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***Final report RL 2013:01e***

**Incident involving the helicopter SE-JNE  
in Gällstad, Västra Götaland County,  
on 6 February 2012**

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1. EASA,
2. The Swedish Transport Agency  
Civil Aviation Department

### **Final report RL 2013:01e**

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The Swedish Accident Investigation Authority (Statens haverikommission, SHK) has investigated an incident that occurred on 6 February 2012 in Gällstad, Västra Götaland County, involving a helicopter with the registration SE-JNE.

In accordance with Regulation (EU) No 996/2010 on the investigation and prevention of accidents and incidents in civil aviation, the SHK investigation team hereby submits a final report on the results of the investigation.

The Swedish Accident Investigation Authority respectfully requests to receive, by 15 April 2013 at the latest, information regarding measures taken in response to the recommendations included in this report.

This document is a translation of the original Swedish report.

On behalf of the Swedish Accident Investigation Authority,

Jonas Bäckstrand

Staffan Jönsson

## **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. The investigation is carried out in accordance with Annex 13 of the Chicago Convention.

## **The investigation**

SHK was notified on 6 February 2012 that an incident involving a helicopter with the registration SE-JNE had occurred at 15.34 hrs that day in Gällstad, Västra Götaland County.

The incident has been investigated by SHK as represented by Mr Jonas Bäckstrand, Chairperson, Mr Staffan Jönsson, Investigator in Charge and Technical Investigator, Mr Agne Widholm and Ms Ulrika Svensson until 16 March 2012, Operations Investigators and Mr Patrik Dahlberg, Investigator specializing in Rescue Services.

The investigation was followed by Mr Thore Brandt of the Swedish Transport Agency.

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Helicopter; registration and model	SE-JNE, Guimbal Cabri G2
Class - Airworthiness	Normal - Certificate of Airworthiness and valid Airworthiness Review Certificate (ARC)
Owner - Operator	SG Finans AS Norway, Swedish branch - Northern Helicopters AB
Time of occurrence	02 Feb 2012, 15.34 hrs in daylight Note: All times are given in Swedish standard time (UTC <sup>1</sup> + 1 hr)
Place	Gällstad, Västra Götaland county, (pos. N 57°39.3' E 013°23.9'; 174 m above sea level)
Type of flight	Training flight
Weather	According to SMHI's analysis: southerly wind 5 knots, visibility >10 km, 5-8/8 with the cloud base at 7000-8000 feet, temp/dewpoint -9/-13 °C, QNH 1038 hPa
Persons on board:	
crew members	1
passengers	0
Injuries to persons	None
Damage to aircraft	Minor
Other damage	None
Pilot:	
Age, licence	22 years, PPL
Total flying hours	69.1 hours, of which 11.9 hours on type
Flying hours previous 90 days	11.9 hours, of which all on type
Number of landings previous 90 days	38, all on type
<b>Aircraft</b>	
TC-holder	Hélicoptères Guimbal
Model	Cabri G2
Serial number	1013
Year of manufacture	2010
Gross mass	Max authorized take off/landing mass 700 kg, actual 538 kg
Centre of gravity	Within the permitted interval
Total flying time	811.3 hours
Flying time since latest inspection, which was a 100-hour inspection	2.4 hours
Number of cycles	No information
Fuel loaded before event	Avgas 100LL
<b>Outstanding remarks</b>	
MEL	None
HIL	None

<sup>1</sup> UTC - Universal Time Coordinated is a reference for the exact time anywhere in the world.

### **History of the flight etc.**

The flight was a navigation flight taking off at Jönköping-Axamo Airport (ESGJ) at 15:08 hrs and was a part of the pilot's training as a commercial helicopter pilot at the flying school Northern Helicopters, which is located at the airport.

The flight was planned for destinations Ulricehamn, Tranemo and Mulseryd at 1500 feet QNH<sup>2</sup> and subsequent final landing at Axamo. The pilot was alone on board and just before crossing Ulricehamn, he turned south to avoid passing over the town. He had also at that time increased the flight altitude to 2000 feet QNH in order to have reasonable obstacle clearance. When he was half way to Tranemo and after less than 30 minutes' flight, he experienced a loud bang from the space behind his back where the engine and transmission are located. The sound changed to one of rattling accompanied by vibrations. Both grew in amplitude very rapidly.

He reduced the speed from 80 to 70 knots and then established autorotation at a speed of 50 knots. The pilot called air traffic control at Axamo and declared an emergency by calling "Mayday" three times and stating "Engine problem" and "Forced landing". Shortly thereafter, he was called by air traffic control, which asked about his position, but on account of vibrations and the critical flying situation, he was only able to state the position as "South".

