AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

				Reference:		CA18/2/3/10522	
Aircraft Registration	ZU-IBE	**Date of Accident**		1 November 2024		**Time of Accident**	1747Z
Type of Aircraft	Jabiru J170			**Type of Operation**		Training (Part 141)	
Pilot-in-command Licence Type	Commercial Pilot Licence			**Age**	49	Licence Valid	Yes
Pilot-in-Command Flying Experience		**Total Flying Hours**		437.9		**Hours on Type**	119.4
Last Point of Departure	Rhino Park Aerodrome, Gauteng Province						
Next Point of Intended Landing	Wonderboom Aerodrome (FAWB), Gauteng Province						
Damage to Aircraft	Destroyed						
Location of the accident site with reference to easily defined geographical points (GPS readings if possible)							
Carlsruhe Private Game Reserve (GPS position: 25°40'50.70" South 028°29'21.05" East), elevation: 4 734 feet							
Meteorological Information	Surface wind: 030°/5kts, temperature: 26°C, dew point: 6°C						
Number of People on Board	2 + 0	**Number of People Injured**	0	**Number of People Killed**	2	**Other (On Ground)**	0

Synopsis

On Friday evening, 1 November 2024, a flight instructor and a pilot (with a Private Pilot Licence) on-board a Jabiru J170 aircraft with registration ZU-IBE took off on a training flight from Rhino Park Aerodrome in Gauteng province, before proceeding to Witbank Aerodrome (FAWI) in Mpumalanga province and Wonderboom Aerodrome (FAWB) in Gauteng province where the crew intended to conduct a full-stop landing. The flight was conducted under visual meteorological conditions (VMC) at night.

The pilot was training towards his night rating. Whilst inbound to FAWB, the engine ran rough, and the pilot contacted the air traffic control (ATC) and declared a MAYDAY. The crew was cleared to land on Runway 29 at FAWB, and the emergency services were alerted. However, the crew was unable to reach FAWB. During an attempt to perform a forced landing on a game reserve, the aircraft impacted high-tension powerlines and burst into flames. It crashed on a rocky terrain and was consumed by the post-impact fuel-fed fire. The two occupants on-board were fatally injured.

Probable Cause

The cause of the accident was total loss of propulsion power due to a fatigue crack on the No. 6-cylinder barrel. The aircraft subsequently impacted the high-tension powerlines during a forced landing on a moonless night.

SRP date	9 September 2025	Publication date	12 September 2025

Occurrence Details

Reference Number	**:** CA18/2/3/10522
Occurrence Category	**:** Accident (Category 1)
Type of Operation	**:** Training (Part 141)
Name of Operator	**:** Legend Sky
Aircraft Registration	**:** ZU-IBE
Aircraft Make and Model	**:** Jabiru J170
Nationality	**:** South African
Place	**:** Carlsruhe Private Game Reserve near Cullinan, Gauteng Province
Date and Time	**:** 1 November 2024 at 1747Z
Injuries	**:** Two fatalities
Damage	**:** Destroyed

Purpose of the Investigation

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

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.

Investigation Process

The Accident and Incident Investigations Division (AIID) of the South African Civil Aviation Authority (SACAA) was notified of the occurrence on 1 November 2024 at 1815Z. The occurrence was classified as an accident according to the CAR 2011 Part 12 and the International Civil Aviation Organisation (ICAO) STD Annex 13 definitions. An investigator was dispatched to the accident site.

Notes:

1. *Whenever the following words are mentioned in this report, they shall mean the following:*
   Accident — this investigated accident
   Aircraft — the Jabiru J170 involved in this accident
   Investigation — the investigation into the circumstances of this accident
   Pilots — the pilots involved in this accident
   Report — this accident report

2. *Photos and figures used in this report were taken from different sources and may have been adjusted from the original for the sole purpose of improving the clarity of the report. Modifications to images used in this report were limited to cropping, magnification, file compression; enhancement of colour, brightness, contrast; or addition of text boxes, arrows, or lines.*

Disclaimer

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Abbreviation	Description
°	Degrees
°C	Degrees Celsius
AGL	Above Ground Level
AIC	Aeronautical Information Circular
AIID	Accident and Incident Investigations Division
AMO	Aircraft Maintenance Organisation
ARCC	Aeronautical Rescue Coordination Centre
ARFF	Aerodrome Rescue and Firefighting
ATC	Air Traffic Control
ATF	Authority-to-Fly
ATO	Approved Training Organisation
CAR	Civil Aviation Regulations
CFI	Chief Flight Instructor
CHT	Cylinder Head Temperature
C of R	Certificate of Registration
CPL	Commercial Pilot Licence
CRS	Certificate of Release to Service
EFIS	Electronic Flight Instrument System
EGT	Exhaust Gas Temperature
EMS	Engine Monitoring System
FAKT	Kitty Hawk Aerodrome
FAWB	Wonderboom Aerodrome
FAWI	Witbank Aerodrome
ft	Feet
GPS	Global Positioning System
hPa	Hectopascal
KIAS	Knots Indicated Airspeed
kt	Knots
m	Metres
METAR	Meteorological Aerodrome Report
MTOW	Maximum Take-off Weight
PFD	Primary Flight Display
PPL	Private Pilot Licence
QNH	Barometric Pressure above Mean Sea Level
SACAA	South African Civil Aviation Authority
SAWS	South African Weather Service
TBO	Time Between Overhauls
TPM	Training and Procedures Manual
UTC	Universal Co-ordinated Time
VDF	VHF Direction-finding Station
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VOR	VHF Omnidirectional Range
Z	Zulu (Term for Universal Co-ordinated Time - Zero Hours Greenwich)

1. FACTUAL INFORMATION

1.1 History of Flight

1.1.1 On Friday evening, 1 November 2024 at 1631Z, a flight instructor and a pilot on-board a Jabiru J170 aircraft with registration ZU-IBE took off on a training flight from Rhino Park Aerodrome in Gauteng province. The crew conducted upper aerial work before proceeding to Witbank Aerodrome (FAWI) and, thereafter, Wonderboom Aerodrome (FAWB) for a full-stop landing. The flight was conducted under visual meteorological conditions (VMC) by night and under the provisions of Part 141 of the Civil Aviation Regulations (CAR) 2011 as amended.

1.1.2 The pilot had a Private Pilot Licence (PPL) and was training towards a night rating. This was the pilot's first flight at night. After take-off, the pair flew north-east of Rhino Park Aerodrome (see Figure 2) where they conducted upper aerial work. Thereafter, they flew to Witbank Aerodrome (FAWI) to intercept the very high frequency (VHF) omnidirectional range (VOR) [*VOR is a ground-based radio navigation system that provides aircraft with accurate directional information*]. The pair then flew westward along the N4 highway. At 1728Z, one of the approved training organisation's (ATO's) flight instructors who was at home at the time received a WhatsApp message on his cellular phone from the pilot who stated: *"We are experiencing an engine abnormality, think we had a magneto failure [sic]".* Shortly after this message was sent, the aircraft flew north-westerly. The flight instructor (who was at home) then tracked the aircraft on the Flightradar24 application he had installed on his cellular phone. At 1747Z, he received two short WhatsApp messages stating the following: *"MAYDAY"* and *"Engine died."* There was no further communication from the pilot.

1.1.3 According to gathered information, during radio contact with air traffic control (ATC) personnel at FAWB, the pilot stated that they were coming up south of Mamelodi at 5 500 feet (ft): *"We have a rough running engine, hopefully, we can pass the ridge and get … you can assist us in getting us in on Runway 29, please?* The ATC stated: *ZU-IBE copied the engine; you can continue for a straight-in approach for Runway 29. (*This above information was extracted from the recordings post-accident.) The pilot's reply to the above was not audible; it could be heard on this radio communication that the ATC had activated the crash alarm during their conversation. Also audible was the sound of the engine, which was erratic; this was consistent with a rough-running engine.

1.1.4 The following communication was recorded between the pilot and the ATC: *Pilot: Wonderboom tower, this is India Bravo Echo (IBE) we are declaring an emergency, Mayday Mayday Mayday, we are at 5 000 feet (ft) heading 320, we are trying to get to your field at this stage, but it is going to be close, we will see.* The time was 1741Z*. ATC: Copied IBE, emergency services are on standby, looks like you are to the south-east of the airfield.*

Pilot: Do you got me visual Mam, or not?
*ATC: Negative, I do not have you in sight, but I can see that the VDF (*VHF Direction Finding station - is a ground-based radio aid that consists of a directional antenna system and a VHF radio receiver, tuned to the operating frequency of an air traffic services unit*) is pointing that you are routing from the south-east of Mamelodi side.*
ATC: India Bravo Echo Wonderboom?
ATC: Zulu Uniform India Bravo Echo?
At 1747Z, the ATC officer lost communication with the aircraft.
There was no further communication between the ATC and the aircraft.
*ATC: Foxtrot Tango One [*Aerodrome Rescue and Firefighting team call sign*] and company I do not think that the aircraft made it to the airfield.*

ATC then declared a distress phase (DETRESFA – *which is a situation wherein there is a reasonable certainty that an aircraft and its occupants are threatened by grave and imminent danger and require immediate assistance*) with the Aeronautical Rescue Coordination Centre (ARCC) who initiated the search and rescue operation.

1.1.5 The game reserve owner on whose property the aircraft had crashed stated that him and his family were sitting outside having a barbeque that evening at about 1745Z. They then heard an aircraft flying low over their house and, seconds later, they heard a loud bang which was followed by a white flash. Thereafter, the electricity failed in the area. They immediately got into their vehicle and drove to the site where they found the aircraft engulfed in flames; they were unable to extinguish the fire. They recovered two cellular phones and an iPad, which was undamaged. Shortly thereafter, one of the cellular phones rang. The person on the other end was advised about the accident (it was later found out that the person who called was the flight instructor who had communicated with the pilot earlier that evening via WhatsApp). All relevant authorities were informed about the accident. The accident occurred 14 nautical miles (nm) or 25 kilometres south-east of the threshold of Runway 29 at FAWB.

1.1.6 The accident occurred at nighttime at Global Positioning System (GPS) co-ordinates determined to be 25°40’50.70” South 028°29’21.05” East, at an elevation of 4 734 ft.

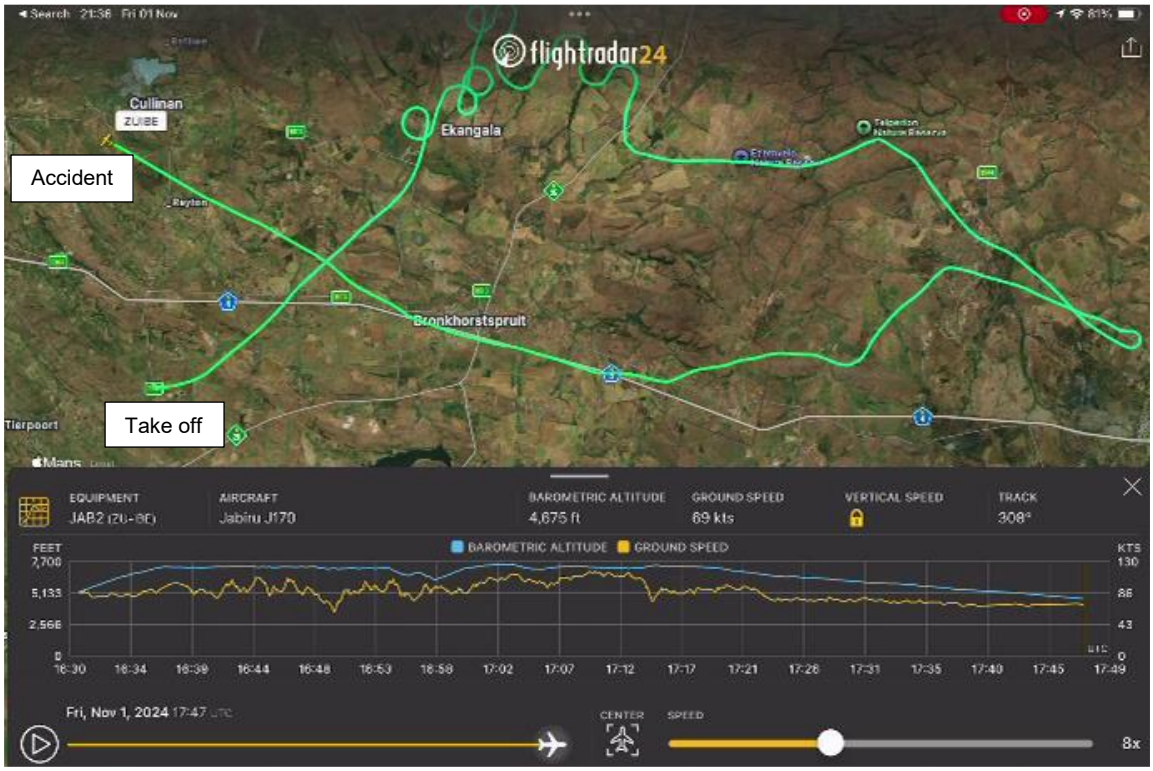


Figure 1: The green line shows the route flown by the ZU-IBE aircraft. (Source: Flightradar24.com)

1.2 Injuries to Persons

Injuries	Pilot	Crew	Pass.	Total On-board	Other
Fatal	2	-	-	2	-
Serious	-	-	-	-	-
Minor	-	-	-	-	-
None	-	-	-	-	-
Total	**2**	**-**	**-**	**2**	**-**

Note: Other means people on the ground.

