CA 18/3/2/8234

SOUTH AFRICAN CIVIL AVIATION AUTHORITY

AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

Aircraft Registration	**ZU-DVY**	**Date of Accident**	12 January 2007	**Time of Accident**	0630Z
Type of Aircraft	SAFARI Helicopter (NTCA)		**Type of Operation**	Private Flight	
Pilot-in-command Licence Type	Commercial Aeroplane) Private Pilot (Helicopter)	**Age**	25	**Licence Valid**	Yes
Pilot-in-command Flying Experience	Total Flying Hours	2901.4		Hours on Type	5.9
Last point of departure	Wonderboom Aerodrome (FAWB)				
Next point of intended landing	Brits Aerodrome (FABS)				

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

In a village called Lethlabile in Rabukalo area.

Meteorological Information	Wind: 360/05, Temperature: 24°C, Visibility: Good and no clouds.				
Number of people on board	1+0	**No. of people injured**	0	**No. of people killed**	1

Synopsis

The pilot flew the helicopter on a visual flight rules (VFR) private flight in daylight conditions from Wonderboom Aerodrome (FAWB) en route to Brits Aerodrome. When the helicopter reached Lethlabile area – Rabukalo Village, approximately 13.7 nautical miles (nm) from FAWB, the pilot was fatally injured in an accident. The helicopter was destroyed by the impact and fire damage.

During the onsite wreckage investigation, the evidence found indicated that the main rotor head spindle had failed, which resulted in the main rotor blades separating from the helicopter in flight. The main rotor head spindle was subjected to metallurgical examinations to determine the cause of failure which determined that the main rotor head spindle had failed due to propagation of a fatigue crack. This crack had originated within the machined radius of the blade spindle. Investigation also revealed that the rotor head had been subjected to a shock overload, i.e. rotor strike or other at some stage during the operation of the helicopter and this may have been the trigger for the initiation of the fatigue crack.

Probable Cause

The main rotor head spindle failed due to propagation of a fatigue crack, resulting in the separation of the rotor blades in flight.

IARC Date		Release Date	

AIRCRAFT ACCIDENT REPORT

Name of Owner/Operator	**:** A P Burger
Manufacturer	**:** Canadian Home Rotors
Model	**:** Safari
Nationality	**:** South African
Registration Marks	**:** ZU-DVY
Place	**:** Lethlabile – Rabukalo Village
Date	**:** 12 January 2007
Time	**:** 0630Z

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

Purpose of the Investigation:

In terms of Regulation 12.03.1 of the Civil Aviation Regulations (1997) this report was compiled in the interests of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents and ***not to establish legal liability****.*

Disclaimer:

This report is given without prejudice to the rights of the CAA, which are reserved.

1. FACTUAL INFORMATION

1.1 History of Flight

1.1.1 The owner was operating the SAFARI X 278 helicopter privately from Wonderboom Aerodrome (FAWB). On Friday morning, the 12th of January 2007* (corrected) at approximately 0348Z, the owner assisted by the pilot, prepared the helicopter for the first flight of the day. They were installing rotor balancing test equipment on the helicopter, with the intention to carry out in-flight rotor balancing checks. The owner and the pilot flew the helicopter for one circuit, at Wonderboom Aerodrome. The duration of the circuit was approximately 2 minutes. No mechanical adjustments were made to the rotors of the helicopter and the balancing was found to be within acceptable limits. The helicopter landed again at Wonderboom Aerodrome at approximately 0350Z. The rotor balancing equipment was removed and the helicopter was refuelled at the fuel bay.

1.1.2 With the approval of the owner, the pilot then took off at approximately 0559Z on a visual flight rules (VFR) private flight by day, destination Brits Aerodrome. At approximately 0707Z, the South African Police Service (SAPS) contacted the Air Traffic Control (ATC) at FAWB and reported that a helicopter had been involved in an accident in Letlhabile District – Rabukala Village. During the on-site investigation of the accident, identified witnesses stated that prior to the accident; they had heard a strange “loud noise” sound and saw the helicopter going down. The pilot was fatally injured and the helicopter destroyed by the impact and fire damage.

1.2 Injuries to Persons

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

1.3 Damage to Aircraft

Photo 1, showing damage caused to the helicopter.

1.3.1 The helicopter was destroyed in the accident.

1.4 Other Damage

1.4.1 None.

1.5 Personnel Information

Nationality	South African	Gender	Male	Age	25
Licence Number	**********	Licence Type	Private Pilot (Helicopter)		
Licence valid	Yes	Type Endorsed	Yes		
Ratings	Night				
Medical Expiry Date	30 March 2008				
Restrictions	None				
Previous Accidents	None				

Aeroplane Experience:

1.5.1 The pilot had submitted an application for the issuance of a Student Pilot's Licence to the SACAA on 16 April 1998. After completion of the flying training with a total of 54.8 hours of experience, he submitted another application for the issuance of a Private Pilot's Licence (PPL).

1.5.2 On 21 December 2000 he submitted an application for a Commercial Pilot's Licence (CPL).

1.5.3 Other aircraft types on the Licence were added on completion of the required type of conversion training.

1.5.4 The pilot submitted an application for issuance of the Airline Transport Pilot's Licence (ATPL) on 21 May 2004 with a total of 1253.3 hours flown.

Flying Experience: - Aeroplane

Grand Total	2815.7 hours
Pilot-in-command last 6 months	303.2 hours
Co-pilot last 6 months	4.3 hours
Dual last 6 months	8.2 hours
Instrument Rating last 6 months	3.1 hours

1.5.5 The above aeroplane (fixed wing) flying hours were taken from the SACAA file of the pilot.

Helicopter Experience:

1.5.6 After completing training with 85.7 hours flown, the pilot applied for issue of a Private Pilot's Licence. The SACAA issued the license on 25 April 2006. On 30 November 2006, the pilot submitted a flight crew license conversion application for the Safari X278 helicopter. At the time of the accident, the pilot had a total of approximately 5.9 hours experience on the helicopter.

Flying Experience: - Helicopter

Grand Total	85.7 hours
Conversion Training	1.5 hours
Total on Type	5.9 hours

1.5.7 The pilot also held a Microlight Pilot's Licence, which was issued on 02 January 2003.

1.5.8 The above hours flown were taken from logbook copies, the flight folio and the conversion application forms on the file of the pilot held by the SACAA.

