HELICOPTER ACCIDENT REPORT AND EXECUTIVE SUMMARY

			Reference:		CA18/2/3/10090		
Helicopter Registration	ZS-HXG	**Date of Accident**	11 December 2021		**Time of Accident**	0420Z	
Type of Helicopter	Bell 206L-3		**Type of Operation**		Private (Part 91)		
Pilot-in-command Licence Type	Private Pilot Licence (Helicopter)		**Age**	56	**Licence Valid**	Yes	
Pilot-in-command Flying Experience	**Total Flying Hours**	314.0			**Hours on Type**	282.1	
Last Point of Departure	Ultimate Heliport, Midrand, Gauteng Province						
Next Point of Intended Landing	New Tempe Aerodrome, Free State Province						
Damage to Helicopter	Substantial						

Location of the accident site with reference to easily defined geographical points (GPS readings if possible)

Short of final approach and take-off (FATO) area at Ultimate Heliport, Midrand, at Global Positioning System (GPS) determined to be S 26° 1'42.98", E 028° 6'38.82" at a field elevation of 4828ft AMSL

Meteorological Information	Surface wind: 017º/ variable; temperature: 17ºC; visibility: 9999m						
Number of People On-board	1+1	**Number of People Injured**	1	**Number of People Killed**	0	**Other (On Ground)**	0

Synopsis

On Saturday, 11 December 2021, a pilot and a passenger on-board a Bell 206L-3 helicopter with registration ZS-HXG took off from Ultimate Heliport in Midrand, Gauteng province, to their planned final destination in Plettenberg Bay, Western Cape province. The pilot had planned to stop for refuelling at New Tempe Aerodrome (FATP) near Bloemfontein in the Free State province. An eyewitness (a pilot) who was at the helipad at the time the helicopter took off noticed smoke emanating from the right-side of the engine compartment and, thereafter, ran to a nearby helicopter that was parked on the helipad on which he switched on the radio to establish communication with the pilot of the ZS-HXG helicopter to inform him of the smoke that was coming from the engine compartment. After receiving the message from the eyewitness, the pilot executed a 180° turn to the helipad with the intention to perform a precautionary landing. A closed-circuit television (CCTV) camera positioned on the side of the Heliport building overlooking the helipads captured the helicopter entering an uncontrolled descent and crash-landing on the field just short of the Heliport's embarkment. The helicopter was substantially damaged during the accident sequence and the pilot sustained minor injuries.

The investigation revealed that an engine oil pressure hose became damaged after coming into contact with the rotating rotor brake disk. This caused oil starvation to the engine and thermal destruction of the Number 6 and 7 bearings, as well as the decoupling of the spline (tie bolt) coupling from the compressor drive shaft. The clash of rotating components as the shaft separated caused the turbine wheel to burst.

Probable Cause/s and/or Contributory Factors

The helicopter experienced an engine failure and landed hard just short of the helipad's embankment. The engine failure was due to insufficient oil being supplied to the engine as a result of a damaged engine oil pressure supply hose, causing the Number 6 and 7 bearings to suffer thermal destruction which led to an internal clash of rotating components, followed by the destruction of the 1st stage gas producer turbine.

- Poor maintenance practise as the engine oil hose was not correctly secured to the required P-clamps as called for in the maintenance manual.

- Non-compliance with regards to the safe standard and recommended practises from the manufacturer as well as the Civil Aviation Regulations (CAR) 2011 as amended.

SRP Date	7 June 2022	Publication Date	9 June 2022

DESCRIPTION OF THE ACCIDENT

Reference Number	**:** CA18/2/3/10090
Name of Owner/Operator	**:** Long Trail Investment 109 CC
Manufacturer	**:** Bell Helicopter
Model	**:** B206L-3
Nationality	**:** South African
Registration Marks	**:** ZS-HXG
Place	**:** Ultimate Heliport, Midrand, Gauteng Province
Date	**:** 11 December 2021
Time	**:** 0420Z

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 was notified to the Accident and Incident Investigations Division (AIID) on 11 December 2021 at about 0500Z. An investigator was dispatched to Ultimate Heliport in Midrand, Gauteng Province on the same day to conduct an on-site investigation. The investigator co-ordinated with all authorities on site by initiating the accident investigation process according to CAR Part 12 and investigation procedures. The AIID is leading the investigation as the Republic of South Africa is the State of Occurrence

Notes:
1. Whenever the following words are mentioned in this report, they shall mean the following:

- *Accident — this investigated accident*
- *Aircraft — the Bell 206L-3 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:

TABLE OF CONTENTS

Abbreviation	Description
'	Co-ordinates minutes (distance)
"	Co-ordinates Seconds (distance)
°	Degrees
°C	Degrees Celsius
AIID	Accident and Incident Investigations Division
AME	Aircraft Maintenance Engineer
AMO	Aircraft Maintenance Organisation
AMSL	Above Mean Sea Level
CCTV	Closed-circuit Television
AMM	Aircraft Maintenance Manual
EASA	European Aviation Safety Agency
FAGC	Grand Central Aerodrome
ft	Feet
GPS	Global Positioning System
hPa	Hectopascal
IPC	Illustrated Parts Catalogue
kt	Knot
m	Metres
MPI	Mandatory Periodic Inspection
POH	Pilot's Operating Handbook
PPL	Private Pilot Licence
SAWS	South African Weather Service
SB	Service Bulletin
SI	Service Instruction
SIB	Safety Information Bulletin
SL	Service Letter
STC	Supplemental type certificate
Z	Zulu (Term for Universal Co-ordinated Time - Zero Hours Greenwich)

1. FACTUAL INFORMATION

1.1. History of Flight

1.1.1 On Saturday, 11 December 2021 at approximately 0420Z, a pilot and a passenger on-board a Bell 206L-3 helicopter with registration ZS-HXG took off from Ultimate Heliport in Midrand, Gauteng province, with the intention to land at Plettenberg Bay Aerodrome (FAPG) in the Western Cape province after making a planned stop at New Tempe Aerodrome (FATP) to uplift fuel. The pilot was the owner of the helicopter, and the passenger was a rated pilot on the helicopter type. All engine parameters were normal prior to lift-off. Take-off approval was obtained from Grand Central Aerodrome (FAGC) tower on 122.80-Megahertz (MHz) frequency and the helicopter was cleared to take-off in a southerly direction. The flight was conducted under visual meteorological conditions (VMC) by day and under the provisions of Part 91 of the Civil Aviation Regulations (CAR) 2011 as amended.

1.1.2 An eyewitness (who is a helicopter pilot) was at the helipad, watching the helicopter take-off when he noticed smoke coming from the ZS-HXG helicopter engine compartment. He then ran to one of the parked helicopters and switched on the radio to establish communication with the pilot of the ZS-HXG helicopter. According to the ZS-HXG pilot, during departure whilst still in communication with FAGC tower on frequency 122.80MHz, another pilot from the helipad contacted FAGC tower and requested the frequency to be changed to Ultimate Heliport frequency 130.75MHz so as to have direct communication with him (ZS-HXG pilot). Upon establishing communication, the eyewitness advised the pilot about the smoke that was coming from the helicopter's engine compartment. The pilot and the passenger then monitored the engine instruments for anomalies; and all instruments were operating normally. However, they decided to perform a 180° turn to the Heliport for a precautionary landing. Whilst returning to the Heliport, they noticed that the engine chip detector light was flashing on the instrument panel.

1.1.3 According to the pilot, they heard a loud bang coming from the engine compartment and the helicopter suddenly yawed aggressively to the right; however, he was able to counteract the right yaw to the left while the helicopter rapidly lost height. The helicopter crash-landed on the grass approximately 10 metres (m) from the helipad's embankment. During crash-landing, the helicopter's main rotor blades struck the ground (elevating terrain), followed by a hard-landing on its skids. The helicopter was substantially damaged during the accident sequence.

