AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

				Reference:	CA18/2/3/10551		
Helicopter Registration	ZS-RAC	**Date of Accident**		5 February 2025		**Time of Accident**	0705Z
Type of Helicopter	Bell 206L-4 Long Ranger IV			**Type of Operation**	Private (Part 91)		
Pilot-in-command Licence Type	Commercial Pilot Licence (CPL) Helicopter		**Age**	34		**Licence Valid**	Yes
Pilot-in-command Flying Experience		**Total Flying Hours**		1 675.5		**Hours on Type**	230.9
Last Point of Departure	Rand Airport (FAGM), Gauteng Province						
Next Point of Intended Landing	Polokwane Civil Airport (FAPI), Limpopo Province						
Damage to the Helicopter	Destroyed						
Location of the accident site with reference to easily defined geographical points (GPS readings if possible)							
On the border of Polokwane Game Reserve at Global Positioning System (GPS) co-ordinates determined to be 23°56’54’’South 029°27’23’’East, at an elevation of 4 265 feet (ft)							
Meteorological Information	Wind velocity: 020° at 3KT; Temperature: 26°C; Dew Point: 18°C; Visibility: ≥10000m; Cloud ceiling: FEW020; QNH: 1021 hPa						
Number of People On-board	1 + 0	**Number of People Injured**	0	**Number of People Killed**	1	**Other (On Ground)**	0

Synopsis

On Wednesday morning, 5 February 2025, a pilot on-board a Bell 206L-4 Long Ranger IV helicopter with registration ZS-RAC took off on a ferry (private) flight from Rand Airport (FAGM) in Gauteng province with the intention to land at Pietersburg Civil Aerodrome (FAPI) and, thereafter, Polokwane International Aerodrome (FAPP), both located in Limpopo province, South Africa, before proceeding to Harare in Zimbabwe.

According to the owner, the helicopter departed from FAGM at 0536Z and routed north-east to refuel at FAPI and then route to FAPP to clear customs before proceeding to Zimbabwe where the operator was contracted to transport personnel and goods. The pilot’s father stated that the pilot noticed an oil pressure anomaly, torque fluctuation and engine metal chip warnings whilst en route to FAPI. Communication between the pilot and the aircraft maintenance engineer (AME) at FAGM revealed that the pilot had enquired about the oil indication anomaly to the AME; however, he proceeded with the flight to FAPI. At approximately 0705Z whilst overhead Polokwane Game Reserve, about 1.4 nautical miles (nm) west of FAPI, the helicopter crash-landed in a bush-type terrain in a game reserve. The pilot was fatally injured, and the helicopter was destroyed during the accident sequence. Teardown inspection of the engine by the manufacturer revealed that the engine oil had escaped through the accessory gearbox orifice and, consequently, starved the engine of lubrication which resulted in a contained engine failure.

Probable Cause/s and/or Contributory Factors			
The engine failed due to loss of lubrication which resulted in a rapid loss of engine power, subsequently followed by an unsuccessful forced landing on a bush-type terrain approximately 1.4 nautical miles (nm) west of FAPI. **Contributory Factor** Lack of service on the gearbox oil system for a period exceeding 2000 hours which was beyond the engine manufacturer's recommendation. The centrifugal breather gearshaft support seal was not tightly fitted to the breather gearshaft; this led to the oil escaping the system through the oil breather orifice.			
SRP Date	13 January 2026	Publication Date	20 January 2026

Occurrence Details

Reference Number	**:** CA18/2/3/10551
Occurrence Category	**:** Accident (Category 1)
Type of Operation	**:** Private (Part 91)
Name of Operator	**:** Dellaria Leasing (PTY) LTD
Helicopter Registration	**:** ZS-RAC
Helicopter Make and Model	**:** Bell 206L-4 Long Ranger IV
Nationality	**:** South African
Place	**:** Polokwane Game Reserve, Limpopo Province
Date and Time	**:** 5 February 2025 at 0705Z
Injuries	**:** One Fatality
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) was notified of the occurrence on 5 February 2025 at 0730Z. 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. Notifications sent to the State of Registry, Operator, and Design and Manufacturer in accordance with the CAR 2011 Part 12 and the ICAO Annex 13 Chapter 4. The State of Design and Manufacture appointed an accredited representative and advisor. Investigators were 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
   Helicopter — the Bell 206L-4 Long Ranger involved in this accident
   Investigation — the investigation into the circumstances of this accident
   Pilot — the pilot 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 clarity of the report. Modifications to images used in this report were limited to cropping, magnification, file compression; or enhancement of colour, brightness, contrast; or addition of text boxes, arrows, or lines.*

Disclaimer

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Table of Contents

Abbreviation	Description
°	Degrees
°C	Degrees Celsius
ACCID	Accident
AD	Airworthiness Directive
AGL	Above Ground Level
AIID	Accident and Incident Investigations Division
AME	Aircraft Maintenance Engineer
AMO	Aircraft Maintenance Organisation
ATC	Air Traffic Control
CAA	Civil Aviation Authority
CAR	Civil Aviation Regulations
CAVOK	Ceiling and Visibility OK
CEB	Commercial Engine Bulletin
CVR	Cockpit Voice Recorder
CWP	Caution and Warning Panel
C of A	Certificate of Airworthiness
C of R	Certificate of Registration
CRS	Certificate of Release to Service
FAGM	Rand Airport
FAPI	Pietersburg Civil Aerodrome
FAPP	Polokwane Gateway International Airport
FAWB	Wonderboom Airport
FCU	Fuel Control Unit
FDR	Flight Data Recorder
Ft	Feet
GPS	Global Positioning System
hPa	Hectopascal
IIC	Investigator-in-Charge
Kt	Knots
Lb	Pounds
L	Litres
M	Metres
METAR	Meteorological Aerodrome Report
MHz	Megahertz
Nm	Nautical Mile
POH	Pilot's Operating Handbook
QNH	Barometric Pressure Adjusted to Mean Sea Level
SACAA	South African Civil Aviation Authority
SAWS	South African Weather Service
TBO	Time Between Overhaul
UTC	Co-ordinated Universal Time
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
Z	Zulu (Term for Universal Co-ordinated Time - Zero Hours Greenwich)

1. FACTUAL INFORMATION

1.1. History of Flight

1.1.1. On Wednesday morning, 5 February 2025, a pilot on-board a Bell 206L Long Ranger IV helicopter with registration ZS-RAC departed from Rand Airport (FAGM) in Gauteng province with Harare International Airport (FVRG) in Zimbabwe as the final planned destination. The flight was conducted under visual flight rules (VFR) by day and under the provisions of Part 91 of the Civil Aviation Regulations (CAR) 2011, as amended.

1.1.2. A VFR flight plan was filed with 0500Z as the estimated departure time. The intended routing included intermediate stops at Pietersburg Civil Aerodrome (FAPI) in Limpopo province for refuelling, followed by Polokwane International Airport (FAPP) also in Limpopo province to clear customs, before proceeding to FVRG in Harare, Zimbabwe, for a full-stop landing. The helicopter lifted off at 0536Z from FAGM and routed north-east to refuel at FAPI. According to the owner of the helicopter, these stops formed part of the planned ferry flight to reposition the helicopter for operations in Zimbabwe where the operator had been contracted to transport personnel and goods.

1.1.3. Whilst en route to the first planned stop at FAPI and in the vicinity of Wonderboom Airport (FAWB), the pilot reportedly noticed warning indications of low oil pressure and engine metal chip detection, as relayed by the pilot's father. According to communication records via WhatsApp (a messages application) that were obtained from the pilot's mobile phone (from the pilot's father), there were several warning indications on the caution and warning panel (CWP) in the cockpit during the flight.

1.1.4. The information received from the pilot's father revealed that the pilot, whilst en route to FAPI and near FAWB, was in communication with the aircraft maintenance engineer (AME) who was at the base station at FAGM; in the text messages, the pilot was relaying to the AME the cautions and warnings in-flight.