1.3 Damage to Aircraft

1.3.1 The aircraft was destroyed by post-impact fuel-fed fire that erupted.

Figure 2: The wreckage after the post-impact fire.

1.4 Other Damage

1.4.1 Several Eskom powerline pylons and conductors were damaged after impact with the aircraft. Some parts of Cullinan experienced power failure after the accident.

1.4.2 The local fire services responded to the scene and doused the fire.

Figure 3: One of the high-tension cables that snapped from the pylon during the accident.

1.5 Personnel Information

1.5.1 Pilot-in-Command (PIC) - Flight Instructor

Nationality	South African	Gender	Male	Age	49
Licence Type	Commercial Pilot Licence (CPL)				
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Instrument, Flight Instructor Grade 3				
Medical Expiry Date	30 September 2025 (Class 1)				
Restrictions	VNL: Valid only with correction for defective near vision				
Previous Accidents	None				

Note: Previous accidents refer to past accidents the pilot was involved in, when relevant to this accident.

Flying Experience:

Total Hours	437.9
Total Past 90 Days	28.7
Total on Type Past 90 Days	22.8
Total on Type	119.4

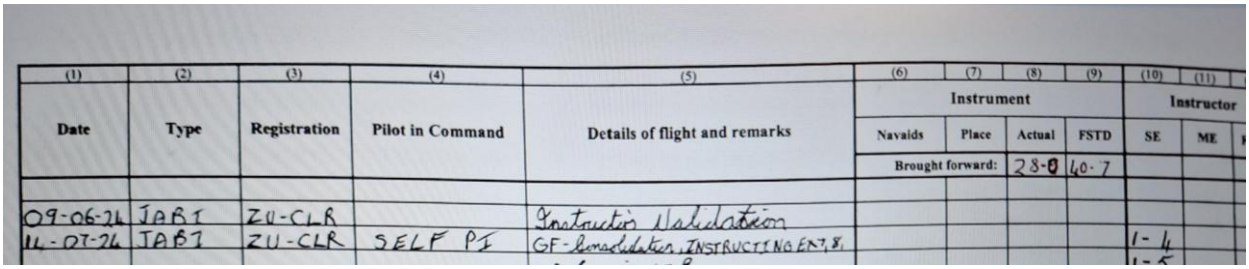
*NOTE: The flying hours entered in the table above were obtained from the pilot's second logbook, which he started in 2015; his first logbook could not be located. The recorded flying hours were also obtained from the two ATOs to which he provided flight instruction during the period 3 September 2023 to 1 November 2024. This was conducted on an ad hoc basis (as a freelance flight instructor).

According to the flight instructor's logbook (including the endorsement section), he last renewed his Instrument Flying (IF) rating on 20 April 2024, which was valid until 30 April 2025 as per his licence details. According to his logbook, he had flown a total of 77.2 hours of IF of which 40.7 hours were acquired on a flight simulation training device (FSTD).

According to the logbook and information available to the investigator, the flight instructor had accumulated a total of 17.5 night flying hours of which 7.2 hours were dual hours and 10.3 hours were as pilot-in-command (PIC). The first time the flight instructor pilot had conducted night flying since starting the new logbook in 2015 was on 27 September 2024. This was a 2-hour flight on which he was pilot-in-command (PIC) aboard the Jabiru J170 aircraft, registered ZU-IBE. The flight was a night navigation flight with a student pilot. He, again, flew at night on 25 October 2024 as PIC on-board a Cessna 172 (ZS-IDT) aircraft; this was a 3.3-hour training flight.

It was noted that on 9 June 2024, the flight instructor made an entry in his logbook indicating that he had flown a Jabiru SP aircraft with registration ZU-CLR. Details of the flight were entered as Instructor Validation, but there was neither a name as to who the PIC on this flight was, nor was there a duration of the flight. The flight instructor's logbook was poorly

maintained, with several entries lacking detailed content. Part 61.01.8 of the CAR 2011 (Logging of flight time) as well as Appendix A on the South African Civil Aviation Technical Standards (SA-CATS) 61 document provide guidance on how a pilot should complete and maintain his/her logbook.



(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Date	Type	Registration	Pilot in Command	Details of flight and remarks	Instrument				Instructor	
					Navaids	Place	Actual	FSTD	SE	ME
				Brought forward:			28-0	40-7		
09-06-24	JAB1	ZU-CLR		Instructor Validation						
14-07-24	JAB1	ZU-CLR	SELF PI	GF-Consolidation INSTRUCTING EN7.8.					1-4	

Figure 4: Logbook entry.

According to the approved training organisation (ATO) Training and Procedures Manual (TPM) Issue 3, dated 13 February 2024, subheading 1.20.6 on pages 1-49 states that the flight instructor needs to have an endorsement in his logbook from the CFI to complete night flying instruction/ratings; there was no such endorsement in the pilot's logbook.

1.20.6 QUALIFICATIONS REQUIRED BY FLIGHT INSTRUCTORS

Whenever conducting flight training and/or signing any official documents in the capacity of "Flight Instructor" any flight instructor employed by company is to have.

(i) At least a valid Grade 3 Flight Instructors Rating, issue by the SACAA

(ii) Be an instructor rated on the aircraft type used for training

(iii) Be approved by the CFI to act as a Flight Instructor for this company

(iv) *Have a valid Class 1 aviation medical certificate.*

GRADE III FLIGHT INSTRUCTORS

Are limited to giving the following types of training under the supervision of a higher grade Instructor:

- *Any air exercise theory briefing relevant to PPL training*
- *All dual flight instruction for training to obtain a PPL except the dual check leading to the initial solo flight by a Student Pilot.*
- *Conversion to type training, provided they are instructor-rated on that specific type and when authorized to do so by the CFI.*
- *If indorsed by the appropriate instructor, in their logbook to do Night Ratings and Instrument Ratings and authorized to do so by the CFI.*

The following regulation indicates the requirements for a Grade 3 instructor to complete instruction at night:

SACAR 61.12.5

Privileges and limitations of holder of Grade III Flight Instructor Rating (Aeroplane)

(2) A Grade III Flight Instructor (Aeroplane) may give ground or flight instruction only under the supervision of a holder of a valid Grade I or Grade II Flight Instructor Rating (Aeroplane).

(3) The requirements for the endorsements referred to in subregulation (1) are as follows—

(a)an instructor must have—

(d)in the case of night rating instructor endorsement, an instructor must have—

(i)a night rating and show evidence of having completed appropriate training as prescribed in Document SA-CATS 61;

(ii)demonstrated to a DFE I or II (A), in the case of an initial Grade III skills test, or the CFI of an approved ATO in the case of an existing Grade III instructor, the ability to give—

(aa)a suitable night flying briefing;

(bb)instruction in an aeroplane or approved FSTD on instrument flying to the level required for a night rating; and

(cc)flight instruction at night in an aeroplane which must consist of at least three take-offs and three landings; and

(iii)his or her logbook endorsed by a DFE or CFI with the words "Authorised to give instruction for night ratings";

No record of the above training was provided to the investigator.

1.5.2 Pilot (Under Training)

Nationality	South African	Gender	Male	Age	27
Licence Type	Private Pilot Licence (PPL)				
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	None				
Medical Expiry Date	31 January 2028 (Class 2)				
Restrictions	None				
Previous Accidents	None				

Note: Previous accidents refer to past accidents the pilot was involved in, when relevant to this accident.

Flying Experience:

Total Hours	70.7
Total Past 90 Days	13.0
Total on Type Past 90 Days	4.4
Total on Type	4.4

*NOTE: The flying hours entered in the table above were obtained from the pilot's logbook, with the last entry recorded on 6 October 2024. Additional flying hours were obtained from the ATO records. The accident flight was the pilot's first training flight towards his night rating.

1.6 Aircraft Information

1.6.1 Jabiru J170 (Source: www.jabiru.co.za)

The J170 is a high-winged, strut-braced monoplane with wing flaps, mass-balanced elevators and in-flight adjustable trim. The ergonomically designed cockpit has side-by-side seating, centre controls and panel-mounted throttles, plus the option of adjustable rudder pedals. It is fitted with two large doors to provide easy entry and exit, and in South Africa, there is the added advantage of a luggage door at the back for easy access and stowing of luggage in the back compartment. Low cowls and large, blue-tinted windows provide excellent visibility, and the snap vents provide good interior ventilation. The aircraft has a tricycle undercarriage, a steering nose wheel, and hand-operated hydraulic disc brakes.

1.6.2 Airframe:

Manufacturer/Model	Shadow Lite CC / Jabiru J170	
Serial Number	358	
Year of Manufacture	2014	
Total Airframe Hours (at time of the accident)	3 563.4	
Last Inspection (Hours & Date)	3 533.1	10 October 2024
Airframe Hours Since Last Inspection	30.3	
CRS Issue Date	10 October 2024	
ATF (Issue Date & Expiry Date)	15 July 2016	10 December 2024
C of R (Issue Date) (Present Owner)	9 October 2023	
MTOW	600kg (1 323lbs)	
Operating Category	Production Built	
Type of Fuel Used	Avgas	
Previous Accidents	On 13 April 2016, the left wing of the aircraft struck an object when the aircraft veered off the runway. The wing and fuselage carry-through beams were replaced, and the engine was subjected to a teardown inspection. (Aircraft logbook entry) On 9 October 2022, the aircraft was involved in a landing accident at Kitty Hawk Aerodrome in which the nose gear broke off when the aircraft was nearing to overrun the runway. The pilot steered the aircraft off the asphalt runway and onto the grass surface; however, the nose gear broke off as the aircraft exited the runway. The AIID reference number is CA18/2/3/10082.	

Note: Previous accidents refer to past accidents the aircraft was involved in, when relevant to this accident.

According to the issued Authority-to-fly (ATF) Certificate, the aircraft was allowed to be flown during visual meteorological conditions (VMC) by day and night only. The Pilot's Operating Handbook (POH) stated that the aircraft was approved for day VFR operations only.

Engine:

Manufacturer/Model	Jabiru A3300
Serial Number	33A2114
Hours Since New	3 563.4
Hours Since Overhaul	665.4

Propeller:

Manufacturer/Model	Pieter de Necker
Serial Number	N4197
Hours Since New	665.4
Hours Since Overhaul	TBO not yet reached

1.7 Meteorological Information

1.7.1 The weather information below was obtained from the Meteorological Aerodrome Report (METAR) that was issued by the South African Weather Service (SAWS), recorded at Wonderboom Aerodrome (FAWB) on 1 November 2024 at 1900Z and 2000Z. The accident site was 14nm from FAWB.

FAWB 011900Z AUTO 03005KT //// // ////// 26/06 Q1019=

Wind Direction	030°	Wind Speed	5kt	Visibility	9999m
Temperature	26°C	Cloud Cover	CAVOK	Cloud Base	Nil
Dew Point	6°C	QNH	1019hPa		

FAWB 012000Z AUTO 00000KT //// // ////// 21/08 Q1020=

Wind Direction	No wind	Wind Speed	Nil	Visibility	9999m
Temperature	21°C	Cloud Cover	CAVOK	Cloud Base	Nil
Dew Point	8°C	QNH	1020hPa		

1.8 Aids to Navigation

1.8.1 The aircraft was equipped with standard navigational equipment as approved by the Regulator (SACAA). There were no records indicating that the navigational equipment was unserviceable before the flight.

1.9 Communication

1.9.1 The aircraft was equipped with a standard communication system as approved by the Regulator. There were no recorded defects with the communication system before the flight.

1.9.2 There was radio communication between the pilot and the ATC officer at FAWB on tower frequency 118.35-Megahertz (MHz). At 1741Z, the pilot declared a MAYDAY and informed the ATC personnel that the aircraft had a rough-running engine.

1.9.3 The ATC personnel activated the crash alarm, and the ARFF personnel responded by taking up positions next to Runway 29, awaiting the arrival of the aircraft.

1.10 Aerodrome Information

1.10.1 The accident did not occur at or close to an aerodrome.

1.11 Flight Recorders

1.11.1 The aircraft was neither equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR), nor was it required by regulation to be fitted to the aircraft type.

1.12 Wreckage and Impact Information

1.12.1 The aircraft impacted high-tension powerlines whilst flying in a north north-westerly direction. The wreckage distribution covered an approximate 30m radius, and the fuselage was consumed by post-impact fire that erupted. The aircraft parts that were not totally destroyed were scorched.

Figure 5: The accident site.

Figure 6: The aircraft fuselage.

Figure 7: A section of the left outer wing.

Figure 8: The horizontal plane with the vertical fin ripped off.

Figure 9: The vertical fin with the rudder still attached.

1.13 Medical and Pathological Information

1.13.1 At the time of conclusion of this report, the medico-legal postmortem (PM) reports had not been received yet. Should these PM reports become available and contain information that might change the outcome of this investigation, the AIID will issue a revised report.

1.13.2 The two authorities (Department of Health and South African Police Service) were contacted regarding the PM reports via cellular phone and email, and the reply was not yet received when the draft final report was concluded on 3 June 2025.

1.14 Fire

1.14.1 The aircraft impacted high-tension powerlines, and the fire erupted due to impact. Fuel in the aircraft exacerbated the fire.

1.15 Survival Aspects

1.15.1 The accident was not considered survivable as the aircraft was consumed by the post-impact fuel-fed fire. The accident site is a game reserve; therefore, specialised vehicles were required and used to reach the accident site.

