REPUBLIC OF NAMIBIA

MINISTRY OF WORKS AND TRANSPORT

Directorate of Aircraft Accident and Incident Investigations

Accident Reference: ACCID/07172023/01-06

Aircraft Accident Investigation Final Report

Robinson R44 Raven II: ZS-HLG

RELEASE DATE: 24 SEPTEMBER 2024

MINISTRY OF WORKS AND TRANSPORT
Directorate of Aircraft Accident & Incident Investigations
2024-09-24
Office of the Director
Private Bag 12042, Ausspannplatz
Republic of Namibia

Foreword

This report presents the information, data analysis, conclusions, and safety recommendations reached during the investigation. The purpose of the investigation was to establish the circumstances surrounding this accident.

In accordance with the provisions of Annex 13 to the Convention on International Civil Aviation Organization and the Namibian Civil Aviation Act (Act No 06 of 2016), the accident's analysis, conclusions, and safety recommendations contained herein are intended neither to apportion blame or liability nor to single out any individual or group of individuals. The main objective was to identify the systemic deficiencies and draw lessons, from the occurrence, which might help to prevent accidents and incidents in the future. To this end, many a time, the reader may be interested in whether or not an issue was a direct cause of the accident (that has already taken place), whereas the investigator is mainly concerned with the prevention of future accidents/incidents.

As a result, the usage of this report for any purpose other than (the latter and spirit of Annex 13 and other relevant statutes) prevention of similar occurrences in the future might lead to erroneous interpretations and applications.

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ABBREVIATIONS

AMO	-	Aircraft Maintenance Organization
AOC	-	Air Operator Certificate
ATC	-	Air Traffic Control
AGL	-	Above Ground Level
˚C	-	Degrees Celsius
CAVOK	-	Ceiling and Visibility OK
CG	-	Centre of Gravity
CoA	-	Certificate of Airworthiness
CoR	-	Certificate of Registration
CPL	-	Commercial Pilot License
CVR	-	Cockpit Voice Recorder
DAAII	-	Directorate of Aircraft Accident and Incident Investigation
FAA	-	Federal Aviation Administration
FDR	-	Flight Data Recorder
ft	-	feet
GPS	-	Global Positioning System
Hpa	-	Hectopascal
lbs	-	Pounds
ICAO	-	International Civil Aviation Organization
IFR	-	Instrument Flight Rules
IIC	-	Investigator-in-charge
LOC	-	Loss of Control
kts	-	Knots
m	-	Meters
METAR	-	Meteorological Aerodrome Report

MHz	-	Megahertz
MPI	-	Mandatory Periodic Inspection
MR	-	Main Rotor
MTOW	-	Maximum Take- Off Weight
NAMCARs	-	Namibian Civil Aviation Regulations
NCAA	-	Namibia Civil Aviation Authority
nm	-	Nautical Miles
NPFSI	-	Namibian Police Forensic Science Institute
NWS	-	Namibia Weather Services
POH	-	Pilot's Operating Handbook
PIC	-	Pilot-in-command
QNH	-	Query Nautical Height (Barometric Pressure Adjusted to Sea Level)
R22	-	Robinson Helicopter Company helicopter model R22
R44	-	Robinson Helicopter Company helicopter model R44
RPM	-	Revolution(s) Per Minute
RWY	-	Runway
SB	-	Safety Bulletin
SFAR	-	Special Federal Aviation Regulation
SL	-	Service Letter
SN	-	Safety Notice
THR	-	Threshold
TR	-	Tail Rotor
UTC	-	Universal Time Co-ordinated
VFR	-	Visual Flight Rules

Aircraft Accident Report

DESCRIPTION OF OCCURRENCE:	Robinson R44 II Helicopter accident
Reference number	: ACCID 07172023-01-06
Name of the owner	: Aristocratic Disinctive (Pty) Ltd (As per last CoR)
Type of operation	: Maintenance Test Flight
Manufacturer	: Robinson Helicopter Company
Model	: Robinson R44 Raven II
Date of Manufacture	: 16 November 2006
Nationality	: South African
Registration marking	: ZS-HLG
Place	: East of Swakopmund Airfield (FYSM), Erongo Region, Namibia
Date	: 17 July 2023
Time	: 13H50 UTC

Figure 1: The Robinson 44 Raven II Helicopter ZS-HLG, accident aircraft (source: Flight Zone)

	Ministry of Works and Transport	ACCID/083022/01-03
	DIRECTORATE OF AIRCRAFT ACCIDENT AND INCIDENT INVESTIGATION	
	ACCIDENT REPORT – EXECUTIVE SUMMARY	

Aircraft Registration	ZS-HLG	**Date of Accident**	17th Jul 2023	**Time of Accident**	13:50 UTC
Type of Aircraft	ROBINSON R44 RAVEN II	**Type of Operation**	Maintenance Test Flight		

Pilot- In - command License Type	CPL	**Age**	54	**License Valid**	valid
Pilot-In-command Flying Experience	Total Flying Hours	10958,7		**Hours on Type**	84,7

Last point of departure	Swakopmund Airport (FYSM)- Erongo Region
Next point of intended landing	Swakopmund Airport (FYSM)- Erongo Region
Location of the accident site with reference to easily defined geographical points **(GPS readings if possible)**	
GPS 22°39'30"S 014°34'00"E	
Meteorological Information	Wind direction and speed: 280°/08kts, CAVOK, Temperature: 31°C, Dew point -01°C, Air Pressure QNH 1020 Hpa

Number of people on board	2	**No. of people injured**	0	**No. of people killed**	2

Synopsis

On Monday afternoon, 17 July 2023, at around 13:35 UTC (15:35 Local Time) a Robinson R44 Raven II helicopter with registration ZS-HLG (the displayed tail mark was V5-HGG) departed from Swakopmund Airfield (FYSM) to perform a maintenance test flight. The purpose of the flight was to conduct final rotor balancing and execute auto-rotations. Onboard the helicopter was the pilot and an apprentice engineer.

The accident flight was the last test flight (after two other test flights) which required rotor balancing and to execute auto-rotations. During the auto-rotation one of the main rotor blades hit the tailboom causing it to detach from the main fuselage. Witnesses heard a loud bang and saw the helicopter spiraling down to the ground.

The helicopter impacted the ground on the left side at a high velocity. The tailboom was found 158 meters away from the wreckage. The accident was not survivable.

Eyewitnesses, the local Flying school crew and the AMO crew rushed to the crash site. The Police, the Ambulance and the Swakopmund Municipal Fire Brigade were called to the scene. The pilot and the maintenance engineer on-board the helicopter were fatally injured.

The Directorate of Aircraft Accident and Incident Investigations (DAAII) was informed of the accident at 14:00 UTC (16:00 Local Time) of a Robinson Helicopter that crashed east of Swakopmund Airfield. The DAAII appointed an Investigator- in- charge and a Co-investigator to lead the investigation and issue the final report. The investigators commenced with the investigation immediately.

The State of the aircraft manufacture and the State of registry was notified of the accident.

Unless otherwise indicated, recommendations in this report are addressed to the Regulatory Authority of the state having responsibility for the matters with which the recommendation is concerned.

All times used in the report are Coordinated Universal Time (UTC), which is local time minus 2 hours.

Probable Cause(s): Rotor stall
In flight break up, due main rotor blade hitting the tailcone

Contributing factor(s): Low RPM
Pitch Link Failure

AIRCRAFT ACCIDENT REPORT

Name of Owner	: Aristocratic Disinctive (Pty) Ltd (As per last CoR)
Manufacturer	: Robinson Helicopter Company
Model	: Robinson R44 Raven II
Date of Manufacture	: 16 November 2006
Nationality (Aircraft)	: South African
Registration	: ZS - HLG
Location	: East of Swakopmund Airfield GPS: 22°39'30"S 014°34'00"E
Date	: 17th July 2023, Time: 13:50 UTC

All times given in this report are in Co-ordinated Universal Time (UTC).

Disclaimer:

The report is given without prejudice to the rights of the Directorate of Aircraft Accident and Incident Investigations, which are reserved.

Purpose of the Investigations:

In terms of the Namibia Civil Aviation Act (Act No. 6 of 2016) and ICAO Annex 13, this report was compiled in the interest of the promotion of aviation safety and the reduction of risk of aviation accidents or incidents and **not to apportion blame or legal liability.**

This report contains facts relating to the aircraft accident that have been determined at the time of issue. The report may therefore be revised should new and substantive facts be made available to the investigators.

1. FACTUAL INFORMATION

1.1 History of Flight

1.1.1. On Monday afternoon, 17 July 2023, at around 13:35 UTC (15:35 Local Time) a Robinson R44 Raven II helicopter with registration ZS-HLG (the displayed tail mark was V5-HGG) departed from Swakopmund Airfield (FYSM) to perform a maintenance test flight. No flight plan was filed for the local maintenance test flight as it was not required by regulations.

1.1.2. The purpose of the flight was to conduct final rotor balancing and to execute auto-rotations. Onboard the helicopter was the pilot and apprentice maintenance engineer.

1.1.3. The helicopter was brought into Namibia by local operator on a trailer in February 2022 from South Africa and transported to a local Aviation Maintenance Organization (AMO) for maintenance inspection and certification. The helicopter and engine required a twelve-year inspection.

1.1.4. After all maintenance work on the helicopter was complete, the test flights started. The first test flight was on Thursday the 13th of July 2023.

1.1.5. Another test flight was conducted on Friday the 14th of July 2023, a fix wing pilot who had just landed at Swakopmund Airfield was asked by the PIC of the helicopter to join them on the test flight. The fix wing pilot was sitting in the right back seat, behind the PIC as the apprentice engineer occupied the left front seat. The fix wing pilot described the flight as very "bouncy" and vibrating a lot. According to the fix wing pilot, the PIC apologized for the vibrations as they took a short scenic flight over the dune belt. The fix wing pilot made four short videos (which were shared with the investigators) during the flight and the vibrations can clearly be seen on the control stick and the legs of the pilot and apprentice engineer. After landing and shutdown, the apprentice engineer said that he would add another 120 grams to main rotor blades to curb the vibrations. According to the fix wing pilot, the PIC told him that he did not understand why the vibrations got worse.

1.1.6. The accident flight (Monday afternoon, 17 July 2023) was the last test flight which required (according to the maintenance schedule) rotor balancing and to execute auto-rotations. The pilot followed regulations not to do the maintenance test flight over populated areas and proceeded to an open area east of Swakopmund Airfield. During the auto-rotation one of the main rotor blades hit the tailcone causing it (tailcone) to detach from the main fuselage. Witnesses heard a loud bang and saw the helicopter spiralling down to the ground.

1.1.7. The helicopter impacted the ground on the left side at a high velocity. The tailcone was found 158 meters away from the main wreckage. The accident was not survivable.

