AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

				Reference:	CA18/2/3/8845
Aircraft Registration	**ZS-HTJ**	**Date of Accident**	8 October 2010	**Time of Accident**	1245Z
Type of Aircraft	Hughes 269C (Helicopter)		**Type of Operation**	Game darting operation	
Pilot-in-command Licence Type	Private Pilot	**Age**	47	**Licence Valid**	Yes
Pilot-in-command Flying Experience	Total Flying Hours	1 594.8		Hours on Type	1 568.1
Last point of departure	Farm Eulalie in the Marken district (Limpopo Province)				
Next point of intended landing	Farm Eulalie in the Marken district (Limpopo Province)				
Location of the accident site with reference to easily defined geographical points **(GPS readings if possible)**					
Farm Eulalie in the Marken district (GPS position; South 23° 25.229' East 028° 17.137', elevation 3 100 feet)					
Meteorological Information	Surface wind; 040°/4kts, Temperature; 34°C, Visibility; + 10 km				
Number of people on board	1 + 1	**No. of people injured**	1 + 1	**No. of people killed**	0

Synopsis

The pilot, accompanied by a passenger/darter, took off with the helicopter from the game farm Eulalie with the intention of catching several antelope (Eland). The intention was to dart the animals from the helicopter, whereafter ground capturing teams would have captured the animals.

Shortly after lift-off, whilst they were still looking for the antelope, they experienced a sudden increase in engine RPM, followed by a decay in main rotor RPM. They were unable to sustain flight and the pilot was committed to executing a forced landing in dense bush-type terrain. The helicopter landed hard in an upright position on its skid gear, which subsequently collapsed and separated from the helicopter, causing the helicopter to roll over onto its right-hand side.

The pilot was seriously injured in the accident when his shoulder harness failed. He was admitted to hospital for medical treatment. The passenger/darter sustained minor cut and bruises. During the post-field investigation it was found that the lower coupling driveshaft, part number 269A5559-3, serial number S1206, had failed in fatigue.

Probable Cause

Unsuccessful forced landing, following the failure of the engine-driven lower coupling driveshaft, which in turn resulted in a loss of power to the main rotor transmission system.

IARC Date		Release Date	

AIRCRAFT ACCIDENT REPORT

Name of Owner	: Britannia Bay Developers (Pty) Ltd
Name of Operator	**:** Renken Game Capture (Pty) Ltd
Manufacturer	**:** Hughes Helicopter Company
Model	**:** 269C
Nationality	**:** South African
Registration Marks	**:** ZS-HTJ
Place	**:** Farm Eulalie, Marken district
Date	**:** 8 October 2010
Time	**:** 1245Z

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 interest 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 produced without prejudice to the rights of the CAA, which are reserved.

1. FACTUAL INFORMATION

1.1 History of Flight

1.1.1. The intention of the flight was to capture several Eland antelope by darting them from the helicopter, whereupon ground capturing teams would have moved in to catch the animals.

1.1.2 The pilot, accompanied by a passenger/darter became airborne with both doors of the helicopter removed. The darter was seated on the right-hand side and had a dart gun with him. They started flying in search for Eland antelope to dart from the air.

1.1.3 Whilst flying, looking for antelope to dart, they experienced a sudden increase in engine RPM, followed by a decay in main rotor RPM. It was not possible to sustain flight and the pilot was committed to executing a forced landing in dense bush-type terrain. The helicopter landed hard in an upright position on its skid gear, which subsequently collapsed and broke off and the helicopter rolled over onto its right-hand side.

1.1.4 During the impact sequence the shoulder harness of the pilot who was seated on the left-hand side, failed. He sustained serious injuries to his back and was admitted to hospital. The passenger sustained minor cuts and bruises. He disposed of the dart gun by throwing it to the ground prior to impact.

1.1.5 The accident occurred during daylight conditions at a geographical position determined to be South 23°25.229' East 028°17.137' at an elevation of approximately 3 100 feet above mean sea level (AMSL).

1.2 Injuries to Persons:

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

1.3 Damage to Aircraft:

1.3.1 The helicopter sustained substantial damage during the impact sequence.

1.4 Other Damage:

1.4.1 There was no other damage caused.

1.5 Personnel Information:

Nationality	South African	Gender	Male	Age	47
Licence Number	****************	Licence Type	Private		
Licence valid	Yes	Type Endorsed	Yes		
Ratings	Game/Livestock Cull Rating				
Medical Expiry Date	31 March 2011				
Restrictions	None				
Previous Accident	1 September 2007. During flight the engine lost power. The pilot executed a forced landing, and the helicopter impacted with trees.				

Flying Experience:

Total Hours	1 594.8
Total Past 90 Days	129.9
Total on Type Past 90 Days	129.9
Total on Type	1 568.1

1.6 Aircraft Information

1.6.1 Airframe:

Type	Hughes 269C	
Serial Number	540308	
Manufacturer	Hughes Helicopter Company	
Year of Manufacture	1975	
Total Airframe Hours (At time of Accident)	5 035.8	
Last MPI (Hours & Date)	4 940.5	15 July 2010
Hours since Last MPI	95.3	
C of A (Issue Date)	11 July 1988	
C of R (Issue Date) (Present owner)	27 May 2004	
Operating Categories	Standard	

Engine:

Type	Lycoming HIO-360-D1A
Serial Number	L-19761-51A
Hours since New	4 940.8
Hours since Overhaul	1 212.5

1.6.2 Weight and Balance:

Item	Weight (lbs)	Arm (inches)	Moment (lbs x inches)
Helicopter Empty Weight	1 159.4	101.6	117 756.65
Pilot (100 kg)	220.5	83.2	18 345.60
Passenger (100 kg)	220.5	83.2	18 345.60
Fuel (40 litres Avgas)	63.2	107.0	6 762.40
Doors (x2) removed (6 kg)	- 13.2	73.0	- 963.60
Weight on impact	**1 650.4**	**97.0**	**160 246.65**

The maximum certified takeoff weight for the helicopter was 2 050 pounds according to the pilot's operating handbook (POH), Section 2, Limitations, Pg. 2-6. The helicopter was last reweighed on 25 August 2009, according to the airframe logbook entry on pg. 85.

CG Limitation, POH, Section 2, Pg. 2-6

Forward CG limit station = 95.0
Aft CG limit station = 101.0
The helicopter was operated within the allowable CG limit.

NOTE: Both fuel tanks were intact following the accident, and both tanks still contained some fuel. The total amount of fuel that was drained from the helicopter during the recovery amounted to 40 litres. For calculation purposes to convert the fuel (Avgas) weight from litres to pounds, a conversion factor of 1.58 was used.

NOTE: The passenger that was occupying the right-hand seat had a dart gun with him during the flight. When he realised that they were in trouble, he disposed of the dart gun by throwing it to the ground prior to impact. The dart gun weighed 4 kg.

1.6.3 Lower Coupling Driveshaft Part # 269A5559-3

Quoted from: Schweizer 300C/CBi Service Training Manual, Section 4

"The lower coupling driveshaft, which is considered part of the lower pulley assembly, connects the engine to the belt drive and subsequently the main and tail rotor transmission. ***It is undoubtedly, one of the most important components in the powertrain.*** *The shaft is a highly stressed component subject to torsion forces between the engine and drive belt. The shaft is constructed from Hy-Tuf steel with convex curved splines on either end. The forward end is inserted into the engine drive adapter after the plug was inserted into the engine crankshaft. The aft end meshes with the lower pulley of the belt drive, coupling the engine and the belt drive assembly.*

Since the lower coupling driveshaft is subject to such high stresses, it is imperative that proper alignment and care be exercised at all times when performing maintenance on and near the shaft. The shaft is coated with an extremely tough primer but is not damage proof. Consequently, any damage to the paint finish and cadmium plating should be immediately touched up in accordance with the Maintenance Instruction. Any damage to the metal, no matter how slight is cause for replacement of the shaft. There are no allowable repairs to the shaft. If at any time, the engine rpm reaches 2 000 with the rotor system disengaged (overspeed), the shaft must be removed and magnaflux inspected before it is allowed to continue in service.

The shaft has three rubber components installed on it. The alignment ring is specifically for engine to belt drive alignment; it serves no other purpose. The retainer keeps the grease in place where it's needed. The retainer ring is installed to keep the retainer from moving too far forward. The boot on the forward end of the shaft prevents grease loss where the shaft mates with the engine adapter.

The life limit of the lower coupling driveshaft is 6 000 hours time in service. Thorough lubrication of the shaft splines is essential in order to achieve the maximum service life. When lubricating the lower coupling driveshaft, DO NOT MIX DIFFERENT TYPES OF GREASES. If the type of grease used previously is not *known or cannot be determined, the shaft and mating parts must be removed, thoroughly cleaned and the regreased with the type of grease specified in the Handbook of Maintenance Instructions.*

Engine to belt drive alignment is critical. The maximum amount of misalignment is only a 5° between the belt drive and the engine. In order for the maximum service life to be obtained from the lower coupling driveshaft, alignment checks should be done often and misalignment kept to an absolute minimum. The convex splines on the driveshaft are designed to operate within the 5° misalignment. The alignment ring on the lower coupling driveshaft will make contact with the inside surfaces of the lower pulley coupling shaft when misalignment has reached 5°.