1.1.4 Also, a closed-circuit television (CCTV) camera installed at the Heliport captured some white smoke emitting from the engine compartment during start-up. As the helicopter lifted off from the helipad, the smoke intensified. After the helicopter had lifted off, the footage showed a large amount of oil on the surface of Bay 8. From the video, "*the helicopter approaches the helipad and, whilst on short finals, smoke emits from the engine compartment and an object is ejected from the engine compartment; thereafter, the helicopter yaws to the left as it loses height.*

1.1.5 The pilot sustained minor injuries during the accident sequence whilst the passenger was not injured. Medical personnel at the Heliport administered first aid to the pilot before he was transported to hospital by ambulance. The pilot was admitted to the hospital for a few hours after being assessed but was later discharged (the same day).

1.1.6 The accident occurred during daylight at Global Positioning System (GPS) determined to be: South 26°01'42.98" 028°06'38.82" East at a field elevation of 4 828ft above mean sea level (AMSL).

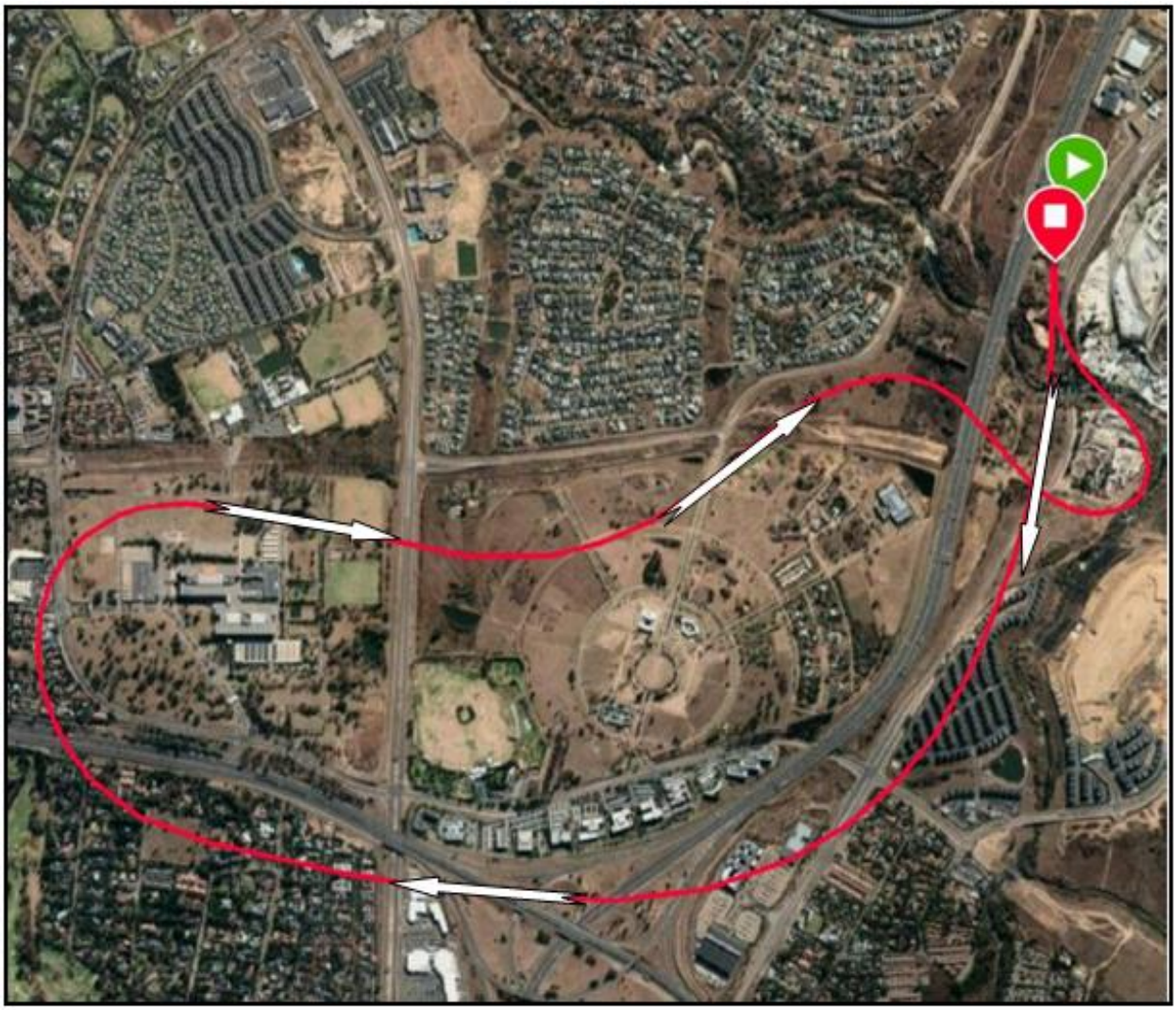

Figure 1 : A view of the accident site and the helicopter route after take-off and back to the helipad. (Source: Pilot)

1.2. Injuries to Persons

1.2.1 The pilot sustained minor injuries during the accident sequence and was admitted to hospital for further medical checks; he was discharged later the same day.

Injuries	Pilot	Crew	Pass.	Total On-board	Other
Fatal	-	-	-	-	-
Serious	-	-	-	-	-
Minor	1	-	-	1	-
None	-	-	1	1	-
Total	1	-	1	2	-

Note: Other means people on ground.

1.3. Damage to Aircraft

1.3.1 The helicopter was substantially damaged during the accident sequence.

Figure 2: The helicopter at the accident site.

1.4. Other Damage

1.4.1 None.

1.5. Personnel Information

Nationality	South African	Gender	Male	Age	56
Licence Number	0272615644	Licence Type	Private Pilot Licence		
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	None				
Medical Expiry Date	28 February 2022				
Restrictions	None				
Previous Accidents	None				

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Flying Experience:

Total Hours	314.1
Total Past 24 Hours	0.3
Total Past 7 Days	0.3
Total Past 90 Days	9.2
Total on Type Past 90 Days	9.2
Total on Type	282.1

1.5.1 The pilot had a Private Pilot Licence (PPL) which was initially issued on 18 June 2019. The licence currency revalidation was issued by the Regulator (SACAA) on 11 August 2021 with an expiry date of 31 August 2023. His Class 2 medical certificate was valid from 2 February 2021 with an expiry date of 28 February 2022. The helicopter type was endorsed on his licence.

Aircraft Maintenance Engineer

Nationality	South African	Gender	Male	Age	65
Licence Number	0272002536	Licence Type	Aircraft Maintenance Engineer		
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Cat A Maintenance: • Bell 206 and 407 Series; Aerospatiale:(AS 350 BA Arriel 2: 355 Series, SA 316 (Airframe); Alouette III Series, SA 341G Gazzelle; Aviatika 890/900 Series Cat B Maintenance: • Hughes Schweizer 269 Series • Aerospatiale AS 350 BA (Airframe) Cat C Maintenance: Engine fitted to rotor for which CAT A is held. P&W large PT6 Series				
Licence Issue Date	28 January 2020				
Licence Expiry Date	7 March 2022				

Note: The AME was qualified and rated for the maintenance conducted on the helicopter type.

1.5.2 The aircraft maintenance engineer (AME) who signed off the helicopter (release to service) following the compressor removal and fitting maintenance had a valid AME licence issued by the Regulator on 28 January 2020 with an expiry date of 7 March 2022. The AME is rated on the helicopter type as a mechanic for both airframe and engine maintenance.

1.6. Aircraft Information

1.6.1 The Bell 206L-3 is a two-bladed main/tail rotor-equipped helicopter powered by a Rolls Royce 250-C30P turboshaft engine. The helicopter features a seven-seat cabin.