1.1.8. Eyewitnesses, the local Flying school crew and the AMO crew rushed to the crash site. The Police, the Ambulance and the Swakopmund Municipal Fire Brigade were called to the scene. The pilot and the apprentice engineer on-board the helicopter were fatally injured.

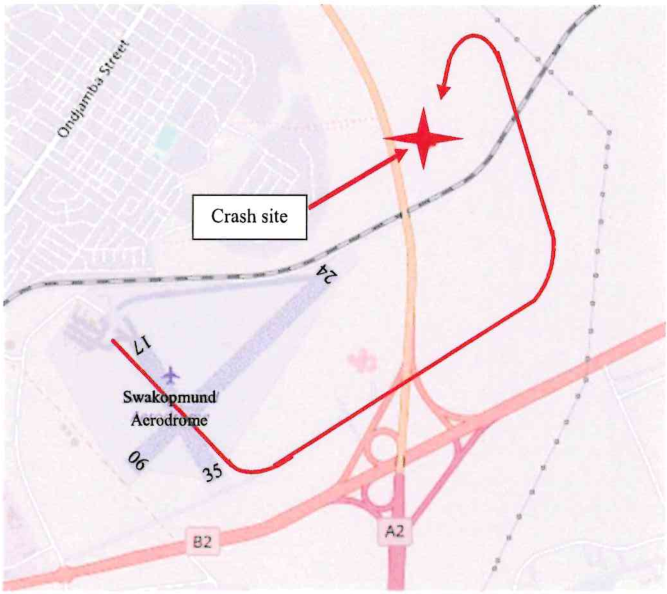

Figure 2: Image showing the route the helicopter had flown (according to an eyewitness) and the crash site.

1.2 Injuries to Persons

Injuries	Pilot	Crew	Pass.	Other
Fatal	1	1	0	0
Serious	0	0	0	0
Minor	0	0	0	0
None	0	0	0	0

1.3 Damage to Aircraft

1.3.1 The helicopter was destroyed.

Figure 3: Picture showing the destroyed Helicopter as it came to rest.

1.4 Other Damage

1.4.1 There was no other damage.

1.5 Personnel Information

1.5.1 Pilot-In-Command

The pilot was a holder of a valid Namibian Helicopter Commercial Pilot License (HCPL) issued according to the Namibian Civil Aviation Regulation (2001) part 61.01.10. His R44 endorsement was valid until 07/12/2023.

Nationality		Namibian			
Licence No	CR 0652	Gender	Male	Age	54
Licence valid		Yes	Type Endorsed	Yes	
Ratings		Helicopter (Rotorcraft): R22, R44, Gyroplane Fix Wing: PA28, C150, C172, C182, C206, C210, C402, C404, F406, Microlights Military: K8, Y12, C337			
Medical Expiry Date		28/02/2024			

Restrictions	Valid only with correction for defective near vision
Previous Accidents	Unknown

Flying Experience

The pilot had extensive fix wing flight experience and was a flight instructor at the local flying school in Swakopmund. He also had military flight experience flying Yak 12 (Y12) and Cessna 337 Skymaster "Push Pull" (C337) as well as fighter jet; K8 for the Namibian Defense Force Air wing.

Helicopter Flying Experience:

Total Hours	181.9*
Total on Type	84.7

**as on 01/02/2023*

Fix Wing Flying Experience:

Total Hours	10210,7
Total Past 90 Days	62.5
Total on Type Past 90 Days	N/A

Military Flying Experience:

Total Hours	687.1

1.5.2 Apprentice Aircraft Maintenance Engineer

The Apprentice Engineer was not licensed, as no record could be found at the regulator (NCAA).
He had also not attended the Robinson Helicopter Company's maintenance course.
He, however, had company approval from the AMO, the next renewal date was 09/01/2024.

1.6 Aircraft Information

1.6.1. The Robinson R44 Raven II Pilot Operating Handbook (POH) describes the helicopter systems as follows:

The Robinson R44 is a four-seater, single main rotor, single-engine helicopter constructed primarily of metal and equipped with skid-type landing gear. The primary fuselage structure is welded steel tubing and riveted aluminium sheets. The tail cone is a monocoque structure in which aluminium skins carry most primary loads. Fiberglass and thermoplastics are used in various other cabin structures, engine cooling shrouds and various other ducts and fairings.

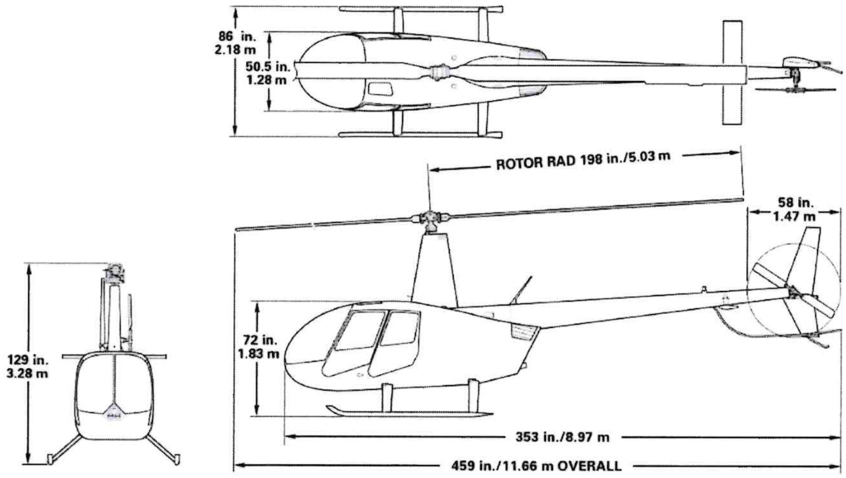

Figure 4: Robinson R44 helicopter (Source: Robinson Helicopter Company)

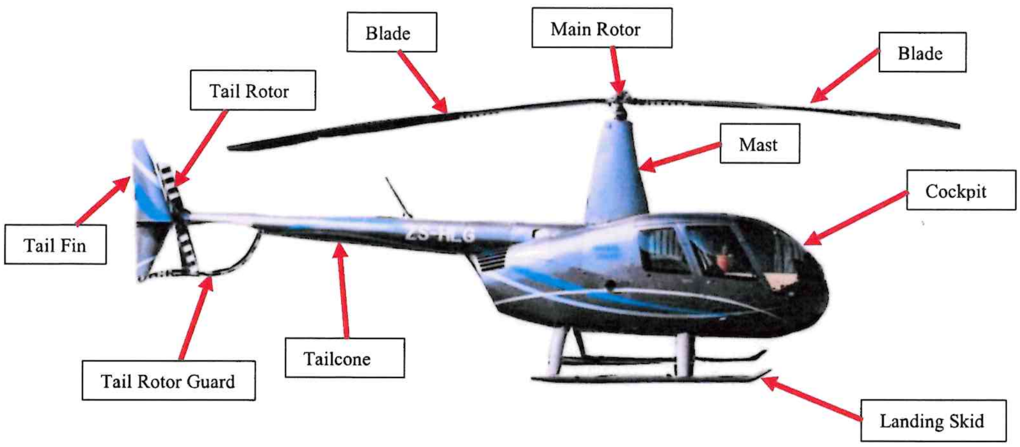

Figure 5: Picture shows the basic parts of the Robinson R44 helicopter.

Airframe:

Type	Robinson R44 Raven II
Serial No.	11517
Manufacture	Robinson Helicopter Company
Year of Manufacture	16 November 2006
Total Airframe Hours (At time of Accident)	975.6 (as per last recorded entry on the log book date 15/08/2017)
Last MPI (Date & Hours)	975.6 (as per last recorded entry on the log book date 15/08/2017) by SA AMO 1266
Hours since Last MPI	Unknown
C of A (Issue Date)	None
C of R (Issue Date)	Not Valid

Engine:

The engine that the helicopter (ZS-HLG) arrived with in Namibia was replaced with an engine that belonged to a Namibian registered helicopter, V5-HJL (R44). The helicopter (V5-HJL) was also involved in an accident on the 28th of August 2021 (See final report on https://mwt.gov.na/web/mwt/completed-investigations). After the investigation into the circumstances why V5-HJL crashed was completed, the engine of V5-HJL was removed, shock load tested and overhauled. The engine was found serviceable. The data below is of the engine of V5-HJL:

Type	Textron Lycoming
Serial No.	L-35693-48E
Engine total hours	1526.5
Hours since Overhaul	151.

Main rotor blades:

The Main Rotor (MR) blades that the helicopter (ZS-HLG) arrived with was replaced with second hand MR blades (including spindles). The MR blades were sent to an AMO in South Africa, the MR blades were serviced and was found serviceable. The data below is of the second hand MR blades:

Part no	C016-7	
Serial numbers	6585	7116
Hours since new	132.6	
Hours since overhaul	137.3	

1.6.2. The Maintenance inspection that was carried out on the Helicopter was the 12-year inspection. The AMO started with the maintenance work when the helicopter arrived in Namibia. Several parts required to be replaced or overhauled.

1.6.3. **Weight and Balance**

The weight and balance calculations were considered to be within limits before take-off and prior to the accident, as prescribed by the manufacture specifications. The AMO refuelled the helicopter on the 13th of July 2023 with 100 lt (27 US gallons) Avgas. A video recording (by the fix wing pilot) on Friday the 14th of July 2023 during the second test flight that was conducted before the accident flight, showed that Aux Tank had 5 US gallons (18.9 lt) and the main tank had 9.22 US gallons (34.82 lt). After the video was made the flight lasted for another 10 minutes. The average fuel consumption for this helicopter type was 57 lt or 15 US gallons per hour. The helicopter consumed approximately 2.5 US gallons or 9.4 lt for the 10 minutes of flight. The resultant fuel remaining on board at the time of lift off was concluded as being 11.72 US gallons (44.36 lt). The helicopter was considered to have sufficient fuel on board before the crash.

R44 II Weight and Balance					
	Weight	Long. Arm	LONG. MOM.	LAT. ARM	LAT. Moment
Empty Weight	1552.00	103	159856	0.00	0.00
Pilot (Right seat)	182,1 (82,60 kg)	49,5	9009	+12.2	2818.20
Pilot Baggage	11 (5 kg)	49.5	544.5	+11.5	0.00
Front seat passenger (L)	167,55 (76kg)	49,5	8293	-10.4	-1944.80
Front seat passenger (L) Baggage	0	44.0	0.00	-11.5	0.00
Rear seat passenger (R)	0	79.5	0.00	+12.2	0.00
Rear seat passenger (R) Baggage	0	79.5	0.00	+12.2	0.00
Rear seat passenger (L)	0	79.5	0.00	-12.2	0.00
Rear seat passenger (L) Baggage	0	79.5	0.00	-12.5	0.00
TOTAL Empty weight and Balance (No Fuel)	**No Fuel Weight**	**No Fuel Long. C.G.**	**Long. Empty Moment**	**No Fuel Lat. C.G.**	**Lat. Empty Moment**
	1912	92	177702.00	0.44	873.40
Main Tank	58 lbs	106	6148	-13.5	-1932.498
Aux Tank	12 lbs	103	1224	-13.5	-1932.498
Total weight before Take-off (with Fuel)	**Take-off weight**	**Long. Full C.G.**	**Long. Full Moment**	**Lat. Full C.G.**	**Lat. Full Moment**
	1982	93.37	185074	-0.50	-1059.10

Note: *The weight of the pilot and engineer were obtained during the Post-Mortem examination. The Weight and Balance calculations were done by the IIC and an R44 Instructor.*

1.7. Meteorological Information

1.7.1. An official weather report was obtained from the Namibia Weather Services (NWS). The closest automatic weather station (20 NM away), where data was recorded at the time of the accident was at Walvis Bay Airport, which was also the closest weather station to the accident site.

