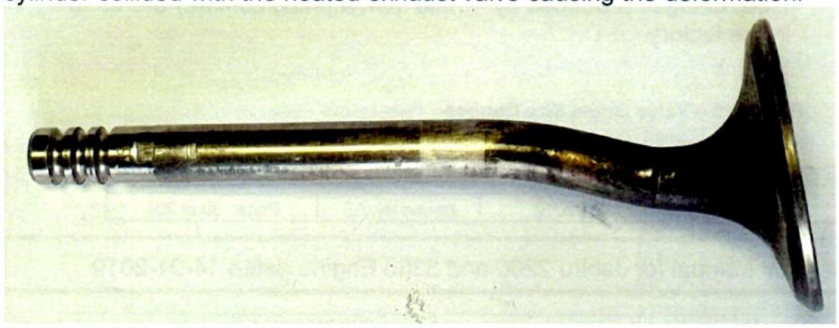
The valve that broke was an inlet valve. The head of the valve separated from the stem of the valve. The nature of the break was consistent to signs of metal fatigue and not thermal stress. The stem of the valve shows two distinct areas of wear, indicating that the valve was wobbling in the valve guide.



Above Picture of Broken intake Valve

Above picture showing the wear areas

One exhaust valve was bent. This is likely to have happened after the inlet valve broke and the debris in the cylinder collided with the heated exhaust valve causing the deformation.



Above picture of the bent exhaust valve

The other valve stems showed scuffing of the stems. The valve keep collets were of the correct shape

Above pictures showing the condition of the other valves and on the right showing the wear markings on the valves

CONCLUSION:

It cannot be determined exactly the cause as the engine must be inspected in its entirety to determine contributing factors i.e. oil filter, oil cooler, rocker shafts, rocker arms, rocker bearings, valve springs – just to mention a few.

The evidence lends to the fact that the valve guide was worn in excess of the tolerances which allowed the valve to operate at unusual angles, which leads to the fatiguing of the valve and catastrophic failure of the valve was the end result. All valve stems show scuffing marks which could be lubrication failure, either lack of oil or overheated oil or dirt in the oil.

Compiled by

Mr LW Alford
Accountable Manager

9.2 Build Tolerances

ANNEXURE A to report on cylinder 106-52-22J

- All dimensions are given in millimetres

Table 10 – Build Tolerances

Part	New Build	Top End Overhaul	Full Overhaul
Prop flange run-out (Measured at outer diameter)	0.060 Max	Per New Build	Per New Build
Crankshaft run-out	0.050 Max	Per New Build	Per New Build
Crankshaft Main journals	47.930 – 47.950	N/A	Per New Build *See Note 1
Crankshaft Big end journals	44.998 – 45.010	Per New Build	Per New Build
Crankshaft Thrust face	56.950 - 57.050	N/A	Per New Build
Crankcase Main bearing bores (no bearing)	51.980 – 52.040	N/A	Per New Build *See Note 1
Crankcase Main bearings (bearings fitted)	47.985 - 48.030	N/A	Per New Build *See Note 1
Crankcase Crank thrust (bearings fitted)	56.650 - 56.850	N/A	Per New Build
Crankcase Cam bearing bores	19.99 – 20.040	N/A	Per New Build
Crankcase Cam thrust face	14.95 – 15.10	N/A	Per New Build
Crankcase Lifter stems: solid lifter	8.965 - 8.990	N/A	Per New Build
Crankcase Lifter bores: solid lifter	9.000 - 9.050	N/A	Per New Build
Crankcase Lifter bores: hydraulic lifter	21.420 – 21.440	N/A	Per New Build
Connecting Rods Big Ends (no bearings)	48.015 – 48.030	Per New Build	Per New Build
Connecting Rods Big ends (bearings fitted)	45.040 - 45.070	Per New Build *See Note 1	Per New Build *See Note 1
Connecting Rods Small ends	23.02 – 23.03	Per New Build	Per New Build
Connecting Rods Length between bore centres	109.95 – 110.05	Per New Build	Per New Build
Camshaft Journals	19.94 – 19.95	N/A	Per New Build *See Note 1
Camshaft Valve lift	6.900 - 7.100	N/A	Per New Build
Camshaft Fuel pump lift	2.450 - 2.550 at pump 2.9 – 3.1 at cam	N/A	Per New Build
Camshaft Thrust faces	15.18 – 15.25	N/A	Per New Build
Pistons Diameter	97.480 - 97.530	Per New Build	Per New Build
Pistons Height	65.500	Per New Build	Per New Build
Pistons Pin diameter	22.990 - 23.000	Per New Build	Per New Build
Cylinder Bore diameter	97.610 – 97.630	97.610 – 97.700	Per New Build
Cylinder Length over flanges	106.95 – 107.00	N/A	Per New Build
Valves Stem diameter Inlet and Exhaust	6.970 - 6.990	Per New Build	Per New Build
Valves Guide ID Inlet and Exhaust	7.040 - 7.050	Per New Build	Per New Build
Valve Spring free length (single spring)	38.000 - 40.000	Per New Build	Per New Build