1.6 Aircraft Information

Airframe:

Type	Safari helicopter
Serial No.	BB2087
Manufacturer	Canadian Home Rotors
Date of Manufacture	01 July 2005
Total Airframe Hours (At time of Incident)	Approximately 257.0
Last Annual Inspection (Date & Hours)	31 October 2006 | 241.1
Hours since Last Annual Inspection	Approximately 15.9
Authority to Fly (Issue Date)	09 November 2006
C of R (Issue Date) (Present owner)	11 July 2005 (A P Burger)
Operating Categories	Private Authority to Fly

1.6.1 The owner of the helicopter had submitted an application to the SACAA for the allocation of a build number to assemble the non type certificated helicopter. The owner specified in the application that a responsible person would oversee the building/assembly project and would be the holder of an Aircraft Maintenance Engineer's licence (AME). The application was approved and building number: CAA 05159 was issued. After the building/assembly project was completed, the owner submitted another application for issuance of "Proving Authority to Fly". The Proving Authority to Fly included a restriction that required a total of 25 hours to be flown. When the Proving Flights were completed, the owner submitted an application for and was issued with a Private Operation Authority to Fly.

1.6.2 To comply with regulations, in terms of maintenance requirements, the owner was required to perform Annual Inspections on the helicopter. The initial Annual Inspection that was performed on the helicopter was certified by an AMO on 15 November 2005, after the helicopter had been operating for a total of 25 hours. The second Annual Inspection was done when the helicopter had reached a total of 241.1 hours. Records indicated that the helicopter was flown for a total of 216.1 hours within 12 months, prior to performance of the second Annual Inspection. This implies that the required 100 hour interval of mandatory maintenance was not adhered to.

Note: -

Ref. Safari Flight Manual, Section 9 states:
In addition to the annual inspection, the Safari Maintenance Manual requires an inspection every 100 hours of operation. The manufacturer further states that all limits, procedures, safety practices, time limits, servicing and maintenance requirements contained in this handbook are considered to be mandatory. The above requirement of a 100 hour service interval was found not have been complied with.

1.6.3 According to the requirements of the Civil Aviation Regulations (CARS), a Type Acceptance Certificate was to have been issued prior to the helicopter being registered in South Africa. However, no evidence could be found that a Type Acceptance Certificate had been issued for the helicopter type by the SACAA.

1.6.4 The logbook of the helicopter did not have all the required maintenance information certified in it. The compass swing was last certified on 16 June 2005. There were no entries in the logbook to show that the test and inspection requirements of the Altimeter

and Airspeed Indicator of the helicopter had been complied with.

Airframe Scheduled Inspections Record:

1.6.5 The entries made in the maintenance logbook indicated that the Annual Inspections performed on the helicopter were certified by two AMOs.

(i) The first AMO performed maintenance and certified the Annual Inspection and Release to Service of the helicopter on 15 November and 16 July 2005. The Release to Service documents were certified within the privileges of the AMO Licence. When the circumstances were investigated, the evidence indicated that the Certificate of Release to Service for the Annual Inspections were signed in contravention of CARS, Part 145 and the AMO approved MoP.

(ii) The second AMO performed maintenance and certified the Annual Inspection Release to Service on 31 October 2006. As was the case in 1.6.5 (i) above, on investigation, the evidence indicated that the Release to Service for the Annual Inspection was certified in contravention of CARS, Part 145 and the AMO approved MoP.

(iii) There was also evidence of unauthorised maintenance which was performed on the helicopter by the owner:

Date	Time	Inspection
30 July 2005	4.0	Fix oil leak on engine to sump drain
28 November 2005	38.9	Remanufacture carb. heat for better efficiency.
13 December 2005	60.6	Replace oil seal on bottom of gearbox.
28 January 2006		Replace tail rotor input seal and rebalance tail rotor.
02 February 2006	81.6	Change main transmission oil and clean chip detector.
24 February 2006	103.5	100 hour Annual Inspection.
15 April 2006	155.0	Installed Turbocharger and Remanufacture exhaust manifold stainless steel. Install fuel pump seal carburettor. Install EGT; boost pressure and fuel pressure gauge.
10 June 2006	182.8	Replace tail rotor drive gear in main rotor gearbox – teeth chipped. Stripped and inspected main rotor and tail rotor gears. Replaced tail rotor drive bearings in main rotor gearbox.

(iv) The information in the table above indicates that on 15 April 2006, a modification of the turbocharger, remanufacturing of parts and equipment of the helicopter was done, which was in contravention of the regulations. There was no evidence of a modification application and/or that the modification was approved by the Commissioner. There was also no authorisation given by the Commissioner or an organisation designated, like MISASA, to the owner in order to certify the release of the parts, equipment and helicopter after the modification.

(v) According to entries of maintenance information in the logbook, the evidence shows that the helicopter was last weighed on 16 July 2005. The empty weight was given as 451.9 kg and maximum permissible mass 680 kg. The helicopter was not weighed after the installation of the unapproved modification. Thus it is not known how the modification influenced the Centre of Gravity (C o G) of the

helicopter.

Note:

The aircraft manufacturer published in Safari Flight Manual dated September 6, 2000, Section 9 the following:

"The small size, compactness and many unique features of the Safari Helicopter make any modification to the aircraft inadvisable. The dynamic characteristics and susceptibility to fatigue of the helicopter rotor, drive and control system make any modification to these systems extremely hazardous. Also hazardous is the installation of any electronic equipment or avionics not approved and supplied by Manufacturer. Because of potential hazards, the Manufacturer does not approve any modification or alteration to the helicopter other than those which are supplied by the factory."

The modification of the turbocharger was verified with the manufacturer. The response received from the Manufacturer was that the design, manufacture and testing of the helicopter never included the installation of a Turbocharger. The Manufacturer was also not consulted about the installation of the Turbocharger. The Manufacturer had no data available against which the performance of the helicopter could be measured with the installation of the Turbocharger. The Pilots Operating Handbook/ Flight Manual of the helicopter were also not amended with the performance information after installation of the Turbocharger.

(vi) There was only one logbook and both airframe and engine maintenance information was entered in it. The logbook was not designed to include all the above information. As a result important engine maintenance history, such as Airworthiness Directives (AD) and Service Bulletin (SB) compliance was not written in the logbook. The flight Folio TV2/168 makes reference to the Air Navigation Regulations (ANRs).

(vii) The owner was issued with Private Operation Authority to Fly, which restricted the use of the helicopter for training purposes. Entries made in the flight folio, indicate that the helicopter was used for unauthorised Crew Conversion Type Rating Training.

1.6.6 According to the maintenance records on the aircraft file, the main rotor blades' serial numbers (S/N) were identified as follows: 2041 and 2042. There were no serial numbers or part numbers on the tail rotor. During the accident site investigation, it was found that the main rotor blades had failed at the spindle (S/N: 047) and had separated from the helicopter. The two main rotor blades were recovered, checked and S/N verification done.

Engine:

Type	Lycoming O-360 C2C
Serial No.	L-38293-36A
Hours since New	241.1
Hours since Overhaul	Overhaul Time not reached

1.7 Meteorological Information

1.7.1 The meteorological information identified below was obtained from the South African Weather Service.

Wind direction	360° TN	Wind speed	05kt	Visibility	Good
Temperature	24°C	Cloud cover	None	Cloud base	None
Dew point	None				

1.8 Aids to Navigation

1.8.1 The helicopter crashed in a village. There were no navigation and landing aids available.

1.8.2 The aircraft had standard navigation equipment installed, which was approved for the aircraft type. The instrument panel and all the navigation instrumentation were destroyed by fire.