1.16 Tests and Research

1.16.1 The engine, a Jabiru 3300A with serial number 33A2114, that was fitted to this aircraft was

removed from the wreckage after it was recovered. It was taken to an engine maintenance facility where it was subjected to a teardown inspection.

1.16.2 The engine was severely scorched due to the post-impact fire. During an external inspection, it was found that all three cylinders on the left side of the engine crankcase (Cylinders No. 2, 4, and 6) were loose. These engine cylinder assemblies consisted of two major parts, the cylinder barrel and the cylinder head. During a visual examination of the engine, it was also noted that the No.6 cylinder had a crack approximately 180° around its circumference and close to the crankcase on the barrel area (see Figure 11). The engine still contained a substantial amount of oil (see pistons in Figures 11 and 12); the sump still contained a small amount of oil. Apart from the observation mentioned above, no other mechanical defects were noted during the teardown procedure. All six-cylinder barrels were measured, and they met the specifications of the engine manual. The magnetos and all associated ignition wiring were destroyed in the post-impact fire. There was neither evidence of any modifications having been made to the engine, nor were there any unauthorised parts used.

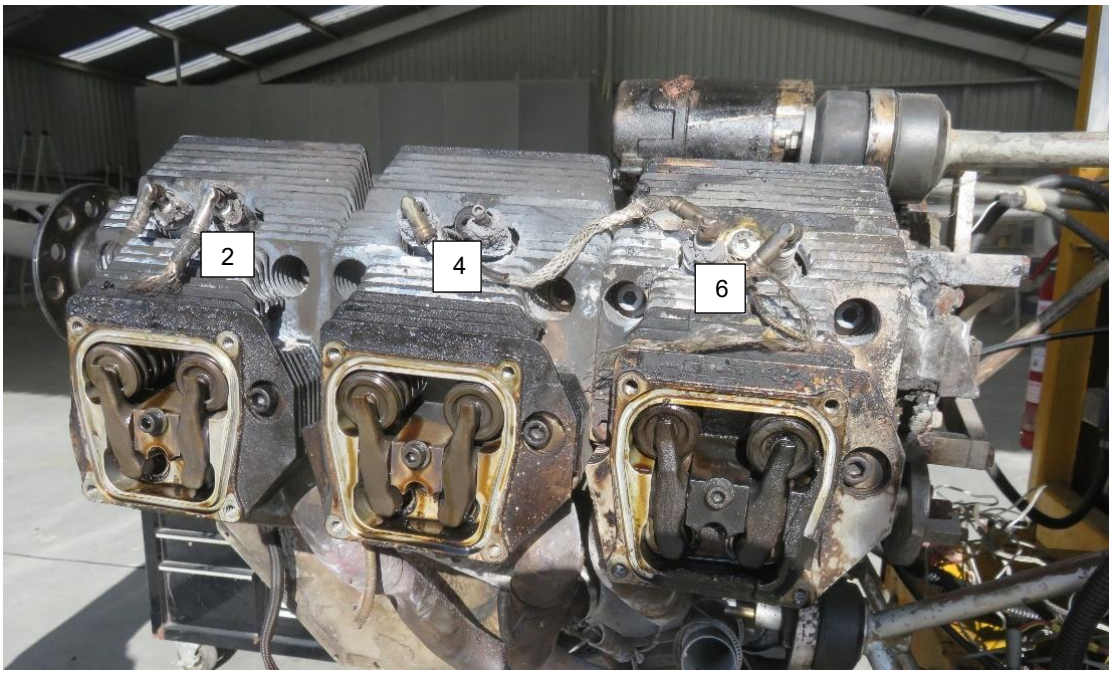


Figure 10: A view of the left side of the engine with the numbers 2-, 4- and 6-cylinder tappet covers removed.

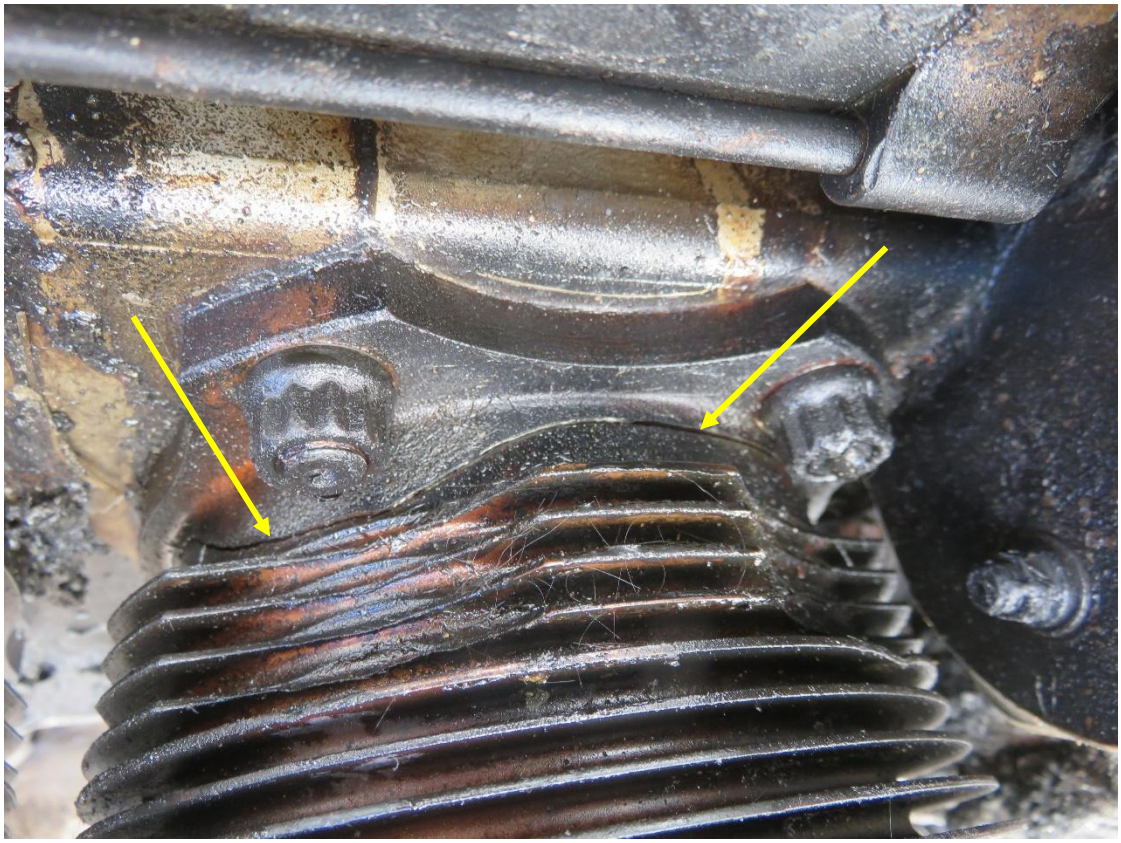


Figure 11: The cracked No.6 cylinder viewed from the top.

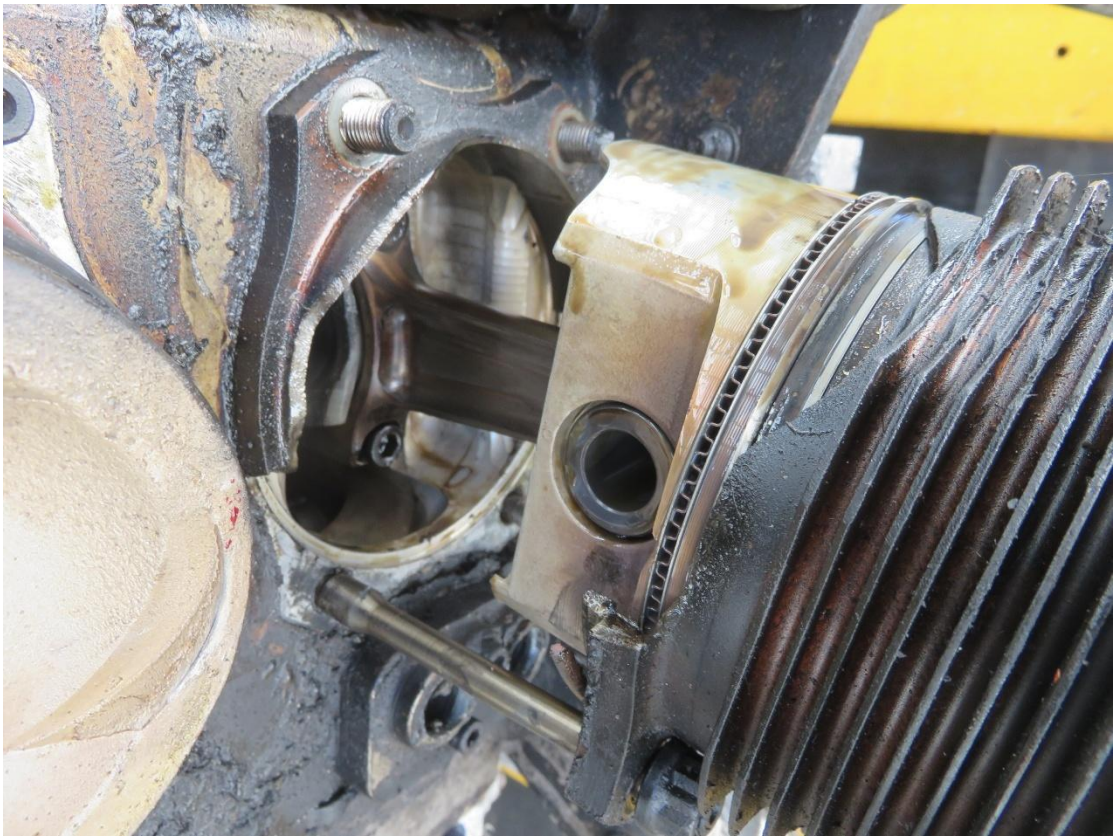


Figure 12: During the removal of the No.6 cylinder, a section separated on the cracked surface.

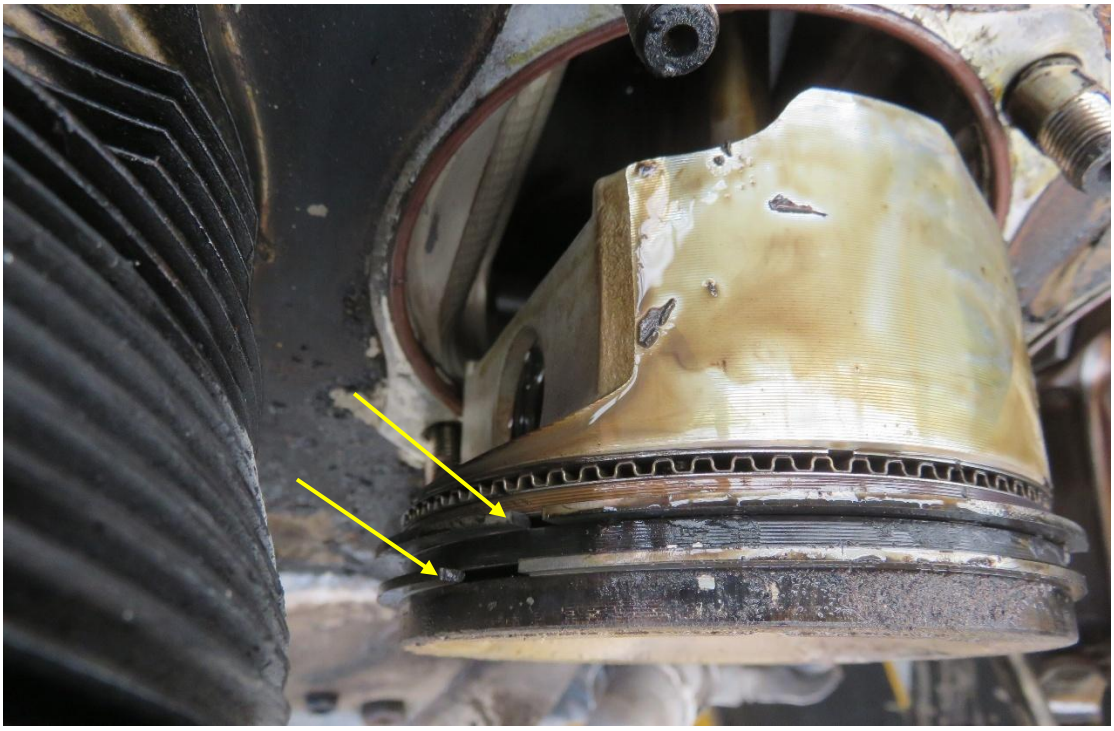


Figure 13: Both the compression rings on the No.4 piston were broken.

Figure 14: All six-cylinder barrels were measured and were found to be within limits.

