Statens haverikommission
Swedish Accident Investigation Authority

Final report RL 2014:09e

Accident in Porjus, Norrbotten county on November 8, 2012 involving the helicopter SE-HOM of the model Bell 206B, operated by Fiskflyg AB.

File number L-125/12

7/3/2014

SHK investigates accidents and incidents from a safety perspective. Its investigations are aimed at preventing a similar event from occurring again, or limiting the effects of such an event. The investigations do not deal with issues of guilt, blame or liability for damages.

The report is also available on SHK´s web site: www.havkom.se

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This document is a translation of the original Swedish report. In case of discrepancies between this translation and the Swedish original text, the Swedish text shall prevail in the interpretation of the report.

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Content

General observations

The Swedish Accident Investigation Authority (Statens haverikommission – SHK) is a state authority with the task of investigating accidents and incidents with the aim of improving safety. SHK accident investigations are intended to clarify, as far as possible, the sequence of events and their causes, as well as damages and other consequences. The results of an investigation shall provide the basis for decisions aiming at preventing a similar event from occurring again, or limiting the effects of such an event. The investigation shall also provide a basis for assessment of the performance of rescue services and, when appropriate, for improvements to these rescue services.

SHK accident investigations thus aim at answering three questions: *What happened? Why did it happen? How can a similar event be avoided in the future?*

SHK does not have any supervisory role and its investigations do not deal with issues of guilt, blame or liability for damages. Therefore, accidents and incidents are neither investigated nor described in the report from any such perspective. These issues are, when appropriate, dealt with by judicial authorities or e.g. by insurance companies.

The task of SHK also does not include investigating how persons affected by an accident or incident have been cared for by hospital services, once an emergency operation has been concluded. Measures in support of such individuals by the social services, for example in the form of post crisis management, also are not the subject of the investigation.

Investigations of aviation incidents are governed mainly by Regulation (EU) No 996/2010 on the investigation and prevention of accidents and incidents in civil aviation and by the Accident Investigation Act (1990:712). The investigation is carried out in accordance with Annex 13 of the Chicago Convention.

The investigation

SHK was informed on November 8, 2012 that an accident involving a helicopter with the registration SE-HOM had occurred at Porjus Airfield, Norrbotten county, on the same day at 12.30 hrs.

The accident has been investigated by SHK represented by Mr Jonas Bäckstrand, Chairperson, Mr Staffan Jönsson, Investigator in Charge until August 21 2013, thereafter Mr Sakari Havbrandt, and by Mr Agne Widholm, Operations Investigator from December 2 2012.

Accredited representative has been Mr Brad Vardy from the Transportation Safety Board of Canada.

The investigation was followed by Mr Yngve Östlund of the Swedish Transport Agency.

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Final report RL 2014:09e

Aircraft:	
Registration, type	SE-HOM, Bell Helicopter Textron
Model	206B
Class, Airworthiness	Normal, Certificate of Airworthiness and Valid Airworthiness Review Certificate (ARC)
Owner and Operator	Fiskflyg AB
Time of occurrence	November 8, 2012, 12.30 hrs in daylight Note: All times are given in Swedish standard time (UTC + 1 hr)
Place	Porjus, Norrbotten county, (position N 66° 58’ E 019° 50’, 394 metres above sea level)
Type of flight	Proficiency check
Weather	According to SMHI’s analysis: Westerly wind 5-10 kts, visibility >10 km, cloud 1-2/8 with base above 5 000 feet, temperature/dewpoint -6/-9 °C, QNH[1] 988 hPa
Persons on board:	
crew members	2
passengers	0
Injuries to persons	None
Damage to aircraft	Limited
Other damage	None
Instructor:	
Age, licence	55 years, CPL (H)[2] , FIH[3]
Total flying hours	11 000 hours, of which 7 000 hours on type
Flying hours last 90 days	72 hours, of which 65 hours on type
Number of landings last 90 days	250
Commander:	
Age, licence	54 years, CPL (H)
Total flying hours	10 288 hours, of which 2 400 hours on type
Flying hours last 90 days	146 hours, of which 46 hours on type
Number of landings last 90 days	367

[1] QNH- Atmospheric pressure at an airport or other defined area calculated at sea level in accordance with the International Standard Atmosphere.
[2] CPL (Commercial Pilot Licence – Helicopter).
3 FIH (Flight Instructor Helicopter).

SUMMARY

An autorotation landing was performed during an OPC.

Shortly after touchdown the helicopter began to vibrate and a heavy scraping sound was heard accompanied by vibrations of a frequency corresponding to the rotor speed. The vibrations continued when the main rotor speed decreased and they then increased sharply, after which the entire main rotor separated from the helicopter and ended up about 10 metres to the left of the helicopter.

Those on board, who were uninjured, were able to exit the helicopter unassisted.

The technical investigation concluded that the mast had failed due to torsional overload. Furthermore a contaminant was found in the oil system which supplies the free wheel assembly with lubricant. The contaminant was found in a designed restrictor in the oil system. The failed lubrication resulted in a free wheel malfunction.

It is likely that the free wheel released as intended during previous autorotations, but did not engage when the free turbine speed was to meet the rotor speed at the same time as the rotor geared down. If the speed of the free turbine was significantly higher than that of the rotor when the sprags engaged, possibly faster than normal, an additional dynamic moment arose. The energy that was stored up in the engine and transmission was braked by the inertia of the main rotor, whereby the moment on the mast exceeded the fracture strength.

The accident was caused by the design of the free wheel's lubrication system allowing a contaminant of a size that can occur in a Part-145 shop to block the oil flow to the freewheel.