1.9 Communications

1.9.1 The last known communication by the pilot was with Wonderboom Aerodrome, when he and the Air Traffic Control (ATC) were broadcasting on radio frequency 120.6 MHz. The pilot requested permission from ATC to take off. No further communication was reported.

1.9.2 According to records found on the aircraft file, an ICOM A200 type of radio was installed in the helicopter. The radio was in a serviceable condition prior to the accident and had a valid radio station licence.

1.9.3 There are no Air Traffic Control services available at Brits Aerodrome.

1.10 Aerodrome Information

1.10.1 The location of the accident site was in an area which was not near to any aerodrome.

1.11 Flight Recorders

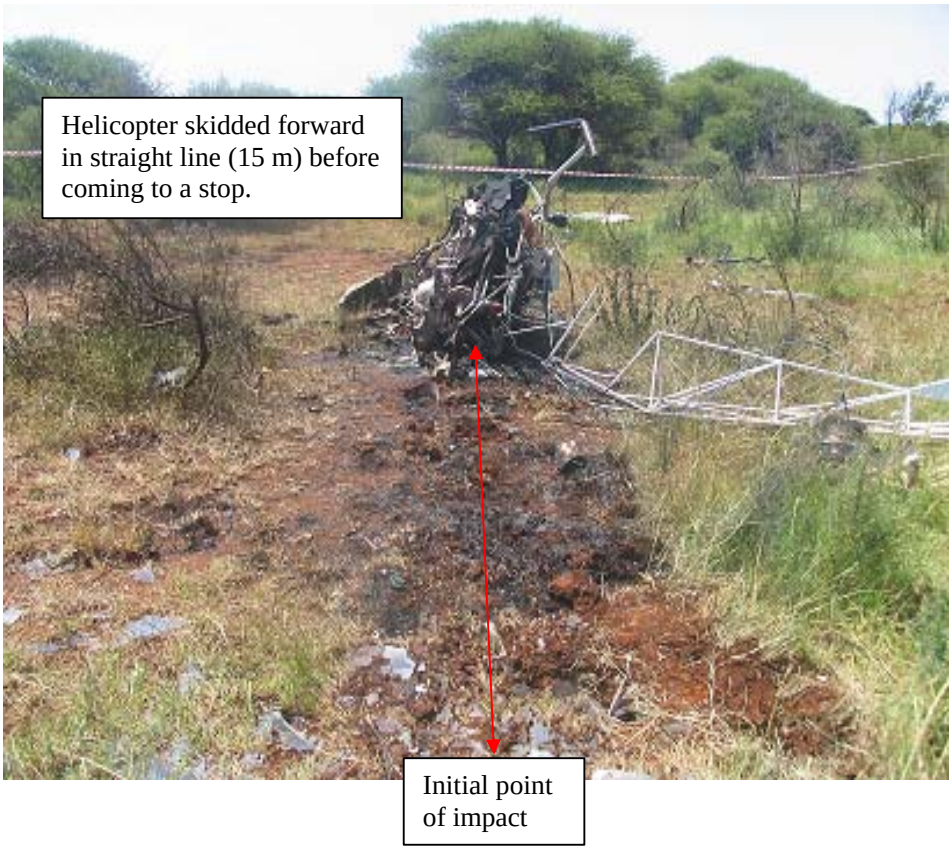
1.11.1 The helicopter was not fitted with a Cockpit Voice Recorder (CVR) or a Flight Data Recorder (FDR) and neither was required by regulations to be fitted to this type of helicopter.

1.12 Wreckage and Impact Information

1.12.1 The accident site was located at GPS co-ordinates reading: S25°32,399' E027°54,304' elevation of 3814 feet and approximately 13.71 nautical miles (nm) from the point of departure. During the onsite investigation, the following was noted:

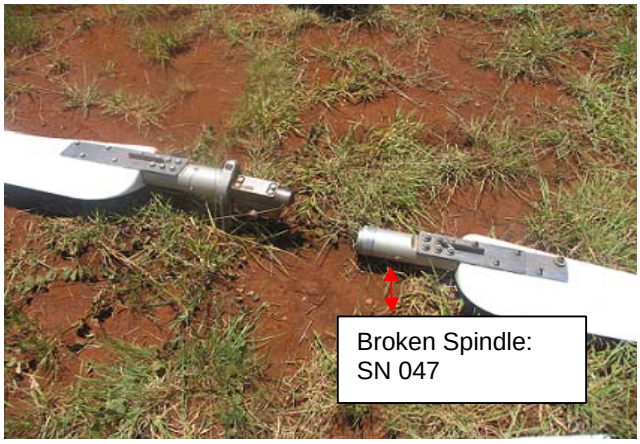
(i) The helicopter first impacted with the ground with its nose section. The wreckage then skidded forward for approximately 15 metres before stopping.

(ii) Several airframe structural parts and components broke off and separated from the main wreckage. (see pictures and information below)



Main Rotor Blade: S/N 2040
(GPS co-ordinates: S25°32.4444' E027°54.237')

Main Rotor Blade: S/N 2041
(GPS co-ordinates: S25°32.4001'E027°54.382')



Tail Rotor Assembly

1.12.2 When the helicopter impacted with the ground, the tail rotor and tail boom broke off and then separated from the fuselage. The tail boom was found on the right side of the main wreckage, approximately 5 metres away. The tail rotor drive shaft installation was still secured to the main wreckage. The tail boom and drive shaft were twisted and were bent. There was also no evidence of fire damage sustained to the parts.

1.12.3 The helicopter had two external fuel tanks mounted on top of the engine, on the left and right side of the main rotor gearbox. Indications are that during the ground impact, the left side fuel tank broke off and separated from the main wreckage. The left side fuel tank was found approximately 5 metres away.

1.12.4 The location of impact impressions on the ground, trees and other objects were identified as follows:

(i) The damage sustained to the fuselage of the helicopter was on the right side and inwardly deformed.
(ii) The force of the ground impact caused severe damage to the helicopter.
(iii) The helicopter was "free falling" from the sky, and from an unknown altitude, after the main rotor blades separated.

1.13 Medical and Pathological Information

1.13.1 The Medico-Legal Post-Mortem Examination of the pilot was submitted to the SACAA by the South African Police Services. The conclusion was that the cause of death of the pilot was Multiple Injuries.

1.13.2 When the police were requested to give a copy of the toxicology report, their response in a letter dated 07 March 2007, was as follows:

South African Police Services, reference: 41/2/1. The Investigating Officer stated:

"Kindly take note that no blood sample was sent to the Department of Health for analysis. On receipt of the report the samples were destroyed by the Department of Health: Forensic Pathology Services Brits".