1.1.5. The pilot sent a video message to the AME at 0551Z shortly after lift-off which showed oil pressure indication fluctuations to which the AME responded: '*could be some air in the system*'. The next phone message records showed that at 0606Z, the oil pressure warning indicator fluctuated; and at 0611Z, a torque fluctuation indication was noted. At 0639Z, there was an oil temperature decay indication which was followed by the activation of a metal chip light (ENG CHIP) at 0640Z. The engine metal chip warning indicated a detection of metal particles in the oil lubrication system. The pilot made a voice call to the AME which lasted approximately 57 seconds. The engine failed at 0703Z, and the helicopter crash-landed shortly afterwards.

1.1.6. The accident occurred on the border of Polokwane Game Reserve at Global Positioning System (GPS) co-ordinates determined to be 23°56'54''S 029°27'23''E, at an elevation of 4 265 feet (ft).

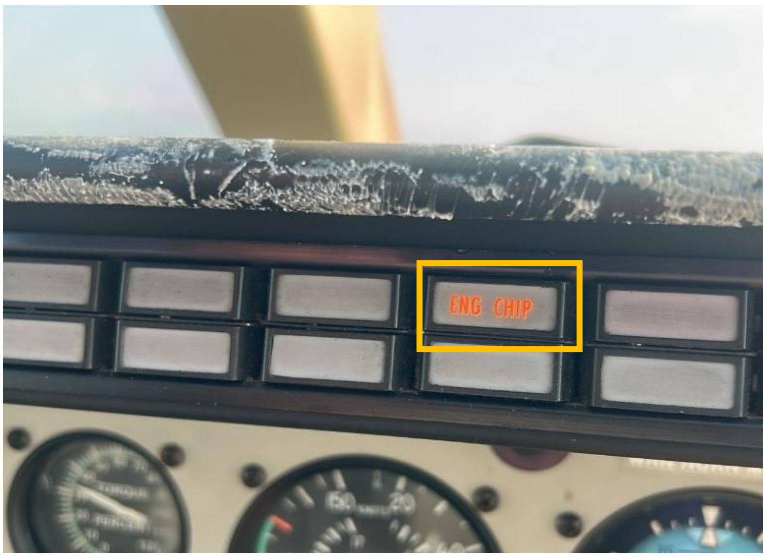

Figure 1: Engine chip warning in-flight on the caution and warning panel (CWP). (Source: Pilot's phone)

Figures 2 and 3: Unstable (erratic) engine oil pressure warning indication (yellow arrows) which is low on the left picture and high on the right picture. (Source: Pilot's phone)

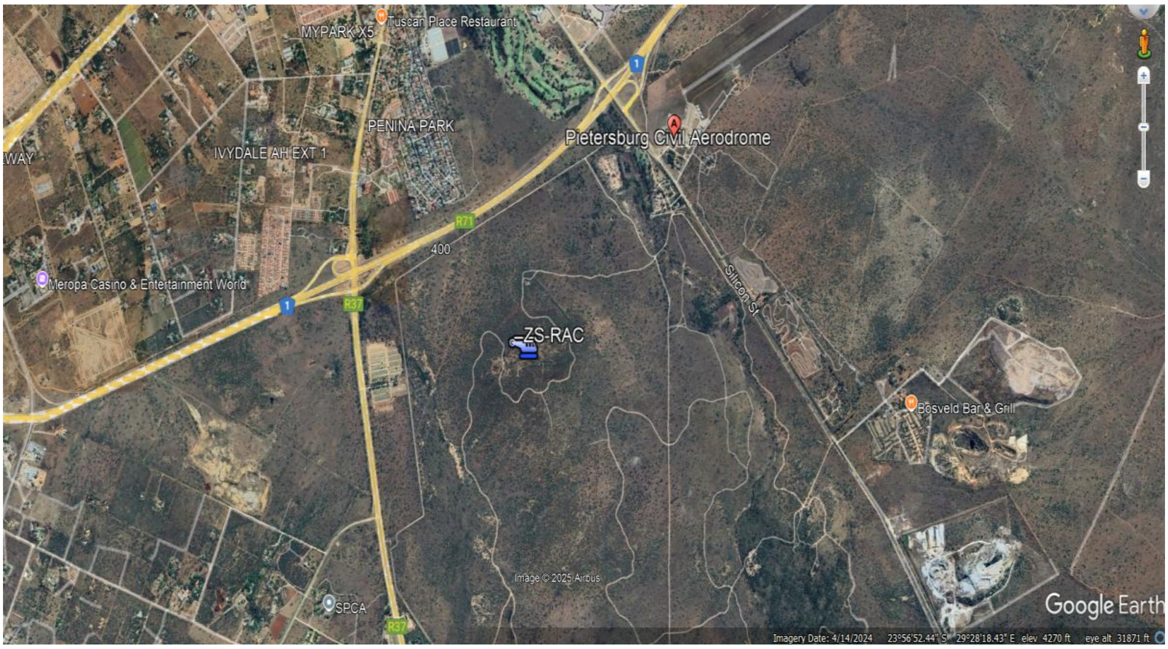

Figure 4: An overview of the accident site. (Source: Google Earth)

1.2. Injuries to Persons

Injuries	Pilot	Crew	Pass.	Total On-board	Other
Fatal	1	-	-	1	-
Serious	-	-	-	-	-
Minor	-	-	-	-	-
None	-	-	-	-	-
Total	**1**	**-**	**-**	**1**	**-**

Note: Other means people on the ground.

1.2.1. The pilot was fatally injured during the accident.

1.3. Damage to Helicopter

1.3.1. The helicopter was destroyed during the accident sequence.

1.4. Other Damage

1.4.1. None.

1.5. Personnel Information

Pilot-in-Command (PIC)

Nationality	South African	Gender	Male	Age	34
Licence Type	Commercial Pilot Licence (CPL) Helicopter				
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Night Rating				
Medical Class & Expiry Date	31 January 2029				
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	1 675.5
Total Past 24 Hours	1.3
Total Past 7 Days	1.8
Total Past 90 Days	131.8
Total on Type Past 90 Days	33.6
Total on Type	230.9

1.5.1. The pilot had a Commercial Pilot Licence (CPL) Helicopter that was initially issued on 8 January 2020 by the Regulator (South African Civil Aviation Authority [SACAA]) in accordance with (IAW) Part 61 of the CAR 2011. The licence was revalidated on 25 November 2024 with an expiry date of 31 December 2025. The pilot conducted his CPL renewal test on a Robinson R44 helicopter; the flight duration was 0.9 hours.

1.5.2. The pilot was issued a Class 1 aviation medical certificate on 21 January 2025 with an expiry date of 31 January 2026 with no restrictions.

1.6. Helicopter Information

1.6.1. Helicopter Description: (Source: Pilot's Operating Handbook [POH])

The Bell 206L Long Ranger 4 is a two-bladed, single-engine seven-seat light utility helicopter produced by Bell Helicopter Company in the United States of America (USA). It is equipped with a Rolls-Royce 250-C30P, single-stage centrifugal flow compressor, two-stage gas generator and two-stage power turbine engine producing approximately 490 Shaft

Horsepower (SHP) for take-off and 370 SHP for maximum continuous operation. The fuel system incorporates a single bladder-type fuel cell located below and aft of the passenger rear seat. Installed within the lower surface of the fuel cell are 2 electrically operated boost pumps, lower and upper tank indicating units, and an electrically operated sump drain valve. The boost pumps are interconnected and supply fuel through a single hose assembly to the fuel shut-off valve. From the shut-off valve, fuel is supplied to the airframe fuel filter and to the engine fuel system. The fuel cell is filled from the right side. Fuel capacity is 416 litres (L).