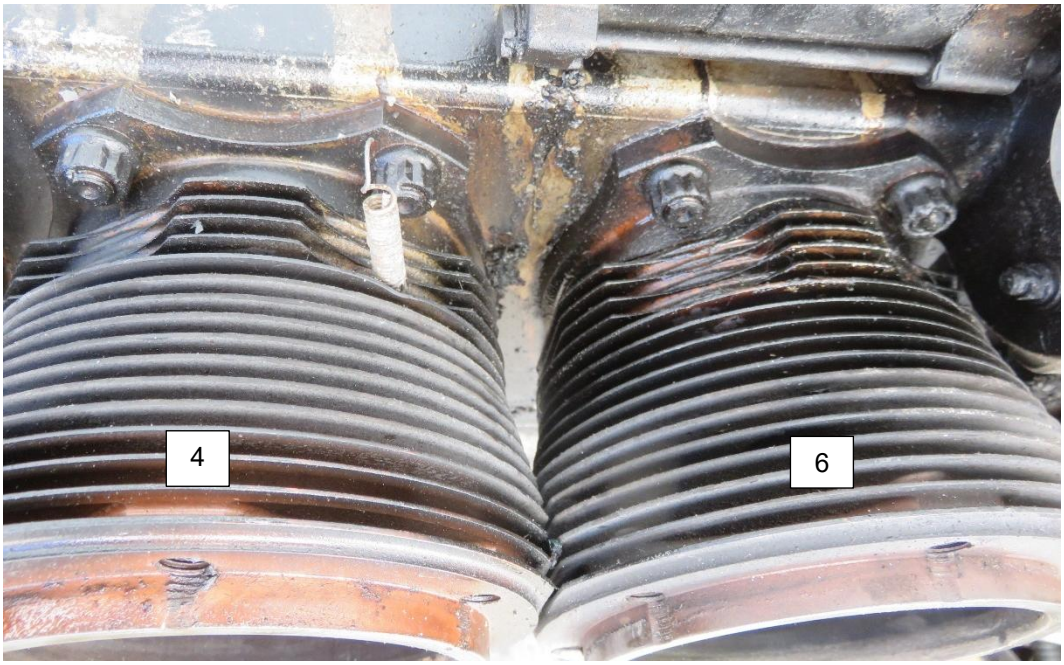


Figure 15: The No.4 and No.6 cylinders. A substantial discolouration is visible on the No.6 cylinder in the area of the crack and cooling fins.

1.16.3 Laboratory Examination of the Failed Cylinder

The fractured No.6 cylinder was taken to a Structural and Materials Laboratory for examination. The laboratory report is attached as Appendix A.

Summary of the failure mode

*(a) The high-magnification inspection confirmed **fatigue** as the primary fracture mode during the initial stages of the failure.*

(b) Secondary fracture initiations close to the fatigue fracture initiation zones, suggesting exceedingly high tensile loads during operation. No clear surface stress raisers (nick marks, corrosion pitting, etc.) were noted.

1.17 Organisational and Management Information

1.17.1 The training flight was conducted under the provisions of Part 141 of the CAR 2011 as amended. The ATO had a valid ATO Certificate that was issued by the Regulator (SACAA) on 15 July 2021 with an expiry date of 30 April 2026.

1.17.2 The last maintenance inspection of the aircraft was conducted and certified on 10 October 2024 at 3 533.1 hours. The aircraft maintenance organisation (AMO) that maintained the aircraft had a valid AMO Certificate that was issued by the Regulator on 31 August 2024 with an expiry date of 31 August 2025.

1.18 Additional Information

1.18.1 Extracts from the Jabiru J170 Pilot's Operating Handbook, Section 3, Emergency Procedures

Engine Failure During Flight

1. Airspeed……..65 KIAS.*
2. Carburettor Heat…….. ON
3. Fuel Pump…….. ON
4. Fuel Shutoff Valve…… CONFIRM ON
5. Fuel Quantity…….. CHECK
6. Oil…… CHECK TEMP AND PRESSURE
7. Ignition…… CYCLE BOTH ON
8. Throttle…….... CHECK LINKAGE OPERATION
9. Airstart…… ATTEMPT IF PROP STOPPED

** - A slightly higher speed may give better distance over the ground if gliding into wind; a slightly slower speed if gliding downwind.*

Forced Landings

Emergency Landing Without Engine Power

1. Airspeed……..... 65 KIAS
2. Ignition…… OFF
3. Fuel Shutoff Valve…… OFF
4. Fuel Pump…….. OFF
5. Throttle……... CLOSED
6. Wing Flaps…… FULL PRIOR TO TOUCH DOWN
7. Master Switch……..... OFF AFTER LOWERING FLAPS
8. Braking……..... HEAVY AFTER TOUCH DOWN

The POH extract elaborating on rough engine/loss of power is attached as Appendix B.

1.18.2 Cockpit Instrumentation

The aircraft's primary flight display (PFD) was the Dynon SkyView Touch, an electronic flight instrument system (EFIS) as shown in Figure 16.

SkyView Touch displays can act as a PFD with synthetic vision, an engine monitoring system (EMS), and a moving map in various customisable screen layouts. The system has a backup battery in case of an electrical failure, which will power the system for at least 60 minutes.

The screen configuration, displayed in Figure 16, is the 80%-20% layout. The engine parameters on the right of the PFD screen are engine revolutions per minute (RPM), oil pressure, temperature, fuel flow, battery voltage and amperes. The six horizontal bars indicate a combined display of either cylinder head temperatures (CHT), exhaust gas temperatures (EGT), or both.

Figure 16: A view of the instrument panel of ZU-IBE taken at night.
The content displayed in the yellow window indicates the engine parameters. (Source: ATO)

Engine Page Layout
(Source: SkyView Touch Pilot's User Guide
https://dynonavionics.com/includes/guides/skyview/SkyView_Classic_Touch_Pilots_User_Guide-Rev_AL.pdf)

The three engine pages (100%, 50%, and 20%) are configurable by the pilot and should be configured during system installation. The specific widgets and the overall appearance of the 20% and 50% engine pages are not scaled-down versions of the 100% engine page. They are unique layouts and must be laid out individually. Each of the three engine pages display important parameters acquired using an SV-EMS-220/221 module, sensors and other

advanced engine monitoring features. The engine page shown in Figure 17 is the 50% page. It provides insight on what engine parameter options are available on the PFD.

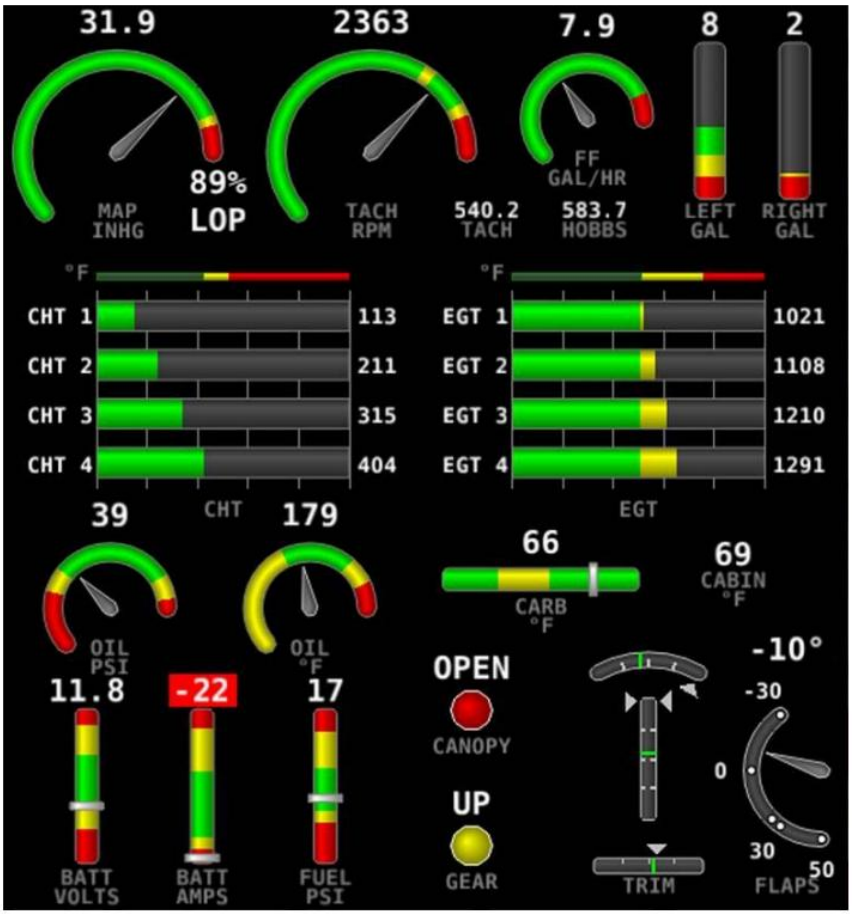


Figure 17: An example of a 50% engine page for single engine.

1.18.3 Diversion Aerodromes in the Area Following an Engine Abnormality

The pilot sent a WhatsApp message to a flight instructor on the ground at 1728Z, stating *"Abnormality on engine".* At that stage of the flight, the aircraft was 14nm west of Witbank Aerodrome (FAWI), 22nm from Rhino Park Aerodrome (departure aerodrome), and 41nm from FAWB. The crew opted to continue with the flight to FAWB and, later, impacted high-tension wires after they had flown a further 27nm, which was shortly after engine failure. Figure 18 shows the position of the aircraft at 1728Z and the vicinity of the different aerodromes mentioned above.

FAWI is a licensed aerodrome. It is equipped with a single asphalt runway oriented 04/22. There are runway lights and a VOR beacon at the aerodrome; however, unlike FAWB, it is not a controlled facility with ATC and ARFF services.

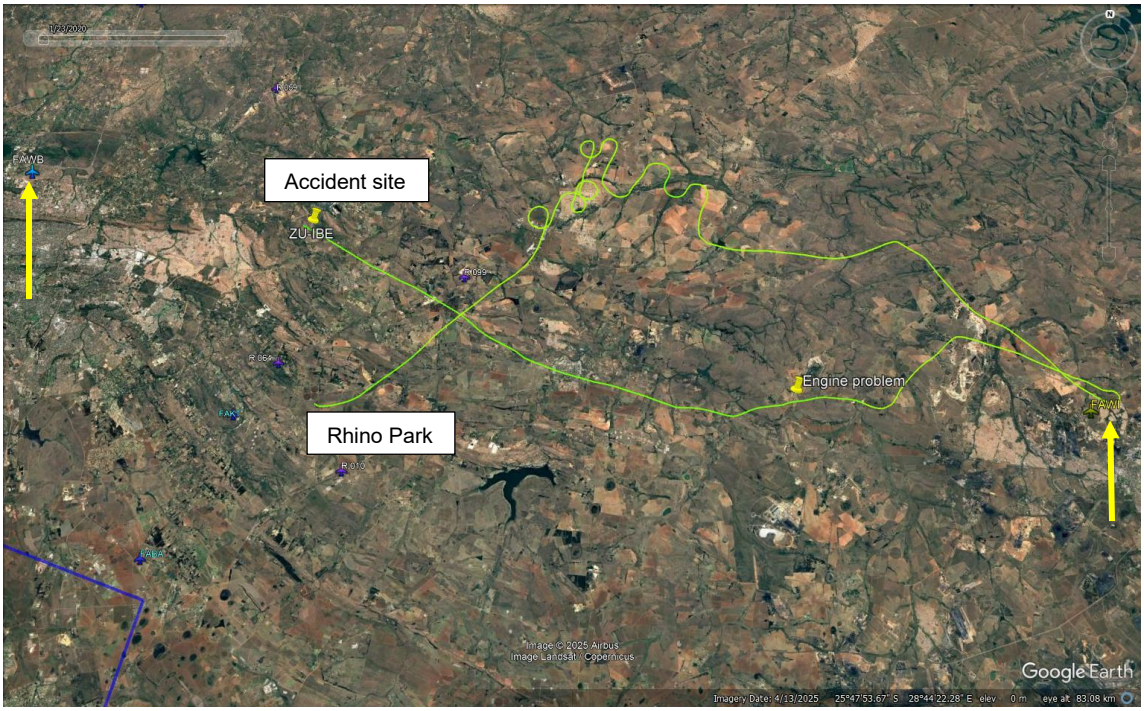


Figure 18: The flight profile indicates the locations for FAWB, FAWI, Rhino Park and the position of the aircraft when the engine abnormality was reported.

1.18.4 Authority-to-fly (ATF)

The aircraft had a valid ATF Certificate that was issued by the Regulator. Bullet point (2) under the Conditions and Limitations states: *VMC by day and night only.*

SOUTH AFRICAN CIVIL AVIATION AUTHORITY
REPUBLIC OF SOUTH AFRICA

CA 24-C-02

AUTHORITY TO FLY

PERMIT No.: ZU-IBE20240112ATF

1. Nationality and Registration marks	2. Manufacturer/Builder and Designation of aircraft	3. Aircraft serial Number
	SHADOW LITE CC	
ZU-IBE	**JABIRU J170**	**358**
4. Categories	**Production Built**	

5. This aircraft does not meet with the comprehensive requirements of International Civil Aviation, dated 7 December 1944. The Authority to fly is issued in terms of Aviation Act 13 of 2009 as amended and in terms of the Civil Aviation Regulations, 2011 as amended. In respect of the above mentioned aircraft which is considered to be airworthy when maintained and operated in accordance with the foregoing and pertinent operation limitations, and airworthiness code as provided by Part 24 of the Civil Aviation Regulations of 2011,as amended.

6. First Issue: **15/07/2016**
7. Date of Renewal: **12/01/2024**
8. Expiry Date: **10/12/2024**

CONDITIONS AND LIMITATIONS

(1) Aircraft shall be used for sports and recreation. Aircraft may be used in terms of Part 94 and Part 96 subject to the approval of the Director.

(2) VMC by day and night only.

(3) This authority is rendered invalid if the aircraft is involved in an incident or accident and must be returned to the Director within 30 days.

(4) The aircraft may not be operated over any foreign country without special permission from the authority of that country.

1.18.5 South African Flight Instructor's Manual of Training Procedures (issued on 29 June 2009) Aeronautical Information Circular (AIC) 14.3, dated 26 August 2010, refers to the South African Flight Instructor's Manual of Training Procedures as the primary preference for the development of lesson plans.