Misalignment is caused by wear on the rubber pads supporting the aft engine mounts in newer helicopters. As these rubber disks compress, engine misalignment will occur regularly at first and then taper off as the disks take a seat. Consequently, readjustment will become less frequent as the disks wear in".

During the post-field investigation it was found that the lower coupling driveshaft, part number 269A5559-3, serial number S1206 had failed. The lower coupling driveshaft on this helicopter was replaced with a new unit on 21 June 2001 at 3 593.0 airframe hours. The driveshaft, which has a life limit of 6 000 hours, had been in service for 1 442.8 hours at the time of the accident/failure. The failed component (lower coupling driveshaft) can be seen on the diagram on the next page, indicated by an arrow projected from the text box.

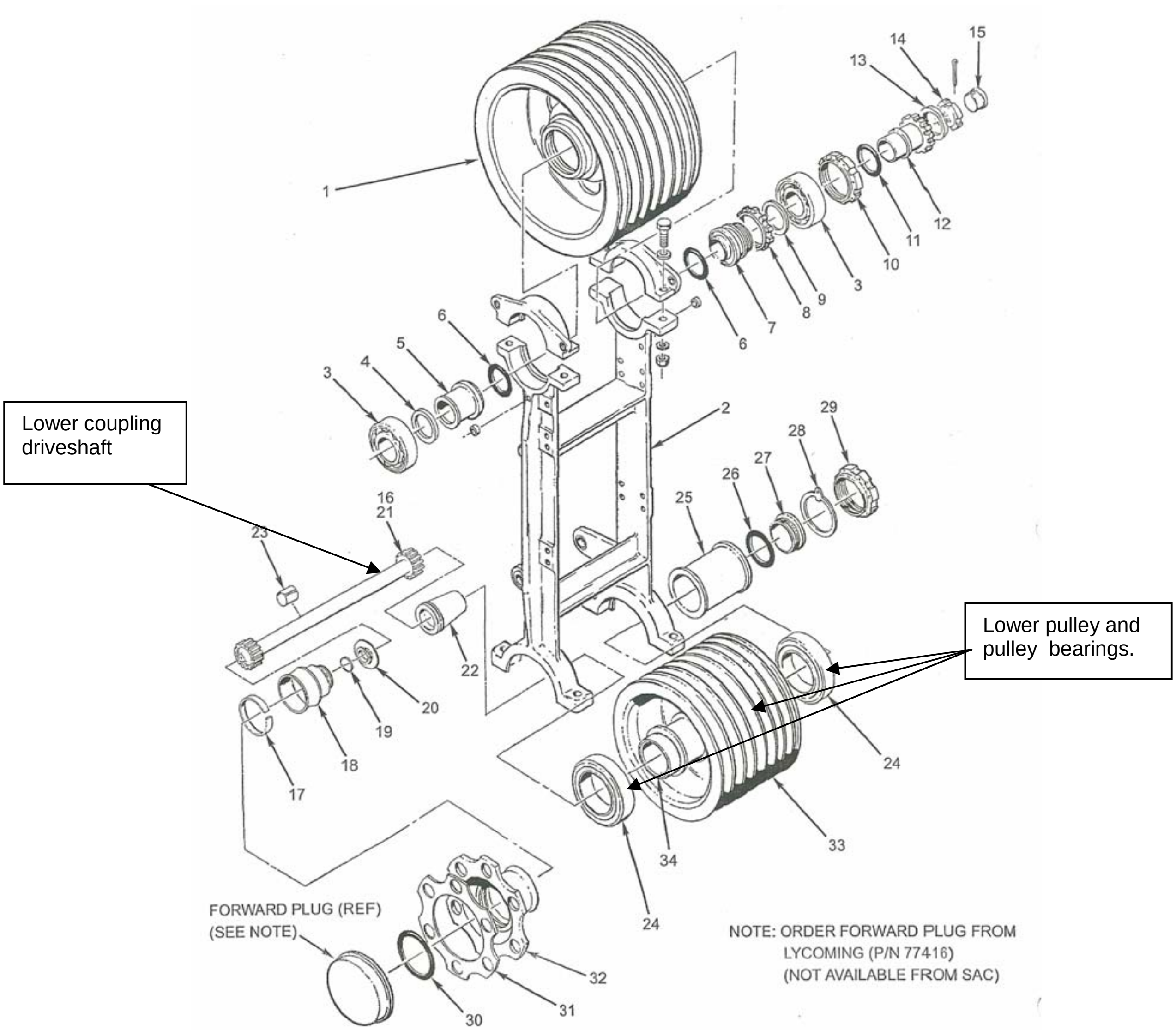


Diagram 1. Lower and upper transmission drive pulley assemblies.

1.6.4 Last Maintenance Prior to Accident Flight:

During the period 6 - 8 September 2010 the following maintenance was performed on the helicopter at an approved maintenance facility after the pilot had entered the following defect into the flight folio; "*Vibration on Engine".*

(i) The lower drive belt pulley (item 33 on the diagram above) Part No. 269A5497-9 was replaced.

(ii) The two bearings (items 24 on the diagram above) Part No. 269A5050-80 were removed, regreased and refitted. In order to perform the task listed in subheading (i) and (ii) the lower coupling driveshaft was removed and refitted.

(iii) Fuel pump, part No. LW 15473 was replaced, as well as all the relevant gaskets.

(iv) The fuel control unit (FCU) was replaced and the unit with serial No. 2524347-10 was installed.

(v) Service Bulletin SB 388 was carried out on the engine.

(vi) Both magneto gaskets were replaced.

(vii) Landing gear shocks were overhauled .

(viii) The main rotor blades were removed and the blade grip bushings were replaced.

(ix) Following completion of all the work listed above, a ground run was carried out and the magneto timing was adjusted.

1.6.5 Airworthiness Directive (AD) 93-17-13 and Service Bulletin (SB) B-257.1

On 20 October 1993 the Federal Aviation Administration (FAA) issued AD 93-17-13 Schweizer Aircraft Corporation and Hughes Helicopters, with applicability to Model 269A, 269A-1, 269B, 269C and TH55A helicopters certificated in any category.

AD 97-17-13 may be found attached to this report as Annexure A. This AD is supported by Schweizer Aircraft Corporation Service Bulletin B-257-1, dated 21 May 1993, which is referred to in paragraph (f) of the AD.

PURPOSE: To prevent the failure of the lower coupling driveshaft (shaft), loss of power to the rotor system, and subsequent loss of control of the helicopter.

According to the airframe logbook for this helicopter that was opened on 13 June 1995, three entries were made under the heading “Recurring Airworthiness Directives Compliance Record” pertaining to AD 93-17-13. The three entries were dated as follows:

(i) 17 March 2005, at 3 918.8 airframe hours.

(ii) 3 February 2006, at 4 018.2 airframe hours.

(iii) 12 September 2007, at 4 216.0 airframe hours.

There were no other entries in the logbook with reference to the airworthiness directive.

1.6.6 Lower Coupling Driveshaft Inspection:

Table B-2 (Periodic Inspections) in Appendix B, Section 2 of the Helicopter Maintenance Manual requires that the lower coupling driveshaft be inspected every 300 hours in accordance with subheading 5 (see attached extract from the document below). The aircraft maintenance organisation (AMO) that was responsible for maintaining the helicopter since February 2008 until the accident, had complied with this requirement.

Models 269A, TH-55A, A-1, B & C - Appx B Section 2

Table B-2. PERIODIC INSPECTIONS

What to Inspect - 300-Hour Inspection (con't)	INITIALS
4. Upper and lower H-frame bearings for excessive wear, damage and loss of grease (Basic HMI, Section 10). Idler pulley bearings for noise, roughness and loss of grease. Clean and repack upper, lower and adapter mounted idler pulley bearings with grease. (If helicopter does not fly more than 300 hours per year, it is recommended that bearings be repacked with fresh grease annually and mandatory each 24 months.)	
5. Using 10X magnification, visually inspect lower coupling drive shaft for wear, corrosion and damage (refer to Periodic Inspection of Lower Coupling Drive Shaft, Basic HMI Section 10). Magnetic particle inspection of drive shaft is mandatory only when engine speed exceeds 2000 RPM with rotors disengaged (Table B-3). Visually inspect engine adapter for damage. Clean and repack with grease. NOTE Servicing with Anderol or Syn-Tech (Table 2-1, Item 6a.) removes 50-Hour clean and repack requirement.	

1.6.7 Safety Harnesses Inspection:

Appendix B, Section 2 of the Helicopter Maintenance Manual requires the helicopter safety harnesses, which include the seat belts, shoulder harness and fittings, to be inspected for condition and security prior to each flight as called for in Table B-1, Daily Inspection - Before the first flight of the day, subheading 19 (see attached extract from document below).