1.13.3 Further enquiry revealed that the Department of Health had destroyed the blood samples without conducting the tests.

1.14 Fire

1.14.1 The helicopter was destroyed by the post-impact fire. The pilot was inside the helicopter, when it started burning. The witnesses that were interviewed at the accident site stated that they rushed to the location of the accident. On their arrival, the fire had already started. The witnesses tried to help the pilot by attempting to extinguish the flames by means of throwing soft soil on the body of the pilot. The witnesses had no source of water close by. When the fire became bigger, the witnesses ran away from the wreckage.

1.14.2 The fuel tanks sustained major damage and as a result caused a fuel spillage. The fuel became a major source of the fire.

1.14.3 The main rotor blades, tail rotor and tail boom were the only components that did not sustain any fire damage in the accident.

1.15 Survival Aspects

1.15.1 This accident was considered not survivable as the impact forces on the helicopter were fairly high, resulting in the fuel tanks rupturing and the subsequent post-impact fire.

1.15.2 The emergency personnel would have taken too long to get to the accident site as a result of not being nearby the accident site.

1.16 Tests and Research.

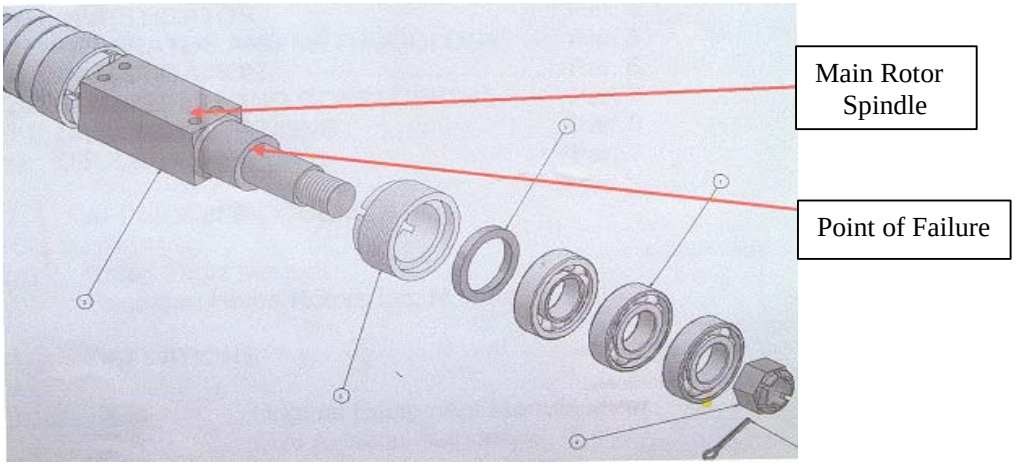
1.16.1 The engine of the helicopter was removed from the wreckage and recovered to an AMO for examination. Due to the impact and fire damage sustained, the engine could not be bench-tested for performance evaluation. An engine “tear-down” inspection was performed. The engine was completely disassembled and no anomalies were identified with the parts and components of the engine.

Engine of the helicopter

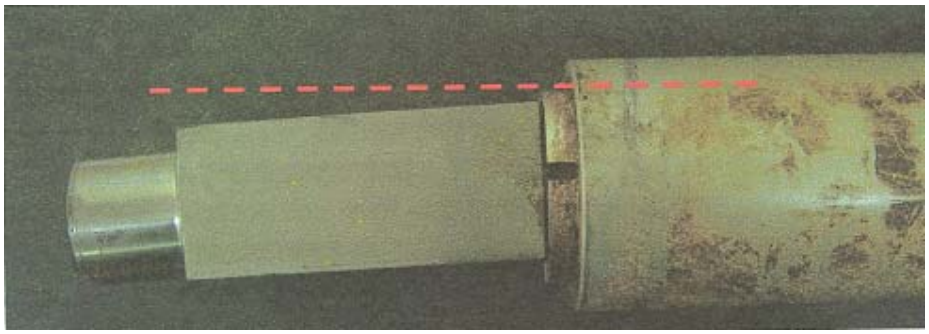
Disassembled Engine Parts stored on trolley after the "tear – down" inspection

Metallurgical Analysis of Parts:

1.16.2 The broken main rotor spindle was taken for metallurgical tests/analysis, and the following findings were made:



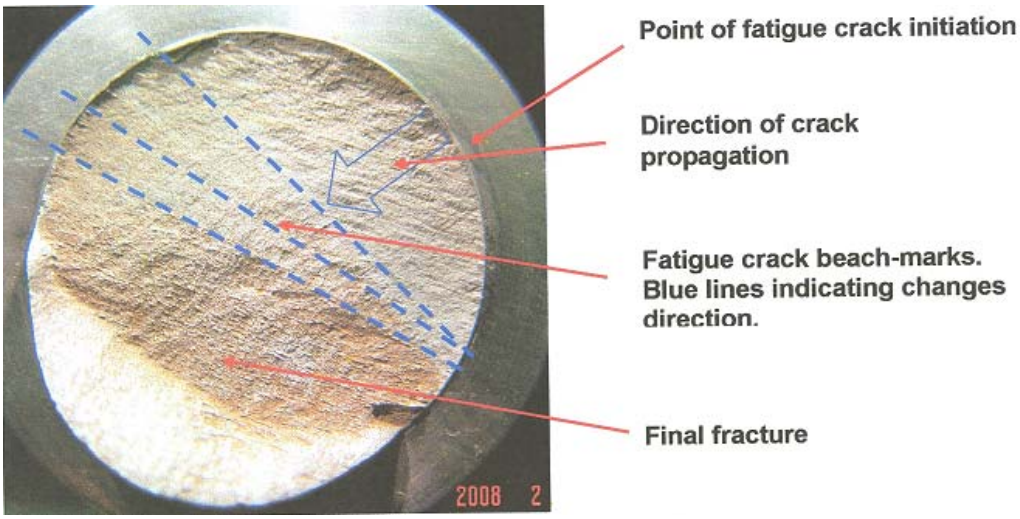
Main Rotor Bearing Assembly



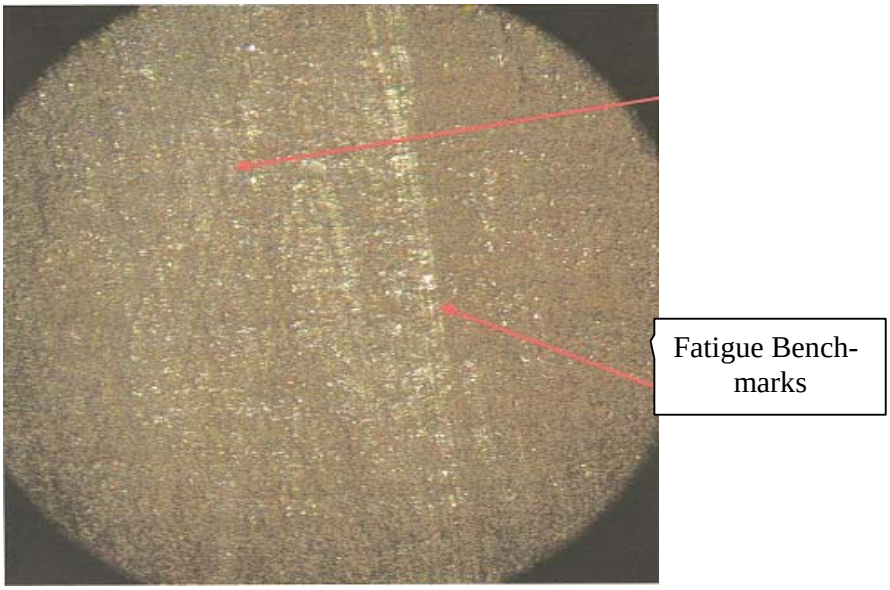
Main Rotor spindle

1.16.3 A visual and stereo – microscope investigation was performed on the tested parts. The visual inspection of the spindle indicated evidence of fracture surface which revealed clear indications of fatigue. (See below, evidence of fatigue failure caused to the

spindle.)



1.16.4 The picture above shows evidence of fatigue crack which propagated to approximately 55% of the spindle thickness, before the final fracture occurred. The directional changes in the fatigue crack, as presented by the blue lines, can be attributed to the effect of resultant strain combined with the varying operating position of the spindle relative to the rotor blade.



Main Rotor Spindle fracture surface showing clear fatigue bench-marks

1.16.5 The stereograph had clear indications that the fatigue crack originated in the sharp machined edge at the position indicated above with red lines. However, no clear signs of possible stress raises i.e. nick or machine marks, could be detected in the vicinity of the crack point of initiation.

1.16.6 The conclusions of the metallurgical tests/analysis report was then summarised as follows:

(i) No clear evidence of post-manufacturing, mechanically induced surface stress raisers could be detected that may have caused the fatigue crack initiation.

(ii) The most probable cause for the initiation of the fatigue crack may be one or more of the following:

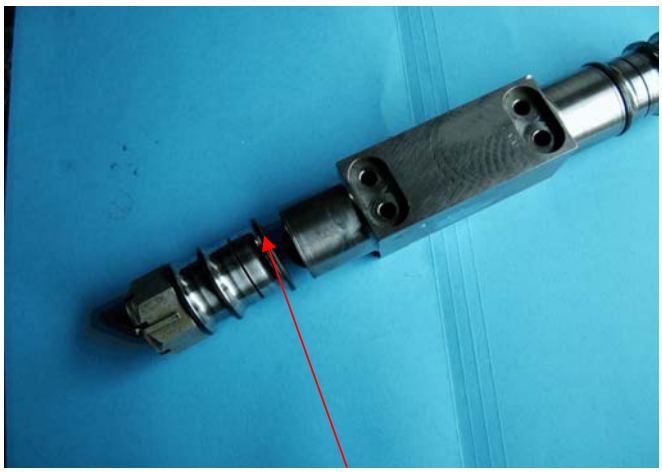
(a) The main rotor spindle was manufactured with a sharp corner without any radius at the point of crack initiation, leading to a higher surface stress.

(b) Shock overload, i.e. rotor strike or others.

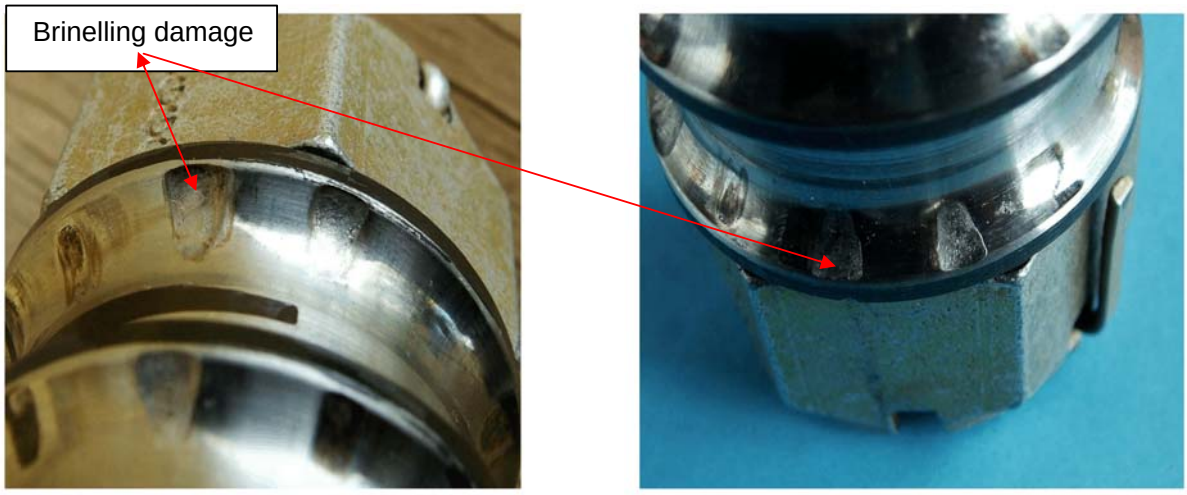
(c) Over-torque of the castle nut during assembly.

1.16.7 In order to verify the findings of fatigue made in the metallurgical report in paragraph 1.16.3 to 1.16.6 above; the main rotor spindle was taken for a second opinion and another metallurgical examination done. The outcome of the metallurgical examination was presented in a report and explained as follows:

(i) The rotor head has failed in fatigue, with the cracking most probably being initiated in the sharp radius as the result of an impact-loading event some time in the past. This impact also damaged the rolling element bearings on which the blade turns to change the pitch angle. It is considered that the lack of a sufficiently large radius at the point of failure contributed significantly to the failure by acting as a stress raiser.



The rotor head showing the position of the fracture in the radius between the bearing diameter and oil seal diameter.



Main Rotor Bearing Assembly

(ii) The main rotor spindle has been machined from a high strength titanium alloy containing aluminum and vanadium as principal alloying elements. This material is commonly used in applications, such as this, where high strength and minimal weight are required. The damage to the rolling element bearings indicate that the failed rotor blade was involved in some kind of impact loading some time prior to failure, which event produced the true brinelling observed. This mechanism is confirmed by the "piling" of material around the indentations. However, the surface of the brinell indentations was worn; indicating that fretting had occurred after the initial damage was incurred. This indicates that the rotor head had been operated following the impact.