Airframe:

Manufacturer/Model	Bell Helicopters 206L-3	
Serial Number	51346	
Year of Manufacture	1989	
Total Airframe Hours (At Time of Accident)	5 739.7	
Last MPI (Hours & Date)	5 739.4	10 December 2021
Hours Since Last MPI	0.3	
C of A (Issue Date)	25 June 2021	
C of A (Expiry Date)	31 July 2022	
C of R (Issue Date) (Present Owner)	25 March 2015	
Type of Fuel Used in the Aircraft	Jet A1	
Operating Categories	Part 91	
Previous Accidents	Hard landing during autorotation on 30 April 2013	

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

Engine:

Manufacturer/Model	Rolls Royce250-C30P
Serial Number	CAE-895406
Part Number	23004545
Hours Since New	5 739.7
Hours Since Overhaul	Modular type engine

Main Rotor:

Manufacturer/Model	Bell	
Serial Number		
Rotor Blades	A 3805	A-3978
Hours Since New	2206	2206
Hours Since Overhaul	TBO not yet reached	TBO not yet reached
Transmission Type	206-040-004-101	
Serial Number/s	BMC-51608	
Hours Since New	5 739.7	
Hours Since Overhaul	TBO not yet reached	

Note: Main rotors have a life-limit of 4000 hours and were installed at 4391.3 airframe hours.

Tail Rotor:

Manufacturer/Model	Van Horn/2062200-301	
Serial Number		
Tail Rotor Blades	B997	B998
Hours Since New	1227.7	1227.7
Hours Since Overhaul	TBO not yet reached	TBO not yet reached
Transmission Type	206-040-402-003	
Serial Number	A-FS2332	
Hours Since New	5 739.7	
Hours Since Overhaul	TBO not yet reached	

Note: Tail rotors have a life-limit of 5000 hours and were installed at 4512 airframe hours.

1.6.2 A review of the helicopter's maintenance records was conducted, which included the logbooks for airframe and engine, mandatory periodic inspection (MPI) work-packs (last two), the engine and airframe manufacturer-related Service Bulletins (SB), Service Letters (SL) and Airworthiness Directives (AD). According to the records, all maintenance tasks were carried out in accordance with the manufacturer's prescribed procedures.

1.6.3 Although the helicopter had undergone the MPI on 10 December 2021, a review of the maintenance record revealed that an engine governor was replaced, followed by an engine run test. The engine had 80 hours remaining before the next overhaul. The helicopter was issued a maintenance certificate on 10 December 2021 at 5739.4 airframe hours. The aircraft maintenance organisation (AMO) that conducted the maintenance had an aircraft maintenance approval certificate issued by the Regulator on 1 December 2020 with an expiry date of 30 November 2021.

1.6.4 A review of the maintenance records from a previous AMO was also considered. According to the maintenance records of job card No: 07110 dated 28 April 2021, the engine compressor section was removed at engine hours 5567.1 for repairs, and it was reinstalled by the same AMO. The maintenance carried out was not logged on the engine logbook section of major defects and the engine removal/installation record; however, the job card records were attached in the engine logbook. This maintenance was followed by the MPI

which was conducted by the same AMO on 4 May 2021. The helicopter was then issued a maintenance certificate on 25 June 2021 at 5595 airframe hours. The helicopter was also issued a Certificate of Airworthiness on 25 June 2021 with an expiry date of 31 July 2022. The AMO that conducted the maintenance was issued an AMO certificate by the Regulator on 1 December 2020 with an expiry date of 30 November 2021.

According to the MPI checklist in Powerplant Section as per Rolls Royce 250-C30 Series Operation and Maintenance Manual, 14W2, Chapter 71, Zone 4 of Powerplant Inspection, AMOs are required to conduct the following tasks during maintenance:

- (4) Examine engine for evidence of fuel and oil leaks.
- (5) Examine all flexible and rigid lines for condition and security
- (6) Pay attention for chafing damages and kinked lines.

Note: The tasks above are maintenance instructions that require maintenance organisations personnel to pay attention to (or inspect) all connecting rigid and flexible hoses and all electrical connecting lines for condition and security. The securing clamps on the flexible engine oil pressure supply hose were not noticed that they were missing on the two occasions that the MPI maintenance was conducted.

1.6.5 Helicopter Mass and Balance calculation:

Item	Entered Load (kg)	Weight (lb)	Long Arm	Long Moments	Lat Arm	Lateral Moments
Basic Empty Weight		2073	131.15	271874	0.00	0
Pilot P1	90	198.4	65	12897	14.00	2778
Fwd Left Pax	100	220.5	65	14330	-11.00	-2425
Right Mid Pax	40	88.2	91	8025	12.90	1138
Left Mid Pax	40	88.2	91	8025	-11.00	970
Right Aft Pax	30	66.1	129	8532	15.80	1045
Centre Aft Pax	30	66.1	129	8532	0.00	0
Left Aft Pax	30	66.1	129	8532	-15.80	-1045
Baggage	50	110.2	174	19180	0.00	0
Right Fnt Door	Yes	0	64	0	25.00	0
Left Fnt Door	Yes	0	64	0	-25.00	0
Right Rear Door	Yes	0	122	0	22.00	0
Left Rear Door	Yes	0	122	0	-22.00	0
Dart Bag Extender	0.0lb	0	185	0	0.00	0
ZERO FUEL		2976.9	120.91	359927	0.17	520
	Weight and CG OK (Long limits Forward: 118.4" Aft: 128.38"					
Zero Fuel		2976.9	120.91	359927	0.17	520
Main Fuel Tank		320.4	138.80	44465	0.00	0
Fuel Max Aft CG		**3297.2**	**122.65**	**404391**	**0.16**	**520**
	Weight CG OK (Long Limits Forward: 118.46" Aft 127.89"					
Zero Fuel		2976.9	120.91	359927	0.17	520
Main Fuel Tank	665.0 lb	665.0	128.87	85701	0.00	0
All Up		3641.9	122.36	445628	0.14	520
Weight and CG OK (Long limits Fwd:118.77" Aft: 127.35"			(Loaded fuel weight 665.0; Total Pax Weight 793.7			

Note: The bladder type fuel tank was located in the cabin at the centre, and load was distributed according to seat positions. The weight was within limits.

An extra fuel tank (Turtle Pac) was on-board the helicopter in the cabin compartment between the passenger seats. The weight was distributed according to seat positions (as per the above table). The tank's full capacity is 210 litres. On the day of the flight, 140 litres of fuel was carried in the tank as a precautionary measure, although the pilot had planned to stop at New Tempe Airport to uplift fuel. According to Bell Helicopters, the fuel tank that

was installed in the helicopter was not their approved product and were not aware of any supplemental type certificate (STC)/kits that would approve of this kind of installation.

The CAR 2011 Part 91.01.14, Carriage of Dangerous Goods states:

The owner or operator of the aircraft shall not carry dangerous goods during flight time unless such goods are carried in accordance with the provisions of Part 92.
Part 92.00.18 Loading restrictions in cabin or on flight deck: Unless otherwise provided for in Document SA-CATS 92, dangerous goods shall not be stowed in an aircraft cabin occupied by passengers or on the flight deck of an aircraft.