Exercise 20 – Night Flying

DEFINITION

Night flying comprises all flying done in the period between 15 minutes after sunset to 15 minutes before sunrise and involves a combination of instrument - and visual flying.

WHAT THE INSTRUCTOR IS TO TEACH

i. Discuss the aerodynamic principles involved.

ii. The air exercise briefing:

a. Applicable Procedures and check Lists.

b. Aircraft handling techniques: - Demonstration and Observation.

c. Considerations of Airmanship and engine handling.

d. Similarity to previous exercises.

e. De-briefing after flight.

WHY IT IS BEING TAUGHT

To ensure that the student is proficient to conduct with confidence a flight at night.

HOW THE EXERCISE APPLIES TO FLYING

All day flight manoeuvres may be performed at night, although good airmanship precludes those likely to cause disorientation or those which compromise safety due to a lack of visual ground references.

PRINCIPLES INVOLVED

i. LEGAL REQUIREMENTS

a. Licence qualification – No person shall act as pilot-in-command of an aircraft by night unless he or she is the holder of a valid private pilot's licence with a valid night flight rating or the holder of a valid higher licence.

b. Airfield facilities – pilot's responsibility: Except in an emergency, no aircraft shall take off or land by night unless the aerodrome of take-off or landing is equipped for night flying. The pilot-in-command shall be responsible for ensuring that night flying facilities are available for take-off or landing.

ii. USE OF AIDS

a. Airfield lighting – beacon, hazard, taxiway, and runway lights.

b. Types of VASI's and PAPI's and use thereof.

c. Aircraft instruments, radio equipment, and aircraft lighting.

iii. EMERGENCY PROCEDURES

a. Radio failure:

1) Controlled airfield.

2) Uncontrolled airfield.

b. Aircraft electrical system failure:

1) Partial system failure – priority usage of the remaining system.

2) Total system failure – alternate system (if any) applicable to night flying airmanship (discuss).

c. Engine failure:

1) In the circuit area – discuss the relationship to day situation.

2) Away from the circuit area – discuss factors applicable to night forced landing.

iv. PHYSICAL AND PSYCHOLOGICAL

a. Explanation of vertigo and special disorientation.

b. Optical illusions:

1) Judgement of distance at night.

2) Necessity of a visual scan to provide perspective.

c. Factors affecting night vision – external and internal lighting.

v. NIGHT FLYING TECHNIQUE

Principles applicable to day flying exercise are generally applicable to night flying.

vi. INSTRUMENT FLYING APPLICATION

Discuss the application of instrument flying to night flying.

The document then focuses entirely on circuit work at a suitable aerodrome equipped for night flying, with every phase of flight in the circuit being dealt with in detail, including taxi on runway, line-up on runway, take-off run, airborne, climb, crosswind leg, downwind leg, base leg, final approach, landing, landing run and exiting the runway.

Night navigation flights are dealt with under a separate subheading (Exercise 18) of the above document.

1.19 Useful or Effective Investigation Techniques

1.19.1 None.

2. ANALYSIS

2.1 General

From the available evidence, the following analysis was made with respect to this accident. This shall not be read as apportioning blame or liability to any organisation or individual.

2.2 Analysis

2.2.1 Crew

This was the pilot's first training flight towards obtaining his night rating. The flight instructor provided flying instruction on a freelance basis to the ATO; it was noted that he had limited night flying experience with a total of 17.5 hours, including dual and solo night hours. He (flight instructor) had a valid instrument flight rating with a total of 77.2 hours of instrument flying of which 40.7 hours were acquired on a flight simulation training device (FSTD). What is of concern is that the flight instructor started his second logbook in 2015 after he was unable to locate his first logbook. Since starting the logbook in 2015, he had not recorded any night flying for nine years. His first documented night flight, which was a training flight with him being the flight instructor, was on 27 September 2024. He then conducted a second night training flight on 25 October 2024, which brought his night flying time to 5.3 hours over this period. There was no evidence of documented training to ascertain his competence as a flight instructor at night in line with the regulatory requirements as prescribed in the South African CAR 61.12.5. The ATO did not authorise the flight instructor to conduct night flying training. Without the correct theoretical and practical training, the flight instructor's actions could have been limited when dealing with an emergency at night.
The crew had maintained radio and WhatsApp communication with the ATC and the flight instructor on the ground until shortly before impact with the high-tension powerlines, indicating that they were fully conscious during the flight.

At 1728Z, the pilot sent one of the flight instructors at the ATO (who was at home) a WhatsApp message stating that they had an engine abnormality. However, he did not elaborate on the type of abnormality.

At 1731Z, the pilot sent a second WhatsApp message stating: *Think we might have lost a magneto*.

At 1741Z, the pilot declared a *MAYDAY* with FAWB ATC stating that they had a *rough-running engine.* This was 10 minutes after he had sent a second WhatsApp message to the flight instructor.

At 1747Z, the pilot sent a third WhatsApp message stating: *Mayday,* and *Engine died.* This was the last communication from the pilot.

The terminology used by the pilot when sending the WhatsApp message, stating *"they had an engine abnormality"* was vague as the 'engine abnormality' could have meant anything that might have gone wrong with the engine. The fact that he was not prescriptive indicates that the crew was not in a position to provide a detailed account of the specific engine *'abnormality'* they were experiencing. The pilot mentioned to the FAWB ATC that they had an engine abnormality, and that the engine was running rough and thought it might have been due to a magneto failure; this was 13 minutes after sending the WhatsApp message to the flight instructor. The POH Section 3, Emergency Procedures, sub-heading 3.4.6 presents a few possible causes of a rough-running engine (also attached as Appendix B). The list is, however, very limited, which is disappointing as pilots need to cross-reference (fault finding) the document in-flight. There could be several reasons for a horizontally opposed air-cooled engine to be running rough. Below is a more comprehensive list:

Fuel Delivery Problems:

- Dirty or clogged fuel injectors can disrupt the flow of fuel to the cylinders, causing a lean or rich mixture and rough running.
- Weak or Failing Fuel Pump:

  If the fuel pump cannot maintain consistent pressure, the engine may run rough or misfire.
- Low-Quality Fuel or Bad Fuel:

  Stale fuel or fuel with contaminants can cause erratic engine behaviour.
- A clogged fuel filter can limit fuel flow, leading to a lean mixture and rough running.

Ignition Issues:

- Bad Spark Plugs or Wires: Worn or fouled spark plugs can fail to ignite the air-fuel mixture, causing misfires.
- Weak Ignition Coils: A failing ignition coil can reduce the spark energy, leading to misfires.
- Ignition Timing Problems: Incorrect ignition timing can disrupt the combustion process.

Mechanical Issues:

- Low Engine Compression: Worn piston rings, cylinder walls, or valve seats can lead to low compression, causing misfires.

- Vacuum Leaks: A vacuum leak can cause a lean mixture, resulting in rough running and misfires.
- Damaged Engine Components: Issues with valve train, head gaskets, or other internal parts can cause rough running.
- Mixture Maldistribution:
  Uneven air-fuel ratios between cylinders can lead to a rough idle or rough running.

Other Factors:

- Clogged Exhaust: A restricted exhaust system can disrupt the engine's normal combustion process, leading to rough idling or misfiring.
- Electrical Problems: Issues with sensors and wiring can also cause a rough-running engine.

Night flying is inherently dangerous as humans are diurnal creatures, meaning they are most active during the day and sleep at night, a primary biological rhythm for humans. Their eyesight is best suited for the daytime, and almost everything we do at night just becomes a little harder; this is from conducting the pre-flight inspection, finding switches in the cockpit and taxiing, to spotting terrain, obstructions and landing the aircraft. It is, therefore, essential that pilots understand the hazards and risk factors associated with night flying; as well as acknowledge their limitations and set minimum conditions under which they would be willing to fly at night, and those they would not. Flying during a moonless night substantially increases such a risk, especially for training flights which do not remain within a licensed aerodrome circuit with serviceable runway and approach lights, or over a built-up area.

The planning conducted by the crew was questionable as this was the pilot's first training flight towards his night rating, which deviated from circuit work at a licensed aerodrome with runway lights as outlined in the South African Flight Instructor's Manual of Training Procedures. This would explain why the pilot (PPL) was doing radio work and sending WhatsApp messages as the flight instructor probably took control of the aircraft once the engine abnormality was noticed.

It could not be determined which PFD flight display the crew had opted for. If it were the same screen as displayed in Figure 16, the crew would have been able to monitor the engine oil pressure and temperature during flight, as well as several other engine parameters. Following the cracked cylinder, oil seepage would have occurred, which would have resulted in a decay in oil pressure and an increase in oil temperature because the oil quantity in the engine would have reduced as the flight progressed. It is evident from Figure 15 that the No.6 cylinder displayed discolouration which was caused by the oil seepage coming in contact with the hot cylinder barrel and crankcase. The WhatsApp messages sent by the pilot did not mention any oil pressure or temperature deviations, or a decrease in engine power, which must have occurred during the flight.

The pilot, when he declared a Mayday with FAWB ATC at 1741Z, stated that the engine was running rough. It could be heard on the audio communication between the two stations that the engine noise was present. According to the last WhatsApp message, the engine failed 6 minutes later, which rendered a forced landing inevitable. Following the engine failure, the pilot-in-command (PIC) performed a forced landing straight ahead, but due to the moonless night, he was unable to see the hostile terrain and high-tension powerlines ahead of them, and the aircraft impacted the first set of powerlines (there were three sets of high-tension powerlines next to one another as presented in Figure 2).

By the time this report was concluded, no medico-legal post-mortem reports were available.

2.2.2 Aircraft

The aircraft was maintained in accordance with the provisions of Part 24 of the CAR 2011 as amended.

Pilots do not open the engine cowlings during their pre-flight inspections and would not have been able to notice any discolouration on or in the area of the No.6 cylinder where the crack had initiated. Engine cowlings are removed during scheduled maintenance inspections or if an engine defect is being attended to, post a scheduled maintenance inspection. It could, therefore, be possible that the crack on cylinder No.6 had developed over time, but because the cowling was not removed since the last maintenance inspection, the crack, which had initiated due to fatigue, propagated over an undetermined period to the point where the engine failed, evidenced during the engine teardown inspection. The fatigue crack on the cylinder probably progressed slowly over time. It could, however, have propagated during this flight to an extent that it initiated the engine abnormality, referred to by the pilot in his WhatsApp message to the flight instructor on the ground. The information supplied by the crew could, therefore, be regarded as vague to make a detailed analysis of the reported abnormality, which had elevated from a hazard to a risk and the subsequent failure.

In aircraft, piston rings play a vital role in the proper functioning of an engine, sealing the combustion chamber and ensuring that power is efficiently transferred from the fuel-air mixture that is ignited to the crankshaft. However, despite their importance, piston rings can fail due to a variety of factors, leading to decreased engine performance. Piston ring failure could be attributed to a lack of lubrication, overheating, wear and tear, poor installation, dirt and debris, and improper maintenance. In this accident, it could not be determined when the two compression rings on piston No.4 failed. There was no documented evidence in the flight folio of any defects before the flight; moreover, the crew did not communicate via WhatsApp that they had encountered a decrease in engine power at any stage of the flight.

Of importance is the information recorded in the Authority-to-fly (ATF) that was issued by the Regulator under the Conditions and Limitations section which stated that the aircraft could be flown *VMC by day and night only.* The POH, which is a manual provided by the aircraft manufacturer, contained information about the aircraft, including operating procedures, limitations, performance data, and more. The POH states under Section 2 Limitations, that the aircraft *is approved for day VFR operations only*.

One could, therefore, assume that the Regulator had taken all the necessary information, guidance material and standards into consideration to ensure the aircraft meets the conditions for safe flight before issuing an ATF that states it could be flown VMC by day and night. It is, however, of concern to note that the Regulator provisioned the aircraft, which falls under the Non-type Certified Aircraft (NTCA) category, to be flown under all VMC night flying conditions, including moonless nights or nights with reduced visibility (during waning and waxing crescent moon phases) and during the presence of clouds, which could also obscure moonlight. Flying an NTCA aircraft during VMC during a moonless, waning crescent and waxing crescent night poses a substantially higher risk than when flying during full moon, first quarter, waxing gibbous, waning gibbous, and the third quarter phase on a cloudless evening. The presence of clouds adds another dimension to night flying, as it could also limit visibility, even during a full moon.

2.2.3 Mission

There is no procedure to indicate why a moonless night was selected for the training flight as this was not the ideal environment for a pilot undergoing night training with no prior exposure. According to available information (pilot logbook), the flight instructor had a total of 17.5 hours of night flying before the accident flight, which includes dual as well as solo flying hours. The risks associated with such a flight were much higher. The flight consisted of upper air work, intercepting the VOR at FAWI and routing to FAWB for a full-stop landing. As per the South African Flight Instructor's Manual of Training Procedures, an initial training flight towards a night rating should, preferably, consist of circuit work at an appropriately equipped aerodrome with proper facilities for night flying (such as runway lights, approach lights, etc.).

2.2.4 Environment

The weather conditions were suitable for VFR flying on that evening although it was a moonless night, but this increased the risk substantially because visibility towards terrain and ground obstacles was hard for the human eye to identify.

The crew was in communication with the flight instructor of the ATO (who was at home at the time) via WhatsApp, and they were also in radio communication with ATC at FAWB on frequency 118.35-MHz through which they declared a Mayday.