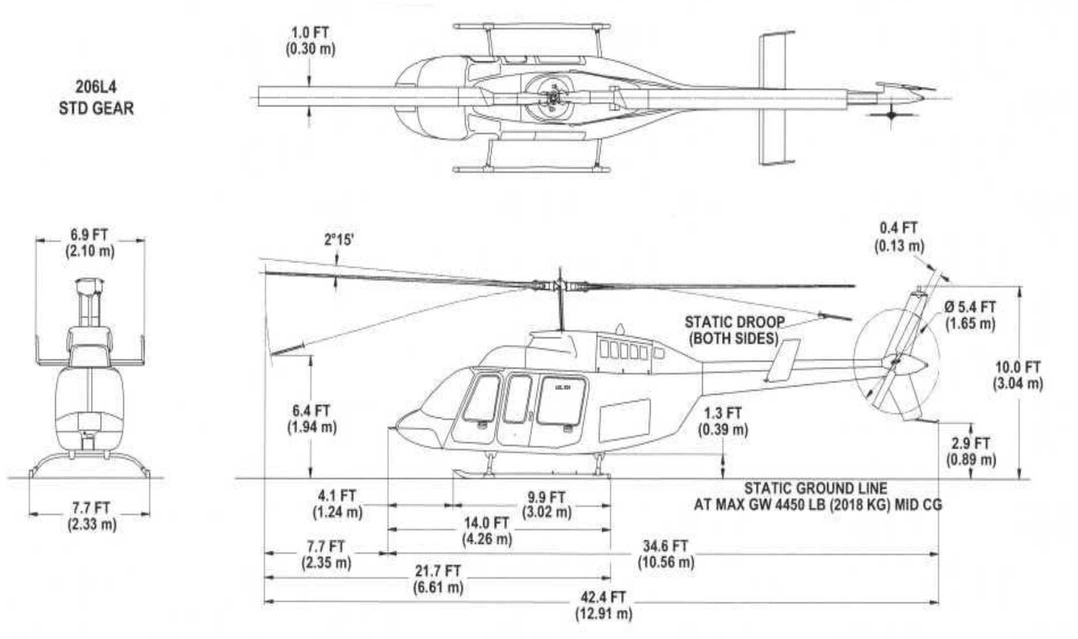

Figure 5: The Bell 206L Long Ranger 4 exterior dimensions.

Figure 6: A file photo of the ZS-RAC helicopter. (Source: https://www.jetphotos.com/photo/7764117)

Airframe:

Manufacturer/Model	Bell Helicopter Company/B206L Long Ranger IV	
Serial Number	52306	
Year of Manufacture	2004	
Total Airframe Hours (At Time of Accident)	5 784.5	
Last Inspection (Date & Hours)	4 February 2025	5 783.2
Airframe Hours Since Last Inspection	1.3	
CRS Issue Date	5 February 2025	
C of A (Issue Date & Expiry Date)	1 May 2024	31 May 2025
C of R (Issue Date) (Present Owner)	28 July 2015	
Operating Category	Standard Normal Category	
Type of Fuel Used	Jet A1	
Previous Accidents	None	

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

Engine:

Manufacturer/Model	Rolls Royce/250-C30P
Serial Number	CAE-895994
Part Number	23051643
Hours Since New	5 783.7
Hours Since Overhaul	Time Between Overhaul (TBO) not reached

Accessory Gearbox:

Part Number	Rolls Royce
Serial Number	CAG-96003
Hours Since New	5 783.7
Hours Since Overhaul	TBO Not reached

1.6.2. A review of the helicopter maintenance records, included the flight folio, airframe and engine records was conducted. According to the flight folio, the following engine oil consumption anomalies were noted: the engine oil uplift increased since 11 December 2024 between operations in Zimbabwe. Approximately nine and a half millilitres (946-millilitre [ml]) cans of engine oil were added to the engine within a four-day period of operations (17.4 hours). The oil uplift was the Mobile Jet Oil 254 for the engine and AeroShell 555 for the gearbox.

1.6.3. On 15 December 2024, the helicopter was ferried by another pilot from FVRG to FAGM for a mandatory periodic inspection (MPI) and to rectify an intermittent higher-than-normal oil consumption using the same route in reverse (via FAPP to clear customs and then to FAPI for refuel, before proceeding to the destination, FAGM). During the initial legs of the flight, the oil consumption and indications were normal.

1.6.4. However, during landing at FAPI, the engine metal chip indication warning light illuminated. The pilot inspected and removed metal particles from the metal chip detector; the oil level was below optimal, which the pilot topped up. He then consulted with the AME at the base in FAGM who deemed it acceptable to continue with the flight. The operator stated that an additional landing between FAPI and FAGM was added to the route to re-check the chip detector; this was planned for Bela-Bela area. A vehicle was positioned at the planned Bela-Bela Landing Zone (LZ). The helicopter landed at Bela-Bela, and the chip detector was examined for any metal particles; none was found.

Figure 7: The Bell 206 chip detector with metal chips.

1.6.5. The helicopter took off and proceeded to the intended destination. Approximately 20 minutes from FAGM, the pilot noted a decay in engine oil pressure indication and a chip detector light illuminated. The pilot executed a precautionary landing on a field to inspect the chip detector and the oil level. During the ground inspection, the pilot discovered metal particles from the engine chip detector and cleared it. He contacted the AME at FAGM, and a decision was taken that the pilot can continue with the flight. The helicopter reached the destination with no further engine metal chip indication recurrence for the remainder of the flight.

1.6.6. During maintenance, the engine compressor and turbine modules were removed and sent to a Rolls-Royce approved engine shop for Metal in Oil Inspection (MIO). According to the Rolls Royce maintenance manuals, the MIO inspection should be conducted on the entire engine stages including the compressor, turbine and gearbox stages. The Number 2 bearing (Illustration 1) on the compressor was inspected by the engine shop as this was believed to be the reason for metal particle detection warning light illuminating. Further teardown of the compressor revealed that the labyrinth seal had failed. This was given by the engine shop as the reason for the higher-than-normal oil consumption. The engine shop stripped the turbine assembly to determine any other sources of metal chips, and the Number 8 bearing (Illustration 1) was found to have spalling. The decision was made to replace all the bearings in the turbine.