Section 2 Models 269A, TH-55A, A-1, B & C - Appx B

Table B-1. DAILY INSPECTION - BEFORE FIRST FLIGHT OF THE DAY

What to Inspect *(Power OFF)*

FRONT - Canopy and Pilot's Compartment

	INITIALS
16. Tail rotor pedal retaining pins and tail rotor pedal arm to socket quick release lock pins for security of retention, wear and looseness.	
17. Magnetic compass correction card in place and legible; Pilot's Flight Manual in helicopter.	
18. Cyclic, collective and tail rotor controls; visible push rods for excessive bearing looseness and free movement; quick release lock pins for security and condition.	
19. Seat belts, shoulder harness and fittings for damage, and installation for security. If snap hook end fitting has safety pin hole provision, a safety device is required.	
20. First aid kit for security.	
21. Instrument panel controls for security and condition.	
22. All visible wires for condition and security.	

1.7 Meteorological Information:

1.7.1 An official weather report for the area where the accident occurred was obtained from the South African Weather Services (SAWS), indicating the following conditions.

Wind direction	040°	Wind speed	4 knots	Visibility	+ 10 km
Temperature	34°C	Cloud cover	Nil	Cloud base	Nil
Dew point	9°C				

1.7.2 Density Altitude at the time of the accident:

Pressure Altitude	3 100 feet AMSL
Temperature	34°C
Density Altitude	**6 000 feet**

1.8 Aids to Navigation:

1.8.1 The helicopter was equipped with standard navigational equipment and no defects were recorded.

1.9 Communications:

1.9.1 The accident occurred outside of controlled airspace with the active VHF frequency at the time being 124.8 MHz. There were no reported defects with reference to the radio equipment on board the helicopter during the flight.

1.10 Aerodrome Information:

1.10.1 The accident occurred in bush-type terrain on a game farm and not close to an aerodrome facility.

1.11 Flight Recorders:

1.11.1 The helicopter was not equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR), nor was it required by regulation to be fitted to this type of helicopter.

1.12 Wreckage and Impact Information:

1.12.1 The helicopter impacted with dense bush-type of terrain on a heading of 010°M. The helicopter landed hard in an upright position on its skid gear, which subsequently collapsed. The airframe structure subsequently separated from the skid gear and rolled over to the right-hand side. According to the ground impact markings, there was very little to no forward movement during the impact sequence. The markings were substantially disrupted by persons who assisted the two occupants that were on board the helicopter, following the accident.

Figure 1. A view of the main wreckage as it came to rest following impact.

Both doors of the helicopter were removed prior to the flight. The entire transparent bubble canopy was found shattered. The safety harness of the right seat was found intact, however, the shoulder harness of the pilot that was seated on the left-hand side was found to have failed where the two shoulder belts joined together and met up with the belt tensioning device. The failed shoulder harness was located outside the cockpit/cabin area.

The three main rotor blades were still attached to the main rotor head, but were severely disrupted during the impact sequence. All the main rotor control linkages were found to be intact and secured, with the collective pitch lever being in the 'down' position and the throttle closed. The cyclic control stick was also still secured to its attachment. The eight drive belts (transferring engine power via the lower pulley to the main transmission, upper pulley) were found to be intact but not under tension. The clutch guide pulley bracket located on the lower right side of the airframe was found to have failed during the impact sequence, which caused the clutch tensioning cable to become slack. The clutch was found engaged; the guarded switch in the cockpit being in the armed position and the clutch actuator tensioning arm in the fully retracted position. The engine was still secured to the engine cradle with some impact damage visible. Both fuel tanks (main and auxiliary) remained intact, and both tanks still contained some fuel, which was measured by making use of a dipstick. With the helicopter lying on its right side it was not possible to determine how much fuel was in the tanks. During the recovery of the wreckage, 40 litres of fuel was drained from both tanks. The instrument panel remained intact, even though it had sustained some impact damage.

The tail rotor drive shaft was found to have sheared in rotational overload approximately 1 m from the output of the main drive transmission as it entered the tail boom. The tail boom and tail rotor assembly displayed very little damage, which included the tail rotor gearbox and the two tail rotor blades. All the control linkages on the tail rotor assembly were found to be intact and secured.

1.13 Medical and Pathological Information:

1.13.1 Not applicable.

1.14 Fire:

1.14.1 There was no pre- or post-impact fire.

1.15 Survival Aspects:

1.15.1 The helicopter landed heavily in an upright position on its skid gear, which subsequently collapsed and broke off, causing the helicopter to roll over to the right into dense bush/vegetation.

The passenger that was seated on the right-hand side sustained minor injuries; however, the pilot was seriously injured in the accident as he sustained three broken vertebra. His shoulder harness failed during the impact sequence and was found to be in a dilapidated state, most probably aggravated by prolonged exposure to the sun. The shoulder harness on the right-hand side was found to be in the same condition, but did not fail. It is believed that if the pilot's shoulder harness had not failed, his injuries might have been much less severe.

Figure 2. A view of the failed shoulder harness at the left seat (pilot side).

1.16 Tests and Research:

1.16.1 The wreckage was recovered to an aircraft maintenance organisation (AMO) where the main transmission components were removed. It was found that the lower shaft part number 269A5559-3, serial number S1206 had failed. The shaft was subjected to metallurgical analysis in order to determine the failure mode. Along with the shaft the two lower pulley bearings (part number 269A5050-80) were also examined. *(The lower coupling driveshaft as well as the two bearings may be viewed in the diagram inserted on page 9 of this report).*

Figure 3. A view of the failed driveshaft being removed from the drive pulley assembly.

Figure 4. A view of the failed driveshaft after it was cleaned (grease removed).

The supporting bracket of the clutch cable guide pulley was found broken off and the cable was wedged in between the pulley and the pulley bracket. It was decided to examine the failure mode of the clutch guide pulley bracket as well, as it was considered to be a possible contributory cause or even the cause of the failure of the lower coupling driveshaft.

Should the clutch cable pulley bracket have failed during operation, it might have led to the disengagement of the clutch, which would have most probably resulted in a sudden increase in engine RPM with a possible engine over-speed condition not being excluded. The effect of an engine overspeed could have been detrimental to the integrity of the lower coupling driveshaft, resulting in the failure of such a shaft.

The metallurgical report concludes the following;

"The investigation revealed that the failure of the drive shaft during operation as being the first in the sequence of events leading to the accident. The fractured surface analysis exposed high cycle fatigue as the primary mode of failure with large areas of final fracture geometry. Taking into account that fatigue, is particular high cycle, is a time dependent failure, then all indications are that the drive shaft fractured propagated over a period of operational time. The extent of this time period could not be determined but it is in all likelihood exceeding the operational time between failure of the drive shaft, and the impact of the aircraft. This rules out the possibility that the clutch guide pulley to be the first in the sequence of events, leading to the disengaging of the clutch and resulting in exceeding the RPM limits of

the drive shaft".

The metallurgical report pertaining to these three components listed above may be found attached to this report as Annexure B.

1.17 Organisational and Management Information:

1.17.1 The purpose of the flight was to dart several antelope that were to be sold on auction. The pilot alleges that the flight was conducted in the pilot's private capacity, with the helicopter being used as a tool to assist in capturing the game he would purchase from the farmer and in turn would auction himself.

1.17.2 According to available records, the Aircraft Maintenance Organisation (AMO) that certified the last maintenance inspection on the helicopter prior to the accident flight was in possession of a valid AMO Approval certificate No. 846.

1.18 Additional Information:

1.18.1 During the investigation it became evident that the main rotor blades of several Hughes 269 model helicopters registered on the South African Register were either removed from the helicopters in order to transport them via road (on a trailer), or in the second scenario two of the drag damper bolts were removed, which allowed the blades to be folded either forward or backwards. The method used depends on the design of the trailer, as certain trailers are designed to support the main rotor blades when in the folded configuration; while on other trailers there is no main rotor blade supporting mechanism. Being a three-bladed system, the helicopter cannot be transported on a trailer without using either of the methods mentioned above.

The photo below was taken on the game farm during the on-site investigation into the accident in question. A main rotor blade box is positioned next to the trailer, as the trailer does not have any supporting structure to accommodate the blade folding method, as discussed above.

During the investigation, evidence was obtained that this had been an ongoing procedure used in the industry for many years.

A view of a helicopter trailer and next to it, a main rotor blade box.

With the blade folding method being used, it became clear that the pilot by himself can pull the two blades in position and reconnect the drag damper bolts to the rotor head assembly and secure it by means of a split pin.

It was further established that in basically all these cases the main rotor blades get removed and installed under the direct supervision of the pilot. In the instances where the main rotor blades are removed, the pilot will be assisted by labourers/bystanders.

Following the installation of the blades, the helicopter will subsequently be flown from the trailer and the task/mission of such a flight will commence. Once such a task/mission has been completed, the helicopter will be landed back onto the trailer and the process will be reversed, and the helicopter will be towed to the next location.

In the case where the main rotor blades are removed, both the blade bolt as well as the damper bolt must be tightened and secured by means of a split pin. The blade bolts must also be torqued.

Although the abovementioned practice did not contribute to, or cause the accident, the Civil Aviation Regulation read in conjunction with the Technical Standards does not allow for this type of maintenance.

1.18.2 Removal and Fitment of Main Rotor Blades:

In order to transport the Hughes/Schweizer 269 type helicopter, (which has three main rotor blades) on a trailer, two of the main rotor blades must either be folded backwards/forward, which require that two of the three blade damper attachment bolts needs to be removed and the blades properly secured once folded backwards or forward depending on the design of the trailer (blade support). The alternative method would be to remove the three main rotor blades once the helicopter is on the trailer, and then transport the blades in a blade box, which is a special container/box designed to restrict/limit blade damage during transportation.