Wind direction	280°	Wind speed	08 kts	Cloud cover and Visibility	CAVOK
Temperature	31°C	Dew point	-01°C	Air Pressure	QNH 1020 Hpa

1.7.2. Visual meteorological conditions prevailed for the area.

1.7.3. One of the eyewitnesses, also a pilot, described the weather at the time of the accident as clear and the wind as moderate.

1.8. Aids to Navigation

1.8.1. There were no navigation aids at the Airstrip where the helicopter departed from nor was it required by the relevant Regulations.

1.9. Communications.

1.9.1. The Helicopter was equipped with standard communication equipment; however, the Radio license had expired. During the test flights the helicopter had a serviceable Radio and communicated with other aircraft in the Swakopmund circuit.

1.10. Aerodrome Information

1.10.1. The aerodrome utilized for the accident flight has cross runways. The runway designators are 06/24, Main Runway, and 17/35, Secondary Runway.

1.10.2. The helicopter did not make use of any runway and lifted off from the *Run-up pad.

Aerodrome Location	Swakopmund Airfield	
Aerodrome GPS coordinates	22°39'30"S 014°34'00"E	
Aerodrome Elevation	170 FT	
Runway Designators	06/24	17/35
Runway Dimensions	1600 x 18	963 x 24
Runway surface	Slurry seal	Sand
Runway used	N/A	
Aids to Navigation	None	

**A Run-up pad is the area where aircraft do engine run-ups, usually before take-off.*

Figure 6: Picture showing the run-up pad at Swakopmund Airfield.

Figure 7: Picture showing ZS-HLG lifting off from the Run-up pad during one of the previous Test flights (source: Local operator)

1.11. Flight Recorders

1.11.1. The aircraft was not equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR) nor was it required by the relevant aviation regulations.

1.12. Wreckage distribution and Impact Information

1.12.1. The Helicopter experienced an inflight break-up when one of the Main Rotor (MR) blades hit the tailcone causing it (tailcone) to detach from the main fuselage. The MR blade (red) hit the tailcone at the No. 4 tailcone bay, however the tailcone separated at the No. 2 bay. The left side of the number 1 and 2 tailcone bays were flattened inward.

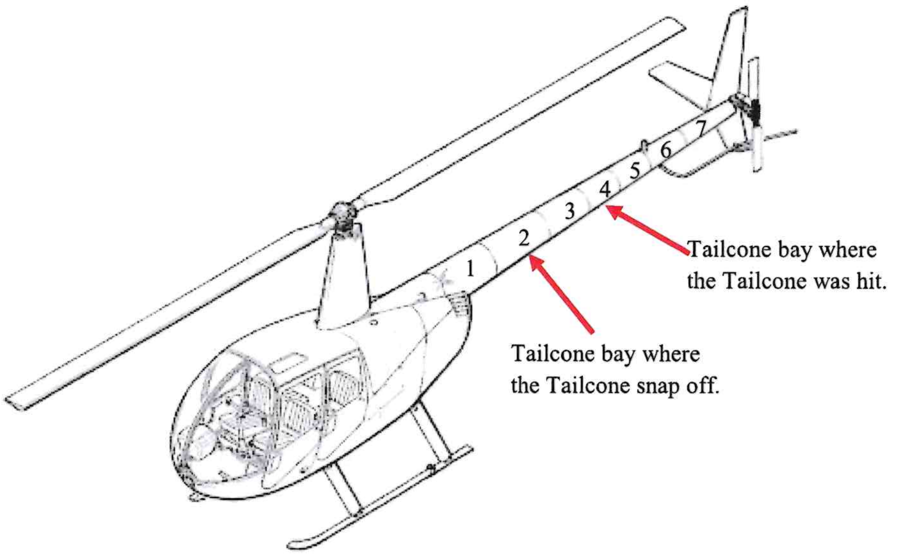

Figure 8: Drawing shows where the tailcone was strike and where it detached from the helicopter.

1.12.2. The helicopter came spiraling down to the ground and impacted the ground on the left side at a high velocity.

1.12.3. The tailcone was found 158 m from the main wreckage, the TR drive shaft was found 117m from the main wreckage. A 3,56 m section of the Red MR blade that hit the tail was found 55 m away from the main wreckage. Plexiglas sections were found throughout the debris field.

1.12.4. The instrument panel was found in front (nose section) of the helicopter.

1.12.5. Pieces of the landing skid were found close to the main wreckage, consistent with being still attached to the helicopter on impact.

1.12.6. When the helicopter hit the ground, the impact was so severe that the main cabin was compressed. The helicopter was destroyed.

MINISTRY OF WORKS AND TRANSPORT
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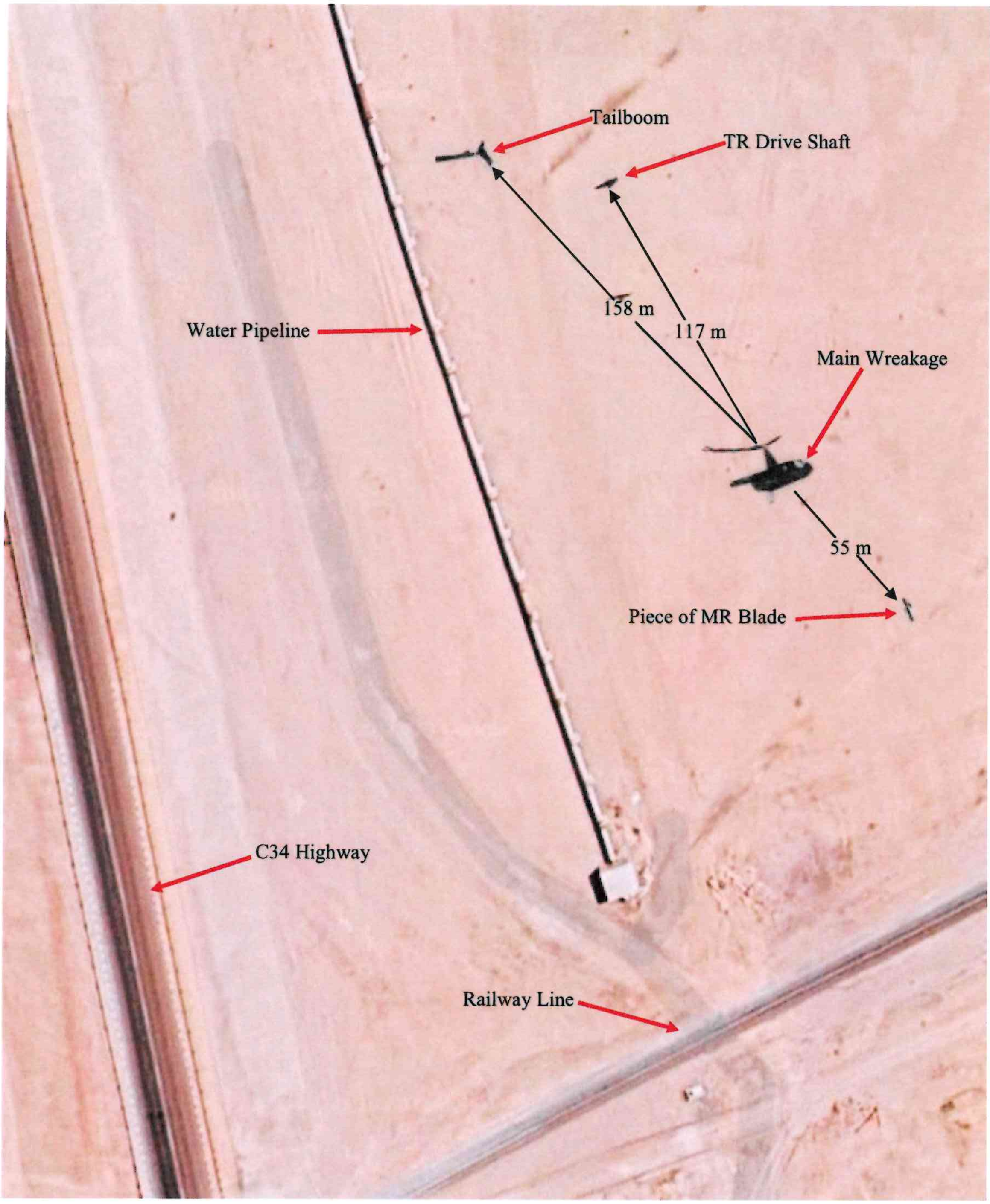

Figure 9: Picture shows how the Wreckage was distributed (Illustration).