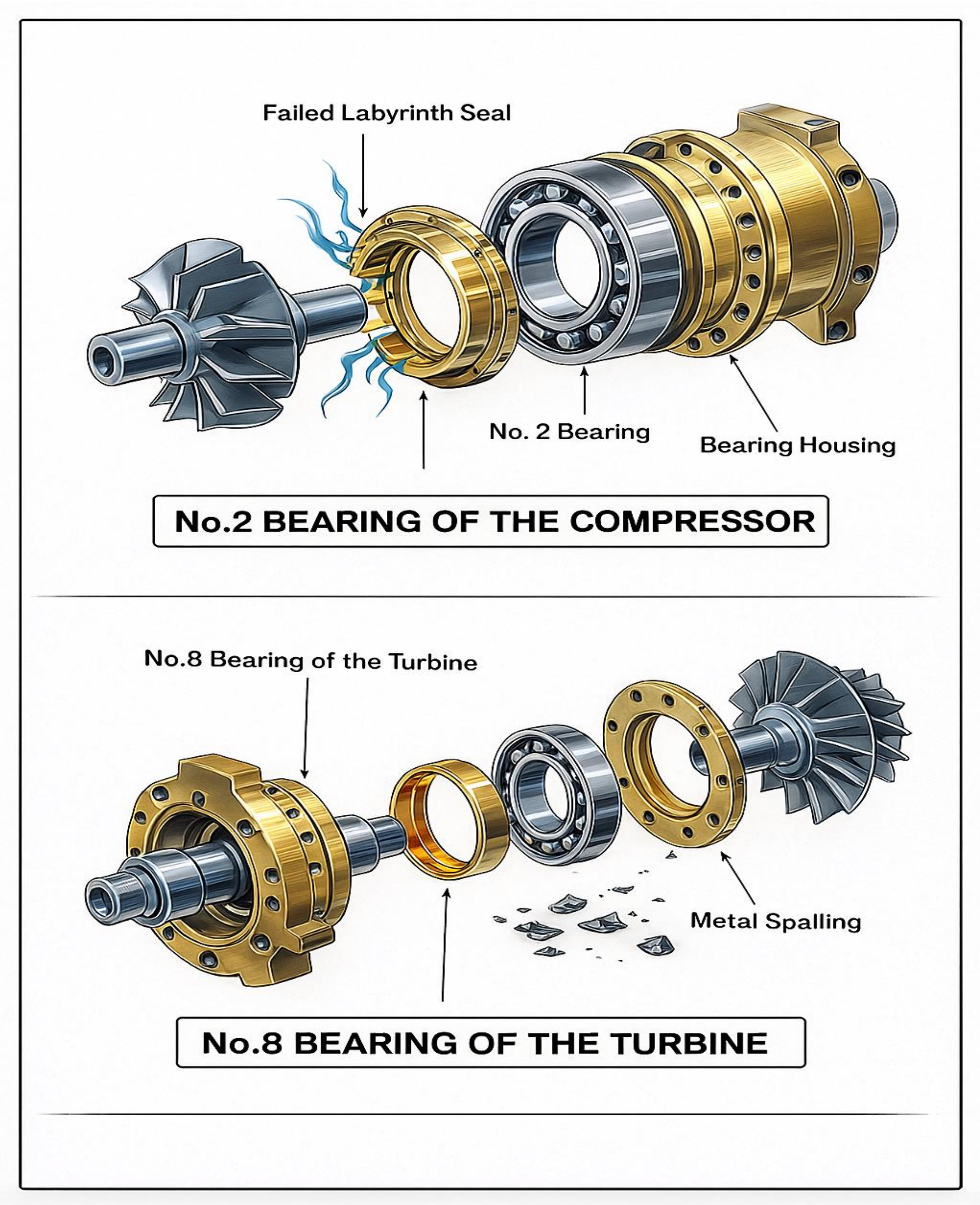

Illustration 1: The schematics of the affected bearings.

Figure 8: One of the spalled balls from bearing Number 8. (Source: Engine shop)

1.6.7. The compressor and turbine maintenance work was completed around 30 January 2025, and the units were reinstalled on the helicopter over the following few days. The AME completed the installation of the compressor and turbine units on 2 February 2025 and conducted ground runs on 3 and 4 February 2025. Several ground runs were conducted as the AME was having a challenge to balance the tail rotor.

1.6.8. During the ground runs, it was noted that the starting temperatures were higher than desired and, thus, the engineer replaced the fuel control unit (FCU). The balancing of the tail rotor was completed on 4 February 2025, and the helicopter was deemed serviceable and ready to return to Zimbabwe. A compass swing and a final test flight was conducted on 5 February 2025 before the ferry flight.

1.6.9. The Certificate of Release to Service (CRS) was issued on 5 February 2025 with an expiry date of 4 February 2026 or at 5 883.4 airframe hours, whichever occurs first.

1.6.10. The engine manufacturer had issued a Commercial Engine Bulletin CEB-72-3299 dated 20 January 2015, with Revision 6 issued on 18 May 2023 which stipulated the installation of a new power accessory gearbox oil delivery tube prior to 2 000 flight hours. There was no record of compliance of the CEB-72-3299 engine bulletin.

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 Polokwane International Airport (FAPP) on 5 February 2025 at 0700Z. The accident site was 9 nautical miles (nm) north of FAPP.

Wind Direction	020°	Wind Speed	3 kt	Visibility	10 km
Temperature	26°C	Cloud Cover	FEW	Cloud Base	2000 ft
Dew Point	18°C	QNH	1021 hPa	Density Altitude	6 283 ft

1.7.2 The weather conditions on the day of the flight did not contribute to this accident.

1.8 Aids to Navigation

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

1.9 Communication

1.9.1 The helicopter was equipped with a standard communication system as approved by the Regulator. There were no recorded defects with the communication system prior to the flight. The pilot was in contact with the FAPP air traffic control (ATC) tower and there were no records of an emergency broadcast to ATC personnel.

1.10 Aerodrome Information

1.10.1 The accident occurred in the Polokwane Game Reserve, approximately 1.4 nm west of FAPI.

Aerodrome Name	Pietersburg Civil Aerodrome
Aerodrome Location	Pietersburg, Limpopo Province
Aerodrome Status	Unlicensed
Aerodrome Co-ordinates	23°55’34” South, 029°29’04” East

Aerodrome Altitude	4 354 feet
Runway Headings	08/26
Runway Dimensions	2 200 meters X 25 meters
Heading of Runway Used	Not Applicable
Runway Surface	Asphalt
Approach Facilities	None
Radio Frequency	122.70 MHz

1.11 Flight Recorders

1.11.1 The helicopter 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 helicopter type.

1.12 Wreckage and Impact Information

1.12.1 The accident occurred in a bush-type terrain within the Polokwane Game Reserve situated approximately 1.4 nm west of FAPI. The damage pattern was indicative of a helicopter that had descended in a steep angle before it crashed on the ground in a nose-high attitude and left roll. The tail rotor and vertical fin impacted a tall tree and, subsequently, separated from the tail assembly. The helicopter sustained significant damage to the skid landing gear, fuselage, main rotor and tail boom.

1.12.2 There was no evidence of a significant engine power during impact with the ground. All airframe components and controls were accounted for post-accident. There was evidence of fuel at the accident site although the quantity could not be determined. There were no noted pre-impact anomalies; all fractures were consistent with impact forces.

Figure 9: The helicopter as it rested after the crash. (Source: EMS)

Figure 10: The helicopter during the recovery phase.

1.12.3 The separated vertical tail fin displayed a sheen oil residue, indicative of oil discharge rearwards during flight prior to impact. There was a concentrated area of dark coked oil residue on the upper engine cowling aft of the exhaust stack which was consistent with prolonged exposure to overheated or burnt lubricant. The examination of the exhaust pipe revealed molten metal particles which suggested internal engine component distress and localised overheating. The outer oil reservoir was found completely empty at the accident site, corroborating significant in-flight oil loss. Additionally, two full 946ml cans of AeroShell 555 and Mobile Jet Oil 254 were recovered from the wreckage, confirming that no oil replenishment had been performed before the occurrence.

Figures 11 and 12: The coked oil residue on the upper engine cowling and oil sheen on the vertical separated fin.

1.12.4 The exhaust stack contained numerous molten metal particles, indicating that internal engine components had experienced severe overheating and localised thermal breakdown. These particles were fused and irregularly shaped, consistent with high-temperature distress within the turbine section where metallic fragments are expelled through the exhaust flow path after component degradation.

Figure 13: The molten metal particles inside the exhaust stack.

1.13 Medical and Pathological Information

1.13.1 A post-mortem examination of the pilot was performed. The results of the post-mortem and the toxicology tests were not yet available at the time of release of this report. Should the results have substantive impact which might be considered as new evidence, the Accident and Incident Investigations Division (AIID) will reopen the investigation.

1.14 Fire

1.14.1 There was no evidence of a pre- or post-impact fire.

1.15 Survival Aspects

1.15.1 The accident was considered not survivable due to the high-impact forces at the time of crash. The impact compromised the structural integrity of the cockpit and the cabin area of the helicopter, which resulted in a fatal injury.

1.15.2 The helicopter was equipped with a Kannad 406 emergency locator transmitter (ELT). The Aeronautical Rescue Coordination Centre (ARCC) did not receive a signal from the ELT. The ELT was removed from the helicopter at the accident site, and the switch was found in "ARM" position.

Figure 14: The Kannad 406 ELT at the scene.

1.16 Tests and Research

1.16.1 On 13 February 2025, an engine teardown inspection of the Rolls-Royce engine with serial number (CAE-895994) was conducted in the presence of the investigators as well as the representatives from Rolls-Royce and Bell Helicopters.

1.16.2 The findings of the engine examination by Rolls-Royce were as follows:

Compressor:

The compressor module was removed and not disassembled. The thickness of the alignment shims removed from the gearbox mount pads matched the markings on the compressor assembly. The impeller displayed no FOD indications and was normal in appearance. The rotor spun freely when operated by hand. The No. 2 bearing was dark in appearance with coked oil present on the rear support adjacent to the sump. The Spur Adapter Gearshaft (SAG) was dry and neither of the two required O-rings were present. The SAG was intact but was discoloured, which was consistent with overtemperature operation.