During the investigation of this accident it became apparent that for the Hughes/Schweizer 269 type helicopter, these types of practices had been the norm in South Africa, and in several other countries for many years already. Certain pilots/owners had even received training in the removal and fitment of the main rotor blades in order to transport these helicopters on trailers, even though they did not have an aircraft maintenance engineering (AME) licence.

Once the pilot arrives at his intended location with the helicopter, transported on a trailer, he first needs to reconnect the two drag damper bolts (if the blades were folded) prior to flight. If the blades were removed, they need to be installed by making use of labourers/bystanders assisting the person fitting the blades. In both these instances the pilot plays an important role, as he is in most instances the responsible person performing or overseeing the task.

This procedure is reversed once the task/mission has been completed and the helicopter lands back on the trailer. This remains an ongoing process, as these helicopters are being relocated from one location to the next. These types of helicopters are widely used in South Africa in the game capturing, culling and darting of animals as well as in neighbouring states. Being a very versatile helicopter, these types of operations make it cost-effective to operate, however, long distance ferry flights are being avoided as the helicopter's average cruise speed is relatively slow. Maintenance needs to be performed at intervals of 100 flying hours or every 12 months, whichever comes first. During ferry flights the flying hours escalate rapidly without any income being generated, which makes the transportation of these helicopters from location to location via road (on a trailer), a much more viable option.

It would appear that the pilot removed and refitted the blades without the appropriate authorisation.

1.18.3 Certificate of Airworthiness Currency Fee

According to available records, the last C of A annual currency fee payment that was received by the regulating authority for this helicopter was on 13 September 2007.

Civil Aviation Regulation Part 21.08.1 states the following:

"(4) The holder of a standard, restricted or special category of airworthiness certificate shall pay the annual currency fee as prescribed in Part 187, applicable to the type of certificate of airworthiness, on the anniversary date of such certificate."

1.18.4 Certificate of Airworthiness

The Certificate of Airworthiness (C of A) No. 4859/ZS-HTJ/5 was found to be incorrectly issued by the regulating authority. Under heading 9, Special conditions; the following entry was made: "*Operational Category Under Part 135*". Commercial helicopter operations are being conducted under the provisions of Part 127 and private operations under Part 91 of the Civil Aviation Regulations of 1997 as amended. Part 135 operations are applicable to commercial operations involving aeroplanes with a maximum certified takeoff weight of 5 700 kg or less.

The Expiry Date for the C of A under heading 11 was entered as 10 July 2008. The last currency fee payment received by the regulating authority according to available records took place on 13 September 2007.

According to Part 21.08.9 of the CARs the C of A expiry date had lapsed, which rendered the C of A for this helicopter invalid at the time of the accident (see the appropriate regulation on the next page).

Civil Aviation Regulation Part 21.08.9 states the following;

(1) "A Certificate of Airworthiness shall be valid until –

(a) it expires, if an expiry date has been determined by the Commissioner, or

(b) it is surrendered by the holder thereof, or is suspended by an airworthiness inspector, or cancelled by the Commissioner, in terms of Regulation 21.01.6.

(2) Subject to the provisions of sub regulation (1), a certificate of airworthiness shall remain valid for as long as –

(a) the aircraft remains a South African registered aircraft; and

(b) in respect of an aircraft with a standard or restricted category certificate of airworthiness, the aircraft is maintained in accordance with the Regulations".

1.18.5 Documents to be Carried On Board:

No documentation was found on board the helicopter during the on-site investigation, or any certified copies thereof as required by the Civil Aviation Regulation of 1997, as amended.

Civil Aviation Regulation Part 91.03.1 states the following;

"The owner or operator of an aircraft shall ensure that the following documents, or certified copies thereof, are carried on board the aircraft on each individual flight:

(b) if the aircraft is engaged in a domestic flight –

(i) the certificate of registration;
(ii) the certificate of airworthiness;
(iii) the appropriate licence of each flight crew members;
(iv) the aircraft radio station licence;
(v) the certificate of release to service;
(vi) the aircraft flight manual referred to in Regulation 91.03.2 or an equivalent document;
(vii) the mass and balance report;
(viii) the flight folio;
(ix) the MEL, if applicable;
(x) the noise certificate, if such certificate has been issued for the type of aircraft; and
(xi) the list of visual signals for use by intercepting and intercepted aircraft."

1.19 Useful or Effective Investigation Techniques:

1.19.1 None.

2. ANALYSIS

2.1 The helicopter crashed during a game darting operation while flying at low level over dense bush-type of terrain. The pilot experienced a sudden increase in engine RPM, accompanied by a decay in main rotor RPM. The helicopter was unable to sustain flight and the pilot immediately closed the throttle and opted for a forced landing. The helicopter landed hard and rolled over.

2.2 The post-field investigation revealed that the lower coupling driveshaft had failed in fatigue during operation. The driveshaft, which has a service life of 6 000 hours, failed after being in service for 1 442.8 operational hours, according to available records. The investigator did consider the possibility that the failure could have been attributed to an engine over-speed condition that might have been induced by the deactivation of the clutch assembly in-flight, due to the clutch guide pulley bracket that was found to have failed.

2.3 Several components, being the; (i) failed lower coupling driveshaft, (ii) the clutch guide pulley bracket and (iii) the two lower pulley bearings were subjected to metallurgical examination.

(i) Following a detailed examination of these components, it was determined that the lower coupling driveshaft failed first due to fatigue cracking that propagated over a period of operational time. It was, however, not possible to determine the period over which the failure had developed but in all likelihood this period exceeded the operational time between the failure of the driveshaft and the impact of the helicopter.

(ii) The clutch guide pulley bracket was found to have failed in overload mode, which was associated with impact damage. This eliminated the fact that an engine over-speed condition occurred during the flight in question, which could have contributed or propagated the failure that presented itself.

(iii) The two bearings were examined in order to ascertain if there had been any alignment problem with reference to the lower pulley assembly that could have induced any unnecessary stresses on the lower coupling driveshaft; seeing that maintenance was performed in this area during the period 6 to 8 September 2010, when the lower pulley bearings were removed, regreased and replaced. (The pilot had reported an engine vibration.) The metallurgical examination did not reveal any evidence of wear on the bearings that could have been associated with an alignment problem. The helicopter was flown for a further 23 hours after the maintenance intervention took place in early September 2010, until the accident occurred.

2.4 The possibility that the engine could have been subjected to an over-speed condition during start-up with the rotor system disengaged some time prior to the accident flight could not be excluded. Such an event(s) could have initiated cycle fatigue cracks to develop, which progressed as time passed until failure occurred. The investigating team, however, could not find any documented evidence to substantiate the fact that such an event occurred, which did not eliminate the fact that such an event could have occurred, as it might never have been documented nor reported to any maintenance facility. In the POH, Section 2, Limitations under the heading Power Plant Limitations as well as additional supporting documentation (Service Bulletin B-257.1) it clearly states that if such an event/condition should occur, the lower coupling driveshaft should be inspected as called for in the maintenance manual Appendix B, before any future flight.

3. CONCLUSION

3.1 Findings:

3.1.1 The pilot was the holder of a valid private pilot's licence and had the helicopter type endorsed in his logbook.

3.1.2 The pilot was the holder of a valid aviation medical certificate that was issued by an approved CAA medical examiner.

3.1.3 The helicopter was in possession of a Certificate of Release to Service following the last maintenance inspection that was certified on 15 July 2010.

3.1.4 The expiry date on the Certificate of Airworthiness reflects that it had lapsed on 10 July 2008. It was also incorrectly issued by the SACAA (1.18.3)

3.1.5 There were no documents in the helicopter as required in accordance with Part 91.03.1 of the CARs.

3.1.6 The helicopter landed hard in an upright position on its skid gear, which collapsed during the impact sequence with the airframe separating from the skid gear, and then rolled over to the right.

3.1.7 The pilot's shoulder harness failed during the impact sequence, and was found to be in a dilapidated state (not fit for the purpose).

3.1.8 The pilot was seriously injured in the accident.

3.1.9 The prevailing outside air temperature at the time of the accident was 34°C (94°F).

3.1.10 The density altitude at the time and place of the accident was 6 000 feet AMSL.

3.1.11 The pilot was flying at a low level when the in-flight emergency occurred.

3.1.12 The purpose of the flight was to capture game by darting the antelope from the helicopter.

3.1.13 The darter, who was seated on the right-hand side, discarded the dart gun prior to ground impact. 3.1.14 The clutch cable guide pulley was found to have failed in overload mode.

3.1.15 The lower coupling driveshaft, which had a service life of 6 000 hours, was found to have failed in fatigue at 1 442.8 operational hours.

3.1.16 The helicopter had been flown for a further 23 hours since the last maintenance intervention (6 to 8 September 2010) prior to the accident. During maintenance the lower coupling shaft had been removed in order to rectify the defect.

3.1.17 The pilot was carrying out routine maintenance which he was not authorised to carry out.

3.1.18 Pilot alleges that the flight was a private operation.

3.2 Probable Cause/s:

3.2.1 Unsuccessful forced landing, following the failure of the engine-driven lower coupling driveshaft, which in turn resulted in a loss of power to the main rotor transmission system.