(iii) There are two forms of brinelling, or indentation, of rolling element bearing raceway surfaces. "True" brinelling is defined as the result of an impact loading on the bearing, causing the rolling elements, in this case spherical, into the raceway surface. This results, in severe cases, of "piling" or bulging of the raceway material around the damage. This form of damage is clearly visible in the bearings from this component, indicating clearly that it had been subjected to impact loading. A second form of brinelling, known as "false" brinelling results from the bearing being subjected to oscillating loading over a small range of angular displacement. This form of damage results in a form of wear similar to fretting, which is also clearly visible in the bearings from this component, indicating that it has been operated for a considerable period of time after the initial damage was incurred.

(iv) It can therefore be presumed that the bearings were damaged by some form of impact loading at some significantly long time in the past, and had continued being operated with this damage present. Operation of the rotor head in this condition would have resulted in irregular movement of the blade when the pitch angle was changed. It is probable that the fatigue crack was initiated by the impact loading, and then propagated slowly in operation. The rotational speed of the rotor and the centrifugal forces on the hub is more or less constant, and will not induce the cyclic loadings needed for fatigue propagation. It is more probable that the fatigue crack propagation was controlled by the lifting forces generated by the rotor blade, inducing bending forces in the head. The evidence shows that the fatigue initiated on the bottom surface. Brinelling damage to the bearing raceways was evident on the failed side of the rotor head. The raised ridge due to "piling" is visible. Note that the indented surface shows signs of wear.

Further investigation into the fatigue failure

1.16.8 In the Helo Experimental Magazine, of January 2005, information published indicated that during an incident that occurred approximately five years ago, the removal of damaged components and switching between two kits – S/N BB 2085 and BB 2087 had occurred. The article heading was the following: "A story out of Africa with a good ending" and the author reported the following:

(i) "During the Airventure 2002 air show in Potchefstroom, a helicopter: ZU-CPO (S/N BB 2085) was on static display to the public. The author of the article in the magazine was also present at the air show and he was looking at ZU-CPO. There was a crack in one of the tubes, plus bent tubes which caught his eye. He asked the owner of the helicopter what had happened, who disclosed to him information of an incident involving the helicopter. They were conducting vibration balancing testing at the time. The helicopter was running at full r.p.m, when the tail rotor broke and separated from the tail boom. The helicopter became airborne, facing nose down and started to spin. The owner was at the controls and he slammed down the collect and then pulled it up slowly to avoid a hard landing. The tail boom was severely damaged and skids struts bent.

(ii) The owner of ZU-CPO wanted to display a serviceable helicopter at the Airventure 2002 air show, hence he 'patched up' the tail boom, replaced the tail rotor and transmission from the other kit (S/N BB 2087)."

1.16.9 After he was told of the incident, the author proposed to help with the repairs. The owner agreed to take the helicopter to Klerksdorp for the repairs and maintenance. The author identified other components on the helicopter which were also damaged. According to the author, the incident damaged components that were removed from ZU-CPO were replaced with serviceable components taken from crates and boxes of the other kit (S/N BB 2087). The incident-damaged components were then put inside the crates and boxes of the other kit. Based on the evidence, the possibility exists that the main rotor head, blades assembly or spindle of ZU-CPO could have been of the components that were installed in ZU-DVY.

1.16.10 In order to verify the comments made in 1.16.9, the owner was requested to give information of an inventory for all the components given to him when he had received the kit of the helicopter. The owner responded as follows: "Only now, when searching for markings on the packing crates, did I come upon two numbers written on the end of the blade case in felt pen. These numbers are 2044 and 2045. It is possible that these are the serial numbers of the blades that were installed. Maybe the other helicopter is flying with the serial numbers I used". Based on this information, we can assume that indeed, components were replaced.

1.16.10 In order to determine if any evidence existed that would support the information discussed in paragraph 1.16.8 and 1.16.9, the maintenance records of both helicopters were audited. The following evidence was found on ZU-DVY: (see the photo below)

Tail Rotor Drive Shaft Gear

(i) The identified gear was replaced on 10 June 2006 after the helicopter had been operational for 182.8 hours. It is possible that the drive shaft had sustained damage in the reported incident and was also replaced with a serviceable part from the other kit. That is the damaged part that was subsequently installed in ZU-DVY.

1.17 Organisational and Management Information

SACAA

1.17.1 The actions of the SACAA were also investigated. Based on the evidence, it appears that there was little or no oversight conducted to ensure the safe operation of the helicopter. The owner had also performed maintenance on the helicopter. Not all of this maintenance may have been authorised or within the skill capabilities of the owner. It is the opnion of the investigator that if the SACAA staff had been adequately trained and had properly checked the annual maintenance documents, submitted by the owner, the anomalies should have been detected.

1.17.2 The incident of ZU-CPO was reported to the SACAA. No evidence could be found to show that the SACAA had conducted an investigation into determining the cause of the incident.

1.17.3 The helicopter was privately operated and issued with an Authority to Fly in the private operational category. The purpose of the flight on the day was for the pilot to accumulate hours towards his helicopter Commercial Pilot's Licence. The owner of the helicopter and the pilot were close friends and as a result the pilot was allowed to fly the helicopter privately. They normally agreed that the pilot had to pay for the fuel that he was using.

1.17.4 The owner held a Private Pilot's Licence (PPL) and an appropriate helicopter-type rating for the SAFARI Helicopter.

Aviation Training Organisation (ATO)

1.17.5 The pilot had completed conversion training on the helicopter at an ATO. The flight training school submitted proof of a Type Technical for Safari Baby Belle X278 examination, which the pilot had successfully completed. The pilot flew the helicopter

for a practical flight test on 11 November 2006, for a duration of 1.2 hours. The total flight experience on the helicopter was 4.6 hours.

(i) The ATO was last audited on 01 March 2007, issued with a licence on 06 March 2007 and with the expiry date of 10 February 2008. The ATO was appropriately rated to give a Private Pilot's Licence and Aircraft Type Rating training.

(ii) The helicopter that was involved in the accident was not on the approved list of aircraft to be used by the ATO. No evidence could be found to show that the ATO was given permission by the SACAA to utilise the helicopter.

1.17.6 In the light of the conditions of the Authority to Fly, the management of the Training Organisation was asked if the pilot had paid for the helicopter conversion training. The ATO response was that they were not party to any agreement between the owner of the helicopter and the pilot. The conversion onto the Safari – X278 helicopter was not charged.

1.18 Additional Information

1.18.1 The aircraft type is currently classified in South Africa as a "Non-Type Certificated Aircraft". According to the operating requirements of the aircraft type, the owner was required to comply, when applicable with the regulations and conditions of CAR, Part 24, 94 and 96. To clearly understand the principle meaning of "Non-Type Certificated" in the South African context, attention is drawn to the intent of "Type Certificate" as it is defined:

> "It means a design approval for Class 1 product, normally awarded by aviation regulatory bodies to aerospace manufacturers after it has been established that the particular design of a civil aircraft, engine, or propeller has fulfilled the regulating bodies' current prevailing airworthiness requirements for the safe conduct of flights under all normal conceivable conditions. Aircraft produced under a type certificate design are then issued with a Standard Airworthiness Certificate."