Combustor:

The Outer Combustion Case (OCC) was undamaged, and the armpit patches were present with no obvious cracking. The combustion liner displayed a sand brown appearance on the aft outer shell and all the louvres within the liner were present. Black carbon was deposited around the fuel nozzle orifice and there was no evidence of an abnormal burn pattern.

Turbine:

During the turbine removal, the alignment shims on the gearbox mount pads were measured and matched the markings on the module. The N1 rotor was not connected to the turbine to compressor coupling and the N2 rotor remained frozen once the turbine was removed from the gearbox. The turbine to compressor shaft was intact and the turbine tie bolt "acorn nut" was discovered within the shaft. The nut was fractured from the gas producer rotor. The power turbine to pinion gear shaft was intact.

The No. 5 bearing was dark in colour and oil drenched. The bearing spun with some resistance and roughness. Oil was noted within the gearbox breather orifice (located within the exhaust collector) and on the exhaust collector surface around the orifice. The airframe supplied exhaust stack displayed a dark, carbon-like coating which was concentrated on the right side, aft of the gearbox breather orifice (Figure 15).

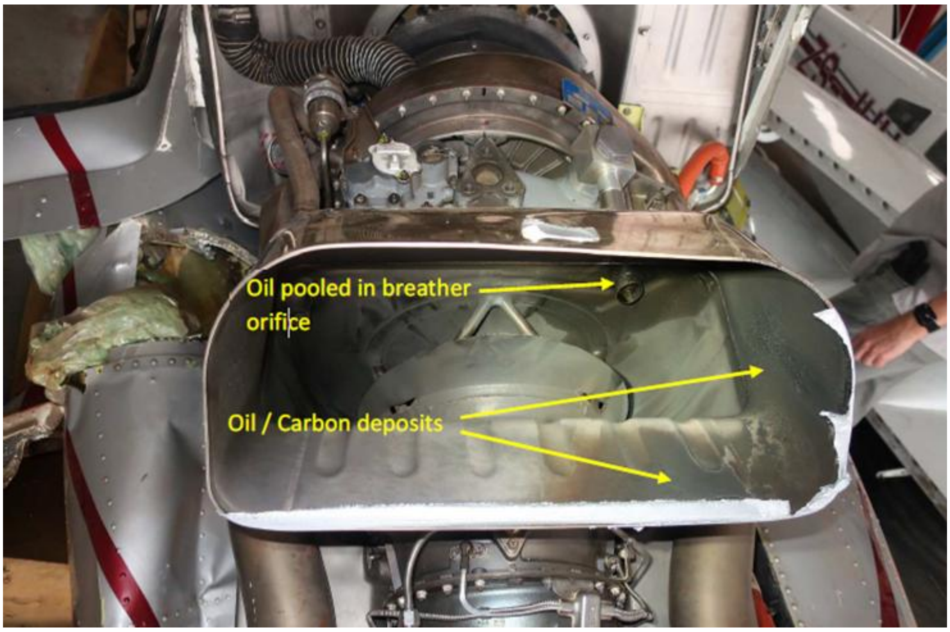

Figure 15. Oil in exhaust collector and stack.

The gas producer support case bulged outward in-plane with the first stage turbine wheel and was cracked at the 6 o' clock position. The No. 8 bearing sump cover was dented outward from impact with the turbine tie bolt. The No. 8 bearing sump was dry and the No.8 bearing was disintegrated beyond recognition. The first stage turbine wheel had burst into numerous pieces and circumferential scoring was noted on the aft face of the second stage *turbine nozzle. Localised, heavy circumferential gouging was observed on the forward face of the first stage turbine wheel near the hub, just outboard of the curvic splines. The second stage nozzle airfoils were heavily damaged with notable heat distress and missing material from the trailing edges. The second stage turbine wheel blades were present but thermally degraded and their tips were absent. The turbine splined adapter was separated from the second stage turbine wheel shaft and lodged within the power turbine support in the No. 6/7 bearing area.*

The power turbine support case was intact and the No. 6/7 bearing sump was dry. The thermocouple leads were continuous, and the power turbine assembly was generally undamaged and not disassembled further.

Gearbox:
The accessory gearbox was opened and internally dark in appearance. The oil was black. All the gears and bearings were present with no mechanical damage noted. Both the N1 and N2 geartrains turned freely once the turbine was removed. The oil pump was removed and all the visible scavenge and pressure gears turned when the drive shaft was rotated. Ferrous material was observed in the oil pump turbine scavenge cavities. The upper magnetic chip detector retained a large amount of ferrous debris while the lower detector retained a relatively smaller amount. Ferrous material was also noted and removed from the oil pressure filter bowl and filter element.

The centrifugal breather gearshaft support seal was not tightly fitted to the centrifugal breather gearshaft. The seal was dark in colour and the inner diameter did not retain the same stiffness as an exemplar seal. The seal mating surface on the centrifugal breather gearshaft felt normal with no obvious nicks or damage.

Lubrication System: The oil system lines and tubes were checked for security and obstructions to include:

- *Oil in line from aircraft mounted reservoir to the engine*
- *Oil out line from the engine to the aircraft oil cooler*
- *Engine mounted oil supply and scavenge tubes to and from the No. 6/7 and*

No. 8 bearing sumps

- *No. 6/7 bearing oil jet*
- *No. 6/7 bearing sump can (dry with coked oil residue)*
- *No. 8 bearing oil jet*
- *No. 8 "j-tube" oil jet*
- *All the accessory gearbox internal oil passages*
- *Disassembly of the oil regulator housing check valve*

- *Disassembly of the oil regulator*
- *Pressure check of the turbine supply line check valve (opened at 2.5 psi)*

None of the lines or tubes were obstructed or loose.

Accessories:
The Power Turbine Governor (PTG), Fuel Control Unit (FCU), fuel pump and fuel nozzle were removed. The fuel nozzle primary and secondary orifices were clean with some carbon noted on the air shroud. The nozzle was not disassembled. The fuel pump was normal in appearance and the drive shaft turned with moderate resistance. It was not disassembled.
The FCU was normal in appearance and not separated from the fuel pump.
The PTG was normal in appearance and the input drive spun freely with no axial play. It was not disassembled.

Engine Investigation:
The following components were shipped to the Rolls-Royce Materials Laboratory in Indianapolis, IN, for further analysis.
Part Name Part Number Serial Number
Centrifugal Breather Gearshaft 6898642 1104-269
Support Seal 23075960 N/A
Support Seal Housing 6889300 N/A
Ball Bearing (Forward) 23007151 MP122255
Ball Bearing (Aft) M250-10123 MP013941
1st Stage Turbine Wheel M250-10227 X648835
Governor Seal 23079054 N/A
Starter Seal 23063371 N/A
FCU Seal 23079054 N/A

The findings of Materials Evaluation Report 25FAE-022 (Appendix A) were:
* *The centrifugal breather gearshaft support seal inner diameter exceeded the component definition requirement. The inner diameter of the support seal exceeded the outer diameter of the gearshaft sealing surface.*
* *The 1st stage turbine wheel was fractured into four larger fragments and many smaller fragments. The 1st+ stage turbine wheel web exhibited circumferential rub consistent with contact with the 2nd stage turbine nozzle during engine operation.*
* *The preserved fracture features of the 1st stage turbine wheel were visually consistent with overload. The centrifugal breather gearshaft sealing surface was measured with callipers. The outer diameter of the sealing surface measured 0.876 inch, which met the component definition requirement of 0.870 – 0.877 inch.*
The support seal and housing assembly was assembled onto the breather gearshaft sealing

surface (Figure 16) to demonstrate the fit of the seal onto the gearshaft. The support seal exhibited a loose fit on the gearshaft sealing surface. The support seal inner diameter was measured optically and with callipers. The seal inner diameter measured approximately 0.885 inch with each method, which exceeded the component definition requirement of 0.790 – 0.830 inch.