4. SAFETY RECOMMENDATIONS

It is recommended that the Director of Civil Aviation:

4.1 In conjunction with the Airworthiness Department, conduct a feasibility study into this type of practice and that a workable solution be found that would be in the best interests of both parties.

4.2 Require the Airworthiness Department, to issue a Mandatory Advisory Notice (MAN) with reference to the safety harnesses on all Hughes/Schweizer 269 model helicopters.

This MAN should be applicable to all Hughes/Schweizer 269 helicopters on the South African Register, and according to this MAN, the safety harnesses of these helicopters should be inspected (with special emphasis on the shoulder harness) by an approved AMO facility within the next 100 hours of operation or the next maintenance inspection, whichever comes first.

The MAN should highlight the fact that such devices should be in a good overall condition, and that the integrity of such inspection should not compromise the intent of such a device in any way. Should the harness not meet the minimum required standard(s), or should the integrity thereof be questionable, the unit (harness) should be replaced without further delay.

This status of the MAN should be; Continuous/Ongoing.

The MAN inspection should be signed out in the airframe logbook once completed by the AMO as well as every follow-up inspection thereafter at time frames to be determined by the Airworthiness Department.

4.3 Require the Airworthiness Department, to consider the withdrawal of the MAN (Mandatory Maintenance Advisory Notice) No. J15/9/Gen (Certificates of Airworthiness).

To require that payment of the C of A currency fee, as well as all other documents that should be on board the aircraft, the responsibility of the AMO, is considered unreasonable and only constitutes an additional workload/responsibility being placed on the AMO instead of the aircraft owner(s), whose sole responsibility it is to ensure that the required fees are paid, and all the necessary documents apart from maintenance-related documents are on board the aircraft.

4.4 Require the Airworthiness Department to consider reissuing Airworthiness Directive 93-17-13, read in conjunction with Service Bulletin B-257.1.

4.5 Require the Airworthiness Department to consider the introduction of a proper NDT (non destructive test) procedure on the shaft at regular intervals in order to prevent recurrence of this nature. The status of such a procedure should be ongoing and should not be limited by the lower coupling driveshaft serial number.

4.6 Require the Flight Operations Department to review the adequacy of the current regulations addressing operations and experience requirements in respect of the conduct of game culling operations.

5. APPENDICES

5.1 Annexure A (Airworthiness Directive 93-17-13 and Service Bulletin B-257.1)
5.2 Annexure B (CrashLab Metallurgical Report - Lower Coupling Driveshaft)

Report reviewed and amended by the Advisory Safety Panel 8 February 2011.

-END-

Airworthiness Directive

Federal Register Information

Header Information

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 39

Docket No. 93-SW-11-AD; Amendment 39-8684; AD 93-17-13

Airworthiness Directives; Schweizer Aircraft Corporation and Hughes Helicopters, Inc. Model 269A, 269A-1, 269B, 269C, and TH55A Helicopters

PDF Copy (If Available):

Preamble Information

AGENCY: Federal Aviation Administration, DOT

DATES: Effective October 20, 1993.

Regulatory Information

93-17-13 SCHWEIZER AIRCRAFT CORPORATION and HUGHES HELICOPTERS, INC.: Amendment 39-8684. Docket Number 93-SW-11-AD.

Applicability: Model 269A, 269A-1, 269B, 269C, and TH55A helicopters, certificated in any category.

Compliance: Required as indicated, unless accomplished previously.

To prevent failure of the lower coupling drive shaft (shaft), loss of power to the rotor system, and subsequent loss of control of the helicopter, accomplish the following:

(a) Within the next 30 days or 100 hours' time-in-service after the effective date of this AD, whichever occurs first--

(1) Install engine and rotor tachometer markings in accordance with Part II of Schweizer Aircraft Corporation Service Bulletin B-257.1, dated May 21, 1993 (SB).

NOTE: Figure B-257.1-2 indicates the position of the white slippage mark on the lens and lens frame.

(2) Visually inspect the shaft for cracks, machining steps, manufacturing tool marks, surface defects, and lack of cleanup during the production grinding operation in accordance with Part I of the SB.

NOTE: Failure to accomplish proper cleanup of the shaft surface is evidenced by a non-uniform surface smoothness. The actual surface finish value may vary from shaft to shaft.

(b) Repeat the visual inspection for cracks as described in paragraph (a)(2) of this AD at intervals not to exceed 300 hours' time-in-service from the last inspection.

(c) Replace any shaft found to be unairworthy during the inspection required by this AD with an airworthy shaft, before further flight.

(d) An alternative method of compliance or adjustment of the compliance time, which provides an acceptable level of safety, may be used when approved by the Manager, New York Aircraft Certification Office, FAA, New England Region, 181 South Franklin Avenue, Valley Stream, New York 11581. Operators shall submit their requests through an FAA Principal Maintenance Inspector, who may concur or comment and then send it to the Manager, New York Aircraft Certification Office.

NOTE: Information concerning the existence of approved alternative methods of compliance with this AD, if any, may be obtained from the New York Aircraft Certification Office.

(e) Special flight permits may be issued in accordance with FAR 21.197 and 21.199 to operate the helicopter to a location where the requirements of this AD can be accomplished.

(f) The modification and inspections shall be done in accordance with Part I and II of Schweizer Aircraft Corporation Service Bulletin B-257.1, dated May 21, 1993. This incorporation by reference was approved by the Director of the Federal Register in accordance with 5 U.S.C. 552(a) and 1 CFR Part 51. Copies may be obtained from Schweizer Aircraft Corporation, P.O. Box 147, Elmira, New York 14902. Copies may be inspected at the FAA, Office of the Assistant Chief Counsel, 4400 Blue Mound Road, bldg. 3B, room 158, Fort Worth, Texas 76106; or at the Office of the Federal Register, 800 North Capitol Street, NW., suite 700, Washington, DC.

(g) This amendment becomes effective on October 20, 1993.

Footer Information

Comments

SCHWEIZER SERVICE BULLETIN

MANDATORY MANDATORY MANDATORY

SUBJECT: ONE-TIME INSPECTION OF LOWER COUPLING DRIVE SHAFTS, AND NEW ENGINE/ROTOR TACHOMETER MARKINGS

APPROVAL STATUS: MODIFICATION FAA APPROVED

MODELS AFFECTED:

- PART I: Model 269A, TH55A, 269A-1, 269B, and 269C Helicopters equipped with any lower coupling drive shaft listed in the following:

  – All lower coupling drive shafts produced by Hughes/McDonnell Douglas (any drive shaft with Serial Number prefix other than "S").

  – Lower coupling drive shafts produced by Schweizer; Serial Numbers S001-S256, S258-S339, S341-S382, S384-S448, S450-S476, S508, S511, S513, S519, S579, S582, S590, S597, S599, S612, S614, S616, and S617.

  (Model 269C Helicopter Serial Number 1628 and subsequent were delivered from the factory with lower coupling drive shafts exempt from Part I inspection.)

- PART II: All Model 269A, TH55A, 269A-1, 269B Helicopters, and Model 269C Helicopters Serial Numbers 0001 thru 1629.

TIME OF COMPLIANCE: Parts I and II shall be accomplished on affected helicopters within the next 100 hours flight time, or 90 days from issue date of this bulletin whichever occurs first. If B-257 was previously complied with, reinspection in accordance with this bulletin is not necessary.

REFERENCE: 269 Series Basic HMI (Reissued: 15 March 1982; Revised 08 May 1992)

PREFACE:

- Surface defects can contribute to drive shaft failure.
- Field reports indicate that lower coupling drive shaft damage/failure has occurred as a result of engine declutched operation above the limits specified in the Pilot's Flight Manual.
- This Service Bulletin specifies a one-time inspection to check for drive shaft defects; provides marking data to display the speed limitation on the ENGINE/ROTOR tachometer to reinforce existing operating limits; and reiterates the prohibition of engine declutched operation above 1600 RPM.
- SAC recommends installation of Engine Overspeed Control Kit on 269C Model Helicopters to help prevent drive shaft failure due to overspeed.

(▌) Denotes portion of text added or revised.

***Supersedes B-257, dated 20 Jan 1993** **1 of 6**

- Failure to comply with this Service Bulletin may lead to loss of control of the helicopter, and subsequent serious injury, death and/or property damage.
- This revision provides additional and clarified information to aid in the proper inspection of the lower coupling drive shafts. If B-257 was previously complied with, no further action is required.

NOTE

The Flight Manuals for Model 269A, TH55A, 269A-1, 269B, and 269C will be updated to reflect the instrument markings specified in this Service Bulletin.

TOOLS & EQUIPMENT

Nomenclature	Source
Surface Comparator (Model S-22)	GAR Electroforming, Augusta Drive, Danbury, Conn. 06810, Fax 203-790-0700, Phone: 203-744-4300

MATERIALS

Nomenclature	Source
Mineral Spirits	Commercial
Alcohol	Commercial
Stoddard Solvent	Commercial
3M Scotch Brite	Commercial
BST-4 Presto Black	Birchwood Casey, 7900 Fuller Road, Eden Prairie, MN 55344, Fax: 612-937-7979, Phone: 612-937-7931
Contact Cement	Commercial

PROCEDURE:

PART I: ONE-TIME INSPECTION FOR DEFECTS ON LOWER COUPLING DRIVE SHAFT (SHORT SHAFT)

a. Remove lower coupling drive shaft (Basic HMI, Section 10).