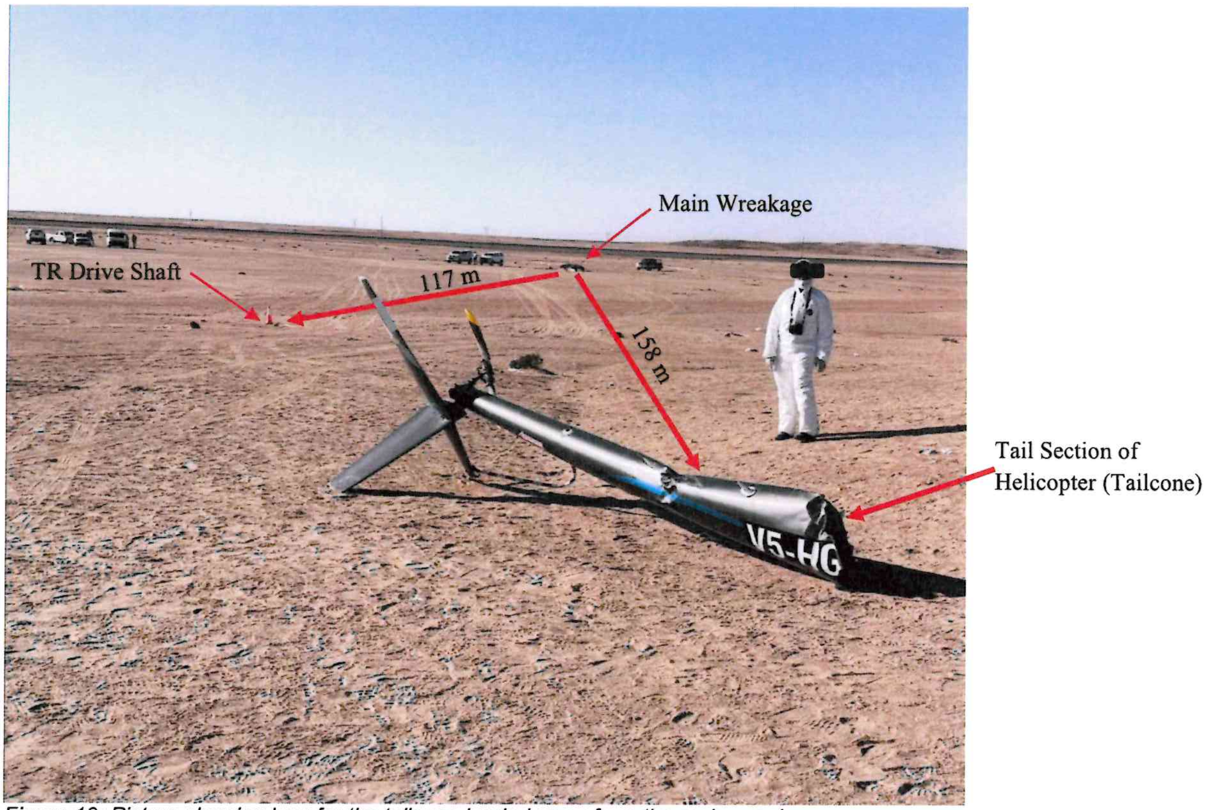

Figure 10: Picture showing how far the tailcone landed away from the main wreckage.

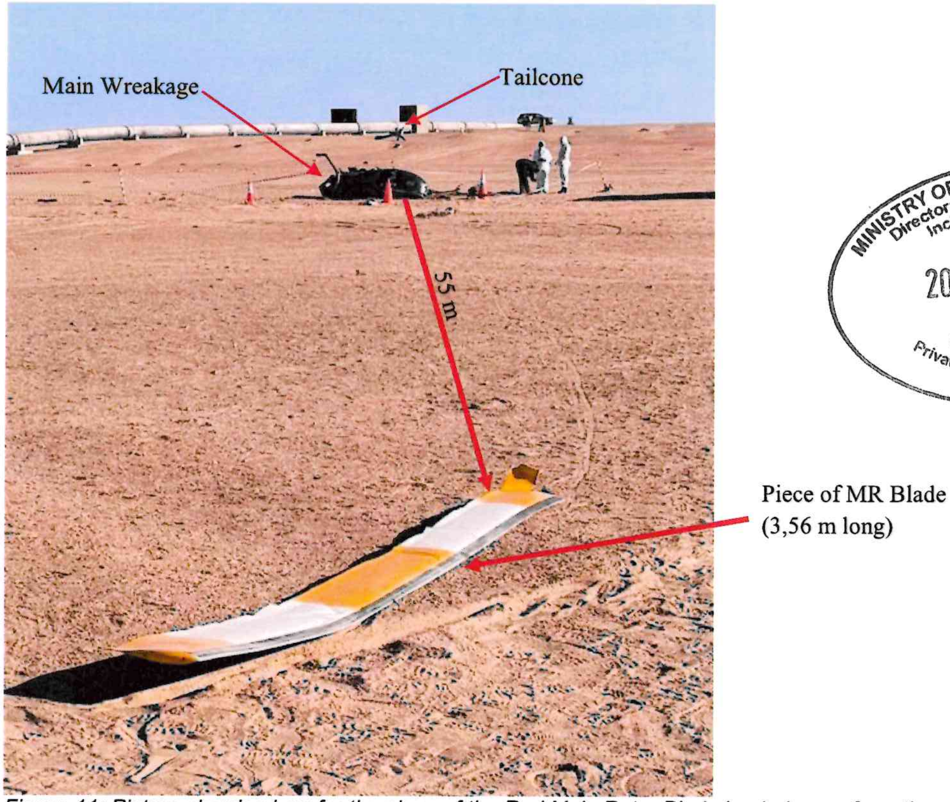

Figure 11: Picture showing how far the piece of the Red Main Rotor Blade landed away from the main wreckage.

1.13. Medical and Pathological Information

1.13.1. Autopsy and body examination data available revealed that the pilot and the engineer suffered total body blunt force injuries during the helicopter crash.

1.13.2. The pilot had no previous health issues reported and therefore was fit to perform the test flight.

1.13.3. The blood sample of the pilot was sent to the Namibian Police Forensic Science Institute (NPFSI) for analysis and it was found to contain a concentration of not more than 0.00 g of ethyl alcohol per 100 milliliters of blood.

1.14. Fire

1.14.1. There was no pre or post impact fire.

1.15. Survival Aspects.

1.15.1. The helicopter impacted the ground on the left side at a high velocity.

1.15.2. The safety harnesses (seat belts) were effective as per the specification, however, the compression of the cabin and the impact forces were beyond human body tolerance resulting in both occupants being fatally injured in the crash.

1.15.3. The safety harnesses were cut by the first responders to release the deceased.

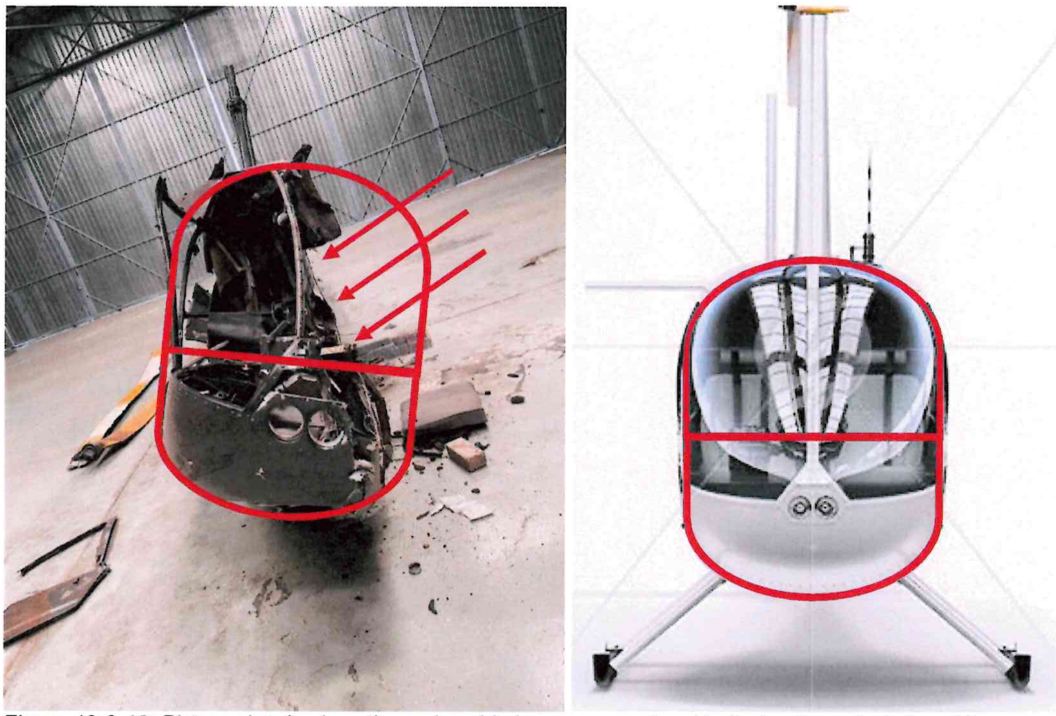

Figure 12 & 13: Picture showing how the main cabin is compressed, red indicates the actual size of the helicopter.

1.15.4. The accident was not survivable.

Figure 14: Picture showing how the main cabin is compressed.

1.16. Tests and Research.

1.16.1. The helicopter (wreckage) was transported to the DAAII facility in Windhoek, Eros Airport, for further investigation. Several parts of interest were removed and inspected while some were sent away for further testing.

1.16.1.1. The Fuel Control Unit (FCU) was removed, presence of fuel in the in closure was detected. The FCU was then bench tested at a facility in Johannesburg, South Africa and it was found that it was working as per specifications.

Note: The FCU that the helicopter arrived with was not working according to the work pack, the AMO therefore loaned the part from another helicopter to perform the test flights.

1.16.1.2. Spark Plugs: The spark plugs were removed and bench tested at a local AMO and were found to be serviceable. A note in the work pack stated that prior to the test flight, one of the spark plugs was not giving spark resulting in a rough running engine and the action that was taken was that all the spark plugs were replaced before the test flights.

1.16.1.3. Swashplate: On site investigation found that the rotating swashplate was rotated 180° from its normal position. The rod end on the Fork Assembly was also fractured. The swashplate was removed, inspected and was found to be lubricated. The presence of grease was found in the in-closure. The bearings were not ceased as the swashplate could easily be rotated by hand and no rough or dry bearings was found.

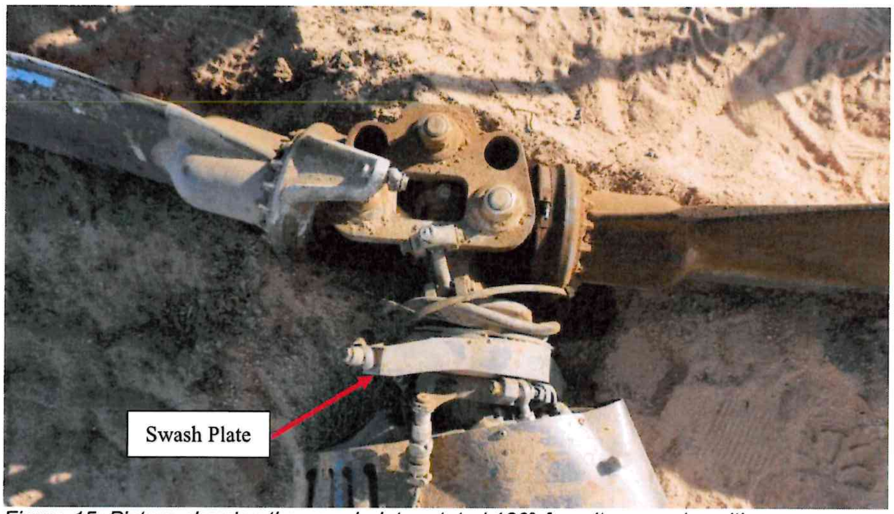

Figure 15: Picture showing the swashplate rotated 180° from its normal position.

1.16.1.4. <u>Pitch Links (Part Number: C258-1)</u>. The one Pitch Link (blue) was fractured at the upper rod end and was relatively straight, while the other Pitch Link (red) was fractured at the upper rod end and in the middle of the Link. The missing piece of the red Pitch Link could not be found.