1.6.6 Engine Oil System

Information below is an extract from the Helicopter Maintenance Manual (BHT-206L-MM-1) and Illustrated Parts Catalogue (IPC) (BHT-206L-SERIES-IPB)

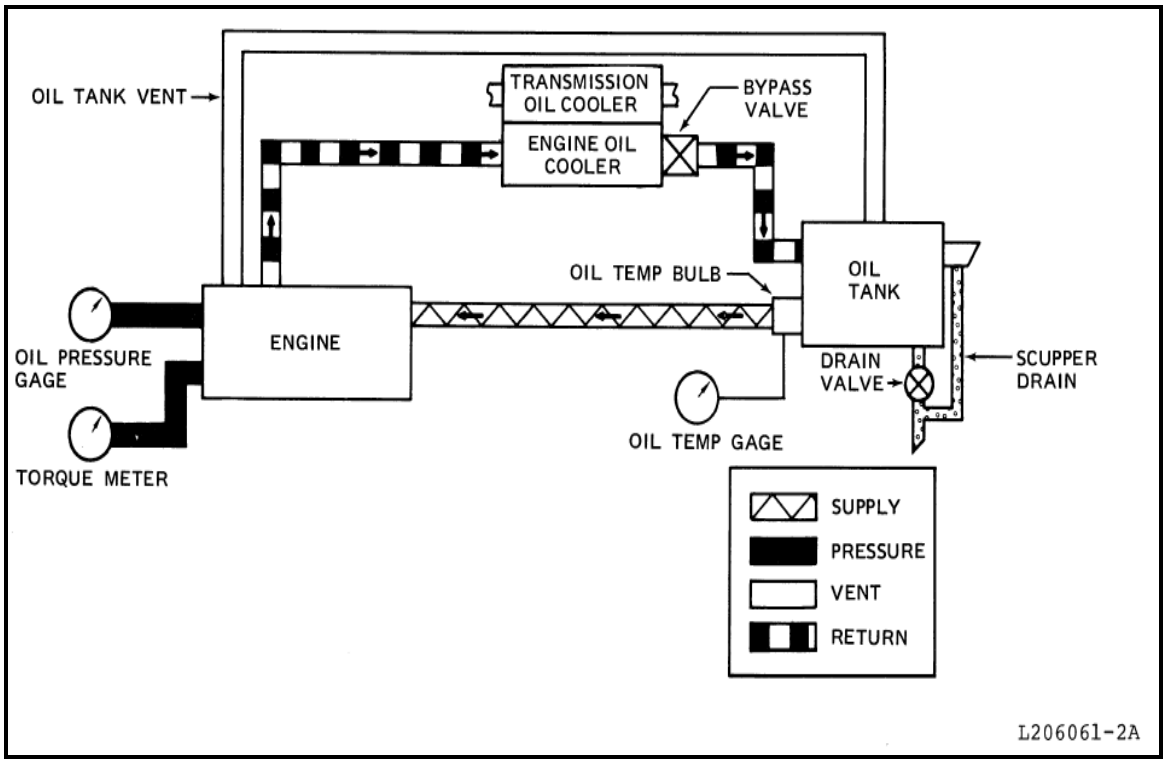

Illustration 1: Engine oil system schematics.

The engine oil system is a dry sump type with an externally mounted supply tank and oil cooler located on the top aft section of the fuselage and enclosed by the aft fairing. Oil is supplied by the oil tank to gear type pressure and scavenger pump mounted within the engine accessory drive gearbox. Return oil is routed from the engine oil outlet port to the oil cooler and from the oil cooler to the tank. An oil cooler blower assembly is mounted on the tail rotor driveshaft and provides cooling air to the oil cooler. Engine oil pump will normally self-prime. However, there have been a few instances where pump has continued to run in a dry or unprime condition following initial engine start.

An engine oil tank has a normal capacity of 1.5 US gallons and oil level is checked using a dipstick mounted on the adaptor assembly. The oil tank provides port openings for the supply tube, vent tube, scavenge tube, temperature bulb and drain valve.

1.6.7 Powerplant Removal and Installation:

Engine removal:
According to BHT 206L MM-1 for the powerplant removal and installation, the following task is carried out for the engine oil pressure hose (35) which is only disconnected at the firewall.
Engine removal: g) Disconnect oil pressure hose (35) at firewall.
Engine installation: Connect oil pressure hose to the firewall.

The oil hose securing clamps are attached to the compressor casing. A clear procedure of the compressor removal was not made available to the investigators; however, it is evident that the oil hose was completely removed during the compressor removal.

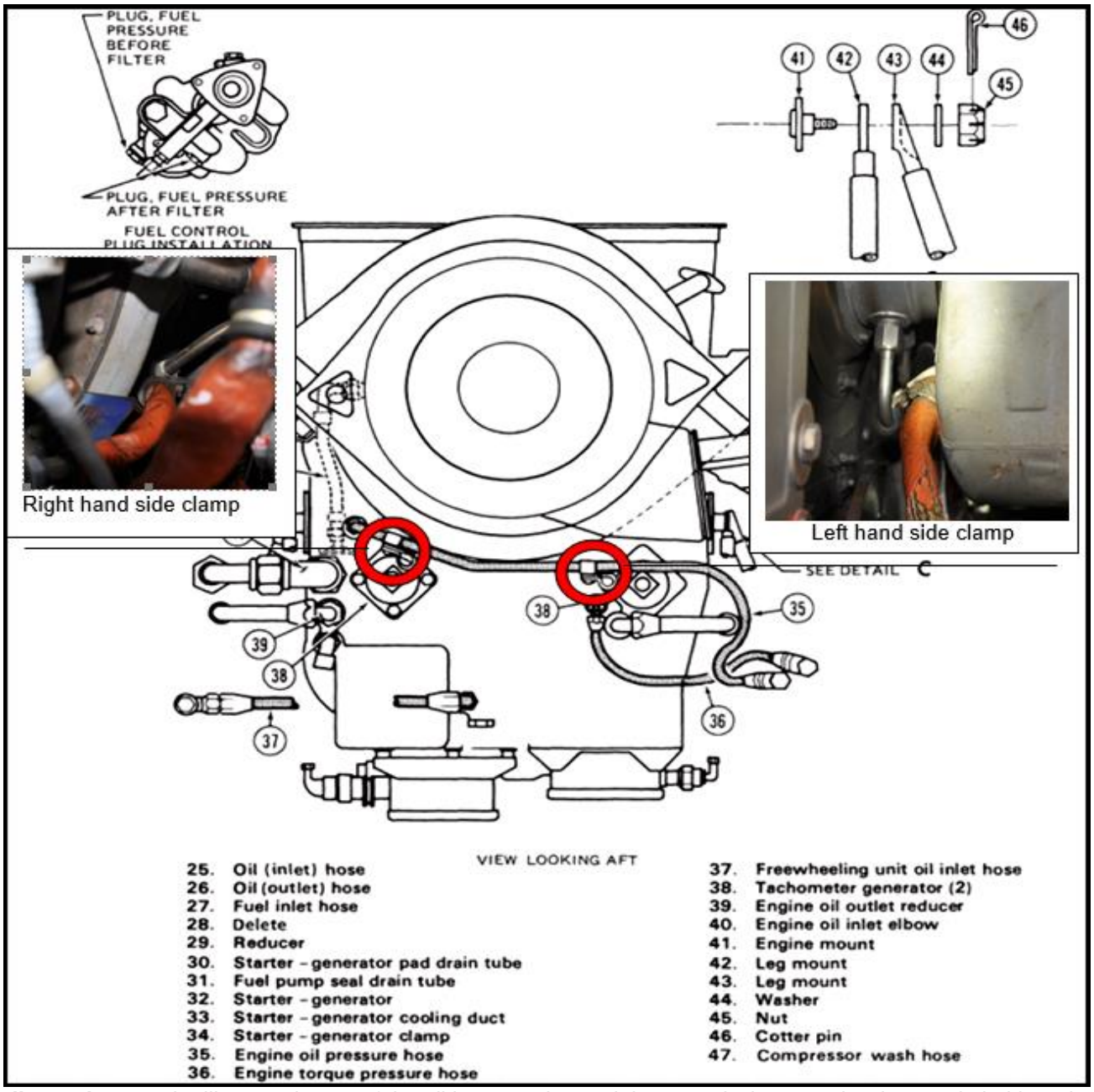

Illustration 2 : The illustrated parts of the oil hose routine and the two missing security clamps circled in red; and the engine oil pressure hose/pipeline (35) that was damaged (in this report).