Safety recommendations

EASA is recommended to:

- act for a reduction in the oil system's sensitivity to contaminants. *(RL 2014:09 R1).*

- act so that operators of the helicopter type are provided with information and suggestions for preventive measures regarding the risk of contamination of the free wheel's lubrication system. *(RL 2014:09 R2)*

Transport Canada is recommended to:

- act for a reduction in the oil system's sensitivity to contaminants. *(RL 2014:09 R3).*

- act so that operators of the helicopter type are provided with information and suggestions for preventive measures regarding the risk of contamination of the free wheel's lubrication system. (*RL 2014:09 R4*)

1. FACTUAL INFORMATION

1.1 History of the flight

Over two days, the instructor had conducted approximately twenty autorotation exercises without disturbances or deviations. On the morning of the same day that the event occurred, he had carried out OPCs[4] with two other pilots.

After lunch, the pilot took off with the instructor. The flight that ended in the accident began with normal flight. Prior to the event, emergency exercises were conducted, first with simulated malfunction of tail rotor control and subsequently autorotation exercises from 1000 feet with clockwise turns of 180 degrees at a speed of approximately 50 knots to final for landing on the snow-covered gravel runway.

In the final phase of the third autorotation with a rotor speed of 100-102 %, the pilot came a little too far forward in relation to the intended touchdown point. During the flare when the pilot brought the collective lever up in order to reduce the vertical rate of descent, the nose swung to the left against the wind. The helicopter temporarily touched ground, the instructor pointed out the deviation, the pilot corrected this and at the same time the helicopter lifted to a height of half a metre to one metre above the runway prior to the final touchdown. Shortly afterwards when the collective lever was completely down to the floor, the helicopter began to vibrate. The instructor took hold of the cyclic stick, which was then in the neutral position. According to the crew, the throttle remained in the idle position.

The helicopter was stationary when a heavy scraping sound was heard accompanied by vibrations of a frequency corresponding to the rotor speed. The vibrations continued when the main rotor speed decreased and they then increased sharply. The instructor shut off the engine. At the same time, a "schoff", "schoff" sound was heard, after which the entire main rotor separated from the helicopter and ended up about 10 metres to the left of the helicopter, see Figure 1.

Those on board, who were uninjured, were able to exit the helicopter unassisted.

[4] OPC – Operational Proficiency Check

Fig. 1 The helicopter after the accident. (Photo Fiskflyg)

The accident occurred in position N 66° 58’ E 019° 50’, 394 metres above sea level.

1.2 Injuries to persons

	Crew	Passengers	Total in the aircraft	Others
Fatal	-	-	0	-
Serious	-	-	0	-
Minor	-	-	0	Not applicable
None	2	-	2	Not applicable
Total	2	-	2	-

1.3 Damage to aircraft

Limited.

1.4 Other damage

None.

1.5 Crew/Personnel information

1.5.1 Instructor

The instructor was 55 years old and had a valid CPL (H) Licence with FIH.

Flying hours				
Latest			90 days	Total
All types	~	~	72	11 000
This type	~	~	65	7 000

Number of landings this type previous 90 days: 250.
Type rating concluded in 1981.
Latest PC (proficiency check) carried out on 29 November 2011 on EC120 B.

1.5.2 Commander

The commander was 54 years old and had a valid CPL (H) Licence.

Flying hours				
Latest			90 days	Total
All types	~	~	146	10 288
This type	~	~	46	2 400

Number of landings this type previous 90 days: 367.
Type rating concluded in 1989.
Latest OPC carried out on 8 November 2012 on Bell 206B.

1.6 Aircraft information

1.6.1 Helicopter data

Helicopter	
TC-holder	Bell Helicopter Textron
Type	206B
Serial number	2 394
Year of manufacture	1978
Gross mass, kg	Max authorised/actual 1 451/1 093
Centre of gravity	Within permitted limits
Total operating time, hrs	19 787
Operating time since overhaul, 100- and 300-hr inspection, hrs	53.1
Number of cycles	13 456
Fuel loaded before event	Jet A1

Freewheel	
Total operating time, hrs	6 583
Operating time since overhaul, hrs	2 737
Operating time since installation, hrs	629

The aircraft had a Certificate of Airworthiness and a valid ARC.

1.6.2 Helicopter history and operating times of the components concerned

The helicopter was imported second-hand to Sweden in 1987 and has since then been operated by Fiskflyg.

Flying hours utilisation for the last six years was an average of 410 hours per year and a minimum of 310 hours per year. Assignments have been aerial work, such as reindeer herding, power line inspection, flights with a suspended load, and commercial transport and proficiency checks.

The inspection to be performed of the main rotor transmission after 1 500 flying hours was conducted 349 flying hours prior to the event.

1.6.3 Description of the helicopter's engine and rotor systems

The helicopter was equipped with a Rolls Royce Corporation RRC 250-C20 B free-turbine engine. A compressor, a combustion chamber and a turbine module together constitute the engine's gas generator and generate a gas flow that drives a free turbine. Via a gearbox and a freewheel, the free turbine drives the helicopter rotor system. The free turbine's speed is regulated by means of an automatic mechanism so that the predetermined rpm is obtained during normal flight. If the pilot, for example, raises the collective lever, more power will be needed, and the gas generator will automatically receive more fuel, increasing its gas flow, and the free turbine and rotor system can thereby maintain its speed. If the pilot lowers the collective lever, the gas generator receives less fuel, which prevents the rotor speed from increasing.