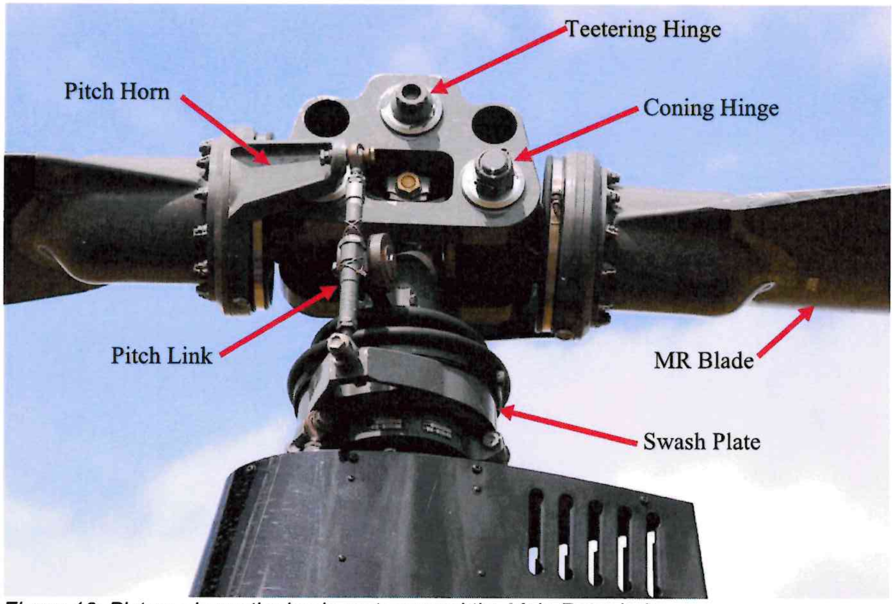

Figure 16: Picture shows the basic parts around the Main Rotor hub.

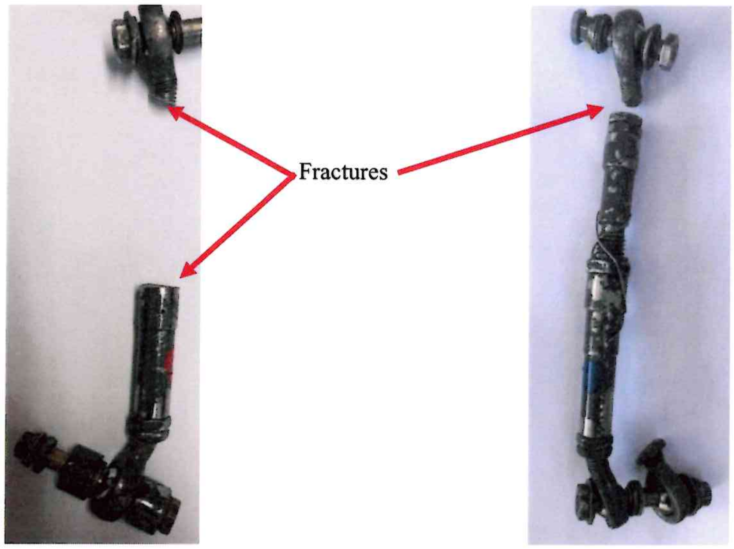

Figure 17 and 18: Pictures showing the two pitch links that was on the helicopter (Red left and blue right)

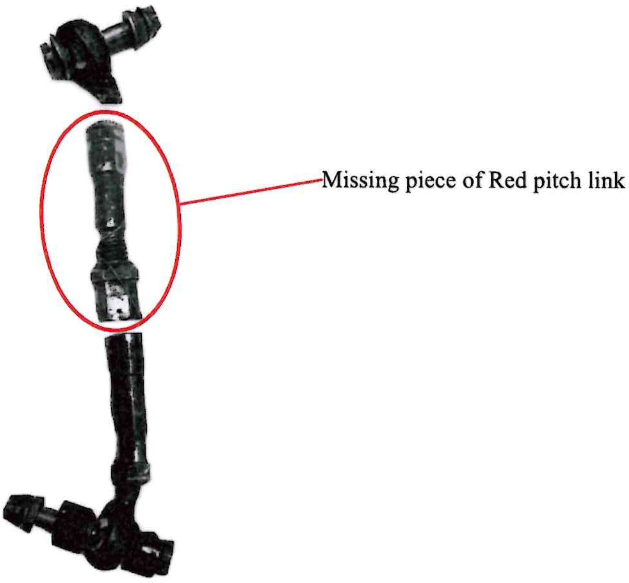

Figure 19: Picture shows how the missing piece of Red pitch link look like (Illustration).

1.16.1.4.1 The Pitch Links were removed and sent to the Namibian Police Forensic Science Institute (NPFSI) for Metallurgic testing. The test was conducted to determine whether the pitch Links failed due to overstress, rust, fatigue or existing cracks. The results were:

- No significant corrosion/ rusting was observed on both Pitch Link Assemblies (Exhibits A1, A2, B1 and B2).

Figure 20: Picture shows the Red Pitch Link, Exhibits A1 and A2.

Figure 21 and 22: Picture shows the Blue Pitch Link, Exhibits B1 and B2.

- Chemical analysis on the surface and inner circumference indicated that ratio (by weight) of Iron to Oxygen was very high in favour of Iron (the ratio of Oxygen to Iron in typical corrosion is 1.5 to 1 in favour of Oxygen. In heavy corrosion Oxygen to Iron ratio is 1.7 to 1, in favour of Oxygen). This is an indication that corrosion/ rust was very minimal on all exhibits.

- In consideration of the above, it was possible to infer that:
  - Strong evidence indicated that Exhibits A1, A2, B1 and B2 failed due to sudden overstress (relatively straight shear lip patterns, relatively flat, smooth pattern, with no significant striation on the inner circumference).

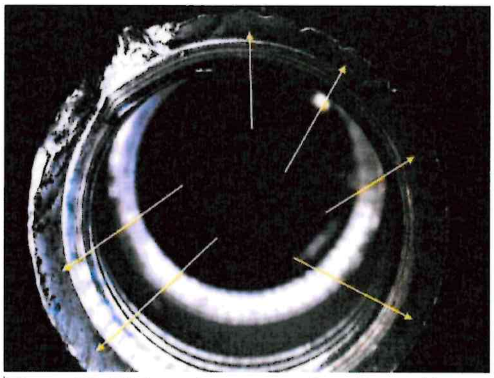

Figure 23: Picture shows smooth pattern with no significant striation on the inner circumference of Exhibit A1 (Red Pitch Link)

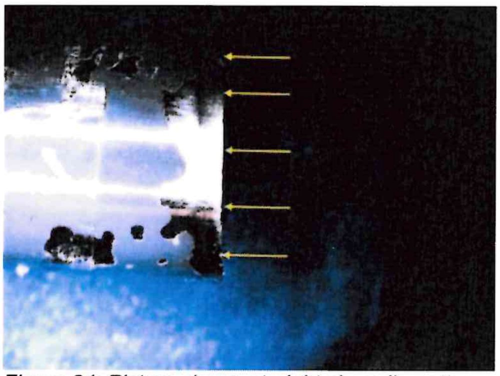

Figure 24: Picture shows straight shear lip pattern on Exhibit A1 (Red Pitch Link)

- No evidence could be found indicating significant rusting/ corrosion (no significant corrosion/ rusting observed, the ratio of Iron to Oxygen was very high in favour of Iron).

1.17. Organizational and Management Information.

1.17.1. The AMO did not follow procedures and did not apply for a Flight Test Permit in terms of NAMCAR 21.08.5(b) and (e) from the regulator (NCAA) to conduct the maintenance test flight.

1.18. Additional Information

1.18.1. During the 12-year inspection the Robinson Helicopter Company Manual states that the C258-1 Pitch Link Assembly should be replaced with the new C258-5 Pitch Link Assembly. See Appendix A for the full page of the Manual.

-36, or -38		damage and no loss of material.
C258-1	Main Rotor Pitch Link Assembly	Replace with new C258-5 link assembly.
C258-5	Main Rotor Pitch Link Assembly	Perform inspection per § 2.630, or replace with new.

Figure 25: Extraction of 12-year inspection manual

1.18.2. Robinson Helicopter Company issued a Service Letter (SL-58 and SL-20) on the 30th of January 2017 informing the R44, R44II and R66 helicopter owners, operators and maintenance personnel that the old Pitch Link part number C258-1 was being phased out and replaced with new Pitch Link part number C258-5. See Appendix B for the full SL-58 and SL-20.

R44 SERVICE LETTER SL-58

R66 SERVICE LETTER SL-20

DATE: 30 January 2017

TO: R44, R44 II, and R66 Owners, Operators, and Maintenance Personnel

SUBJECT: C258-5 Pitch Link Assembly

BACKGROUND: Part number C258-1 pitch link assembly, main rotor, is no longer available and is superseded by new part number C258-5 pitch link assembly. C258-5 link assembly features a separately replaceable lower rod end. This service letter provides instructions for adjustment of the new C258-5 assemblies.

Figure 26: Extraction of SL-58 and SL-20

1.18.3. Robinson Helicopter Company issued a Safety Notice (SN-43) dated January 2015, warning crew to use extra caution when conducting post maintenance test flights. See Appendix C.

1.19. Useful or Effective Investigation Techniques.

1.19.1 Not applicable.

2. ANALYSIS

2.1. Pilot-in Command

2.1.1. The pilot was a holder of a valid Namibian Helicopter Commercial Pilot License (HCPL) and a valid Medical Certificate issued by the Namibia Civil Aviation Authority. The HCPL was issued on the 04th of October 2021. The Medical Certificate was issued on the 10th of February 2023 and was valid until the 28th of February 2024. The Robinson R44 was endorsed in his license on the 16th of November 2021.

2.1.2. A Namibian registration mark, V5-HGG, was pasted on the helicopter as the pilot was not in possession of a South African License Validation Certificate to operate a South African Registered Aircraft.

2.1.3. It is likely when the pilot entered the auto-rotation by rolling the throttle to idle (possibly "chopping" the throttle) result in stoppage of the engine, possibly due to improperly adjusted Fuel Control Unit (See Appendix D and E, Safety Notice SN-27 and SN-38). With the pilot's extensive fixed wing experience, it is likely the pilot's engrained reaction to the loss of power was to push the cyclic forward to gain airspeed (as required in an airplane) (See Appendix F, Safety Notice SN-29) causing a further reduction in rotor RPM, resulting in stalling the rotor. (See Appendix G and H, Safety Notices SN-10 and SN-24). The mechanical actions of the main rotor head when experiencing Low rotor RPM and/or a stall condition likely lead to the main rotor blade (red) clipping the cabin (windshield)*, thereafter contacting the tailcone and an inflight breakup.