1.6.8 Post-accident investigation revealed that the engine oil pressure hose/flexible pipeline with Part Number 70-009E000D236 indicated as numbered (35) was damaged during operation (see Figure 4). The engine oil pressure hose was found leaning against the rotating rotor-

brake disc attachment bolt and was chafed (see Figure 8). The hose was missing two securing P-clamps as indicated in Figure 4. The two P-clamps which were missing are indicated in the two red circles. The P-clamps are mounted Tachometer generators indicated by number (38) which are secured with a bolt on each. According to document BHT-206L-SERIES-IPB of the IPC breakdown, the engine oil pressure hose with Part Number 70-009E000D236 was replaced with oil pressure hose Part Number 70-009E000D236A. According to the maintenance personnel, the hoses are interchangeable as there was no significant change (difference) on the product specifications.

1.7. Meteorological Information

1.17.1 The weather information entered in the table below was obtained from the pilot questionnaire (form CA 12-03).

Wind Direction	017°	Wind Speed	Variable	Visibility	9999m
Temperature	17°C	Cloud Cover	Clear	Cloud Base	None
Dew Point	None	QNH	N/A		

1.8. Aids to Navigation

1.8.1. The helicopter was equipped with standard navigational equipment as approved by the Regulator for the helicopter type. There were no recorded defects with the navigational system prior to the flight.

1.9. Communication

1.9.1. The helicopter was equipped with standard communication equipment as approved by the Regulator for the aircraft type. The pilot did not transmit any emergency call/s before the accident. There were no recorded defects with the communication equipment prior to the flight. The pilot's communication with the eyewitness was transmitted on very high frequency (VHF) 130.75MHz.

1.10. Aerodrome Information

1.10.1 The accident occurred at the Heliport during short final approach for landing.

Aerodrome Location	Midrand, Gauteng Province
Aerodrome Status	Licensed
Aerodrome Co-ordinates	S 26° 1'42.98", E 028° 6'38.82"
Aerodrome Altitude	4828ft
Runway Headings	Helipad
Runway Dimensions	N/A
Runway Used	Helipad
Runway Surface	Paved
Approach Facilities	None
Radio Frequency	130.75MHz

1.11. Flight Recorders

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

1.12. Wreckage and Impact Information

Figure 3: The helicopter as it came to rest.

1.12.1 The accident occurred on the grass next to the embankment just short of Ultimate Heliport helipad.

- The helicopter was found intact with no components missing other than the object that was flung out of the helicopter's engine compartment during the accident sequence. The main rotor blades sustained wrinkle deformation along each blade surface due to contact with the ground at high rotational speed during the accident sequence. Dirt on each blade tip which was associated with ground scars at the same level of the main rotor blades was noticed, which was consistent with the strike marks. This was also observed on the video footage when the main rotor blades struck the ground and sustained wrinkle damages along the blade, followed by the dirt getting airborne during the accident sequence.

1.12.2 The following observations of the helicopter were made at the accident site:

- The helicopter was found resting on its left skid gear facing west and part of the belly (fuselage) was near the elevated terrain due to the fractured right-side skid gear. The left-side skid gear was stretched sideways and was deformed from its original design.

Figure 4: The right- and left-side skid gear damages sustained during the accident

- The engine compartment's right-side door had traces of fire damage. The smoke soot was visible on the upper section of the main rotor blades' root at similar position on each blade near the engine compartment. The helicopter's windshield and the right-side cabin door window were also damaged due to hard landing.

Figure 5: Heat damage on the right-side engine cowling.

- There were signs of oil spillage inside the engine compartment. This was consistent with oil loss/leak at high pressure during engine operation.

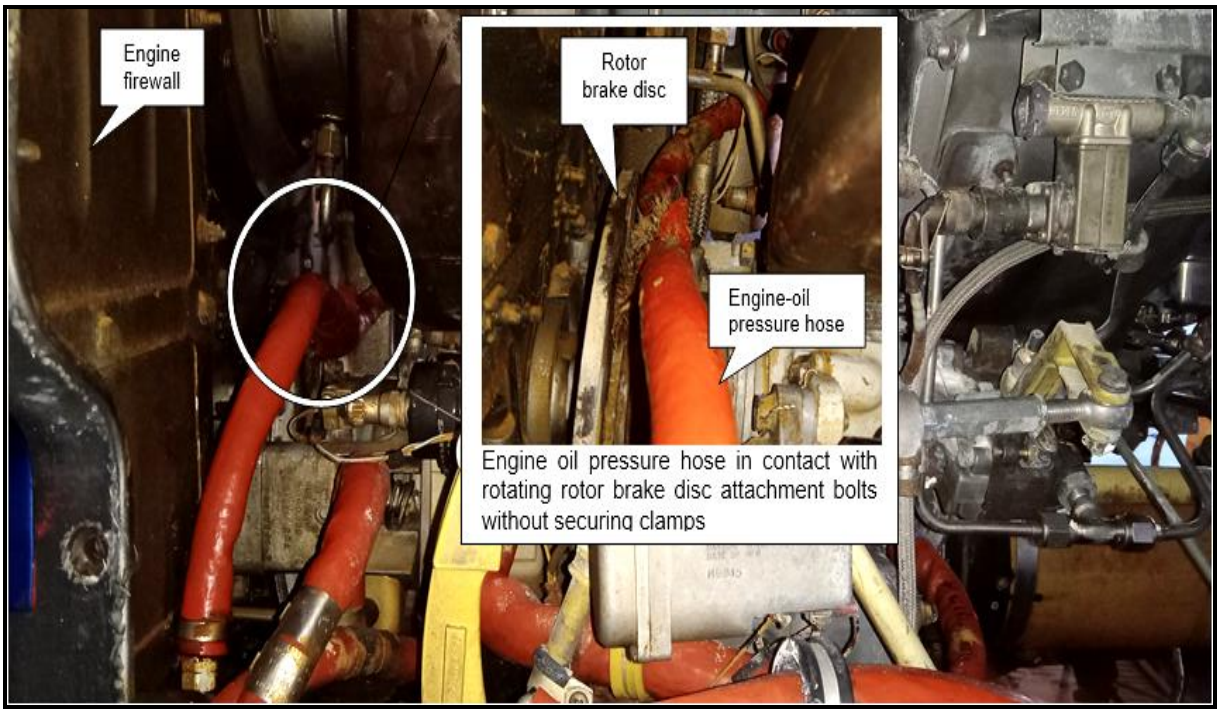

Figure 6: The engine oil pressure hose/pipeline chafing against the rotating rotor brake disk attachement bolt.

- Remnants of the fire extinguishing solution sprayed by the fire and rescue personnel was observed in the engine compartment. The right-side engine mounting bar sustained fracture damages. The flexible oil supply pipe from the engine oil pump sustained damage caused by a rotating object. The flexible engine oil pressure supply line was not secured correctly. According to the helicopter type maintenance manual, the flexible engine oil pressure hose requires that it be secured with two P-clamps. A further security check must be conducted during the annual mandatory period inspection (MPI).

Figure 7: The damaged tailboom.

- The tailboom section near the fuselage attachment point was bent due to hard landing.