The outer part of the freewheel is directly connected to the output drive shaft from the engine gearbox. A sprag clutch transmits the freewheel's power to the inner shaft in the freewheel, see Figure 2. The freewheel is component 4 in the picture.

When the engine transmits power, and the speed of the output drive shaft equals the speed of the main transmission's input shaft, the freewheel locks and transmits moment. When the engine is not transmitting power, the speed of the output drive shaft will become lower than the speed of the main transmission's input shaft. The freewheel is then disengaged from the transmission, see Figure 3. The engine thus does not brake the rotor system upon engine loss, but allows the rotor system to continue rotating, which makes landing possible despite engine loss.

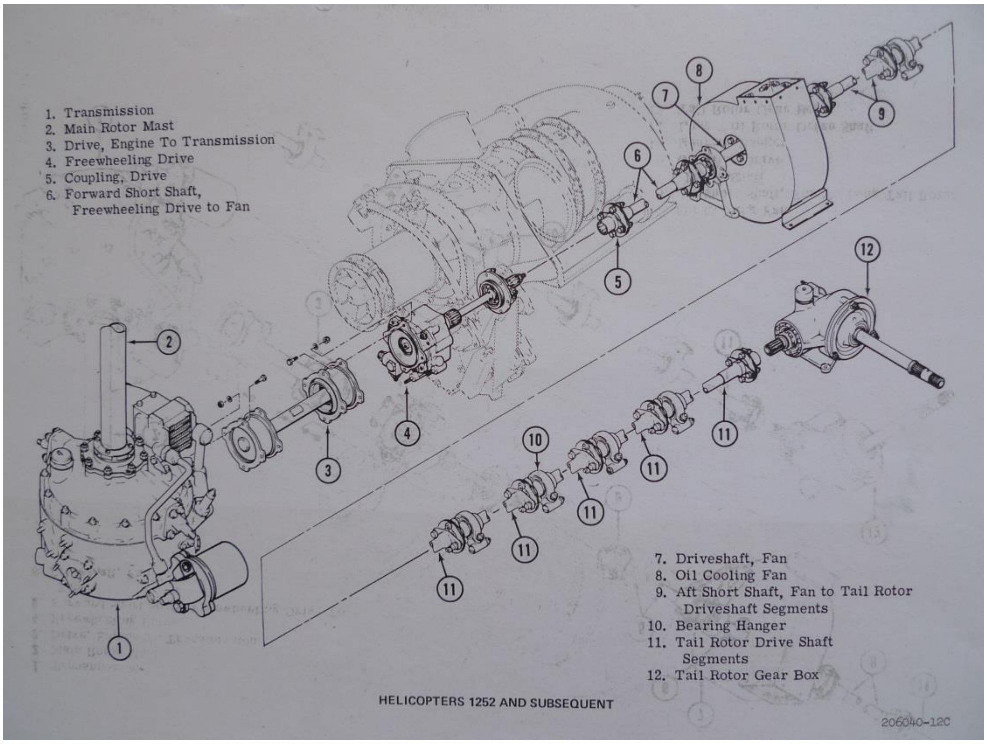

Fig. 2 The helicopter's drive line. (Bell Maintenance & Overhaul Instructions)

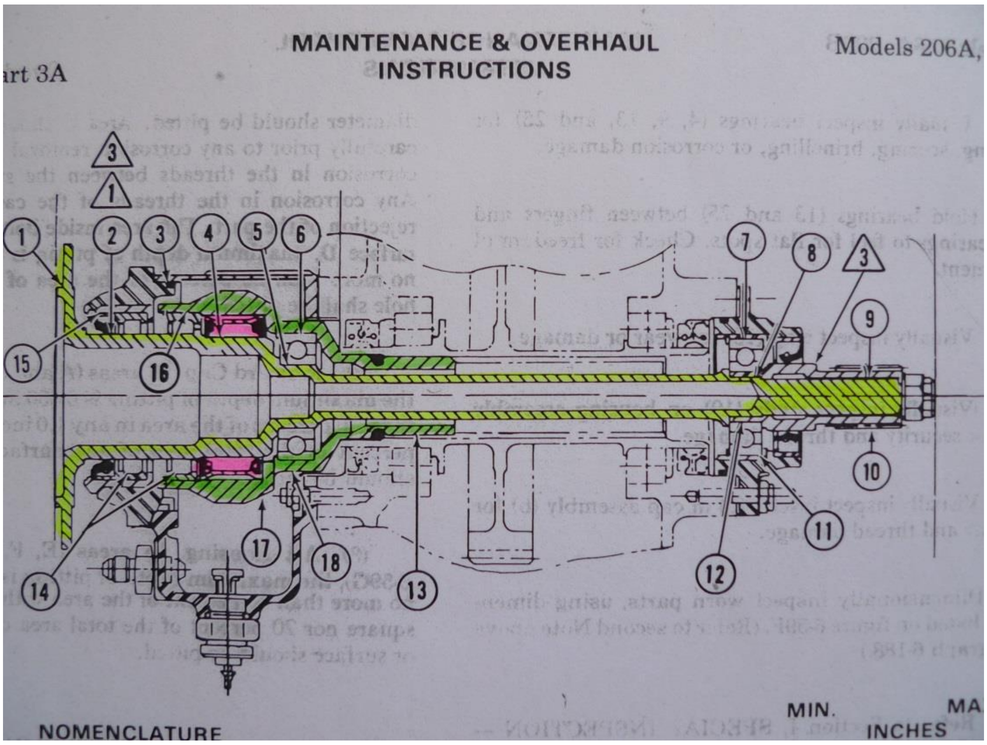

Fig. 3 The freewheel's fundamental structure. (Bell Maintenance & Overhaul Instructions)

Figure 3 illustrates how the freewheel is designed. During normal operation, moment from the engine is transferred in through the (green) outer driveshaft and is transmitted to the (yellow) inner drive shaft via the (red) sprags. The large flange on the (yellow) drive shaft is connected to the main rotor transmission.