2.2.5 Alternate Aerodromes

The alternate aerodrome that was closest to the aircraft location when the engine abnormality was noted was FAWI. This aerodrome has runway lights which are activated by a day/night switch. These lights were installed by the Witbank Aeronautical Association (WAA) and are on the same circuit as the prison, which is located next to the aerodrome, eliminating any possibility of load shedding. The aircraft was approximately 14nm west of FAWI when the engine abnormality was reported. The aerodrome also hosts a VOR (WIV) which was intercepted by the crew of ZU-IBE during the flight. The VOR is on the same electrical circuit as the runway lights and is also equipped with an alternate back-up power supply. Not knowing what the engine abnormality entails at that stage of the flight, the crew decided to continue with the flight to FAWB, which was still approximately 41nm from their position at the time.

As the flight progressed, the closest aerodrome was Rhino Park, which was not equipped with runway lights or any navigational aids. There was also Kitty Hawk Aerodrome, which was also not equipped with runway lights; it might also have been out of reach or not an option for the crew. The crew opted to proceed with the flight without diverting to an alternate aerodrome.

2.2.6 Approved Training Organisation (ATO)

The training school had a valid ATO Certificate that was issued by the Regulator. The flight instructor conducted flight training at two different ATOs on a freelance basis and had a full-time job (self-employed).

The ATO requirements, as stipulated in the Training and Procedure Manual (TPM) subheading 1.20.6 were not met as the chief flight instructor (CFI) did not endorse the Grade III flight instructor to conduct night flying training/ratings.

When evaluating the flight profile in Figures 1 and 18, it is clear that no circuit work was conducted at an aerodrome that was suitable for night operations. The crew conducted upper air work on the aircraft, which was associated with several turns. Thereafter, they flew to FAWI to intercept the VOR, which was their turning point. They then headed west with the intention to return to FAWB for a full-stop landing. The training exercise on the day did not meet the training guidance as outlined in the South African Flight Instructor's Manual for Training Procedures. This was probably a sequence that the flight instructor regarded as appropriate for the pilot's first flight towards obtaining his night rating.

2.2.7 Conclusion

The aircraft engine is a critical safety system and must be reliable to ensure safety of any planned flight. Reliability is not a fundamental property of an engine. It is a result of the correct performance of all subsystems through the phases of design, manufacture, operation and maintenance.
The capability of a reciprocating engine to produce the power specified by the engine manufacturer, reliably throughout flight, is a fundamental requirement of safe operation. Conversely, the failure of engines to produce specified power levels or the complete failure of an engine during flight is a threat to safe operation of an aircraft. The expectation of safe operation is expressed in the design standard for aircraft engines.

This was not an unexpected complete engine failure, but a progressive loss of power followed by a final engine failure approximately 19 minutes after the pilot had sent the first WhatsApp message to the flight instructor on the ground with reference to the engine abnormality. The handling skills of the crew in dealing with the engine abnormality remain one of the fundamental factors which resulted in the accident, as the forced landing was the only option when the engine failed.

The alternate aerodrome that was closer to the aircraft's location when the engine abnormality was first noticed was FAWI, which is a licensed aerodrome that had runway lights as well as VOR. The fact that the crew proceeded with the flight towards FAWB could have been fourfold.

(i) FAWB was their intended aerodrome for a full-stop landing.
(ii) There were runway and approach lights available.
(iii) ATC was on duty at the time.
(iv) ARFF personnel were on duty at the time, who were essential resources for an aircraft that was in distress.

The fact that the crew proceeded with the flight knowing that they had an engine abnormality that could, at any stage, progress to something more serious raises a concern about their decision-making at the time, as well as their technical knowledge. There should have been engine parameters that would have indicated to them that the oil pressure was decaying, and that the oil temperature was rising as oil was seeping from the cracked No.6-cylinder barrel.

However, one of the significant factors that led to the outcome of this accident is that the flight was conducted during a moonless night. The aircraft was flying over a remote area when the engine failed; the crew had no other option but to perform a forced landing on hostile terrain with three sets of high-tension powerlines crossing their approach path, which resulted in the aircraft impacting the first set of high-tension powerlines.

The fact that the Regulator had issued the aircraft with an ATF that states: *VMC by day and night only* allowed the ATO to use the aircraft for night training, irrespective of the natural illumination which is determined by the moon phase at the time of the flight.

3. CONCLUSION

3.1 General

From the available evidence, the following findings, causes, and contributing factors were made with respect to this accident. These shall not be read as apportioning blame or liability to any organisation or individual.

To serve the objective of this investigation, the following sections are included in the conclusion heading:

- **Findings —** are statements of all significant conditions, events, or circumstances in this accident. The findings are significant steps in this accident sequence, but they are not always causal or indicate deficiencies.
- **Causes —** are actions, omissions, events, conditions, or a combination thereof, which led to this accident.
- **Contributing factors —** are actions, omissions, events, conditions, or a combination thereof, which, if eliminated, avoided, or absent, would have reduced the probability of the accident occurring, or would have mitigated the severity of the consequences of the accident. The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil, or criminal liability.

3.2 Findings

Crew

3.2.1 The flight instructor had a Commercial Pilot Licence (CPL) that was issued by the Regulator on 22 February 2021 with an expiry date of 30 April 2025. He had flown a total of 437.9 hours, of which 119.4 hours were on the aircraft type.

3.2.2 According to available information, the flight instructor had logged a total of 17.5 night flying hours, which include dual and PIC hours, before the ill-fated flight. He had only flown 5.3 hours of night flying since he started his second logbook in 2015. His instrument rating was valid at the time of the flight.

3.2.3 The flight instructor had a valid instrument flying (IF) rating. He had logged 77.2 hours of IF flying of which 40.7 hours were accumulated on a flight simulation training device (FSTD).

3.2.4 The flight instructor was issued a Class 1 aviation medical certificate on 5 September 2024 with an expiry date of 30 September 2025 with a restriction to wear corrective lenses when flying an aircraft.

3.2.5 The flight instructor was offering flight instruction training at two different ATOs on a freelance basis.

3.2.6 The pilot (under training) had a Private Pilot Licence (PPL) that was issued by the Regulator on 25 October 2024 with an expiry date of 31 October 2025. The pilot had flown a total of 70.7 hours of which 4.4 hours were flown on the aircraft type.

3.2.7 The pilot was issued a Class 2 aviation medical certificate on 7 February 2023 with an expiry date of 31 January 2028 with no restrictions.

3.2.8 The flight was the pilot's first training towards obtaining a night rating.

3.2.9 The pilot sent a WhatsApp message at 1728Z to one of the ATO's flight instructors who was at home at the time to inform him that they were experiencing an engine abnormality. At 1731Z, the pilot sent him a second WhatsApp message, which stated: *"Think we have lost a magneto"*. At 1747Z, the pilot sent two more short WhatsApp messages stating the following: *"MAYDAY"* and *"Engine died."* There was no further communication thereafter.

Aircraft

3.2.10 The last maintenance inspection of the aircraft was certified on 10 October 2024 at 3 533.1 airframe hours. The aircraft had accrued 28.7 hours since the said inspection.

3.2.11 The aircraft had a valid Authority-to-fly (ATF) Certificate that was initially issued by the Regulator on 16 May 2015. The latest ATF had an expiry date of 31 May 2025. The ATF document stated, under Conditions and Limitations, that the aircraft was allowed to operate *"VMC by day and night only"*. This included all night flying conditions, from full moon to new moon.

3.2.12 The POH, Section 2, Limitations, stated that the aircraft was approved for day VFR operations only.

3.2.13 The aircraft's Certificate of Registration (C of R) was issued to the present owner on 26 April 2021.

3.2.14 The aircraft was issued a Certificate of Release to Service (CRS) on 10 October 2024 with an expiry date of 9 October 2025 or at 3 633.1 airframe hours, whichever occurs first.

3.2.15 A fatigue crack had developed on the No.6 cylinder, and the two compression rings on the No.4 piston were found to have failed. No other mechanical defects were found on the engine.

Meteorological Information

3.2.16 According to the METAR data for FAWB, clear weather conditions prevailed at the time of the flight.

3.2.17 On the day of the accident flight, it was a moonless night whereby the lunar disk was not visible to the naked eye (dark night).

Approved Training Organisation (ATO)

3.2.18 The flight was conducted under the provisions of Part 141 of the CAR 2011 as amended.

3.2.19 The ATO was issued an Approved Training Organisation (ATO) Certificate by the Regulator (SACAA) on 15 July 2021 with an expiry date of 30 April 2026.

3.2.20 According to the Training and Procedures Manual (TPM) for the ATO, the Grade III flight instructor was required to have an endorsement in his logbook, signed by the chief flight instructor (CFI) of the ATO, authorising him to conduct night flying training/ratings; however, no such endorsement was found in his logbook.

3.2.21 The flight was authorised electronically as per the flight authorisation sheet No. 2024110009.

3.2.22 The flight was not conducted as per the guidance material for a night rating (Exercise 20) as provided in the South African Flight Instructor's Manual of Training Procedures, pages 258 to 263.

Air Traffic Control

3.2.23 FAWB is a licensed aerodrome with a manned control tower and an ARFF response team. The ATC personnel and the ARFF team were on duty at the time the crew declared an emergency. The pilot had declared a MAYDAY with the ATC personnel who acknowledged the distress call and activated the crash alarm. The ARFF team responded promptly and assumed position next to Runway 29, awaiting the arrival of the aircraft.

Aerodromes

3.2.24 FAWI is a licensed aerodrome that was equipped with runway lights and a VOR beacon. The

aircraft was 14nm from FAWI when the pilot reported the engine abnormality; however, the crew did not divert to FAWI.

3.2.25 Rhino Park aerodrome, where the flight originated from, is unlicensed and did not have night flying facilities (such as runway lights, Precision Approach Path Indicators, Navigational aids, etc.).

3.2.26 FAWB is a licensed aerodrome equipped with a runway as well as approach lights and has a manned control tower with ATC personnel who were on duty at the time. The ARFF team was also on duty. The aircraft was 41nm from FAWB when the pilot reported the engine abnormality. The crew decided to proceed with the flight.

3.3 Probable Cause

3.3.1 The cause of the accident was total loss of propulsion power due to a fatigue crack on the No.6-cylinder barrel. The aircraft subsequently impacted the high-tension powerlines during a forced landing on a moonless night.

3.4 Contributory Factors

3.4.1 A significant contributory factor to this accident was that the crew was flying during a moonless (dark) night with no visual clues to the ground. This explains why the crew did not take any evasive action before impacting the high-tension powerlines as they could not see the obstacles (such as pylons, wires and terrain) in front of them.

3.4.2 The crew did not divert to an alternate aerodrome or a suitable landing area closer to their current position when the engine abnormality was first reported via WhatsApp but opted to continue with the flight to FAWB, which was approximately 41nm from their position at the time of the initial challenge with the engine. The engine failed approximately 19 minutes later.

3.4.3 The ATF that was issued by the Regulator provisioned the aircraft to be also flown during VMC at night. It did not differentiate between a moonless night and a full moon as flying during the two moon phases present profoundly different conditions; there are eight different moon phases. The ATF remains silent on which moon phases were considered to meet the requirements of VMC flying at night in an NTCA aircraft which, according to the aircraft manufacturer, was approved for day VFR operations only.

According to the ATO TPM, subheading 1.20.6, the flight instructor needed to have an endorsement in his logbook, signed by the CFI. There was no endorsement in the flight instructor’s logbook by the CFI to authorise him to conduct night flying training.

4. SAFETY RECOMMENDATIONS

4.1 General

The safety recommendations listed in this report are proposed according to paragraph 6.8 of Annex 13 to the Convention on International Civil Aviation and are based on the conclusions listed in heading 3 of this report. The AIID expects that all safety issues identified by the investigation are addressed by the receiving States and organisations.

4.2 Safety Recommendations

4.2.1 It is recommended that the Director of Civil Aviation issue a mandatory advisory notice (MAN) which calls for immediate inspection for any possible cracks on the cylinder barrels (as found in this accident) on all Jabiru 3300A engines. These cracks might not be limited to the 3300A series engines, but also on 2200A series engines.

4.2.2 It is recommended to the Director of Civil Aviation that the Regulator reviews the Conditions and Limitations entered on ATFs. Should the Regulator continue to issue Conditions and Limitations, it should be very specific and conducted in consultation with the guidance material and operational limitations as prescribed by the aircraft manufacturer. The POH for this aircraft stated that it was approved for VFR day operations only; however, the Regulator issued an ATF with several Conditions and Limitations, including VMC flight by day and night.

4.3 Safety Message

4.3.1 All pilots conducting night flight general aviation operations should consider the celestial light available for enhanced visibility when completing any training or navigational flights. The risk of flying at night is much higher than during daylight hours. During a dark night, the pilot(s) have no visual clues to the ground or any other obstructions (such as pylons, power lines, terrain, etc.), which can aggravate the situation should an in-flight emergency arise, which might necessitate a forced landing.

5. APPENDICES

5.1 Appendix A (Materials Laboratory report on the failure mode of the No. 6 cylinder)
5.2 Appendix B (POH, Section 3, Emergency Procedures, 3.4.6 Rough Engine/Power Loss)

This report is issued by:

Accident and Incident Investigations Division
South African Civil Aviation Authority
Republic of South Africa

APPENDIX A

Contents:

1. BACKGROUND INFORMATION

1.1 Investigation Tasking:

The No. 6 Cylinder (Photo 2) originating from Jabiru J170 3300A engine assembly (serial No. 33A2114), aircraft registration No. ZU-IBE (Photo 1), serial No. 6061, was submitted to determine the most probable contributing factors towards failure during operation.