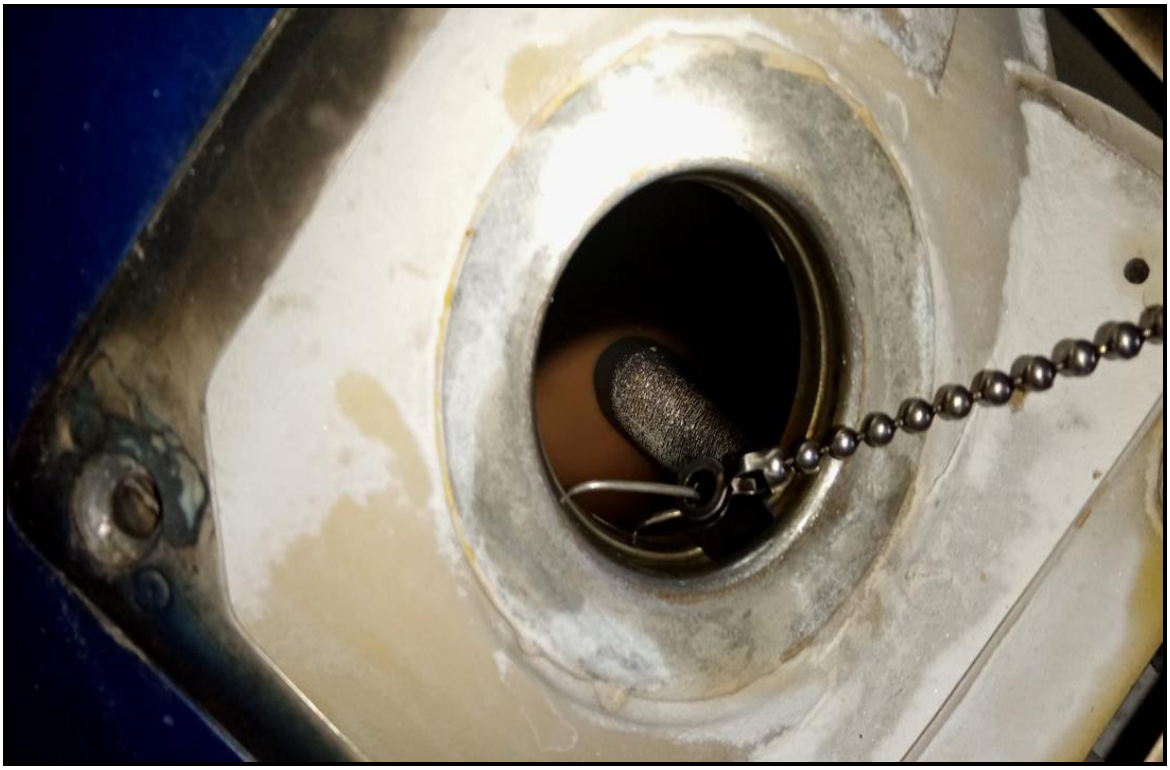

Figure 8: Some oil at the bottom of the engine oil reservior.

- The oil reservoir had a small amount of oil post-accident.

Figure 9: The fuel feeder line connected to the right-side fuel tank cap with a connecting adaptor.

- A bladder type fuel tank was connected to the right-side main fuel tank to feed fuel during the flight. The fuel transfer motor was connected to the helicopter's electrical supply point.

According to the pilot, he bought the aviation-approved (Turtle Pac) bladder type fuel tank and had been using it without attaining approval from the Regulator for fuel cap adaptor modification or enquiring from the helicopter manufacturer for compatibility. The pilot stated that he had used the fuel tank several times after purchase as he believed it did not require any modification for fuel transfer and installation on the helicopter. The investigation revealed that there was an adaptor modification on the right-side fuel tank cap for fuel feed. There was no modification approval (STC) or Service Bulletin (SB) approval attained from either the Regulator or the manufacturer. Also, the helicopter manufacturer stated that they do not have any approval or any modification for the ferry fuel tank on the helicopter type.

Figure 10: The bladder type fuel tank in the helicopter cabin.

- According to the International Air Transport Association (IATA) Dangerous Goods Regulations Table 2.3.A of the Provision for Dangerous Goods: *dangerous goods must not be carried in or by passengers or crew, checked or carry-on baggage except as provided below: Containers that contain a flammable liquid, fuel, empty fuel tank and/or fuel containers require approval and permission from the operator.*
- According to Part 91, Carriage of Dangerous goods Subpart 91.01.14, *the owner or operator of an aircraft (helicopter) shall not carry dangerous goods during flight time unless such goods are carried in accordance with the provision of Part 92.*

  The pilot did not obtain approval from the Regulator to carry tank with fuel on-board the helicopter passenger cabin.

1.13. Medical and Pathological Information

1.13.1 None.

1.14. Fire

1.14.1 There was pre- and post-impact fire during the accident sequence. The accident occurred during short final approach for landing at a helipad following an engine smoke alert. The Aerodrome Rescue and Firefighting (ARFF) personnel from Grand Central Aerodrome (FAGC) had dispatched to the accident site and assisted the heliport safety personnel to secure the accident site.

1.15. Survival Aspects

1.15.1 The accident was considered survivable. The damages sustained by the helicopter in the cabin were not as severe as to have caused the helicopter occupants to sustain serious injuries. Moreover, the height and the altitude at which the helicopter was flown and during impact could not have caused serious/fatal injuries.

1.16. Tests and Research

1.16.1 The helicopter was recovered to a secure location for further investigation post-accident. The engine: a Rolls-Royce 250-C30P with serial No. CAE-895406 was removed from the airframe and was taken to a Rolls Royce approved engine maintenance facility at Rand Aerodrome (FAGM) for a teardown inspection. The engine teardown inspection was conducted on 20 December 2021 in the presence of the engine manufacturer's expert based in the United State of America (USA).

1.16.2 The report from the engine manufacturer was received with the following observations and analysis made following the engine teardown inspection:

- *The initial engine observation revealed that all engine control fittings, including pneumatic and oil lines, B-nuts, clamps and associated hardware, were checked by hand for security and were satisfactory.*

- *Neither the compressor (N1) nor the power turbine (N2) could be rotated by hand.*

- *Visual examination of the compressor revealed no evidence of foreign object damage or operational issues of any kind.*

- *Visual examination of the 4th stage power turbine also revealed no evidence of foreign or operational failure.*

- *The gas generator turbine (N1) was removed, and the compressor was rotated with no further anomalies.*

- *Evidence of impact of the underline of the Number 8 bearing sump cover was consistent with the fracture of the turbine tie bolt, and the subsequent impact of the tie bolt with the underside of the sump cover.*

Figure 11: Turbine section damages.

- *Bulging of the turbine case and energy absorption ring was consistent with a contained burst of one or both N1 (1st/ 2nd stage) turbine wheel/s.*

- *The upper and lower magnetic chip detectors (MCD) were removed and examined. The lower chip detector was free of contaminants, whilst the upper detector was found to be heavily contaminated with ferrous material.*

- *The gas generator turbine (N1) was separated from the power turbine (N2) and revealed that the 1st stage turbine wheel had high fragment with subsequent impact to remaining turbine components.*

Figure 12: Upper magnetic chip detector.

- *Plastic deformation of the splined coupling suggested extreme high temperature was reached in the turbine, softening the metal to the point where the gas generator turbine decoupled from the compressor.*