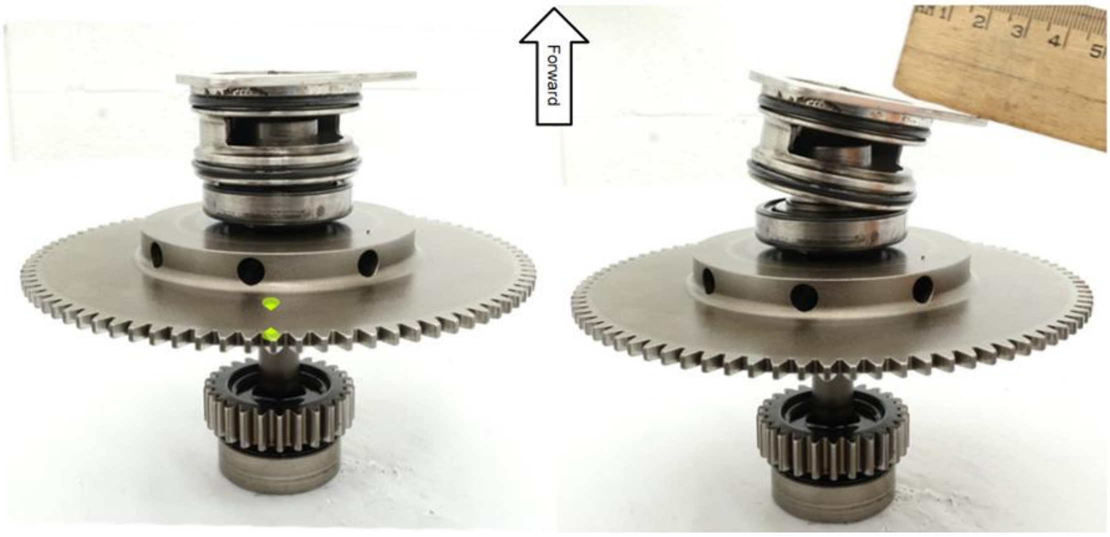

Figure 16. Re-assembled seal and gearshaft demonstrating the amount of looseness between the seal and shaft.

The resultant fit between the seal and gearshaft surface presented a gap of 0.009 inch. The assembly is designed to have an interference (or tight fit) of the seal to the seal land of 0.040 inch to 0.087 inch tight. This gap presented an escape path for the engine oil out of the engine. The subsequent loss of oil resulted in oil starvation to several bearings within the engine, including the No. 8 bearing. The failure of the No. 8 bearing allowed the turbine gas producer rotor to shift axially forward. Which caused the first stage turbine wheel to contact the second stage turbine nozzle and ultimately burst.

Engine Information:
The helicopter was powered by a Rolls-Royce M250-C30P turboshaft engine with a take-off rating of 650shp. The last engine maintenance action conducted 0.3 hours prior to the event flight was a 100/300-hour inspection, compressor inspection for Metal in Oil (MIO), turbine inspection for MIO, fuel nozzle replacement and FCU replacement. After this maintenance action, a 0.3-hour maintenance flight was conducted the morning prior to the event flight.

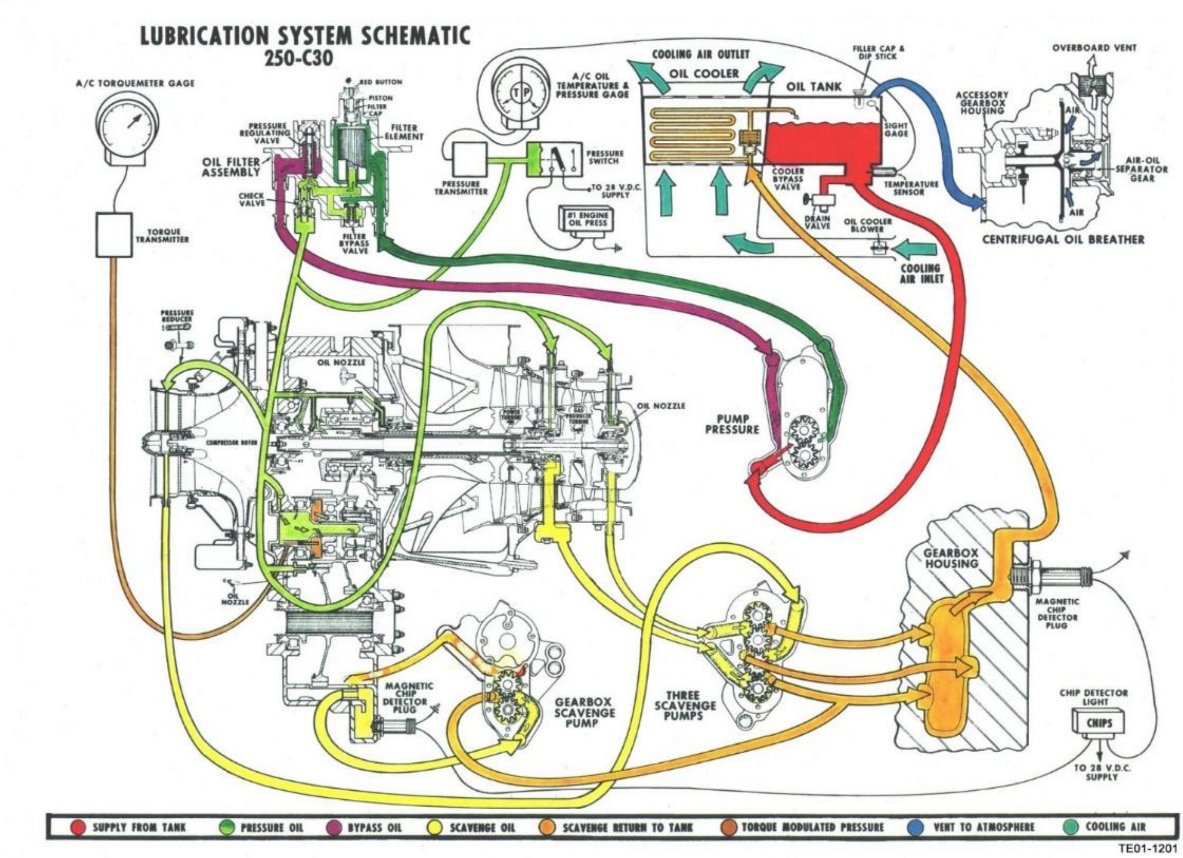

Diagram 1: A Schematic of the lubrication system. (Source: Rolls Royce)

1.16.3 *The lubricating system furnishes lubrication, scavenging and cooling as needed for bearings, splines, and gears in all conditions of flight. The system is a circulating, dry sump type, with an external reservoir and oil cooler mounted and furnished by the helicopter manufacturer.*
The torquemeter in the engine gearbox is hydraulic and uses the engine lubrication system as its oil (hydraulic) pressure source. In order to minimise friction effects and provide accurate measurement of torque, the axial gear thrust on the helical torquemeter gearshaft is high. System pressure must always be greater than the torquemeter oil pressure. Therefore, it is necessary to regulate the system oil pressure to the relatively high value of 115-130 psi.
Oil pressure is a function of (1) volume flow, (2) restriction to flow, and (3) viscosity. Volume flow from the pressure element is determined by N1 RPM...volume flow increases as N1 RPM increases. Restriction to flow is determined by the size of the passages, lines, and nozzles. Viscosity or fluid friction is a function of oil temperature. Thus, if the oil temperature and restriction to flow remain constant, oil pressure will increase with increases in N1 RPM until the regulated oil pressure of 115-130 psi is reached. Further increases in N1 RPM do not result in further increases in pressure because the pressure regulating valve bypasses the excess oil to the inlet of the pump.