1.2. Background Information:

The aircraft was involved in an accident on the 1st of November 2024, resulting in 2x fatalities.

The last maintenance inspection of the aircraft was certified on 10 October 2024 at 3,533.1 airframe hours. The aircraft accrued 28.7 hours since the said inspection.

The aircraft was fitted with a 3300A engine. Cylinders are machined in one piece from solid bar 4140 chrome molybdenum alloy steel, with the pistons running directly in the steel bores. During the OEM teardown, it was noted that the No. 6 cylinder fractured and separated from the crankcase (Photo 3).

Photo 1: Accident aircraft, ZU-IBE[1]

Photo 2: Fractured cylinder, as supplied (digital)

[1] Courtesy SACAA

Photo 3: Fractured No. 6 Cylinder, as found[2]

2. APPLICABLE DOCUMENTS

(a) Accident - Preliminary Report - AIID Ref No: CA18/2/3/10522.

(b) JABIRU 2200 & 3300 AIRCRAFT ENGINES, DOCUMENT No. JEM0001

3. DEFINITIONS

AISI	American Iron and Steel Institute	IR	Infra-Red or Thermal Testing
ASTM	American Society for Testing and Materials	MPI	Magnetic Particle Inspection
BE	Big End	NDE	Non-Destructive Evaluation
D/C	Double cab	NDI	Non-Destructive Inspection
DPI	Dye-Penetrant Inspection	NDT	Non-Destructive Testing
EBSD	Electron Back-Scatter Diffraction	OEM	Original Equipment Manufacturer
ECSA	Engineering Council of SA	OHSA	Occupational Health and Safety Act
EDS	Energy-Dispersive X-ray Spectroscopy	POD	Probability of Detection
FOD	Foreign Object Damage	QMS	Quality Management System
HE	Hydrogen Embrittlement	RC	Rockwell C-scale
HIC	Hydrogen Induced Cracking	RH	Right-Hand
HSS	High-Strength Steels	RT	Radiographic Testing
IG	Inter-Granular	SABS	South African Bureau of Standards
LH	Left-Hand	SCC	Stress Corrosion Cracking
MAUW	Maximum All-Up Weight	SE	Small End
S/C	Single cab	SEM	Scanning Electron Microscope

[2] Courtesy AIID

TTSN	Total Time Since New	TBO	Time Before Overhaul
VHN	Vickers Hardness Number	TG	Trans-Granular
VIN	Vehicle Identification Number	TSO	Time Since Overhaul
X/C	Extra-cab	UT	Ultrasonic Testing
MHSIT	Minimum Hot Surface Ignition Temperature		

4. PERSONNEL

(a) This report's investigative member and compiler is Mr C.J.C. Snyman, ID number 6406105057080. Mr. Snyman is a qualified Physical Metallurgist (ECSA Registration: Prof. Eng. Tech. No 201670194), Radiation Protection Officer (RPO, NNR, No 281), and Aircraft Accident Investigator (SCSI).

5. APPARATUS AND METHODOLOGY

(a) The methodology included visual inspection of the affected part/s, sample preparation and Light-, Stereo-, and Electron microscopy analysis.
(b) Apparatus:

Type	Make/Model	Operator
Stereomicroscope	Zeiss Discover V20	C.J.C. Snyman
Scanning Electron Microscope	Zeiss 540 Crossbeam FEGSEM	C.J.C. Snyman
EDS	Oxford Aztec	C.J.C. Snyman

6. INVESTIGATION RESULTS

Note 2: *The investigation results are based on the supplied evidence only. It is supposed that the evidence is in the as-found condition.*

6.1. Visual and low-magnification Inspection:

The visual inspection revealed a circumferential fracture at the cylinder base flange (Photo 2). The fracture initiated from 2 locations, A and E (Photo 5), within the lipped section (Photo 4, red arrow) (inside the crankcase) and progressed within the flange until the final fast fracture.

Indications of temperature exposure can be attributed to the reported post-impact fire. The color of the surface deposits conforms to that of oil burning, suggesting oil loss during operation before impact.

No clear indications of excessive wear, corrosion, or other discrepancies relating to the cylinder bore area (Photo 7) were noted.

No clear indications of excessive contact surface wear, distortion, or other discrepancies were noted at the flange/crankcase– and/or flange/through bolt/stud interfaces.

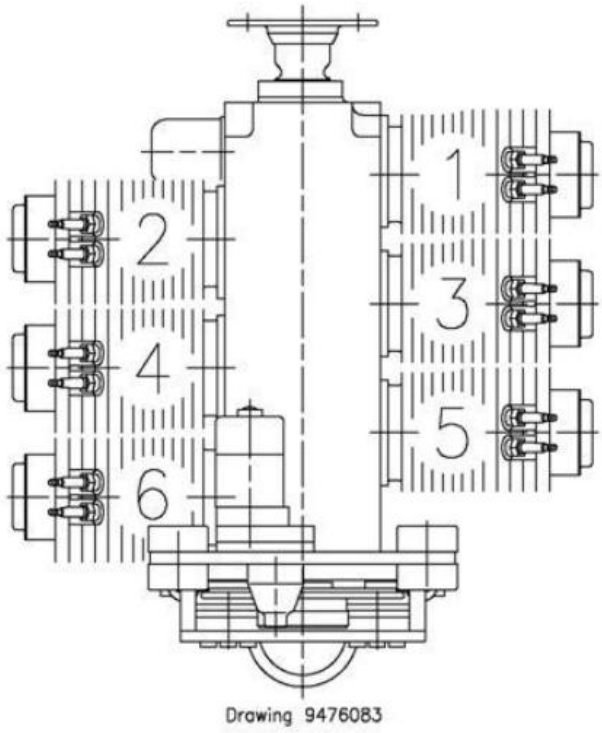
6.2. High-Magnification Inspection:

Although the fracture surfaces (carbon deposits) were extensively damaged and contaminated, the high magnification inspection revealed clear indications of fatigue striations (Fractographs 1 and 2) at locations A and E (Photo 5). This supports the notion that two fatigue fractures initiated within the lipped section (within the crankcase area) and progressed inward towards the top of the bore. In contrast, the final, fast fracture progressed parallel with the flange and perpendicular to the applied force (under normal operating conditions).

Adjacent to the initiation zones, secondary fracture initiations were noted Fractograph 3). This indicates an applied tensile load at the initiation zones during operation.

Clear indications of surface strain (Fractograph 4) adjacent to the flange fractures suggest an exceedingly high applied stress attributed to the tensile loads induced by the compression, intake, and exhaust strokes during operation.

The extent of fracture surface smearing and other mechanical damages (Fractograph 5) is indicative that the fracture progressed over an undetermined period of operation.



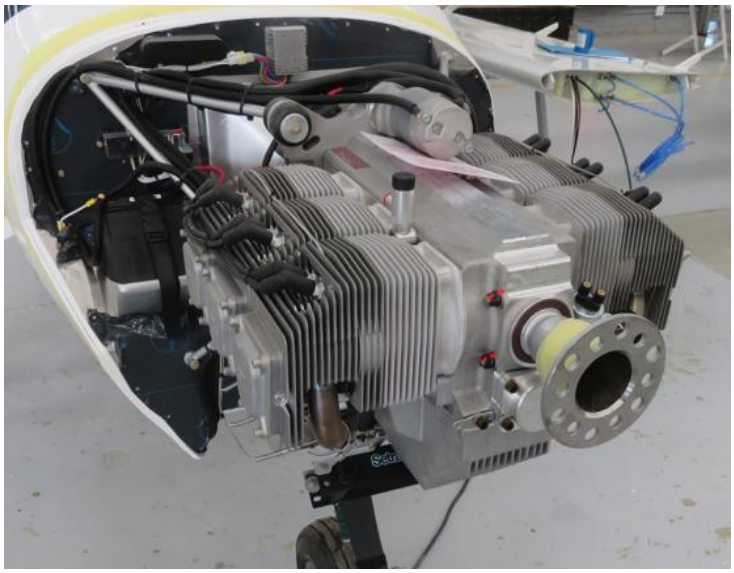


Diagram 1: Cylinder layout[3]

[3] Courtesy Jabiru

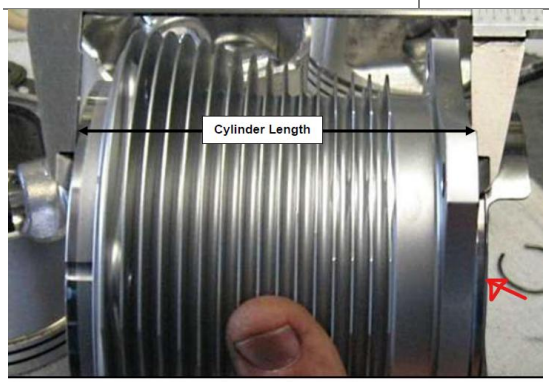


Photo 4: Cylinder layout[4]

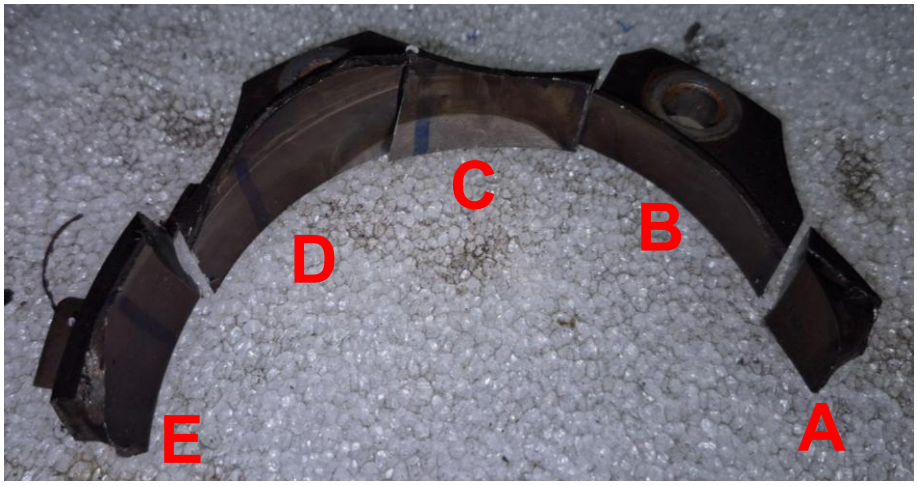


Photo 5: Sectioned fracture surface (digital)

Photo 6: Cylinder condition, outer surfaces (digital)

[4] Courtesy Jabiru

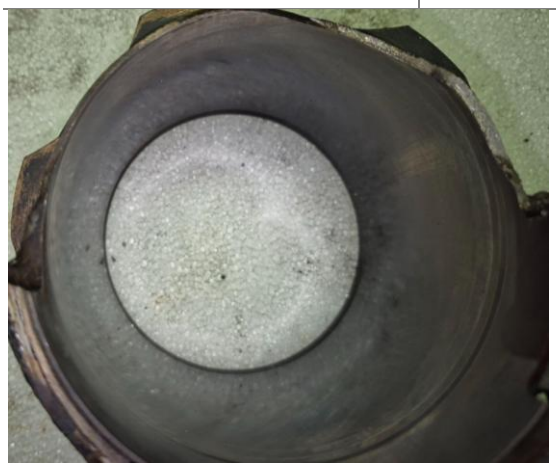
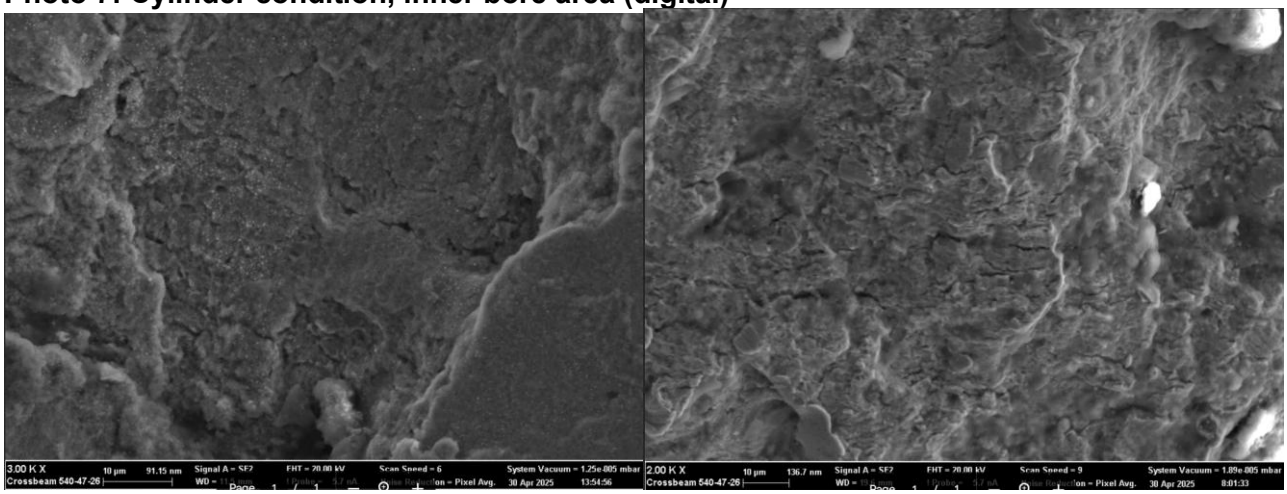
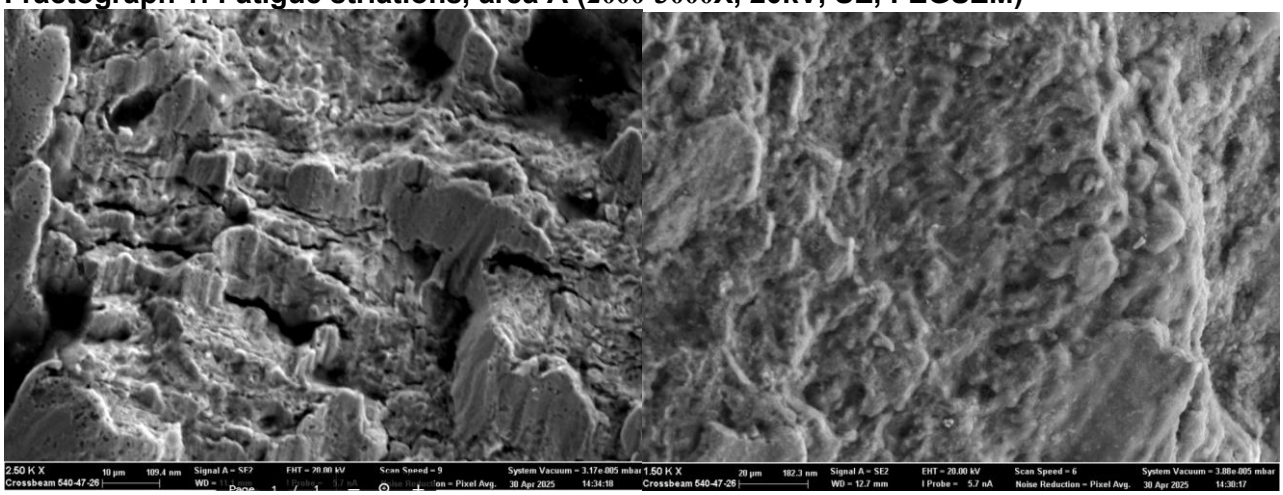