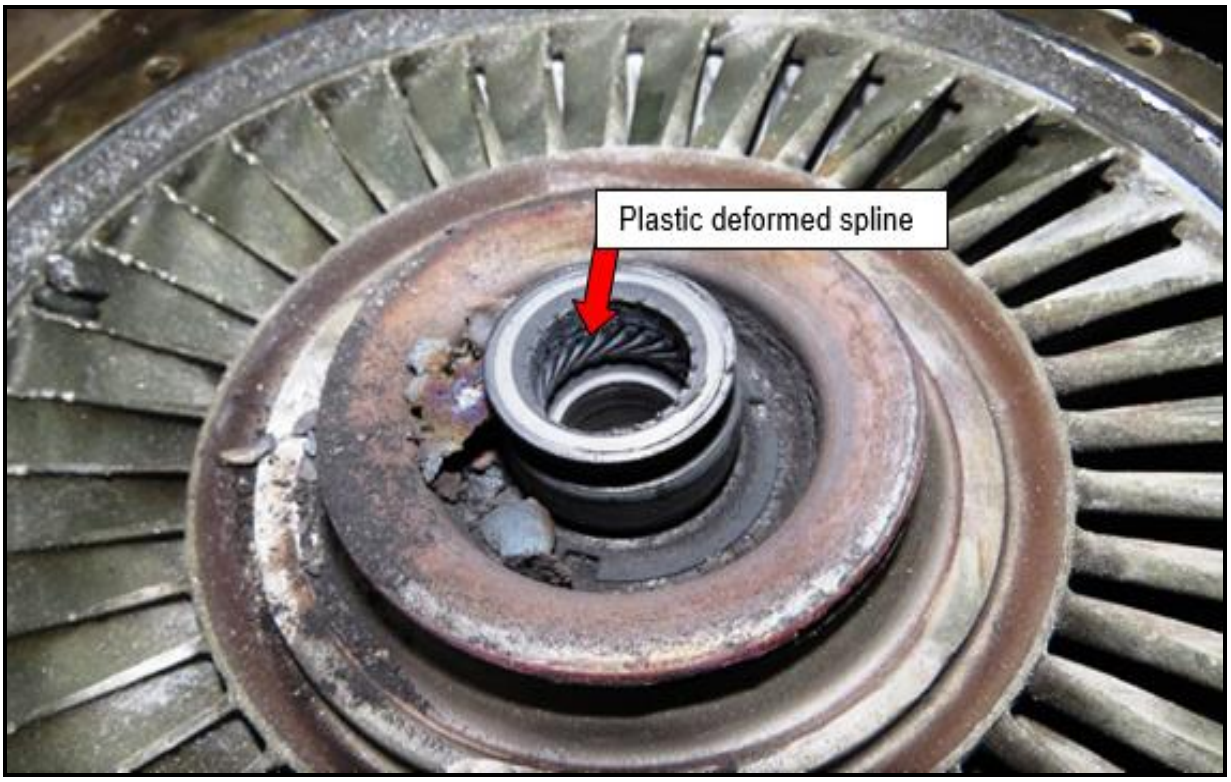

Figure 13: Shows the plastic deformation of the splined coupling due to overheating the turbine section (Source: Manufacture Report)

- *All the turbine bearings were found dry and blackened, the Number 6 and 7 bearings were found to have been mostly vaporized within their bearing chamber.*

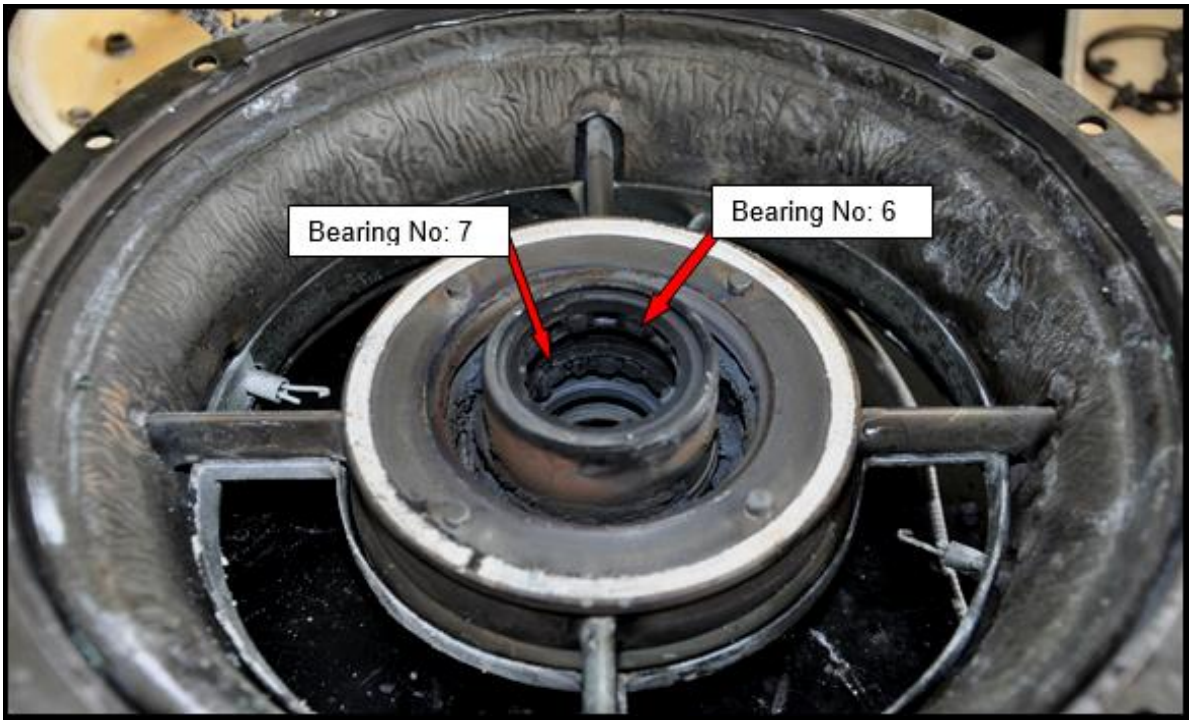

Figure 14: The damaged number 6 & 7 bearings. (Source: manufature's report)

- *No evidence of abnormal combustion or streaking in the combustion chamber was found.*

Conclusion from the engine teardown and inspection:

- All evidence is consistent with loss of engine power due to contained burst of the 1st stage turbine wheel. The turbine wheel burst would be expected due to the internal clash of rotating components following the thermal destruction of the Number 6 and 7 bearings and the decoupling of splined coupling adaptor from the compressor drive shaft due to thermal weakening and distortion of the splined coupling. Overall engine damage is typical of and consistent with operation of the engine with insufficient oil supply.

1.17. Organisational and Management Information

1.17.1 The flight was conducted under the provisions of Part 91 of the Civil Aviation Regulations (CAR) 2011.

1.17.2 The helicopter was maintained by an approved AMO, which was in possession of a Regulator-approved AMO certificate issued on 1 December 2020 with an expiry date of 30 November 2021. The helicopter was issued a maintenance certificate on 25 June 2021 at 5595 airframe hours with an expiry date of 25 June 2022 or at 5695 airframe hours, whichever occurs first. The AMO's operational specification had the helicopter endorsed on it.

1.18. Additional Information

1.18.1 None.

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 particular organisation or individual.

2.2. Analysis

2.2.1 The pilot was qualified for the flight and had a Private Pilot Licence which was initially issued by the Regulator on 18 June 2019. The licence currency revalidation was issued by the Regulator on 11 August 2021 with an expiry date of 31 August 2023. The helicopter type was endorsed on his licence. The pilot's Class 2 medical certificate was issued on 2 February 2021 with an expiry date of 28 February 2022.

2.2.2 The helicopter was issued an Airworthiness Certificate by the Regulator on 25 June 2021 with an expiry date of 31 July 2022. The AMO that maintained the helicopter had an AMO certificate issued by the Regulator on 1 December 2020 with an expiry date of 30 November 2021. The AMO issued a certificate of maintenance on 14 May 2021 to the owner following an MPI maintenance which validated the issuance of the Airworthiness Certificate.

2.2.3 The AME who signed off the helicopter following the compressor removal and fitting maintenance had a valid AME licence issued by the Regulator on 28 January 2020 with an expiry date of 7 March 2022. The AME is rated on the helicopter type as a mechanic for both airframe and engine maintenance.

2.2.4 Post-accident investigation revealed that the engine oil pressure supply pipeline was damaged due to chafing against the rotating rotor brake disc during operation. As a result, the pipeline damages subsequently caused significant loss of oil, and the lubrication system to be starved of oil supply. The pipeline was not secured with the required two P-clamps as per the manufacturer's maintenance manual. This damage occurred over a period during operation.