Components which have pressure oil delivered to them for lubrication and cooling are as follows:

1. *Compressor Rotor Front (No.1) Bearing*
2. *Compressor Rotor Rear (No.2) Bearing*
3. *Helical Power Train Drive (Pinion) Gear Front (No.3) Bearing*
4. *Helical Power Train Drive (Pinion) Gear Front (No.4) Bearing*
5. *Power Turbine Rotor Front (No.5) Bearing*
6. *Power Turbine Rotor Front (No.6) Bearing*
7. *Gas Producer Turbine Rotor Front (No.7) Bearing*
8. *Gas Producer Turbine Rotor Rear (No.8) Bearing*
9. *1st Stage Gear Reduction where the pinion gear and the large gear on the helical torquemeter gearshaft come "out-of-mesh"*
10. *2nd Stage Gear Reduction where the pinion gear and the large gear on the helical torquemeter gearshaft come "out-of-mesh" with the helical power take-off gearshaft*
11. *Turbine to Compressor Coupling Splines*
12. *Torquemeter Front Roller Bearing*
13. *Torquemeter Rear Roller Bearing*
14. *Torquemeter Ball Bearing*
15. *Spur Adapter Gearshaft (No. 2 ½) Bearing*

The remaining gears and bearings in the accessory gearbox are lubricated by the air-oil mist present within the gearbox.
The engine has the following scavenge oil sumps:

1. *Compressor Front Support Sump*
2. *Accessory Gearbox Sump*
3. *Power Turbine Support External Sump*
4. *Gas Producer Turbine Support Sump*

A gear type pressure and scavenge pump assembly, consisting of one pressure element and five scavenge elements, is mounted within the accessory gearbox. An assembly containing an oil filter, check valve, filter bypass valve, and a pressure regulating valve is located in the upper left-hand side of the gearbox housing. The gearbox housing and cover are magnesium alloy castings which have passages for pressure and scavenge oil. The accessory gearbox assembly incorporates a number of oil transfer tubes. External stainless-steel tubes are used to transfer tubes, and the external tubes port pressure and scavenge oil as required by the lubrication system.

1.16.4 The engine manufacturer had issued a Commercial Engine Bulletin CEB-72-3299 dated 20 January 2015, with Revision 6 issued on 18 May 2023 which stipulated the installation of the new power accessory gearbox oil delivery tube. There was no record of compliance with the CEB-72-3299 and it was not mandatory as no Airworthiness Directive (AD) was issued. *Airworthiness Directives (AD) are legally enforceable safety regulations issued by aviation authorities such as the Federal Aviation Administration (FAA) or State of Design to correct an unsafe condition in an aircraft, engine, propeller or appliance. The ADs are mandatory and specify the actions needed to fix the problem, such as inspections, repairs or replacements, and the timeframe for completion. Failure to comply with an AD means the aircraft is not considered airworthy*.

1.17 Organisational and Management Information

1.17.1 The flight was conducted during VFR conditions by day and under the provisions of Part 91 of the CAR 2011, as amended.

1.17.2 The aircraft maintenance organisation (AMO) which conducted the last maintenance inspection of the aircraft was issued an AMO Certificate on 13 December 2024 with an expiry date of 31 December 2025. The helicopter type was duly authorised to be maintained under the AMO.

1.17.3 A copy of the Air Operator Certificate (AOC) that was issued by the Civil Aviation Authority of Zimbabwe was found in the helicopter. The AOC was issued on 14 September 2023 with an expiry date of 30 September 2024.

1.18 Additional Information

1.18.1 Bell 206L-4 Flight Manual: Emergency/Malfunction Procedures (Paragraph Number: 3-3-G; Page Number: 3-7) and Table 3-2.

INDICATIONS:	PROCEDURE:
1. Engine oil pressure below minimum. 2. Engine oil pressure above maximum or fluctuating abnormally.	1. Engine oil pressure below minimum — Monitor engine oil pressure and temperature. Land as soon as possible. 2. Engine oil pressure above maximum or fluctuating abnormally — Monitor engine oil pressure and temperature.

3. Engine Chip (Ferrous particles in engine oil)	Land as soon as practical. 3. ***Land as soon as possible.***

1.18.2 Engine Oil Pressure Low, High or Fluctuating:

If engine oil pressure is below minimum or above maximum, land as soon as possible.

If engine oil pressure fluctuates but does not exceed a limit, monitor engine oil pressure and temperature and land as soon as practical.

Engine Oil Temperature High

Land as soon as possible.

1.18.3 Civil Aviation Technical Standards (CATS) Part 43.02.8, Section A, Subsection 3:

(e) The registered owner or operator of an aircraft shall ensure that a control system is in place ensuring that the requirements of all applicable Ads, as well as any SBs, SLs, Sis or other service information are reviewed, and those that are classified as mandatory, are complied with as specified in each directive before the aircraft is released to service. Where such instruction requires the update of technical data, the update shall be implemented, where applicable—

(i) "Mandatory" in this context means –

(aa) the airworthiness directives (AD) are issued either by the Director or by the appropriate authority of the State of the type certificate holder;

(bb) any SB, SL, SI or other service information classified by the Director as mandatory, shall be complied with in respect of an aircraft, including its components or part; and

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. The pilot had a valid Commercial Pilot Licence (CPL) that was initially issued by the Regulator on 8 January 2020 IAW Part 61 of the CAR 2011. The licence was revalidated on 25 November 2024 with an expiry date of 31 December 2025. The pilot had a Class 1 aviation medical certificate that was issued on 21 January 2025 with an expiry date of 31 January 2026 with no restrictions. The pilot was adequately licensed to conduct the flight with more than 230 hours as pilot-in-command on the accident helicopter type. During his licence renewal, a Robinson R44 helicopter was used for the proficiency test on 25 November 2024. The investigation did not find evidence of any emergency procedures administered in the accident aircraft.

2.2.2. The AMO which conducted the last maintenance inspection of the aircraft was issued an AMO Certificate on 13 December 2024 with an expiry date of 31 December 2025. The aircraft type was duly authorised to be maintained under the AMO. The helicopter was issued a Certificate of Release to Service (CRS) on 5 February 2025 with an expiry date of 4 February 2026 or at 5 883.4 hours, whichever occurs first.

2.2.3. The helicopter departed from FAGM at 0536Z; the flight was conducted in VFR conditions by day and under the provisions of Part 91 of the CAR 2011, as amended. At 0606Z whilst in-flight, the oil pressure indicator started to fluctuate, and at 0612Z the torque fluctuation indicator activated. At 0639Z there was an oil temperature drop warning which was subsequently followed by a chip detector indicator light activation at 0641Z. The pilot continued with the flight after consultation with the AME until the engine failed at 0703Z. The helicopter crashed shortly afterwards in the Polokwane Game Reserve. The decision to continue with the flight at first oil pressure indication was concerning as the pilot was still in proximity to the maintenance facility (homebase). The helicopter showed several indications of system failure after the scheduled maintenance that was aimed at correcting similar symptoms that led to high oil consumptions.

2.2.4. The helicopter engine was signed out for the 300-hour inspection on 4 February 2025 after which a post-maintenance flight was conducted on 5 February 2025. Metal contamination was detected in the engine oil during the ferry flight from FAGM back to Zimbabwe. The detection of metal contamination is a red flag which necessitates landing as soon as possible and should have triggered a more thorough investigation or grounding of the helicopter.

2.2.5. The decision to continue operations after this finding suggested a possible lapse in maintenance judgment or the pressure to return the helicopter to service prematurely. The Commercial Engine Bulletin CEB-72-3299 dated 20 January 2015 followed by Revision 6 on 18 May 2023 which stipulated the installation of the new power accessory gearbox oil delivery tube was not complied with and neither was it mandatory. It is likely that if the bulletin was complied with, the high oil temperature and consumption issues would have been avoided or alleviated.

2.2.6 The Civil Aviation Technical Standards (CATS) 43.02.8 requires that operators review all ADs and service information and comply only with those explicitly classified as “mandatory.” Under the regulation, mandatory status applies solely to ADs issued by the Director or the State of Design, or to service information formally declared mandatory by the Director. Since CEB-72-3299 was neither accompanied by an AD nor classified as mandatory by the SACAA, the operator was not legally obligated to comply, resulting in negative implementation of the bulletin.

2.2.7 The progressive nature of the warnings (oil pressure, torque, temperature, metal chip light) indicated a deteriorating engine condition. The pilot, in consultation with the ground engineer, had nearly an hour from the first anomaly to the engine failure which raises questions about situational awareness, decision-making and adherence to the helicopter operating emergency procedures as per the POH. The pressure from the operator to have the helicopter delivered as soon as possible could not be ignored as a contributory factor. The engine failed at 0703Z, and the helicopter crash-landed shortly afterwards in the Polokwane Game Reserve.