1.7 Meteorological information

According to SMHI’s analysis: Westerly wind 5-10 kts, visibility >10 km, cloud 1-2/8 with base above 5 000 feet, temperature/dewpoint -6/-9 °C, QNH 988 hPa.

1.8 Aids to navigation

Not applicable.

1.9 Communications

Not applicable.

1.10 Aerodrome information

Not applicable.

1.11 Flight recorders

Not carried and not required.

1.12 Aircraft wreckage and accident site

1.12.1 Aircraft wreckage

The damage to the helicopter was confined to the main rotor, mast failure, torn-off pitch links and broken “drive collar”. Upon main rotor separation, one of the blades struck the fairings that cover the main rotor gearbox and then also struck the left side of the fuselage rib at the division between fuselage and tail boom.

1.12.2 Accident site

The site had the dimensions 400 x 30 metres, and the area was covered with about 15 cm of snow.

1.13 Medical and pathological information

Nothing indicates that the general condition of the crew was impaired before or during the flight.

1.14 Fire

There was no fire.

1.15 Survival aspects

1.15.1 The rescue operation

The instructor contacted the aviation company after the accident. The event provoked no other rescue operation.

The ELT[5] of the make Artex and model ME406 was not activated during the crash.

1.16 Tests and research

1.16.1 Main transmission with lubrication system

SHK has dismantled the rotor transmission and taken samples of the oil in the filter housing and in the bottom of the transmission. Figure 4 shows part of the material that was found in the transmission's filter housing.

The presence of iron (Fe) and water was relatively high in both oil samples. A particle count was performed on the sample from the bottom of the transmission, and the sample exhibited a large quantity of particles.

[5] ELT (Emergency Locator Transmitter).

Fig. 4 Contaminants from the filter housing (screen filter) on the main transmission, debris from o-rings, sealants, textiles and paint.

The transmission has a screen meshing to clear the circulating oil from larger contaminants. Here, pieces of solid objects were found, see Figure 5. The most common contaminants were paint debris and sealant material.

Fig. 5 The main transmission's coarse screen meshing with contaminants of sealant and paint debris.

In the transmission filter, there were only very fine, uniformly distributed particles, which is normal. The latest oil change was performed 151 hours before the event. None of the magnetic chip detectors located in the same area as the screen meshing had traces of particles.

Both bearings and sprags in the freewheel exhibited wear damage.

Fig. 6 Restrictor P/N 206-040-244-001, the contaminant is visible at the arrow tip.

The bottom of Figure 8, slightly to the right, shows “Restrictors in fitting”, where the flow out to the freewheel lubrication is limited by means of a restrictor whose orifice is 0.99-1.12 mm in diameter. At this restrictor, see also Figure 9, a contaminant was found.

Figure 6 shows the contaminant as a black dot at the tip of the arrow. Figure 7 shows the contaminant at greater magnification.

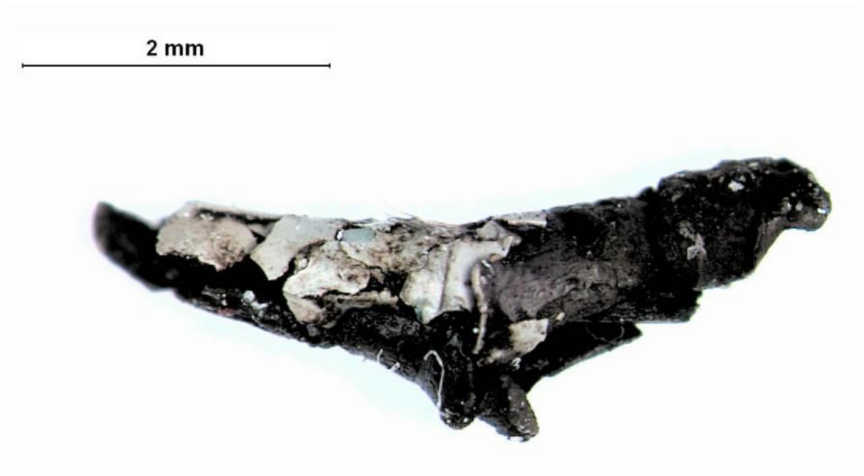

Fig. 7 The contaminant's size was about 1.4 x 4.2 mm.

By means of SEM[6] and FTIR[7] analysis, it has been possible to determine the origin of the contaminant. Comparisons with another sealant and paint debris from the main transmission show that the plug consists of sealant of type Pro Seal 890 Class B (AMS-S-8802, Class B, MIL-S-8802).

An analysis of the contaminant has shown that it consists of sealant material that has been used between the cover and the transmission housing.