A maintenance operation relating to compressor removal that was carried out in May 2021 by the previous AMO revealed that an engine removal and installation was conducted on the helicopter. The compressor removal required that the engine oil pressure hose/pipeline and other connecting air ducts and electrical lines be disconnected during the engine removal from the airframe. The engine oil pressure hose that connects from the engine oil pump to the airframe was also removed as its assembly and securing attachments are mounted on the compressor case's main assembly body. It is likely that during the engine installation, the AMO omitted to secure the engine oil pressure hose with the two P-clamps before assembling it to the airframe as per the maintenance manual illustration of the powerplant installation.

2.2.5 It is also possible that the engine oil pressure hose/pipeline was installed while the engine was already assembled on the airframe, therefore, the AMO personnel did not have enough room to work on during an attempt to secure the engine oil pressure hose/pipeline using the two P-clamps because of restricted space. Thus, the engine oil pressure hose was not secured properly, causing the hose to sustain severe chafing damages to the point where oil leaked at high pressure. This resulted in insufficient oil supply to lubricate the engine components. It is also likely that a thorough inspection was not conducted on the oil supply pipeline during maintenance and pre-flight inspection/s.

2.2.6 The engine teardown and assessment inspection revealed that the Number 6 and 7 bearing failure was due to overheating associated with lack of proper/sufficient lubrication because of oil starvation. The bearing failure resulted because of the high-speed turn of the turbine wheel which subsequently failed. The engine lost power as a result of turbine wheel failure. The turbine wheel burst was inevitable due to the internal clash of rotating components following the thermal destruction of the Number 6 and 7 bearings, as well as the decoupling of splined coupling adaptor from the compressor drive shaft due to thermal weakening and distortion (of the splined coupling).

2.2.7 The helicopter underwent two MPIs carried out by two different AMOs following the compressor change; none of the AMOs noticed the absence of the two P-clamps which secure the engine oil pressure hose/pipeline, although they stated that they were following the manufacturer's maintenance procedures. The same AME personnel was involved in both occasions during the said MPI inspections.

2.2.8 The engine oil reservoir had a small amount of oil remaining after the accident. There was evidence of oil splash in the engine compartment. There was also evidence of oil spillage on the helipad Bay 8.

2.2.9 The observed white smoke during start-up and take-off was associated with high pressure oil being expelled and coming into contact with the hot section of the engine.

2.2.10 The damaged engine oil pressure hose was the old hose type with Part Number 70-009E000D236 which was recommended to be replaced by a hose with Part Number 70-009E000D236A by the manufacturer in the BHT-206L-SERIES-IPB manual. There was no other defect on the hose except for the damages caused by chafing against the rotating rotor brake disk.

2.2.11 There was sufficient fuel on-board the helicopter as well as an extra ferry fuel tank in the cabin which was connected to the right main fuel through a feeder line. However, no approval was obtained from the Regulator nor the helicopter manufacturer for the modification of the fuel feeder adaptor. Neither was there any dangerous goods documents attained by the owner for carrying dangerous goods on-board the helicopter.

2.2.12. Although the fuel bladder tank was on-board the helicopter passenger cabin, the helicopter weight and balance and the centre of gravity (CG) were within limits.

2.2.13 Fine weather conditions prevailed at the time of the flight, and the weather was not a factor in this accident.

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 particular 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 was qualified for the flight and was issued a Private Pilot Licence by the Regulator on 18 June 2019. The licence currency revalidation was issued by the Regulator on 11 August 2021 with an expiry date of 31 August 2023. The helicopter type was endorsed on his licence.

3.2.2 His Class 2 medical certificate was issued by the Regulator on 2 February 2021 with an expiry date of 28 February 2022.

3.2.3 The helicopter had a Certificate of Airworthiness issued by the Regulator on 25 June 2021 with an expiry date of 31 July 2022.

3.2.4 The AMO that maintained the helicopter was in possession of an AMO approval certificate issued by the Regulator on 1 December 2020 with an expiry date of 30 November 2021.

3.2.5 The AMO issued the helicopter with a maintenance certificate on 14 May 2021 following an MPI maintenance, which validated the issuance of the Airworthiness Certificate.

3.2.6 The AME who signed off the helicopter following the compressor removal and fitting maintenance had a valid AME licence issued by the Regulator on 28 January 2020 with an expiry date of 7 March 2022. The AME was rated on the helicopter type as a mechanic for both airframe and engine maintenance.

3.2.7 The engine oil pressure hose was chafing against the rotor brake disc during operation, resulting in an engine oil leak.

3.2.8 The engine oil pressure hose was not secured properly with two P-clamps as prescribed in the maintenance manual following a compressor removal for maintenance and installation on 28 April 2021.

3.2.9 The damaged engine oil pressure hose was the old hose type with Part Number 70-009E000D236 which was recommended that it must be replaced by a hose with Part Number 70-009E000D236A by the manufacturer in the BHT-206L-SERIES-IPB manual. There was no other alarming defect on the hose except for the damages caused by chafing against the rotating rotor brake disk.

3.2.10 The correct procedure of installing engine oil pressure hose and its securing P-clamps was not followed during the engine assembly on the airframe.

3.2.11 It was also noted that two MPIs were carried out by two different AMOs following the compressor change and none of them noticed the unsecured pipeline, although they were following the manufacturer's maintenance procedures. The same AME personnel who was involved during the compressor change was also in-charge of the above-stated MPI maintenance.

3.2.12 The engine teardown inspection revealed that the Number 6 and 7 bearings failed due to overheating associated with insufficient lubrication because of oil starvation.

3.2.13 The engine lost power due to a turbine wheel failure. The turbine wheel burst would be inevitable due to internal clash of rotating components following the thermal destruction of the Number 6 and 7 bearings and the decoupling of splined coupling adaptor from the compressor drive shaft as a result of thermal weakening and distortion of the splined coupling.

3.2.14 The engine oil reservoir contained a small amount of oil following the accident.

3.2.15 The eyewitness observed white smoke during start-up and take-off, which was associated with oil coming into contact with a hot surface.

3.2.16 There was also evidence of a large amount of oil on the helipad bay which was observed from the CCTV footage after the helicopter took off.

3.2.17 There was sufficient fuel on-board the helicopter with an extra ferry fuel tank in the cabin, connected to the right main fuel through a feeder line. However, there was no approval obtained from the Regulator or the helicopter manufacturer for the modification of the fuel feed adaptor. Also, the owner did not attain dangerous goods documents for carrying dangerous goods on-board the helicopter.

3.2.18. The weight and balance calculations and the centre of gravity (CG) were within limits.

3.2.19 Fine weather conditions prevailed at the time of flight, which had no bearing to the accident.

3.3. Probable Cause/s

3.3.1 During short finals for a precautionary landing, the helicopter experienced an engine failure and landed hard just short of the helipad's embankment. The engine failure was due to insufficient oil being supplied to the engine as a result of a damaged engine oil pressure supply hose, causing the Number 6 and 7 bearings to suffer thermal destruction which led to an internal clash of rotating components, followed by the destruction of the 1st stage gas producer turbine.

3.4. Contributory Factors

3.4.1 Poor maintenance practise as the engine oil hose was not correctly secured to the required P-clamps as called for in the maintenance manual.

3.4.2 Non-compliance with regards to the safe standard and recommended practises established by the manufacturer as well as the Civil Aviation Regulations (CAR) 2011 as amended.

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 Safety Massage

The AMO should adhere to the aircraft's maintenance procedures as per the manufacturer prescribed manual. It is also recommended that the AMO embarks on an annual maintenance training which would help to enhance safe maintenance practises. This accident could have been prevented if the correct engine assembly installation procedures were followed.

4.2.2 The operator used a bladder type fuel tank that was carried on-board the helicopter, which was dangerous goods, without the approval by the manufacturer and proper modification approvals by the Regulator. Therefore, AIID recommends that operators utilise manufacturer-approved and compatible components in accordance with the approved procedures for modifications as well as the Civil Aviation Regulations (CAR) requirements.

5. APPENDICES

5.1 None.

This report is issued by:

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