2.2. Machine (Helicopter)

2.2.1. The last Maintenance inspection that was carried out on the helicopter was the 12-year Inspection. At the time of Inspection, the helicopter had a total of 975.6 (as per last recorded entry in the log book) airframe hours. The engine (of ZS-HLG) was replaced with an engine from another helicopter (V5-HJL). At the time of installation, the engine (V5-HJL) had accumulated 1526.5 hours.

2.2.2. Data gathered during the investigation concluded that both Pitch Links failed due to overstress, however it is likely that the red pitch link failed first after the MR blade (red) clipped the windshield, causing the MR blade (red) to lift suddenly then tilt to the side and dive. The sudden dive of the Red MR blade caused the top side of the blade to make contact with the tailcone. After the MR Blade struck the tailcone, it (the tailcone) detached from the helicopter. The helicopter then span out of control and fell to the ground.

Figure 27: Image shows how the MR blade made contact with tailboom (Illustration).

** Pieces of the windshield (Plexiglas sections) were found throughout the debris field.*

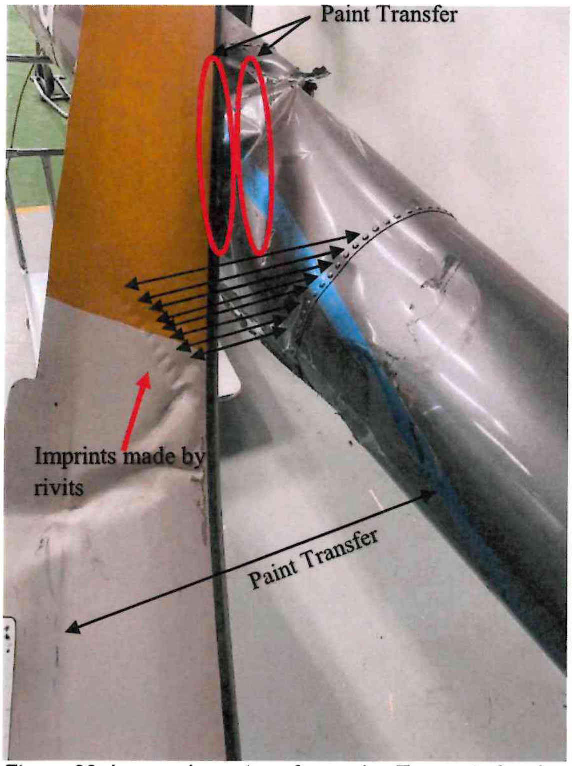

Figure 28: Image shows transfer marks. Top part of main rotor blade and tailboom

2.2.3. When the helicopter impacted the ground, the engine was not working. This was evident from the teeth imprints made by the starter ring gear on the oil cooler on impact. If the engine was working, grinding marks would have been visible instead. The engine likely stalled when the pilot entered the auto-rotation by rolling the throttle to idle (possibly "chopping" the throttle) resulting in stoppage of the engine

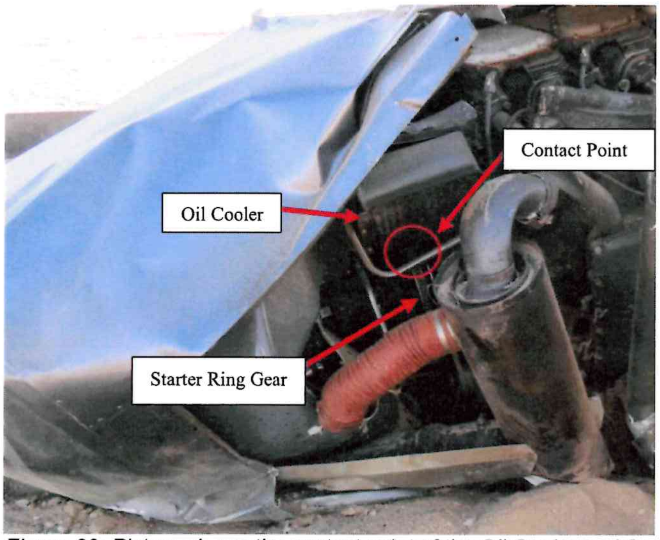

Figure 29: Picture shows the contact point of the Oil Cooler and Starter Ring Gear.

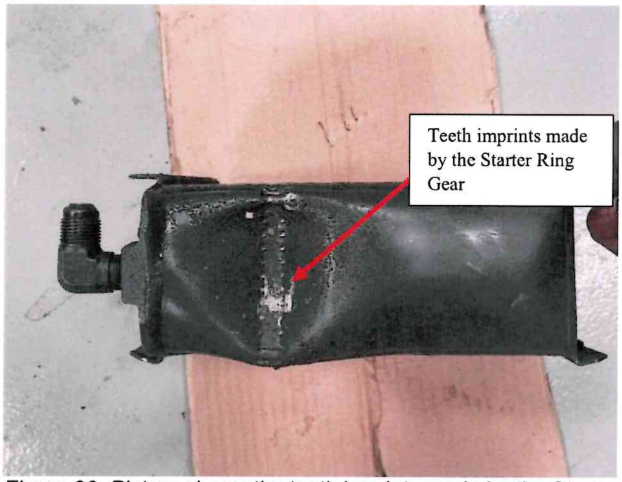

Figure 30: Picture shows the teeth imprints made by the Starter Ring Gear on the Oil Cooler.

3. CONCLUSION

3.1. Findings

3.1.1. The pilot

3.1.1.1. The pilot had a total of 10958,7 flying hours on all types.

3.1.1.2. The pilot had a valid Namibian Helicopter Commercial Pilot License (HCPL). According to the logbook, the pilot had flown a total of 181.9 hours on helicopters, of which 84,7 hours were on the R44 type.

3.1.1.3. The pilot was an experienced flight instructor at the local flying school in Swakopmund.

3.1.1.4. The pilot was a Designated Examiner (DE) for the NCAA.

3.1.1.5. The pilot had a valid class 1 aviation medical certificate that was issued on 10 February 2023 with an expiry date of 28 February 2024.

3.1.1.6. The pilot was fatally injured during the accident.

3.1.2. Apprentice Maintenance Engineer

3.1.2.1. The apprentice maintenance engineer was not licensed as no record could be found at the regulator (NCAA).

3.1.2.2. The apprentice maintenance engineer had not attended the Robinson Helicopter Company's maintenance course.

3.1.2.3. The apprentice maintenance Engineer had company approval from the AMO, next renewal date was 09/01/2024.

3.1.2.4. The apprentice maintenance Engineer was fatally injured during the accident.

3.1.3. The aircraft (Helicopter)

3.1.3.1. The Helicopter did not have any valid Certificate of Airworthiness (CoA) for South Africa or Namibia. The South African Certificate of Airworthiness expired on the 31st of December 2018.

3.1.3.2. The engine that was installed in the helicopter (engine of V5-HJL) was not logged in the engine or airframe logbooks.

3.1.3.3. The registration Number, V5-HGG, that was pasted on the Helicopter was a Namibian registration, but the helicopter was never registered in Namibia. However, when the helicopter arrived in Namibia (February 2022), the AMO did apply for the registration, V5-HGG to be reserved in terms of NAMCAR 47.04.3. Records indicated that the regulator did reserve the registration, V5-HGG, but the process was never completed and the reservation period lapsed which is six months. The helicopter was therefore never registered in Namibia.

3.1.3.4. During the accident the helicopter was still legally registered in South Africa under the South African registration, ZS-HLG.

3.1.3.5. The helicopter also did not have a valid Special (Test) Flight Permit to perform the test flights.

3.1.4. AMO

3.1.4.1. When the12-year inspection on the helicopter was done by the AMO, the Logbooks were not updated, the last entry in the airframe logbook was 15 August 2017?

3.1.4.2. The work pack to perform the 12-year inspection was found to be incomplete.

3.1.4.3. The AMO conducted Post Maintenance Flight Test without a valid Special (Test) Flight Permit.

3.1.4.4. The Pitch Link C258-1 assembly was not replaced with the new C258-5 Pitch Link assembly as prescribed in the Robinson Helicopter Company 12-year service manual.

3.1.5. Weather

3.1.5.1. The investigation found that the prevailing weather did not contribute to the accident.

3.1.6. Regulator

3.1.6.1. The regulator issued the certificate (letter) of no objection for the importation of the helicopter from South Africa dated 23/02/2022. Email communication (seen by the investigators) between the regulator and the AMO showed that the regulator tried to stop the importation after receiving information that the helicopter was not airworthy and that it was requiring a 12-year inspection. However, no evidence was found that the Regulator actuality cancelled the certificate(letter) or informed their South African counter parts that they are objecting to the importation of the helicopter.

3.1.6.2. When the No Objection certificate (letter) was issued, the regulator did not follow their own process, to obtain the helicopter airworthiness information from their counterpart in South Africa (SACAA).

3.1.6.3. The regulator also did not query the AMO where the helicopter was when they (AMO) applied for the reservation of the registration (V5-HGG). On the application form, the serial number was the same as the serial number on the No Objection certificate (letter).

3.2. Probable Cause/s

3.2.1. Rotor Stall

3.2.2. In flight break up, due main rotor blade striking the tailcone.

3.3. Contributing factor/s

3.3.1. Low RPM

3.3.2. Pitch Link (Red) Failure

4. Safety Recommendations

1.SAFETY RECOMMEDATION NUMBER 003/2024 –ZS-HLG

4.1. Investigation into this aircraft accident as well as several other occurrences revealed the presence of counterfeit certificates and permits, posing a significant risk to aviation safety. The current licensing/certification system lacks adequate security features, making it susceptible to forgery and unauthorized replication. Strengthening the certification process is critical to maintaining high safety standards and protecting the integrity of Namibia's aviation sector.
Therefore, DAAII recommends to NCAA to upgrade their certificates/permits and licenses by.

I. Adopting Advanced Security Features:

Integrate modern security features into permit/certificates and licenses such as:

a. **Holographic Seals:** To prevent unauthorized duplication.

or

b. **Watermarks:** Embedded within the document to verify authenticity.

2.SAFETY RECOMMEDATION NUMBER 004/2024 –ZS-HLG

4.2. Investigation into this aircraft accident as well as several other occurrences revealed, there is a critical need to enhance the surveillance and monitoring of aircraft operators within Namibia, especially at outside stations it was revealed Operators know when to expect inspections and prepare for them. Strengthening the surveillance programme especially spot/unannounced

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inspections will ensure that operators are always in compliance with all safety regulations and standards.
Therefore, DAAII recommends that NCAA enhance their surveillance programme for aircraft operators by:

I. **Increasing Frequency of Inspections:** Conduct more and unannounced inspections of aircraft operators and aircraft maintenance organizations. This includes:

   a. **Ramp Inspections:** Regular checks of aircraft on the ground for compliance with maintenance and operational standards.
   b. **Spot Audits:** Surprise audits of operator facilities and records.