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

3.2.1. The pilot had a Commercial Pilot Licence (CPL) that was initially issued on 8 January 2020 by the Regulator (SACAA) in accordance with Part 61 of the CAR 2011. The licence was revalidated on 25 November 2024 with an expiry date of 31 December 2025.

3.2.2. The pilot had a Class 1 aviation medical certificate that was issued on 21 January 2025 with an expiry date of 31 January 2026 with no restrictions.

3.2.3. The flight was conducted in VFR by day and under the provisions of Part 91 of the CAR 2011, as amended.

3.2.4. The aircraft maintenance organisation (AMO) that conducted the last maintenance inspection of the aircraft was issued an AMO Certificate by the Regulator on 13 December 2024 with an expiry date of 31 December 2025. The aircraft type was duly authorised to be maintained under the AMO.

3.2.5. The helicopter engine was signed out for the 300-hour inspection on 4 February 2025 after which a post-maintenance flight was conducted. Metal contamination was detected in the engine oil during the ferry flight on 5 February 2025.

3.2.6. The helicopter was issued a Certificate of Release to Service (CRS) on 5 February 2025 with an expiry date of 4 February 2026 or at 5 883.4 hours, whichever occurs first.

3.2.7. The helicopter departed from FAGM at 0536Z. At 0606Z the oil pressure indicator started to fluctuate, and at 0612Z a torque fluctuation indicator activated. At 0639Z there was a decay in oil temperature which was followed by an ENG CHIP indication light activation at 0641Z. The engine failed at 0703Z, and the helicopter crashed shortly afterwards in the Polokwane Game Reserve.

3.2.8. The operator did not comply with the CEB-72-3299 bulletin because it was not classified as mandatory and no SACAA or State of Design Airworthiness Directive (AD) was issued for the subject bulletin.

3.2.9. Teardown inspection of the engine by the manufacturer revealed that the engine oil escaped through the accessory gearbox orifice and had, consequently, starved the engine of lubrication which then resulted in a contained engine failure. There was a series of high temperature metal failures due to loss of lubrication which allowed metal debris into the oil system.

3.3. Probable Cause/s

3.3.1. The engine failed due to loss of lubrication which resulted in a rapid loss of engine power, subsequently followed by an unsuccessful forced landing on a bush-type terrain approximately 1.4 nautical miles (nm) west of FAPI.

3.4. Contributory Factors

3.4.1. Lack of service on the gearbox oil system for a period exceeding 2000 hours was beyond the engine manufacturer's recommendation. The centrifugal breather gearshaft support seal was not tightly fitted to the breather gearshaft which led to the oil escaping the system through the oil breather orifice.

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 Recommendation/s

4.2.1. It is recommended to the Director of the South African Civil Aviation Authority that a strengthened oversight be established to provide a clearer mechanism for assessing and, where necessary, designating manufacturer service bulletins as mandatory when they have significant airworthiness implications for operators of Rolls-Royce M250-C30 Series engine using AeroShell 555 on the gearbox. In this case, the absence of an AD or mandatory classification for CEB-72-3299 created regulatory ambiguity that allowed the operator to forgo compliance. Implementing a structured review and communication process for incoming service bulletins will ensure that critical safety information is consistently evaluated and, where justified, elevated to mandatory status to enhance continued airworthiness and safety assurance. The engine manufacturer-issued Commercial Engine Bulletin on 20 January 2015, revised on 18 May 2023, which stipulated a new oil delivery tube fitment before 2 000 hours of operation should be mandatory in order to prevent engine damage or loss.

5. APPENDICES

5.1. Appendix A: Commercial Engine Bulletin CEB-72-3299.

This report is issued by:

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

Appendix 1

EXPORT CONTROLLED

COMMERCIAL ENGINE BULLETIN

Rolls-Royce

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ENGINE, GEARBOX ASSEMBLY - REPLACEMENT OF OIL DELIVERY TUBE (PICCOLO TUBE)

1. PLANNING INFORMATION

A. Effectivity

(1) Engines

All Rolls-Royce M250-C28, C30, C40B, and C47 Series engine models and gearbox modules built before November 30th, 2014 are affected by this bulletin.

(2) Spares - Affected

B. Reason

The purpose of this CEB is to production and service release a new oil delivery tube to the M250-C28, C30, C40B, and C47 Series engine models.

For the M250-C28, C30 (except C30G and C30G/2 models), and C47 engines, incorporating the P/N M250-10767 Power Accessory Gearbox Oil Tube or the alternate P/N M250-10715 Power Accessory Gearbox Oil Tube will improve the oil delivery to the #2 thrust bearing. This change will decrease the bearing temperature and improve the bearing performance.

For the M250-C30G, C30G/2 and C40B models, incorporating the P/N M250-10773 Power Accessory gearbox Oil Tube or alternate P/N M250-10772 Power Accessory Gearbox Oil Tube will improve the oil delivery to the #2 thrust bearing. This change will decrease the bearing temperature and improve the bearing performance.

C. Description

This CEB releases P/N M250-10767 Power Accessory Gearbox Oil Tube and alternate P/N M250-10715 Power Accessory Gearbox Oil Tube to M250-C28, C30, and C47 Series engine models except the C30G and C30G/2 engines.

The M250-10767 and M250-10715 Power Accessory Gearbox Oil Tubes are functionally equivalent and only vary in the fact that M250-10767 is machined from wrought, while M250-10715 is finished machined from a casting.

This CEB releases P/N M250-10773 Power Accessory Gearbox Oil Tube and alternate P/N M250-10772 Power Accessory Gearbox Oil Tube to M250-C30G, C30G/2, and C40B Series engine models.

The M250-10773 and M250-10772 Power Accessory Gearbox Oil Tubes are functionally equivalent and only vary in the fact that M250-10773 is machined from wrought, while M250-10772 is finished machined from a casting.

D. Approval

Technical aspects are FAA approved.

E. Compliance

WARNING: FAILURE TO COMPLY WITH THIS BULLETIN IS AT THE OWNER/OPERATOR'S SOLE RISK AND ROLLS-ROYCE IS NOT RESPONSIBLE FOR ANY RESULTING DAMAGE OR LOSS.

Compliance Code 2 or 3: To be complied with prior to 2000 flight hours after receipt of Revision 4 of this bulletin, no later than 31 December 2023 or next time the engine or module is sent to an authorized repair/overhaul facility for any reason, whichever occurs first.

NOTE: Rolls-Royce recommends operators to install M250-10926 bearing at the same time this CEB is accomplished.

F. Interchangeability

For M250-C28, C30 (except models C30G, C30G/2), and C47 series engines, P/N M250-10767 Power Accessory Gearbox Oil Tube or P/N M250-10715 Power Accessory Gearbox Oil Tube can replace previous P/N 23063357 Power Accessory Gearbox Oil Tube.

For M250-C30G, C30G/2, and C40B engines, P/N M250-10773 Power Accessory Gearbox Oil Tube or P/N M250-10772 Power Accessory Gearbox Oil Tube can replace previous P/N 23063373

G. Material Availability

PART NUMBER	TITLE	MODELS AFFECTED
M250-10715	Power Accessory Gearbox Oil Tube	All M250-C28, C30, and C47 Series engine models except the C30G and C30G/2 engines.
M250-10767	Power Accessory Gearbox Oil Tube	All M250-C28, C30, and C47 Series engine models except the C30G and C30G/2 engines.
M250-10772	Power Accessory Gearbox Oil Tube	All M250-C30G, C30G/2, C40B engines.
M250-10773	Power Accessory Gearbox Oil Tube	All M250-C30G, C30G/2, C40B engines.

H. Tooling - Not affected

I. Weight and Balance - Not affected

J. Electrical Load Data - Not affected

K. References

(1) Advance Engineering Memorandum (AEM) CW4221, CW500024623478, CW500021466097, CW500021466094, and CW500024030776.

NOTE: The documents above are referenced for the internal use of Rolls-Royce only.

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