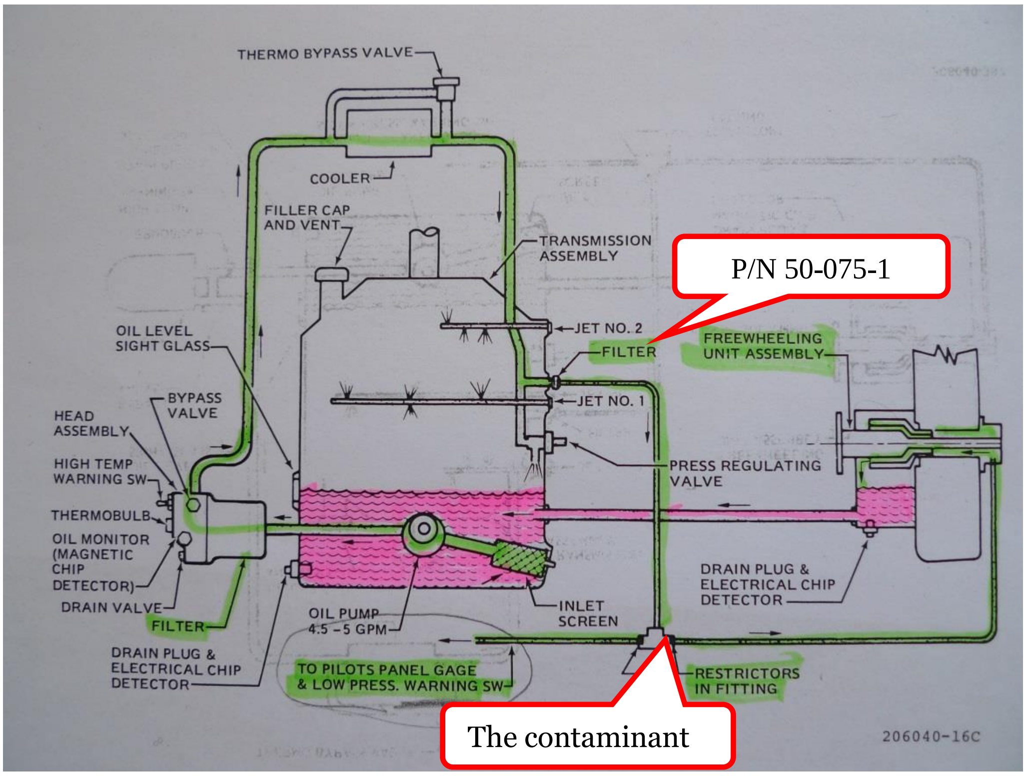

Fig. 8 Lubrication system main transmission and freewheel. The green colouring signifies pressurised oil and the pink colouring return oil. Normal oil pressure is between 2.1 and 3.5 bar. (Bell Maintenance & Overhaul Instructions).

TB 206-79-31 is a recommended modification that was installed. This means that a filter with part number P/N 50-075-1 has been installed.

[6] SEM – Scanning Electron Microscope.
[7] FTIR (Fourier transform infra red) – chemical analysis instrument that detects groups of chemical bonds.

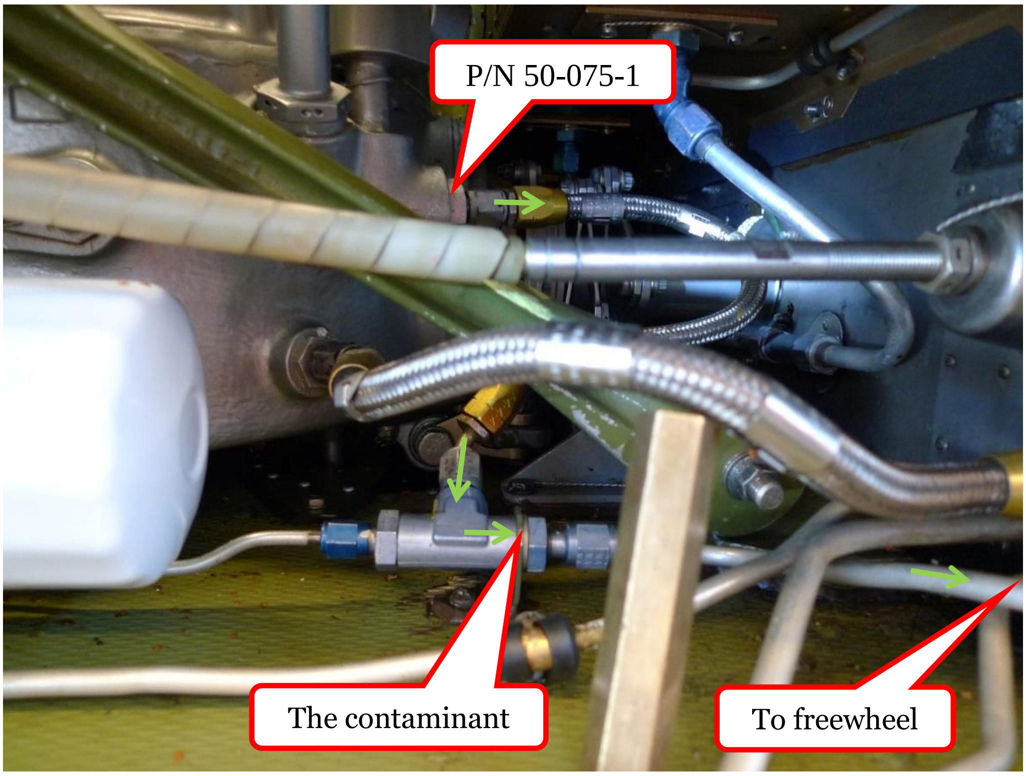

Fig. 9 Parts of the lubrication system to the freewheel.