ANNEXURE B

Consultation Draft
Operating limitations on aircraft fitted with engines manufactured by Jabiru Aircraft Pty Ltd

Summary of Proposed Instrument

November 2014

Introduction

CASA is responding to a high, and increasing, rate of engine failures among aircraft that are powered by engines manufactured by, or under licence from, Jabiru Aircraft Pty Ltd (Jabiru). Such aircraft are referred to in this document as 'Jabiru powered aircraft'.

The issues appear to be the result of several failure modes, which require separate investigation.

CASA has formed the view that its functions under the *Civil Aviation Act 1988* require it to mitigate certain risks to passengers, trainee pilots and persons on the ground.

Accordingly, while CASA works with Jabiru to identify the causes of these engine failures and to implement appropriate corrective actions, CASA proposes a set of operating limitations on Jabiru powered aircraft.

Purpose and scope of the proposed instrument

The instrument will impose operating limitations on Jabiru powered aircraft that are issued with a CASR Part 21 authorisation by way of conditions under CASR 11.068.

The instrument will also impose the same operating limitations on Jabiru powered aircraft that operate under the exemptions in CAO 95.55, by way of a direction under CASR 11.245.

The proposed instrument will:

1. only permit operations by day under the visual flight rule, unless approved by CASA;

2. require that Jabiru powered aircraft are operated in a manner that minimises the risk of a forced landing into a populous areas;

3. define 'populous area' by reference to whether an area is populous at the time of the operation, meaning that (for example) a sports field would generally be a populous area at a time when that field is in use;

4. prohibit the carriage of passengers;

5. prohibit the use of Jabiru powered aircraft for solo operations by student pilots, who generally are less able to respond effectively to an engine failure event;

6. require that a notice be located in each Jabiru powered aircraft, conspicuous to each occupant of the aircraft, that states the limitations in paragraphs (4) and (5) above and notes that the occupants fly at their own risk.

CASA has considered whether to impose further limitations to better protect pilots. On balance, CASA considers that pilots are in a position to make their own assessment of whether to fly in a Jabiru powered aircraft, and to determine their ability to deal with an engine failure event. The proposed instrument therefore does not affect solo operations by qualified pilots, or flying training type activities involving an instructor and a student (including flight reviews and other recurrent checks).

Impact on industry

The instrument will impact on private passenger operations and flying training operations involving solo student flights. The impact is unavoidable in circumstances where CASA is responding to urgent safety risks. However, CASA has formulated the limitations to be no more burdensome than the requirements of safety demand.

The limitations will be lifted, progressively if appropriate, when appropriate corrective actions have been identified and implemented.

Closing date for comment

CASA will consider all comments received as part of this consultation process when determining the final terms of the instrument. Comments must be forwarded to the Project Leader, Lee Ungermann, at sport@casa.gov.au, by close of business on Thursday 20 November 2014.