II. **Implementing a Risk-Based Surveillance Approach:**

Focus surveillance efforts on higher-risk operators and operations by:

   a. **Risk Assessment Models:** Develop and utilize risk assessment models to identify operators that pose higher safety risks.
   b. **Prioritized Inspections:** Allocate more resources to monitoring and inspecting high-risk operators.

4.3. *3. SAFETY RECOMMEDATION NUMBER 005/2024 –ZS-HLG*

The Robinson R-22 and R-44 are popular for their efficiency, but their unique risks require specific safety regulations. **SFAR No. 73** addresses these risks through enhanced pilot training in key areas like energy management and Low-G condition recovery.
SFAR-73 also mandates, enhanced pilot training. The FAA has seen notable success in reducing accidents involving these helicopters, and adopting similar regulations in Namibia would likely yield similar safety improvements.

Therefore, DAAII recommends that the NCAA permanently adopts SFAR No. 73 and associated directives to ensure the highest safety standards for Robinson helicopter operations in Namibia.

Compiled by:

Ben C. A. Engelbrecht
Investigator-in-Charge

Date: 24 September 2024

Hafeni Mweshixwa
Co-Investigator

Date: 24 September 2024

MINISTRY OF WORKS AND TRANSPORT
Directorate of Aircraft Accident & Incident Investigations
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Republic of Namibia

Released by:

Philippine Lundama
ACTING DIRECTOR: AIRCRAFT ACCIDENT AND INCIDENT INVESTIGATION

Date: 24. 09. 2024

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Appendix A

1.102 Additional Component Maintenance (continued)

A. 12 YEARS (continued)

Part Number	Description	Action
C051-1 or -2	Clutch Actuator Assembly	Submit to RHC Repair Station for 12-year service, or replace with new or overhaul exchange.
C119-2	Bumper – Tail Rotor	Replace with new.
C121-1, -3 or -30, -19, & -24 or -28	Push-Pull Tube Assembly – Main Rotor	Visually inspect. If exterior corrosion is evident, record length, disassemble, and inspect tube interior. Repair or replace as required.
C121-9, -15, & -17	Push-Pull Tube Assembly – Tail Rotor	Visually inspect. If exterior corrosion is evident, record length, disassemble, and inspect tube interior. Repair or replace as required.
C121-21	Push-Pull Tube Assembly – Throttle	Visually inspect. If exterior corrosion is evident, record length, disassemble, and inspect tube interior. Repair or replace as required.
C121-25 or -31	Push-Pull Tube Assembly – Swashplate	Measure & record overall length. Remove rod ends and visually inspect, including tube interior. Replace if corrosion is evident.
C169-3, -32, -36, or -38	Muffler Assembly	Visually inspect muffler interior; verify no obvious damage and no loss of material.
C258-1	Main Rotor Pitch Link Assembly	Replace with new C258-5 link assembly.
C258-5	Main Rotor Pitch Link Assembly	Perform inspection per § 2.630, or replace with new.
C315-9	Support Weldment – Lower Aft Flight Controls	Visually inspect. If exterior corrosion is evident, remove and inspect tube interior. Repair or replace as required.
C319-5	Torque Tube – Cyclic	Visually inspect. If exterior corrosion is evident, remove and inspect tube interior. Repair or replace as required.
C334-4	Bellcrank Assembly (Collective)	Visually inspect. If exterior corrosion is evident, remove and inspect tube interior. Repair or replace as required. Verify bearings rotate smoothly without noise.
C336-1	Push-Pull Tube Assembly, Throttle (R44)	Visually inspect. If exterior corrosion is evident, record length, disassemble, and inspect tube interior. Repair or replace as required.
C343-1, -9, & -11	Push-Pull Tube Assembly – Tail Rotor	Visually inspect. If exterior corrosion is evident, record length, disassemble, and inspect tube interior. Repair or replace as required.
C343-8	Tube – Aft Servo	Visually inspect. If exterior corrosion is evident, record length, disassemble, and inspect tube interior. Repair or replace as required.
C348-1	Anchor Assembly – Collective Stop	Visually inspect. If exterior corrosion is evident, remove and inspect tube interior. Repair or replace as required.

Appendix B

ROBINSON
HELICOPTER COMPANY

2901 Airport Drive, Torrance, California 90505 Phone (310) 539-0508 Fax (310) 539-5198

R44 SERVICE LETTER SL-58

R66 SERVICE LETTER SL-20

DATE: 30 January 2017

TO: R44, R44 II, and R66 Owners, Operators, and Maintenance Personnel

SUBJECT: C258-5 Pitch Link Assembly

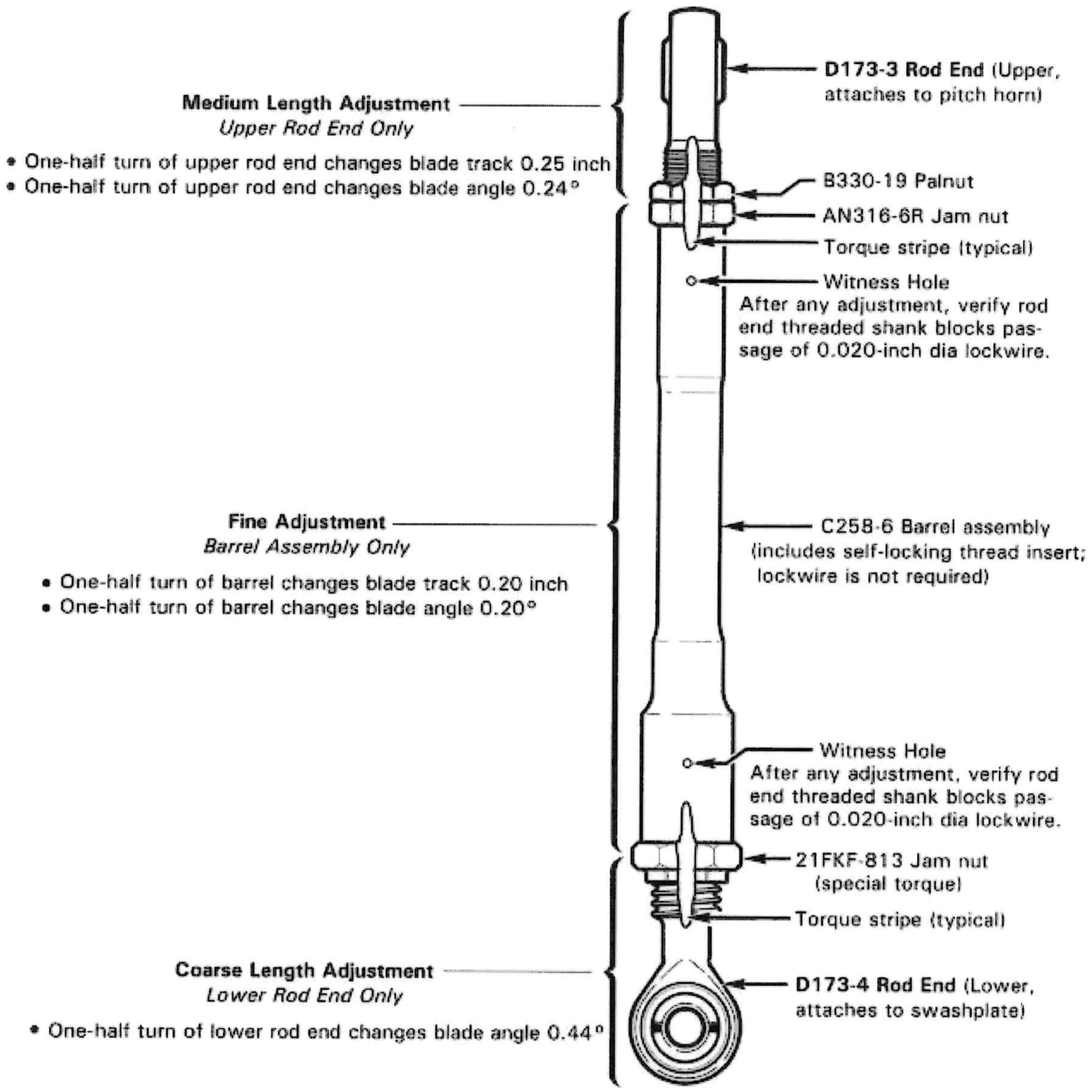
BACKGROUND: Part number C258-1 pitch link assembly, main rotor, is no longer available and is superseded by new part number C258-5 pitch link assembly. C258-5 link assembly features a separately replaceable lower rod end. This service letter provides instructions for adjustment of the new C258-5 assemblies.

C258-5 USAGE AND ADJUSTMENTS: (refer to illustration on page 2)

1. C258-5 pitch link assembly directly replaces C258-1 pitch link assembly, and may be installed singly or in pairs; there is no weight change.
2. When replacing pitch link assembly or pitch link parts, keep overall length within plus/minus 0.005 inch of removed link prior to disassembly.
3. After pitch link installation or adjustment, verify both rod end threaded shanks block passage of 0.020 inch diameter lockwire at witness holes in barrel assembly.
4. Apply torque stripes for maximum preflight visibility after torquing nuts.
5. Due to a self-locking thread insert, lockwire is not required.
6. Similar to C258-1 pitch link assembly, blade tracking fine adjustment is accomplished by rotating barrel with rod ends remaining connected to pitch horn and swashplate; one full turn of barrel is equivalent to one-half turn of upper rod end.
7. Apply light coat of A257-2 or A257-22 oil to threads when replacing rod ends.

Approximate Cost:

Parts: $651 for complete C258-5 link assembly



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Appendix C

ROBINSON
HELICOPTER COMPANY

2901 Airport Drive, Torrance, California 90505 Phone (310) 539-0508 Fax (310) 539-5198

Safety Notice SN-43

Issued: January 2015

USE EXTRA CAUTION DURING POST-MAINTENANCE FLIGHTS

A number of fatal accidents have occurred during flights immediately following maintenance. In several cases, the cause was incorrect or incomplete reassembly of the helicopter, and the error would have been detectable during a careful preflight inspection.

Even the best maintenance personnel can become distracted and make a mistake. Pilots should conduct an especially thorough preflight inspection after maintenance has been performed. If possible, speak to the technicians who performed the work, find out exactly what was done, and pay special attention to those areas. Professional maintenance personnel will appreciate the pilot's commitment to safety and will welcome an additional check of their work.

Any work done on the flight control system deserves special attention because a flight control disconnect is almost always catastrophic. During track and balance work, always climb up to the rotor head for a close inspection of the pitch link and control tube fasteners after each adjustment. Never rush or skip preflight steps.