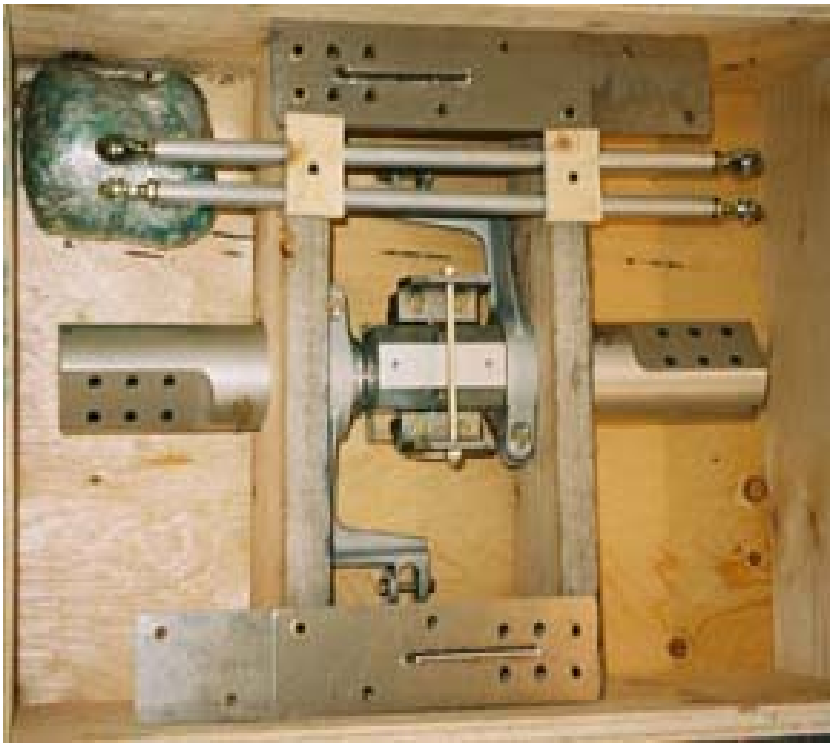
"Non-Type Certificated Aircraft" is defined as

> "'non-type certificated aircraft' means any aircraft that does not qualify for the issue of a certificate of airworthiness in terms of Part 21 and shall include any type certificated aircraft that has been scrapped, of which the original identification plate should have to be removed and returned to the applicable aviation authority and is rebuild as a full-scale replica."

In practice this implies that an NTCA does not have to meet the same certification standards to qualify for the issuance of a Type Certificate. The owner, pilot or passenger is assumed to accept that there is a risk in the operation and flying of an NTCA. For example, in the type certification, the hub of a helicopter would be subjected to fatigue testing whilst with the NTCA, this will not be the case.

1.18.2 The findings made in the metallurgical reports were reviewed and further investigated It was concluded as follows:

(i) No evidence could be found of maintenance done on the main rotor assembly, which required that the castle nut be torqued. According to the aircraft manufacturer, each component comes in a crate and in boxes. The components are not allocated to any specific frame. There would have been enough parts to make up the two helicopters. As a result, there is no requirement for the owners of the helicopters to fasten or torque the castle nut of the rotor head bearing assembly during the build process. The Hub and spindles come pre-assembled. In the light of the evidence, the probable cause identified in 1.16.6 (ii)(c) above was eliminated in the investigation. (See photo of main rotor head assembly packed for shipment.)



Photo, showing Main Rotor Head Assembly

(ii) During the metallurgical examination, the evidence indicated that the fatigue crack originated in the sharp machined edge of the main rotor spindle. In order to verify the correctness of the finding, the aircraft manufacturer was consulted in the investigation and requested to give copies of design drawings, manufacturing and machining processes of the main rotor spindle. The manufacturer responded as such: “We have never had a problem with the main rotor spindle”. None of the requested documents were submitted to the AIID.

(iii) The metallurgical report also identified that a shock overload, i.e. rotor strike or other may have being responsible for initiation of the fatigue crack and the maintenance and operating history of the helicopter was checked. Based on the evidence of information discussed in paragraphs 1.16.8 to 1.16.9, the possibility does exist that the components and/or parts of ZU-DVY were exposed to shock overload and this contributed to the failure of the main rotor spindle.

1.18.3 The helicopter was not maintained in compliance to CARS, Part 24. The applicable requirement states that the owner of a Non-Type Certificated Aircraft (NTCA) for which an Authority to Fly is required in terms of these regulations shall –

(a) ensure that the non-type certificated aircraft is maintained in compliance with –
(ii) To the extent applicable, to the requirements of Part 43.

1.18.4 The helicopter was issued with a "Private Authority to Fly", but it was found that reference is made to an "Authority to Fly" only and nowhere is the word "Private" used or defined in the context of intended operation of the aircraft. Item 4.1 which is a condition listed on the "Private Authority to Fly" states that the aircraft is privately operated and not utilised for remuneration. Again the use of the word "Private" comes to the fore without it having been duly defined.

1.18.5 The helicopter type was not accepted in South Africa, thus currently no information of technical data in the form of a required Built Standard could be found to assist in the investigation.

1.18.6 The manufacturer of the helicopter was requested to give technical information of the aircraft type to help in the investigation, as well as the type of information found pertinent to the design and manufacturing of the helicopter. A short report was requested of the history of the incidents and accidents and directives issued in terms of continued airworthiness. The manufacturer responded by stating that the aircraft is currently in the experimental category and therefore after purchase, the owner becomes responsible for the helicopter. The manufacturer did not provide the information as requested.

1.18.7 In compliance with CARS, Part 96.03.3, no evidence could be found to show that the pilot was informed or warned by the ATO and Owner, that he was boarding the helicopter at his own risk. According to 96.03.3, the disclosure referred to in sub-regulation (1) shall be made to any potential student before commencing flight training, or to any passenger before a ticket is purchased by means suitable to the kind of operation and shall be repeated in the flight training agreement or on the passenger ticket or similar contract of carriage, as applicable.

1.19 Useful or Effective Investigation Techniques

1.19.1 None.

2. ANALYSIS

2.1 The helicopter was operated from Wonderboom Aerodrome (FAWB) for private purposes. On Friday morning, 12th January 2007, the pilot flew the helicopter on a visual flight rules (VFR) flight in daylight conditions en route to the Brits Aerodrome. As the helicopter reached the Lethlabile area – Rabukalo Village, approximately 13.7 nautical miles (nm) from FAWB, the helicopter was invoved in an accident. The helicopter was destroyed by the impact and fire damage and the pilot sustained fatal injuries.