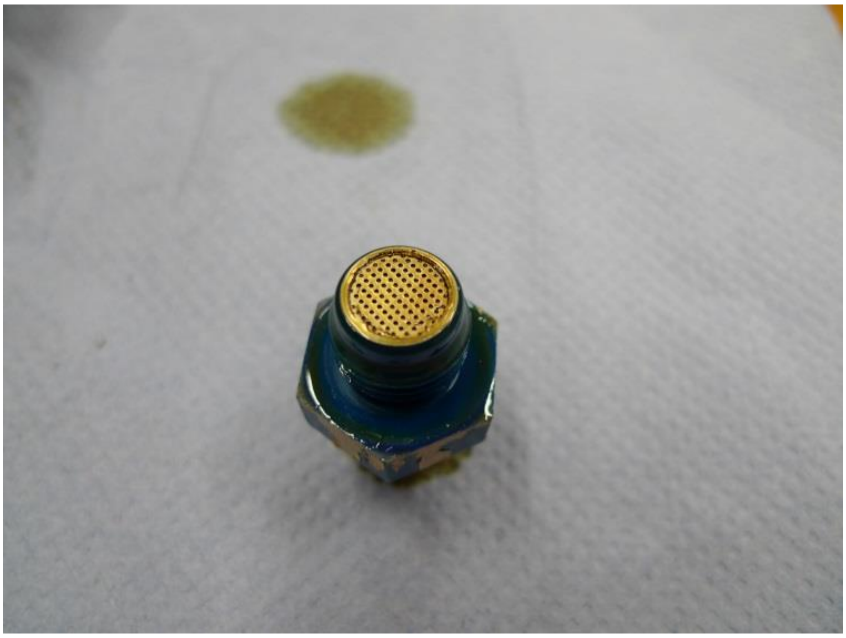
Fig. 10 Filter P/N 50-075-1. Upon examination, the filter was free from visual contaminants.

Filter P/N 50-075-1 is mounted on the main transmission on the outgoing lubrication loop to the freewheel, see Figure 8. After the filter, but before the restrictor, the oil is led in a line that is about half a metre long, see Figure 9. According to the maintenance system, the filter and other parts are to be inspected every 1 500 operating hours.

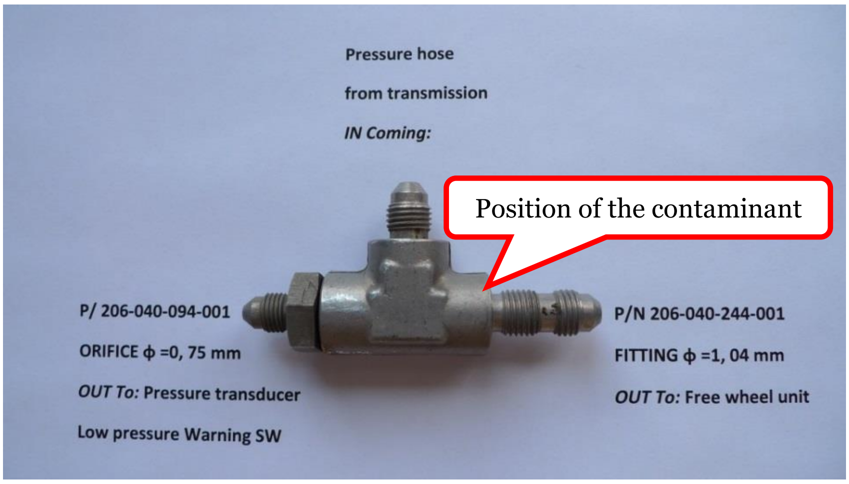

Fig. 11 Ingoing physical parts with the restrictor to the freewheel lubrication and the pressure indicator on the instrument panel warning of low oil pressure.

1.16.2 Examination of the rotor mast

SHK has examined the mast at a materials laboratory.

Fig. 12 Upper part of the helicopter mast.

The examination showed that the fracture surfaces had secondary damage due to “slippage” between the two fracture surfaces. Approximately 30-40 per cent of the section was undamaged, and it could be noted that this part of the fracture surface did not exhibit any traces of fatigue. The mode of failure was momentary overload in torsion, i.e. a shear fracture. The mast's material composition corresponds to the steel qualities stated by the manufacturer, AMS 4340 and AMS 4340H.

The area around the sheared section was examined by means of magnetic particle testing. The examination revealed no indications of cracks or defects.

The engine's maximum power is 420 metric hp. The speed and thus the moment in the engine and transmission undergo gear reduction in several steps. The speed of the rotor mast is 394 rpm at 100 % rpm.

Mechanical power is defined as $Power = Mt * \dot{\omega} = Mt * n * 2\pi/60$

Mt=Torque (Nm)
$\dot{\omega}$=Angular velocity (Rad/s)
$\pi = 3.14$
n=revolutions/min

1 metric hp = 735.5 W

The torque on the mast at maximum power is thus:

$Mt = Power/(n*2\pi/60) = 420*735.5/(394*2\pi/60) = 7\ 491\ Nm$

Mast geometry of fracture surface:
$Ø_{out}$= 50.9 mm, $Ø_{in}$=40.7 mm

The mast's section modulus in torsion, $Wv = \pi(Ø_{out}^4 - Ø_{in}^4)/(16* Ø_{out}) = 15\ 300\ mm^3$

Shear stress, $T = Mt/Wv = 490\ MPa$

The material in the mast, AMS 4340, has a stated tensile fracture stress of 2 070 MPa.

By von Mises hypothesis[8], shear stress corresponds to tensile stress/√3, obtaining a shear fracture stress of 1 242 MPa.

The safety factor for a static load at full power is 1 242/490 = 2.6.

The helicopter model had a flight operational limitation that allows the maximum power drawn to correspond to 317 metric hp at 100 %Tq. This means that the actual safety factor is higher than that calculated above.

8 von Mises hypothesis – A generally accepted strength comparison between tensile stress and shear stress.