NOTE

The following procedure is in addition to all other inspection requirements for the lower coupling drive shaft.

b. Drive Shaft Inspection.

NOTE

In steps (1) and (2) below, it is not necessary to remove grease retainer, rings, and boot from shaft. These parts may be moved on shaft as necessary to perform subsequent steps.

(1) Move grease retainer to center of drive shaft to expose retainer ring (Figure B-257.1-1). Carefully break the bond to allow retainer ring to slide on shaft.

(2) Cut safety wire from alignment ring and remove boot ring from boot to allow these parts to slide on shaft.

(3) Thoroughly clean grease and bonding residue from drive shaft.

(4) Visually inspect drive shaft between forward and aft splines, with particular attention to end radii, for cracks, machining steps, manufacturing tool marks, surface defects, and lack of clean up during the production grinding operation. (See Note below.)(Figure B-257.1-1)

NOTE

The drive shaft is machined to a 125-250 finish, ground to a 32 finish, then shot peened and coated with manganese phosphate or black oxide. In the above inspection look for areas where the 125-250 machine finish has not been removed in the grinding operation. A rough or coarse manganese phosphate coating and/or the effects of shot peening (small indentations or compressions) may change the surface finish value, but are not cause for rejection.

Small indentations near the center of the drive shaft are the result of hardness testing, and are not cause for rejection.

A surface comparator may be used to aid in this inspection. DO NOT USE A PROFILOMETER FOR THIS INSPECTION.

Perform inspection for cracks, steps, tool marks and defects in accordance with PART I: b. (4) prior to removing any protective coating.

(5) If unable to adequately inspect driveshaft for lack of clean up during the grinding operation due to the phosphate coating, perform the following procedures:

(a) Clean and degrease shaft with either mineral spirits, alcohol, or stoddard solvent.

(b) Lightly abrade surface by hand with 3M scotch brite.

(c) Inspect drive shaft in accordance with PART I: b.(4).

(6) If defects are found, the drive shaft must be retired from service or returned to SAC for further evaluation and disposition. Install serviceable drive shaft (PART I: c.).

c. Drive Shaft Assembly and Installation.

(1) If protective coating was removed from drive shaft, touch up affected area with BST-4 Presto Black in accordance with manufacturer's instructions. Locate and reassemble grease retainer, rings, and boot on drive shaft (Figure B-257.1-1).

(2) Lubricate and install lower coupling drive shaft (Basic HMI, Section 10).

d. Record compliance with PART I of this Service Bulletin in the aircraft records.

PART II: INSTALLATION OF NEW TACHOMETER MARKINGS

a. Install declutched limit marking on ENGINE/ROTOR tachometer using the method described in step b. or step c. (The method used is at the discretion of the owner/operator.)

b. Installation of marking, without disassembly (Figure B-257.1-2):

(1) Using pressure sensitive vinyl decal material or paint, install a red triangle on <u>lens</u> of ENGINE/ROTOR tachometer at 1600 RPM.

(2) Paint a white slippage mark at bottom of lens and across adjacent surface of lens frame.

(3) Record compliance with PART II of this Service Bulletin in the aircraft records.

c. Installation of markings, repair facility (Figure B-257.1-2):

(1) Remove ENGINE/ROTOR tachometer from instrument panel (Basic HMI, Section 14).

(2) Have red triangle permanently marked on <u>face</u> of ENGINE/ROTOR tachometer at an FAA approved repair facility, in accordance with AC43.13-1A.

(3) Install ENGINE/ROTOR tachometer in instrument panel (Basic HMI, Section 14).

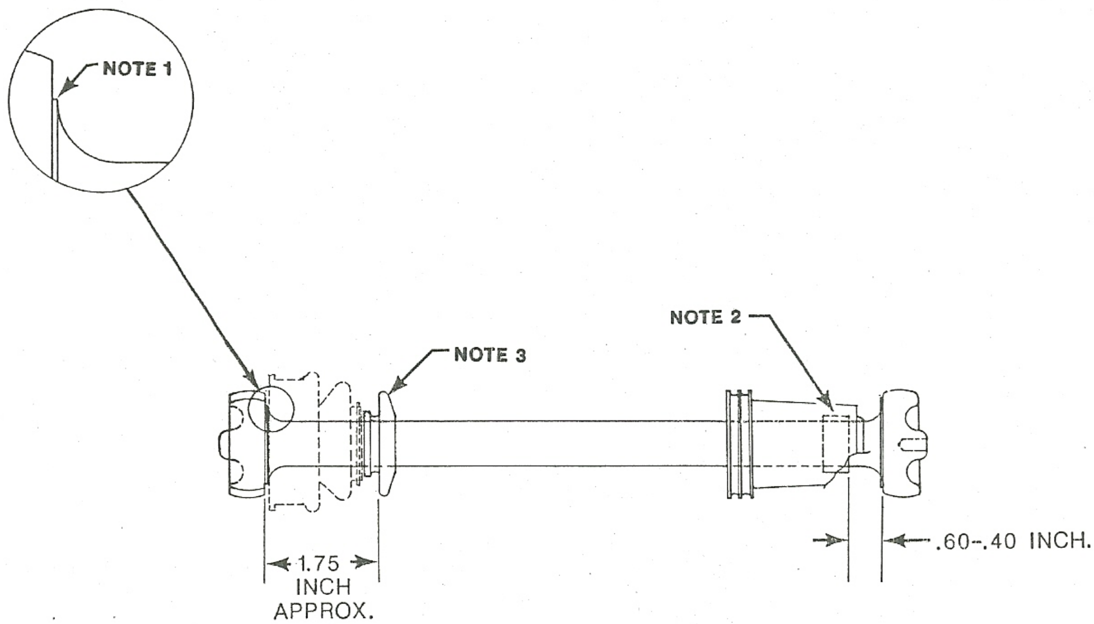
d. Record compliance with PART II of this Service Bulletin in the aircraft records.

NOTE

Engine operation in excess of 1600 rpm with the clutch disengaged is prohibited. To prevent lower coupling drive shaft damage due to overspeed in the event that the pilot inadvertently exceeds the 1600 RPM limit, SAC recommends installation of Engine Overspeed Control Kit, P/N 269A4997-1 or -3 as applicable on Model 269C Helicopters.

WEIGHT AND BALANCE

Weight and balance are not affected.



NOTES:

1. SHOULDER AREA OUTBOARD OF RADIUS IS MACHINED WITH A STEP IN THIS AREA AND IS NOT CAUSE FOR REJECTION - TYPICAL BOTH ENDS.

2. CEMENT RETAINER RING IN PLACE USING CONTACT CEMENT (OR EQUIVALENT).

3. SECURE ALIGNMENT RING IN PLACE USING TWO WRAPS OF SAFETY WIRE.

Figure B-257.1-1. Lower Coupling Drive Shaft

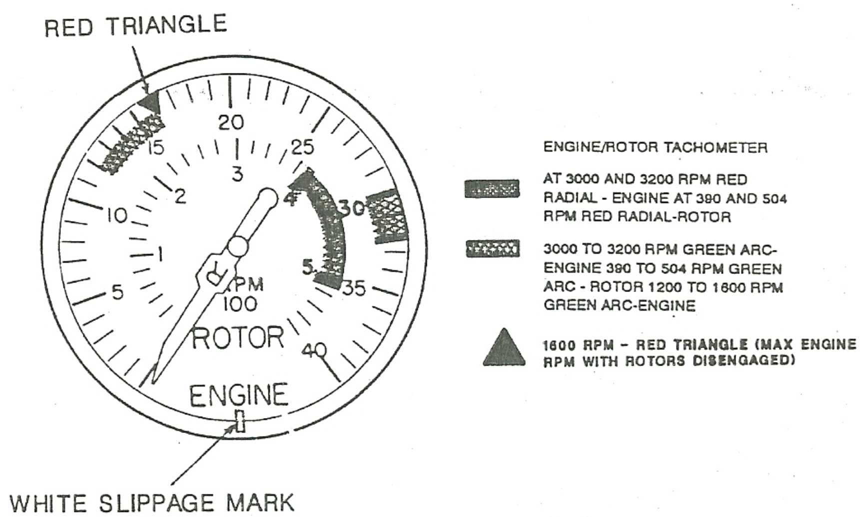


Figure B-257.1-2. Instrument Markings, ENGINE/ROTOR Tachometer

COMPILED BY	Crash LAB	PAGE 1 OF 1
COMPILED FOR: **Civil Aviation Authority**	**INVESTIGATION REPORT: CLUTCH AND DRIVESHAFT ASSY., HUGHES 269, ZS-HTJ**	DOCUMENT NUMBER **MET-012-10-10**
		DATE **2010-10-29** / ISSUE **1**

ITEM: **CLUTCH & DRIVE ASSY., SCHWEIZER HUGHES 269C HELICOPTER, AIRCRAFT NUMBER ZS-HTJ**

1. INTRODUCTION

1.1. Selected components from the clutch and drive shaft assembly (Photo 1) from a crashed Schweizer Hughes 269C helicopter, aircraft number ZS-HTJ, were submitted to determine the failure modes during operation.