2.2 The onsite wreckage investigation indicated that the main rotor blades had failed and separated from the helicopter in flight. The positions of the two main rotor blades were found at different locations approximately 100 metres apart from the main wreckage. In order to determine the cause of failure, the main rotor head spindle to which the blades were installed, were taken for metallurgical examinations.

2.3 The results of the metallurgical examination indicated that the main rotor head spindle failed due to evidence of propagation of a fatigue crack. The causal factors of the fatigue crack could have been the following:

(i) The spindle was manufactured with a sharp corner without an appropriate radius at the point of sectional changes.
(ii) Shock overload; i.e. rotor strike or other.
(iii) Over-torque of castle nut during assembly.

2.4 Evidence was found that incident-damaged components removed from another helicopter, with registration ZU-CPO, were replaced with serviceable components from the kit of the helicopter that was later registered as ZU-DVY. Based on this evidence, the causal factor in 2.3 (ii) was determined to be a probable cause of the main rotor head spindle fatigue failure. The causal factor in 2.3 (i) was examined during the metallurgical testing. The evidence indicated that the lack of a sufficiently large radius at the point of failure contributed significantly to the initiation of the fatigue crack by acting as a stress raiser. It was also determined that the causal factor in 2.3 (i) may have also contributed to the main rotor head spindle fatigue crack failure. There was no evidence found of maintenance performed on the main rotor head which may have resulted in over-torque of the castle nut during assembly of the helicopter. For this reason, the causal factor in 2.3 (iii) was eliminated in the investigation as a possible cause of fatigue failure.

2.5 Based on the evidence of the two causal factors in 2.3 (i) (ii), the lack of proper or appropriate oversight by the SACAA, was determined to be a contributory factor. Aspects in terms of the certification, and relating to airworthiness, assembly and maintenance of the helicopter:

(i) Type acceptance of an aircraft type, prior to it having been registered is an important certification process. Non-conformance thereto has resulted in no information being readily available in respect of the design, manufacture and testing of the helicopter. Therefore no assessment was done to determine and/or ensure that the manufacturing of the main rotor head spindle was in accordance with civil aviation design standards.

(ii) The responsibility of overseeing the assembly/built process of the helicopter was left in the hands of an Aircraft Maintenance Engineer (AME), who was not rated on the aircraft type and had no official maintenance experience on helicopters. The owner, who was even less qualified than the AME, assembled the helicopter. He also performed maintenance on the helicopter.

2.6 The pilot most probably conducted a thorough and objective pre-flight inspection of the helicopter that morning. However, in the light of the evidence, it would not have been possible for him to have seen or identified the latent fatigue failure present in the main rotor head spindle. This could only have been detected during a disassembly of the rotor hub and spindle assembly. This is not an activity associated with a pre-flight

inspection.

3. CONCLUSION

3.1 Findings

3.1.1 The pilot had a valid Private Pilot's Licence and the helicopter (SAFARI) type rating was endorsed on the licence.

3.1.2 The pilot had a valid flight medical certificate.

3.1.3 There was no Type Acceptance exercise conducted on the helicopter type, prior to it having been registered in South Africa.

3.1.4 The responsibility of overseeing the assembly/built project was in the hands of the AME who was not appropriately rated, and had no helicopter maintenance experience. This aspect should have been identied by the SACAA inspector during the review of the submitted airwothiness related documentation.

3.1.5 The Annual Inspection Reports of the helicopter which was certified by the two AMO's was determined to be invalid.

3.1.6 The helicopter was operated over its prescribed maintenance interval of 100 hours and the next Annual Inspection was only done at 216.1 hours.

3.1.7 The owner performed unauthorised maintenance and inspections on the helicopter.

3.1.8 The installation of the turbocharger was an unapproved modification to the helicopter.

3.1.9 The helicopter had been used for training of the pilot, which was in conflict with the restriction of the Private Authority to Fly.

3.1.10 There was no evidence that verified that the Aviation Training Organisation (ATO) and Owner had complied with the regulatory requirement of disclosing to the pilot the operating conditions and restrictions of the helicopter during the time of training.

3.1.11 The evidence found indicated that the Aviation Training Organisation (ATO) and Owner failed to comply with requirement of the restriction on the Authority to Fly, when they allowed the helicopter to be used for training.

3.1.12 The blood of the pilot was drawn, but no official toxicology testing was conducted.

3.1.13 Evidence indicated that the main rotor head spindle sustained a shock overload at a stage, i.e. rotor strike or other, during operation.

3.1.14 The onsite wreckage investigation confirmed that the main rotor head spindle had failed, resulting in the main rotor blades separating from the helicopter in flight.

3.1.15 A metallurgical examination found that the main rotor head spindle was manufactured with a sharp corner without an appropriate radius at the point of crack initiation, leading to a higher surface stress.

3.1.16 There were no anomalies identified with the operation of the engine of the helicopter.

3.1.17 The evidence found during a metallurgical examination indicated that the main rotor head spindle of the helicopter had failed due to the propagation of a fatigue crack.

3.1.18 The possibility exists that incident-damaged components from another helicopter were installed on ZU-DVY.

3.2 Probable Cause/s

3.2.1 The main rotor head spindle had failed due to the propagation of a fatigue crack resulting in the separation of the rotor blades in flight.

Contributing

3.2.1 The main rotor spindle was manufactured with a sharp corner without an adequate radius at the point of crack initiation.

3.2.2 The main rotor head sustained shock overload, i.e. rotor strike or others at a stage in operation, probably whilst installed on another helicopter and subsequently installed on ZU-DVY.

4. SAFETY RECOMMENDATIONS

4.1 The aircraft manufacturer should be informed of the anomaly identified with the main rotor head spindle manufactured in terms of it having a sharp corner without an appropriate radius.

4.2 The owner of the helicopter, registration: ZU-CPO currently operating should be requested to remove the main rotor head spindle and subject it to an appropriate metallurgical examination to verify that no fatigue cracks are present.

4.3 The SACAA should review the adequacy of its oversight and certification processes in respect of home-built and NTCA aircraft to ensure adequate safety oversight. . Adquate training and guidance should be provided to inspectors to ensure the comprehensive review of annual maintenance documents to identify any anomalies and implement approprite preventative actions.

4.4 It is recommended that the SACAA publish an article in the Safety Link magazine stressing the importance of adhering to the NTCA kit built designer and manuafacturing specifications. Any deviation from such plans or installation procedures can result in the introduction of potentially unsafe conditions. For example an incearse in horsepower of the installed engine or installation of a turbocharger can result in the introduction of fatique failures

4.5 It is also recommended that the SACAA should ensure that owners or operators discard or destroy any parts or structures that may have sustained damage to prevent subsequent use of such damaged components.

5. APPENDICES

5.1 None.

-END-

Report reviewed and amended by the Advisory Safety Panel
31 March 2009