1.16.3 The freewheel

SHK has examined the freewheel. All four freewheel bearings showed damage and discoloration caused by lack of oil. Correspondingly, the freewheel's external and internal contact surfaces and its sprags were damaged by lack of lubrication. There were no chips at the chip warning system's indication plug on the freewheel's return oil side.

The contact surfaces both of bearings and the freewheel clutch were affected by heat, but not to the extent that the surface hardness was impaired. The bearing surfaces exhibited colour change. Wear marks on the inner part of the sprags in the freewheel and corresponding contact surfaces show that smearing of material had occurred, see Figure 13.

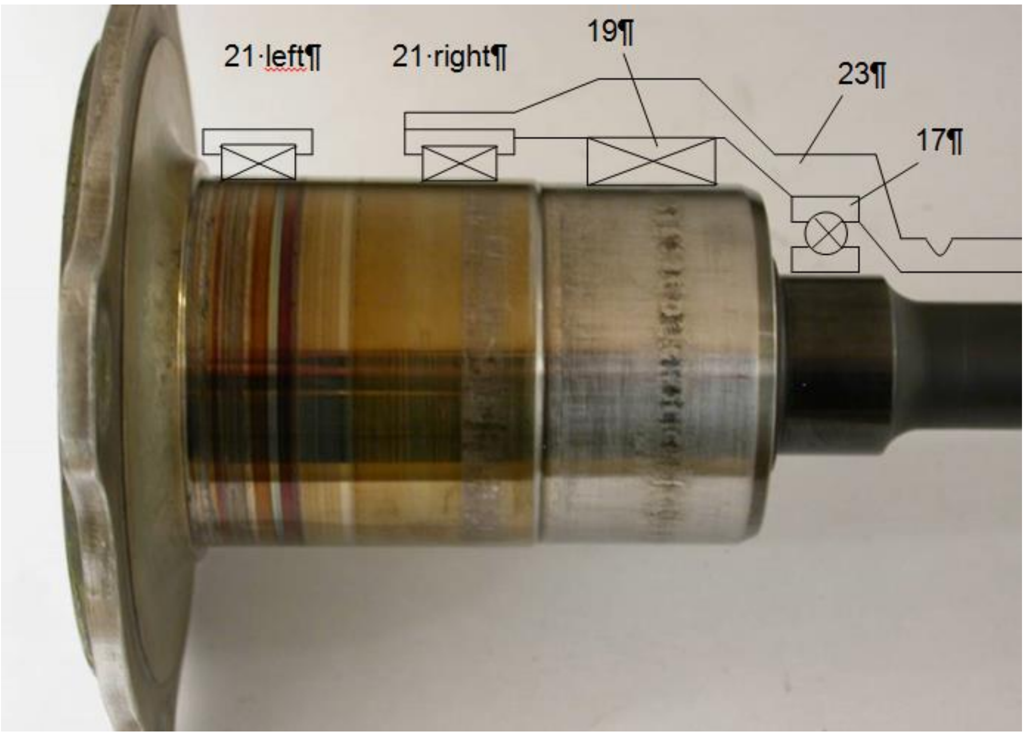

Fig. 13 Inner freewheel shaft with schematic description of bearings and sprags. The freewheel's sprags are Article 19 in the picture. All bearings (Articles 21 L, 21 R and 17) were damaged due to insufficient lubrication. (Photo: Exova)

1.16.4 1 500-hour inspection of the transmission

The operator's Part-145 shop had carried out a 1 500-hour component inspection of the main transmission on November 21 2011. This work involved withdrawing the transmission from the helicopter, and the cover on the transmission was opened. Before it was possible to open the cover, the existing sealant between the cover and transmission had to be removed.

After the inspection, the cover was remounted on the transmission. The joint between the two parts was sealed externally with a polymeric sealant, in this case Pro Seal 890 Class B. Finally, the transmission was remounted in the helicopter, and lines and other rotor components were put into place. Transmission oil was refilled. The transmission was mounted in the helicopter on April 3 2012.

1.16.5 Regulations for a clean environment during maintenance work

Point (c) of the regulation Part-145, Section 145.A.25 *Facility requirements*, which is issued by EASA, specifies that unless otherwise dictated by the particular task environment, the following is prescribed:

Dust and any other airborne contamination are kept to a minimum and not be permitted to reach a level in the work task area where visible aircraft/component surface contamination is evident.

SHK has not identified any specific rules in the Type Certificate Holder's Maintenance Manual or the operator's Part-145 organisation's MOE[9] on instructions concerning a clean environment during work on the transmission of the helicopter type.

1.17 Organisational and management information

The operator has long experience of flying in the mountains and held a permit for aerial work of various kinds and commercial air transport.

Furthermore, the operator had a Part-145 permit that, inter alia, covered periodic inspection, repair and modifications.

1.18 Additional information

1.18.1 Description of the freewheel's use during flight

Depending on how the helicopter is operated, the freewheel is loaded to different extents. The freewheel is installed as a safety solution so that an engine malfunction will not brake the main rotor. During normal operation, the freewheel disengages in connection with engine shutdown. The rotor system then continues to rotate until it stops.

In autorotation exercises, the aim is to keep the main rotor speed close to 100 % during large parts of the flight. Permitted rotor speed during autorotation is 90-107 %.

Depending on the height upon entering autorotation, the exercise flight time normally varies between 30 and 100 seconds. Autorotation exercises give a greater load on the freewheel than when the engine is shut down, because the difference in speed between main rotor and engine is then greater and usually has a longer duration. In addition, the freewheel is reengaged upon throttling after the autorotation exercise.