Photo 1: ZS-HTJ position of supplied components (courtesy SACAA)

1.2. Fatigue

A fracture that is the result of repetitive or cyclic loading is known as a fatigue fracture. A fatigue fracture generally occurs in three stages: it initiates during Stage I, propagates for most of its length during Stage II, and proceeds to catastrophic fracture during Stage III.

The largest portion of a fatigue fracture consists of Stage II crack growth, which generally occurs by trans-granular fracture and is more influenced by the magnitude of the alternating stress than by the mean stress or microstructure. Fatigue fractures generated during Stage II fatigue usually exhibit crack-arrest marks known as fatigue striations (Fig. 17, 19), which are a visual record of the position of the fatigue crack front during crack propagation through the material. Fatigue striations often bow out in the direction of crack propagation and generally tend to align perpendicular to the principal (macroscopic) crack propagation direction. However, variations in local stresses and microstructure can change the orientation of the plane of fracture and alter the direction of striation alignment.

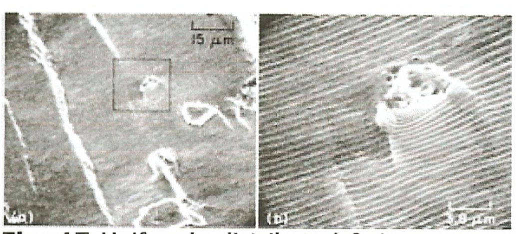


Fig. 17 Uniformly distributed fatigue striations in an aluminum 2024-T3 alloy. (a) Tear ridge and inclusion (outlined by rectangle). (b) Higher-magnification view of the region outlined by the rectangle.

HUCHES 269C ZS-HTJ

1.3. This report is divided into the following sections:

2. APPLICABLE DOCUMENTS

(a) Illustrated Parts Catalogue, Section 3.
(b) Airworthiness Directive 93-17-13
(c) Schweizer Service Bulletin B257.1

3. DEFINITIONS

(a)	OEM	Original Equipment Manufacturer
(b)	SACAA	South African Civil Aviation Authority
(c)	SEM	Scanning Electron Microscope
(d)	EDS	Energy Dispersive X-ray Analysis

4. PERSONNEL

(a) The investigative member and compiler of this report is Mr C.J.C. Snyman, ID number 6406105057080. Mr Snyman is a qualified Physical Metallurgist (H.N.Dip Metallurgical Engineering, Tech. PTA), Radiation Protection Officer (RPO) registered with the National Nuclear Regulator (NNR) and Aircraft Accident Investigator (SCSI).

5. APPARATUS AND METHODOLOGY

(a) The apparatus employed for this investigation are Stereo- and Scanning Electron (With EDS) Microscopes and Digital Camera.
(b) The methodology included a visual investigation of supplied parts followed by a Stereoscopic and SEM investigation.

6. INVESTIGATION RESULTS

The on-site visual examination revealed the drive shaft (Diagram 1, red arrow) to be fractured at the pulley (AFT) end (Photo 2, red arrow) of the assembly. Lubrication remains was evident. The clutch pulley (Photo 1, blue arrow) was fractured with the clutch cable in wedged position (Photo's 15 and 16).

Further inspection revealed fractures to be present at the forward (engine side) end (Photo 3, red arrow) of the drive shaft. The fractures at the FORWARD end proved to be at a position 180° opposite to that of the fractures at the AFT end of the drive shaft. Some scuffing marks were noted at the FORWARD end (Photo 3, blue arrow), most probably induced during the post failure phase. The gears at both the FORWARD en AFT ends of the drive shaft revealed signs of directional damages correlating with the applied power during operation (Photo 3, yellow arrow). At both ends indications of shear orientated fracture initiation were evident (Photo 5, blue arrow). The orientation of the fractures correlated well with that of a high strength drive shaft under torsion loads, combined with possible directional loading. The AFT end drive shaft fracture surface revealed the typical 'thumbnail' geometry of a propagating fatigue fracture (Photo 4, red arrow and dashed line) with extensive 'smearing' damages (Photo 4, blue arrow). The 'smearing' damages are due to the rubbing effect of the opposed fracture surfaces during operation. All indications are that the fatigue fractures originated parallel to and at right angles to the drive shaft surface, 180° angles at opposite ends, and the progressed into a shear directed fatigue fracture before final fracture. This correlates with a typical torsion induced failure in highly strained rotating shafts.

The SEM investigation of the AFT end fracture clearly revealed the fatigue 'beach marks' (Photo's 7 and 8, red arrows), also indicating the varying fracture propagation directions (dashed red arrows) at dissimilar planes of the fracture surface. At higher magnifications fatigue striations are evident (Photo 9) pointing towards high cycle fatigue.

The fracture at the FORWARD end of the drive shaft was opened in the Laboratory to reveal the fracture surface geometry. The existing fracture surface (Photo 10, blue arrow) clearly shows foreign deposits versus that of the 'clean', laboratory induced fracture surface (Photo 10, red arrow). At higher magnifications some indications of fatigue beach marks were visible under the foreign deposits (Photo 11). Compare with the laboratory, single overload type of fracture geometry (Photo 12), at similar 2000x magnifications.

Both pulley bearings (Diagram 1, blue arrows) were removed and inspected but revealed no clear signs (Photo 13) of pre-impact damages, vibration or other that may have contributed to the failure of the drive shaft.

The clutch cable guide pulley (Photo 14, from similar aircraft) was found fractured with the cable wedged between the pulley and pulley frame (Photo 15). In case where the pulley should fail during operation, it may lead to the disengaging of the clutch system, the subsequent exceeding of the RPM limits and resulting in drive shaft damages and/or failure during operation. The ceramic based pulley fracture surfaces revealed no clear indications of pre-existing crack formation (Photo's 16 and 17). The pulley frame was torn apart on impact as the undercarriage was severed from the main fuselage (Photo 17). The pulley frame fracture surfaces compares with that of a single overload failure (Photo 18).

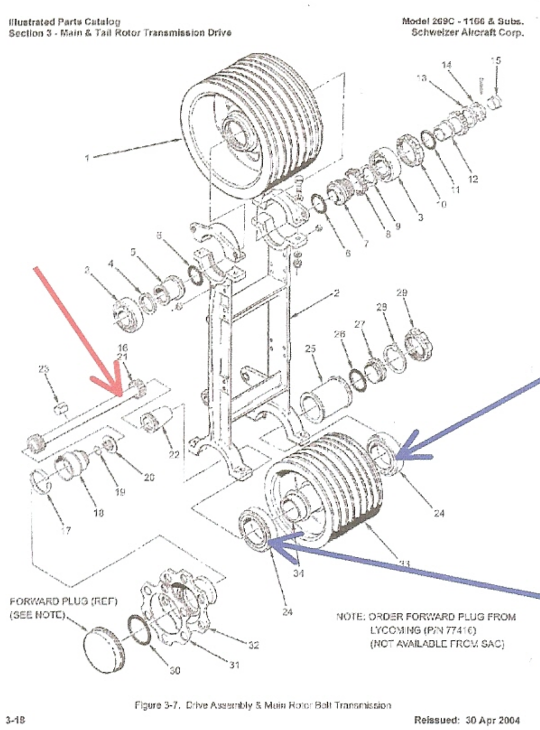


Diagram 1: IPS: Hughes 269C Drive Assembly

Photo 2: Drive shaft (digital)

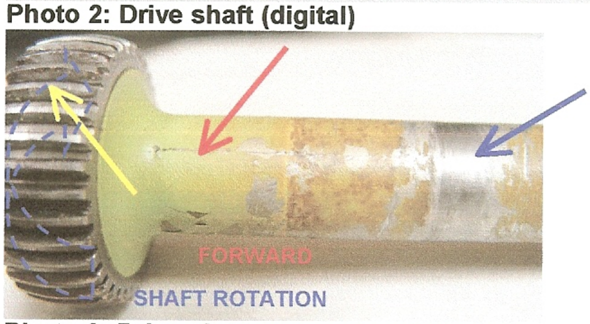


Photo 3: Drive shaft, forward end (digital)

HUCHES 269C ZS-HTJ

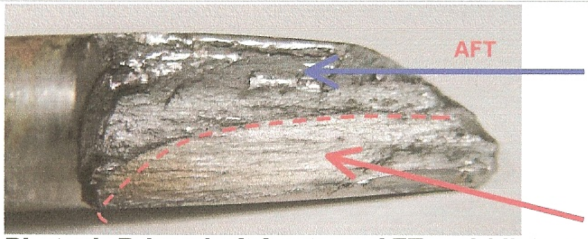


Photo 4: Drive shaft fracture, AFT end (digital)