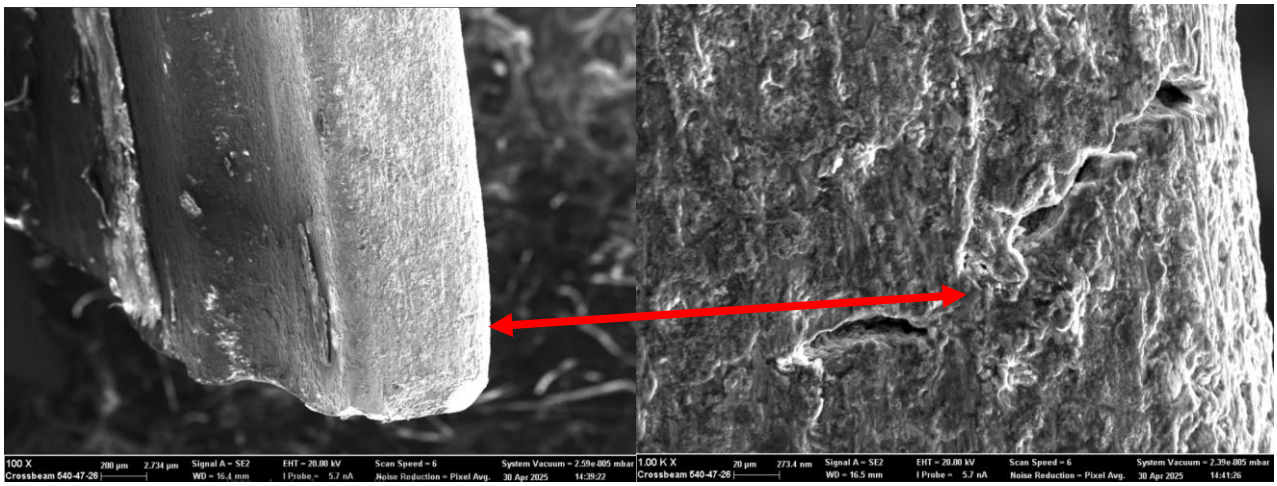
Photo 7: Cylinder condition, inner bore area (digital)



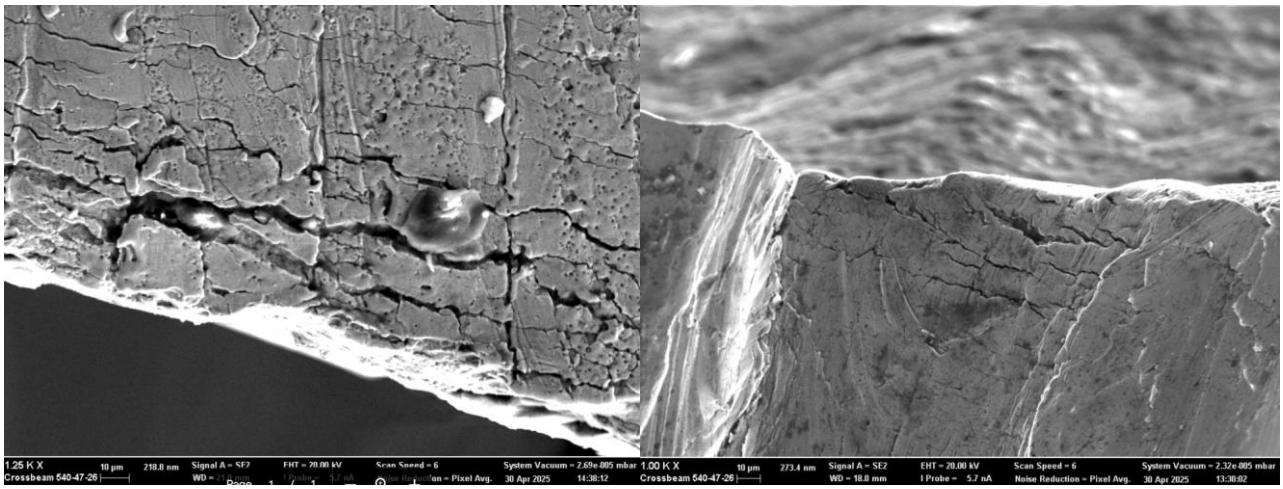
Fractograph 1: Fatigue striations, area A (2000-3000X, 20kV, SE, FEGSEM)



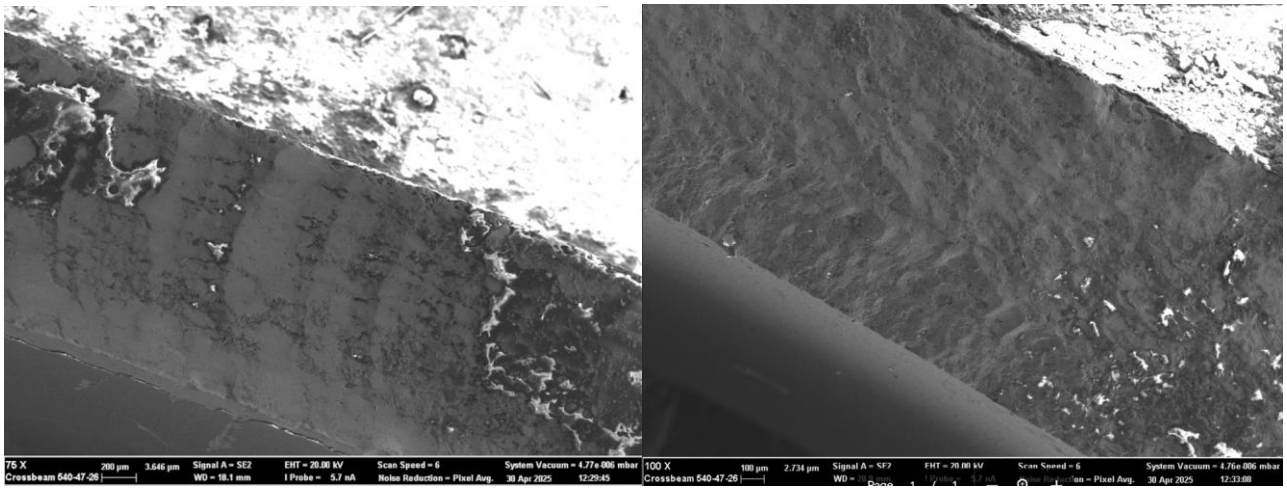
Fractograph 2: Fatigue striations, area D (1500-2500X, 20kV, SE, FEGSEM)



Fractograph 3: Secondary fracture initiations (100-1000X, 20kV, SE, FEGSEM)



Fractograph 4: Secondary fracture initiations (1000-1250X, 20kV, SE, FEGSEM)



Fractograph 5: Fracture surface damages (76-100X, 20kV, SE, FEGSEM)

7. DISCUSSION AND CONCLUSIONS

Note 4: The conclusions are based on the investigation results obtained from the supplied parts/components and information only.

7.1. Visual Inspection:

(a) The visual inspection revealed a circumferential fracture at the cylinder base flange. The fracture initiated from 2 locations within the lipped section (Photo 4, red arrow) (inside the crankcase) and progressed inward (towards the top of the bore), and then parallel with the flange during the final fast fracture.

(b) No other possible contributing factors were noted from the single cylinder supplied to this investigation.

7.2. High-Magnification Inspection:

(c) The high-magnification inspection confirmed **fatigue** as the primary fracture mode during the initial stages of the failure.

(d) Secondary fracture initiations close the fatigue fracture initiation zones, suggesting exceedingly high tensile loads during operation. No clear surface stress raisers (nick marks, corrosion pitting, etc.) were noted.

7.3. Contributing Factors:

The following are considered the **most probable** contributing factors towards the initiation of the fatigue fractures, in no particular order:

(a) **Fitment**. Incorrect cylinder fitment (applied torque) could affect the applied loading distribution surrounding the flange/crankcase interface during operation. This can contribute to exceedingly high tensile loads within the lipped section, initiating surface fractures. On reaching Critical Crack Size, one or more fractures will progress under fatigue conditions.

(b) **Vibration**: Exceedingly high vibration exposure/s will enhance the possibility of fracture initiation/s during operation. No reports suggesting exceedingly high vibration were supplied to this investigation.

(c) **Through Bolt Failure**. A common cause of cylinder failures, however, no report from the OEM engine teardown was supplied to this investigation.

(d) **Piston Misalignment.** A less common cause of cylinder failures, however, no report from the OEM engine teardown was supplied to this investigation.

7.4. Other Remarks:

(a) The most common failures of cylinders relate to breaching and occur within the high-pressure zone (upward from the bottom dead centre (BDC)). However, in this case, the fracture initiated and progressed within the low-pressure zone, supporting the notion that the primary cause relates to **fitment** if vibration, through bolt integrity and piston alignment, can conclusively be excluded.

(b) Considering the location of the fracture (low-pressure zone), it can be derived that it would have resulted in oil seepage during operation. As this would have been noticeable during operation, pre- and post-flight inspections, it can be assumed that the fracture only breached the cylinder during the final flight. However, the initiation of the fracture and the undetected progression thereof could have extended beyond the 28.7 operating hours since the last annual inspection.

8. RECOMMENDATIONS

8.1. OEM (Jabiru):

(a) It is recommended that the OEM revisit the relevant engine assembly with a focus on the abovementioned probabilities.

9. DECLARATION

9.1. The author has acquired all digital images and displayed them un-tampered unless stated otherwise.

APPENDIX B

3.4.6 Rough Engine/Loss of Power

1. USE OF POWER Continuous RPM up to 3300 is allowed in normal operations. In emergencies engine RPM in excess of 3300 may be used, but this will only be available at speeds above about 100 KIAS.

2. SPARK PLUG FOULING Slight engine roughness in flight may be caused by one or more spark plugs becoming fouled by carbon or lead deposits. This may be verified by selecting each ignition switches momentarily to OFF. An obvious power loss in single ignition operation is evidence of spark plug or ignition system trouble. Assuming that the spark plugs are the more likely cause, applying full throttle may clear the plug fouling. If this does not solve the engine problem, plan to land at the nearest practical airfield to have the situation investigated.

3. IGNITION MALFUNCTION A sudden engine roughness or misfiring is usually evidence of carburettor icing or ignition system problems. In the case of ignition system trouble, switching each ignition switch off in turn should identify which system is malfunctioning. Different power settings may alleviate the problem. If not, plan to land at the nearest practical airfield to have the situation investigated.

4. CARBURETTOR ICING Rough running and loss of power may be caused by carburettor icing. This is most likely in conditions of high humidity and at low power settings. If not corrected, ice build up in the carburettor throat will cause complete power loss. If carburettor icing is suspected, immediately apply full carburettor heat until normal engine

   operation is restored, and the heat can be selected OFF. Carburettor heat should only be selected ON or OFF, as partial heat application may exacerbate ice build-up. The aircraft can be safely operated with carburettor heat applied for indefinite periods, but there will be a slight power loss. Hence, carburettor heat should not be used when full power is required; e.g. for take-off.

5. LOW OIL PRESSURE If low oil pressure is accompanied by normal oil temperature, there is a possibility that the oil pressure gauge or the relief valve is malfunctioning, and an immediate precautionary landing is not warranted. A landing at the closest practical airfield is advisable however so that the source of the trouble can be investigated. If a total loss of oil pressure is accompanied by a rise in oil temperature, an engine failure is probably imminent. Reduce engine power immediately and select a suitable forced landing area. Use only the minimum power required to reach the desired touch down point.