[9] MOE – Maintenance Organisation Exposition.

1.18.2 Other events of a similar kind

TSB Canada has investigated a similar case with the same helicopter type when contaminants in the lubrication system to the freewheel resulted in the freewheel not having functioned as intended, which resulted in a broken rotor mast. In that event, moisture had entered the lubrication system and caused corrosion that reduced the oil flow. TSB Canada's report[10] found that the manufacturer, Bell Helicopter, has recommended in a technical bulletin TB 206-79-31 that a filter be installed on the outgoing lubrication loop to the freewheel, see Figures 9 and 10.

The Australian Civil Aviation Safety Authority, with reference to the event in Canada and similar incidents in Australia, has recommended operators to install the filter stated in Bell Helicopter's technical bulletin and also to check the filter with a certain level of regularity.[11]

1.18.3 Environmental aspects

Not applicable.

1.19 Special methods of investigation

Not applicable.

[10] TSB Canada Aviation Investigation Report A11C0152.
[11] Airworthiness Bulletin AWB 62-002, issue 3, 27 November 2013.

2. ANALYSIS

2.1 The flight

The crew remained within the limits set by the flight manual. Approaches and landings were executed with recommended rotor speeds. The final landing was normal for the exercise. Neither environmental nor flight operational factors contributed to the accident.

2.2 The accident sequence

It is likely that the small piece of sealant that got caught in the restrictor ended up in the line between the filter and the restrictor in connection with work on the helicopter at the 1 500-hour inspection.

The investigation has not been able to determine how long the freewheel had been without sufficient lubrication. The lack of lubrication has, inter alia, resulted in a raising of the temperature in the freewheel. This has probably damaged the freewheel's sprags, whereby the freewheel has not functioned in the intended manner.

The approximately twenty autorotations executed in the flying hours before the accident have probably been crucial as the damage occurs faster when the freewheel does not have time to cool down between exercises.

The materials analysis shows that the mast has been twisted off due to overloading. SHK's calculation shows that the safety factor to torsional failure is at least 2.6 for a static load at full engine power. To achieve an overload failure thus requires an increased moment through dynamic effects.

A plausible scenario is that the failure may have occurred incrementally in conjunction with throttling after the preceding autorotations, which could mean that only a portion of the mast was intact before the final landing.

It is probable that the freewheel released as intended during previous autorotations, but did not engage when the free turbine speed was to meet the rotor speed at the same time as the rotor geared down. If the speed of the free turbine was significantly higher than that of the rotor when the sprags engaged, possibly faster than normal, an additional dynamic moment arose. The energy that was stored up in the engine and transmission was braked by the inertia of the main rotor, whereby the moment on the mast exceeded the fracture strength.

How great this additional moment becomes depends on the speed difference, the mass inertia of the motor system and how fast engagement takes place. Of these three variables, it is not possible to establish the speed difference and engagement time, which means that it is not possible to determine the sequence in purely numerical terms.

However, it is clear that the size of the speed difference between free turbine and rotor is crucial to what energy is stored up and can be converted into the force transmitted to the rotor mast.

In the case of the freewheel not engaging when the free turbine's speed increases and goes past the rotor speed, the resistance for the free turbine is low, which means that the speed increase is able to occur very quickly. This means that it can be difficult for the crew to have time to perceive the course of events.

2.3 Sensitivity to contaminants in the freewheel's lubrication system

In the case in question, the contaminant was of the size 1.4 x 4.2 mm. As the restrictor's diameter is 1.1 mm, a ball of diameter 1.2 mm is sufficient to completely block the restrictor.

The general regulations state that contamination in the work task area may not exceed a level where it is evident on an aircraft surface.

SHK's interpretation is that occasional contaminants of around one millimetre in size can occur before becoming evident on an aircraft surface.

This means that there is a risk of contaminants that can lead to catastrophic consequences entering the system during maintenance work.

3. CONCLUSIONS

3.1 Findings

a) The crew was qualified to perform the flight.
b) The helicopter had a Certificate of Airworthiness and valid ARC.
c) The helicopter was operated in accordance with the flight manual.
d) Bell Helicopter's bulletin TB 206-79-31 on the introduction of filters in the freewheel lubrication was introduced.
e) A contaminant had entered an area between a filter and the restrictor of the oil flow to the freewheel.
f) By means of the contaminant, the oil flow to the freewheel was reduced under a critical level for acceptable lubrication.
g) The rotor mast broke due to overloading through dynamic effects.

3.2 Causes

The accident was caused by the design of the freewheel's lubrication system allowing a contaminant of a size that can occur in a Part-145 shop to block the oil flow to the freewheel.

4. SAFETY RECOMMENDATIONS

EASA is recommended to:

- act for a reduction in the oil system's sensitivity to contaminants. *(RL 2014:09 R1).*

- act so that operators of the helicopter type are provided with information and suggestions for preventive measures regarding the risk of contamination of the free wheel's lubrication system. *(RL 2014:09 R2)*

Transport Canada is recommended to:

- act for a reduction in the oil system's sensitivity to contaminants. *(RL 2014:09 R3).*

- act so that operators of the helicopter type are provided with information and suggestions for preventive measures regarding the risk of contamination of the free wheel's lubrication system. (*RL 2014: 09 R4*)

The Swedish Accident Investigation Authority respectfully requests to receive, by **6 Oktober 2014** at the latest, information regarding measures taken in response to the recommendations included in this report.

On behalf of the Swedish Accident Investigation Authority,

Jonas Bäckstrand Sakari Havbrandt