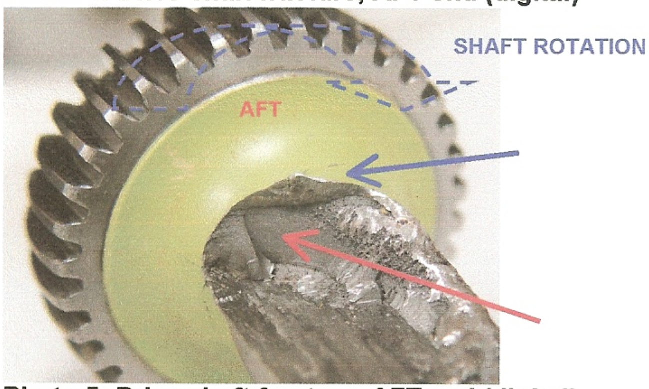


Photo 5: Drive shaft fracture, AFT end (digital)

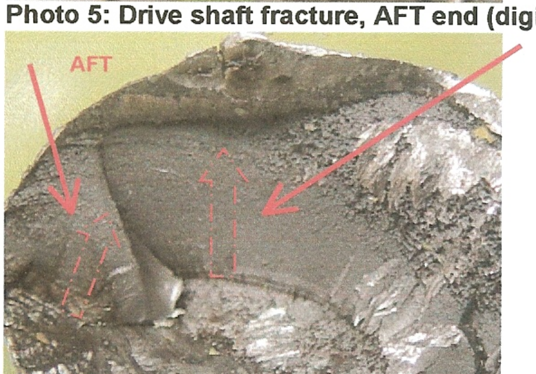


Photo 6: Fatigue fracture surface, AFT end (digital)

Photo 7: Fatigue beach marks on fracture surface, AFT end (x37, SEM)

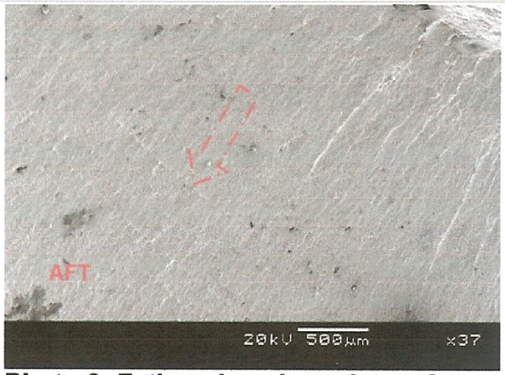


Photo 8: Fatigue beach marks on fracture surface, AFT end (x37, SEM)

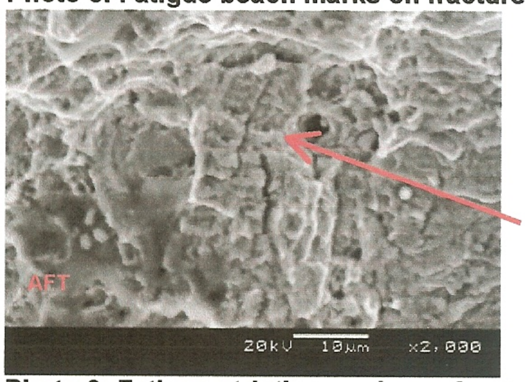


Photo 9: Fatigue striation marks on fracture surface, AFT end (x2000, SEM)

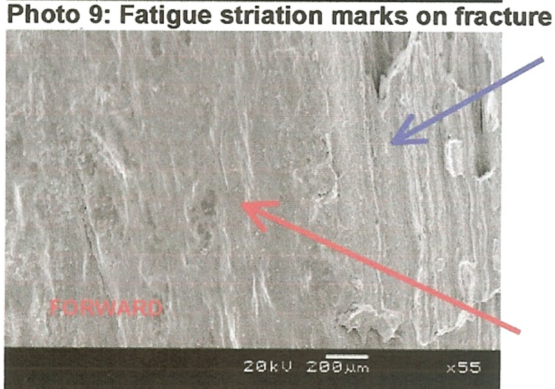


Photo 10: Lab opened fracture showing existing and 'new' surfaces (x55, SEM)

HUCHES 269C ZS-HTJ

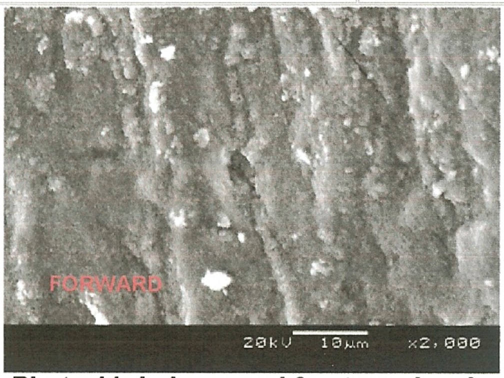


Photo 11: Lab opened fracture showing contaminated existing surface (x2000, SEM)

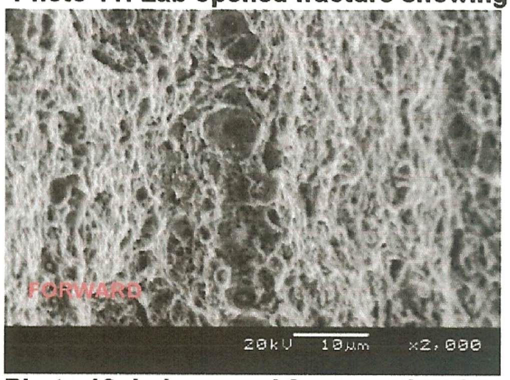


Photo 12: Lab opened fracture showing single tensile overload surface (x2000, SEM)


Photo 13: Lab opened bearing balls and raceway surfaces (digital)

HUCHES 269C ZS-HTJ

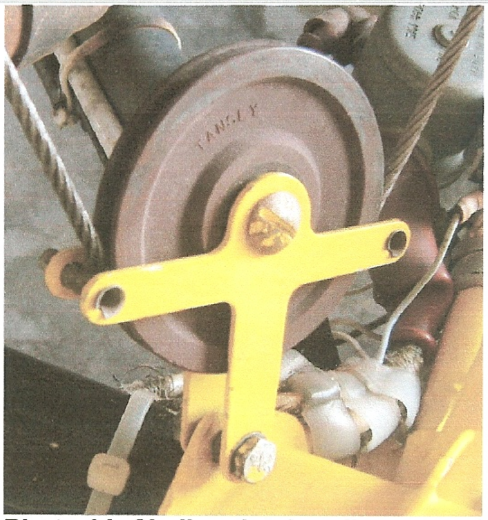


Photo 14: Similar clutch pulley assemble (digital)


Photo 15: Fractured clutch pulley assembly (digital)


Photo 16: Fractured clutch pulley assembly (digital)

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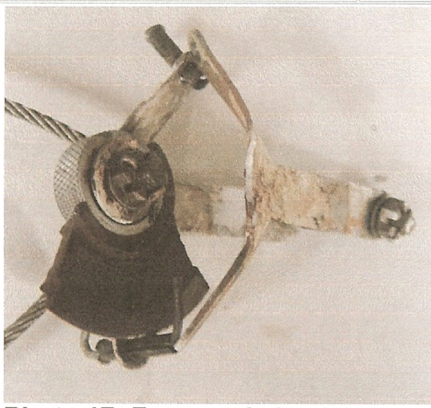

Photo 17: Fractured clutch pulley assembly (digital)

Photo 18: Clutch pulley frame fracture surfaces (digital)

8. DISCUSSION AND CONCLUSIONS

Note: All conclusions are based on the investigation results obtained from the supplied parts only.

8.1. This investigation revealed that the failure of the drive shaft during operation as being the first in the sequence of events leading to the accident. The fracture surface analysis exposed high cycle fatigue as the primary mode of failure with large areas of final fracture geometry. Taking into account that fatigue, in particular high cycle, is a time dependent failure, then all indications are that the drive shaft fractures propagated over a period of operational time. The extent of this time period could not be determined but is in all likelihood exceeding the operational time between failure of the drive shaft, and the impact of the aircraft. This rules out the possibility that the clutch guide pulley to be the first in the sequence of events, leading to the disengaging of the clutch and resulting in exceeding the RPM limits of the drive shaft (see extract from Airworthiness Directive 93-17-13 underneath). No other contributing factors could be attained from the supplied parts.

8.2. The Airworthiness Directive (see extract underneath) clearly states the dangers of exceeding the RPM limits set by the OEM during operation. Another common contributor to fatigue of highly strained shafts is mechanically induced surface indentations (nick marks) resulting in surface stress raisers. However, taking into account the initiation and progression of the fractures in the drive shaft (originating at both ends at opposite orientations) surface marks, to an extent, can be ruled out as the primary contributing factor.

PREFACE:
- Surface defects can contribute to drive shaft failure.
- Field reports indicate that lower coupling drive shaft damage/failure has occurred as a result of engine declutched operation above the limits specified in the Pilot's Flight Manual.
- This Service Bulletin specifies a one-time inspection to check for drive shaft defects; provides marking data to display the speed limitation on the ENGINE/ROTOR tachometer to reinforce existing operating limits; and reiterates the prohibition of engine declutched operation above 1600 RPM.
- SAC recommends installation of Engine Overspeed Control Kit on 269C Model Helicopters to help prevent drive shaft failure due to overspeed.

NOTE

The Flight Manuals for Model 269A, TH55A, 269A-1, 269B, and 269C will be updated to reflect the instrument markings specified in this Service Bulletin.

Airworthiness Directive 93-17-13

9. RECOMMENDATIONS

9.1. None applicable.

10. DECLARATION

9.1. All digital images has been acquired by the author and displayed in an un-tampered manner.

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