Appendix D

ROBINSON
HELICOPTER COMPANY

Safety Notice SN-27

Issued: Dec 87 Rev: Jun 94

SURPRISE THROTTLE CHOPS CAN BE DEADLY

Many flight instructors do not know how to give a student a simulated power failure safely. They may have learned how to respond to a throttle chop themselves, but they haven't learned how to prepare a student for a simulated power failure or how to handle a situation where the student's reactions are unexpected. The student may freeze on the controls, push the wrong pedal, raise instead of lower the collective, or just do nothing. The instructor must be prepared to handle any unexpected student reaction.

Before giving a simulated power failure, carefully prepare your student and be sure you have flown together enough to establish that critical understanding and communication between instructor and student. Go through the exercise together a number of times until the student's reactions are both correct and predictable. Never truly surprise the student. Tell him you are going to give him a simulated power failure a few minutes before, and when you roll off the throttle, loudly announce "power failure". The manifold pressure should be less than 21 inches and the throttle should be rolled off smoothly, never "chopped". Follow through on all controls and tighten the muscles in your right leg to prevent the student from pushing the wrong pedal if he becomes confused. And always assume that you will be required to complete the autorotation entry yourself. Never wait to see what the student does. Plan to initiate the recovery within one second, regardless of the student's reaction.

There have been instances when the engine has quit during simulated engine failures. As a precaution, always perform the simulated engine failure within glide distance of a smooth open area where you are certain you could complete a safe touch-down autorotation should it become necessary. Also, never practice simulated power failures until the engine is thoroughly warmed up. Wait until you have been flying for at least 15 to 20 minutes.

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Appendix E

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HELICOPTER COMPANY

2901 Airport Drive, Torrance, California 90505 Phone (310) 539-0508 Fax (310) 539-5198

Safety Notice SN-38

Issued: July 2003 Revised: July 2019

PRACTICE AUTOROTATIONS CAUSE MANY TRAINING ACCIDENTS

Practice autorotations continue to be the number one cause of helicopter training accidents. Many of these accidents occur because the instructor fails to take decisive action.

Instructors should always perform the following "100 Foot Decision Check":

1) Rotor RPM approximately 100%
2) Stabilized airspeed between 60 and 70 KIAS
3) Stabilized rate of descent, usually less than 1500 ft/min.
4) Turns (if any) completed

Prior to descending below 100 feet AGL, the instructor must make the decision to take the flight controls and make an immediate power recovery if any of the above parameters is not correct. Do not attempt to salvage the situation by coaching the student or trying to correct below 100 feet AGL. At density altitudes above 4000 feet, increase the decision check to 200 feet AGL or higher.

If the decision to continue is made, the instructor should announce "100 Foot Check complete, continue".

A high percentage of training accidents occur after many consecutive autorotations. To maintain instructor focus and minimize student fatigue, limit practice to no more than 3 or 4 consecutive autorotations.

The purpose of the practice autorotation is to teach control and maneuvering during the glide, proper use of the flare, and the power recovery (or landing). While simulated power failure/forced landing practice may involve more abrupt power reduction, practice autorotation entries should be accomplished smoothly and slowly in accordance with the Robinson Flight Training Guide.

Appendix F

Safety Notice SN-29

Issued: Mar 93 Rev: Jun 94

AIRPLANE PILOTS HIGH RISK WHEN FLYING HELICOPTERS

There have been a number of fatal accidents involving experienced pilots who have many hours in airplanes but with only limited experience flying helicopters.

The ingrained reactions of an experienced airplane pilot can be deadly when flying a helicopter. The airplane pilot may fly the helicopter well when doing normal maneuvers under ordinary conditions when there is time to think about the proper control response. But when required to react suddenly under unexpected circumstances, he may revert to his airplane reactions and commit a fatal error. Under those conditions, his hands and feet move purely by reaction without conscious thought. Those reactions may well be based on his greater experience, ie., the reactions developed flying airplanes.

For example, in an airplane his reaction to a warning horn (stall) would be to immediately go forward with the stick and add power. In a helicopter, application of forward stick when the pilot hears a horn (low RPM) would drive the RPM even lower and could result in rotor stall, especially if he also "adds power" (up collective). In less than one second the pilot could stall his rotor, causing the helicopter to fall out of the sky.

Another example is the reaction necessary to make the aircraft go down. If the helicopter pilot must suddenly descend to avoid a bird or another aircraft, he rapidly lowers the collective with very little movement of thecyclic stick. In the same situation, the airplane pilot would push the stick forward to dive. A rapid forward movement of the helicopter cyclic stick under these conditions would result in a low "G" condition which could cause mast bumping, resulting in separation of the rotor shaft or one blade striking the fuselage. A similar situation exists when terminating a climb after a pull-up. The airplane pilot does it with forward stick. The helicopter pilot must use his collective or a very gradual, gentle application of forward cyclic.

To stay alive in the helicopter, the experienced airplane pilot must devote considerable time and effort to developing safe helicopter reactions. The helicopter reactions must be stronger and take precedence over the pilot's airplane reactions because everything happens faster in a helicopter. The pilot does not have time to realize he made the wrong move, think about it, and then correct it. It's too late; the rotor has already stalled or a blade has already struck the airframe and there is no chance of recovery. To develop safe helicopter reactions, the airplane pilot must practice each procedure over and over again with a competent instructor until his hands and feet will always make the right move without requiring conscious thought. AND, ABOVE ALL, HE MUST NEVER ABRUPTLY PUSH THE CYCLIC STICK FORWARD.

Also see Safety Notices SN-11 and SN-24.

Appendix G

Safety Notice SN-10

Issued: Oct 82 Rev: Feb 89; Jun 94

<u>FATAL ACCIDENTS CAUSED BY LOW RPM ROTOR STALL</u>

A primary cause of fatal accidents in light helicopters is failure to maintain rotor RPM. To avoid this, every pilot must have his reflexes conditioned so he will instantly add throttle and lower collective to maintain RPM in any emergency.

The R22 and R44 have demonstrated excellent crashworthiness as long as the pilot flies the aircraft all the way to the ground and executes a flare at the bottom to reduce his airspeed and rate of descend. Even when going down into rough terrain, trees, wires or water, he must force himself to lower the collective to maintain RPM until just before impact. The ship may roll over and be severly damaged, but the occupants have an excellent chance of walking away from it without injury.

Power available from the engine is directly proportional to RPM. If the RPM drops 10%, there is 10% less power. With less power, the helicopter will start to settle, and if the collective is raised to stop it from settling, the RPM will be pulled down even lower, causing the ship to settle even faster. If the pilot not only fails to lower collective, but instead pulls up on the collective to keep the ship from going down, the rotor will stall almost immediately. When it stalls, the blades will either "blow back" and cut off the tail cone or it will just stop flying, allowing the helicopter to fall at an extreme rate. In either case, the resulting crash is likely to be fatal.

No matter what causes the low rotor RPM, the pilot must first roll on throttle and lower the collective simultaneously to recover RPM **<u>before</u>** investigating the problem. It must be a conditioned reflex. In forward flight, applying aft cyclic to bleed off airspeed will also help recover lost RPM.

Appendix H

ROBINSON
HELICOPTER COMPANY

Safety Notice SN-24

Issued: Sep 86 Rev: Jun 94

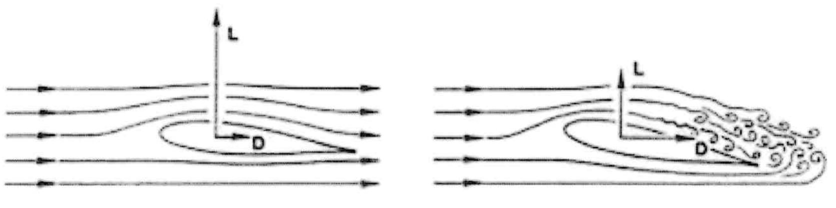
LOW RPM ROTOR STALL CAN BE FATAL

Rotor stall due to low RPM causes a very high percentage of helicopter accidents, both fatal and non-fatal. Frequently misunderstood, rotor stall is not to be confused with retreating tip stall which occurs only at high forward speeds when stall occurs over a small portion of the retreating blade tip. Retreating tip stall causes vibration and control problems, but the rotor is still very capable of providing sufficient lift to support the weight of the helicopter.

Rotor stall, on the other hand, can occur at any airspeed and when it does, the rotor stops producing the lift required to support the helicopter and the aircraft literally falls out of the sky. Fortunately, rotor stall accidents most often occur close to the ground during takeoff or landing and the helicopter falls only four or five feet. The helicopter is wrecked but the occupants survive. However, rotor stall also occurs at higher altitudes and when it happens at heights above 40 or 50 feet AGL it is most likely to be fatal.

Rotor stall is very similar to the stall of an airplane wing at low airspeeds. As the airspeed of an airplane gets lower, the nose-up angle, or angle-of-attack, of the wing must be higher for the wing to produce the lift required to support the weight of the airplane. At a critical angle (about 15 degrees), the airflow over the wing will separate and stall, causing a sudden loss of lift and a very large increase in drag. The airplane pilot recovers by lowering the nose of the airplane to reduce the wing angle-of-attack below stall and adds power to recover the lost airspeed.

The same thing happens during rotor stall with a helicopter except it occurs due to low rotor RPM instead of low airspeed. As the RPM of the rotor gets lower, the angle-of-attack of the rotor blades must be higher to generate the lift required to support the weight of the helicopter. Even if the collective is not raised by the pilot to provide the higher blade angle, the helicopter will start to descend until the



UNSTALLED STALLED

Wing or rotor blade unstalled and stalled.

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Safety Notice SN-24 (continued)

upward movement of air to the rotor provides the necessary increase in blade angle-of-attack. As with the airplane wing, the blade airfoil will stall at a critical angle, resulting in a sudden loss of lift and a large increase in drag. The increased drag on the blades acts like a huge rotor brake causing the rotor RPM to rapidly decrease, further increasing the rotor stall. As the helicopter begins to fall, the upward rushing air continues to increase the angle-of-attack on the slowly rotating blades, making recovery virtually impossible, even with full down collective.

When the rotor stalls, it does not do so symmetrically because any forward airspeed of the helicopter will produce a higher airflow on the advancing blade than on the retreating blade. This causes the retreating blade to stall first, allowing it to dive as it goes aft while the advancing blade is still climbing as it goes forward. The resulting low aft blade and high forward blade become a rapid aft tilting of the rotor disc sometimes referred to as "rotor blow-back". Also, as the helicopter begins to fall, the upward flow of air under the tail surfaces tends to pitch the aircraft nose-down. These two effects, combined with aft cyclic by the pilot attempting to keep the nose from dropping, will frequently allow the rotor blades to blow back and chop off the tailboom as the stalled helicopter falls. Due to the magnitude of the forces involved and the flexibility of rotor blades, rotor teeter stops will not prevent the boom chop. The resulting boom chop, however, is academic, as the aircraft and its occupants are already doomed by the stalled rotor before the chop occurs.