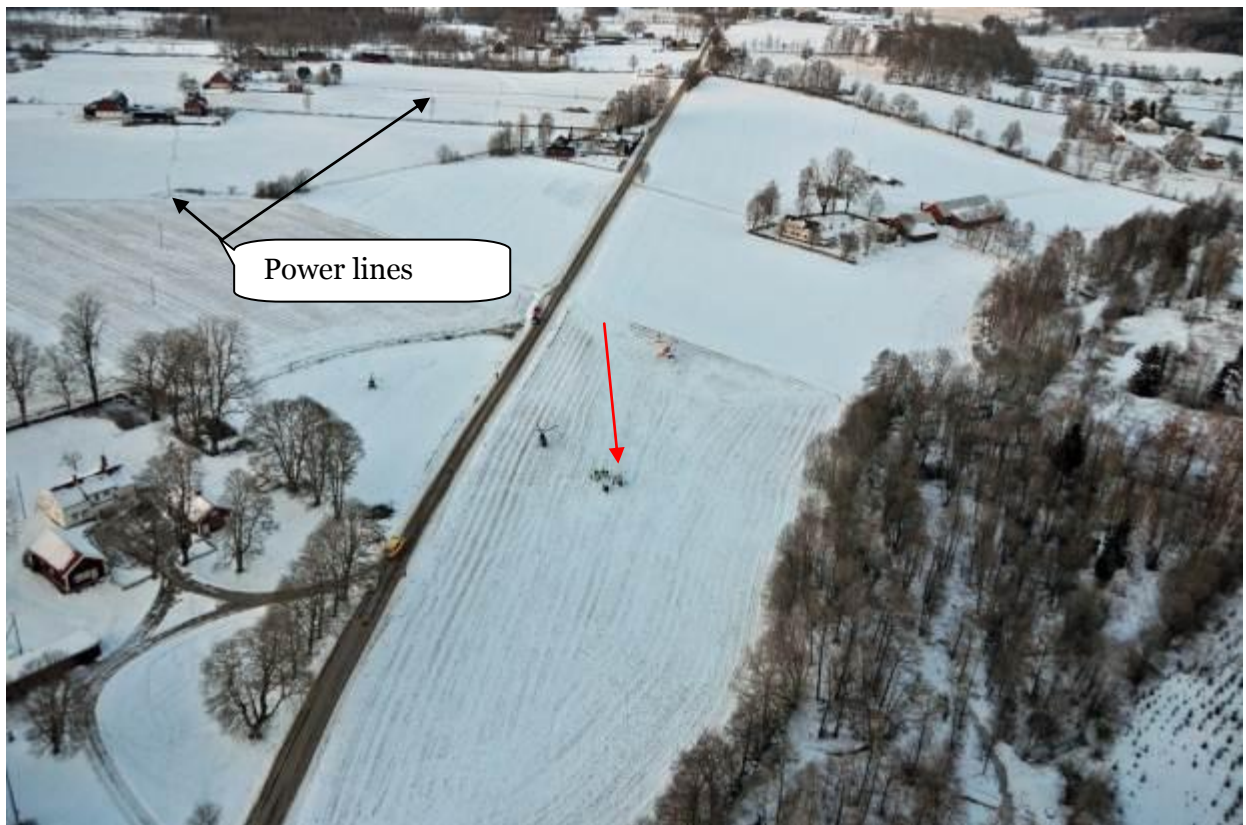
The main rotor speed was about 500 rpm, just below the green rpm (permitted rpm), but never dropped below 466 rpm, which is the rpm at which the warning for low rotor speed is activated. The pilot had difficulty in maintaining the heading, even with full pedal displacement, for which reason he decided to increase the speed to 70 knots so as to achieve better stabilization in yaw from the fin.

During autorotation, the pilot's headset and sunglasses fell off due to the powerful vibrations. The helicopter's warning panel presented no warning, but initially in autorotation, the pilot perceived the rotor speed to be low. The vibration level remained high, and it was not possible for him to read the instruments. He chose to reduce engine speed but was not completely successful in doing so. The pilot has stated that he switched off the engine regulation (the governor function)<sup>3</sup>.

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<sup>2</sup> QNH - Barometric reference area for altimeter setting, based on mean sea level.

<sup>3</sup> Governor - Engine power output is linked to the position of the collective; a high collective position gives high power.



**Figure 1** - The helicopter with pilot and some members of the rescue team; the red arrow tip indicates the emergency-landed helicopter (Photo: The Swedish Police Wing)

The pilot had selected two fields in the direction of flight as possible for an emergency landing, and he manoeuvred towards the larger of the two fields. As he got closer, he noticed that several power lines limited obstacle clearance, see Figure 1, and he then chose the somewhat smaller field further on in the direction of flight. When he raised the nose to reduce forward speed and simultaneously raised the collective to reduce the rate of descent, there was a marked increase in the vibrations. The helicopter yawed to the right, and he was forced to return the collective to the autorotation position. Full displacement of the left pedal did not correct the yaw. In the present case, the rpm was about 10% under the nominal value.

At touchdown, the helicopter had forward speed and made gentle contact with the ground, tail skid<sup>4</sup> first; the tail's contact with the ground decreased the yaw. After this, the right landing skid and then the left landing skid made contact with the ground, and for the final stretch, the helicopter slid forward on both skids. The pilot estimated that the speed at touchdown was about 20 knots.

The time elapsed from the pilot declaring Mayday until he landed on the selected field was 26 seconds (according to the sound recording from Axamo tower). Once on the ground, he confirmed when questioned by the air traffic controller that he was "Down on the ground".

After touchdown, the pilot switched off the main switch in view of the fire risk and the fact that he detected a distinct odour of burnt rubber.

The Emergency Locator Transmitter was not activated during the landing.

<sup>4</sup> Tail skid - Protection or support far back on the underside of the tail boom or the fin

## Description of the helicopter's transmission and engine mount

The engine is mounted in three points using a statically determinate mount. The front point consists of a single row deep groove ball bearing mounted in the engine pulley (Fixed and moving points, see Figure 2). The bearing is at the same time the engine's moving bearing point for the eccentric that tensions the drive belt between engine and transmission. The second point (bolt) of the eccentric is fixed in the helicopter's firewall - structure (unit 30 in Figure 3).

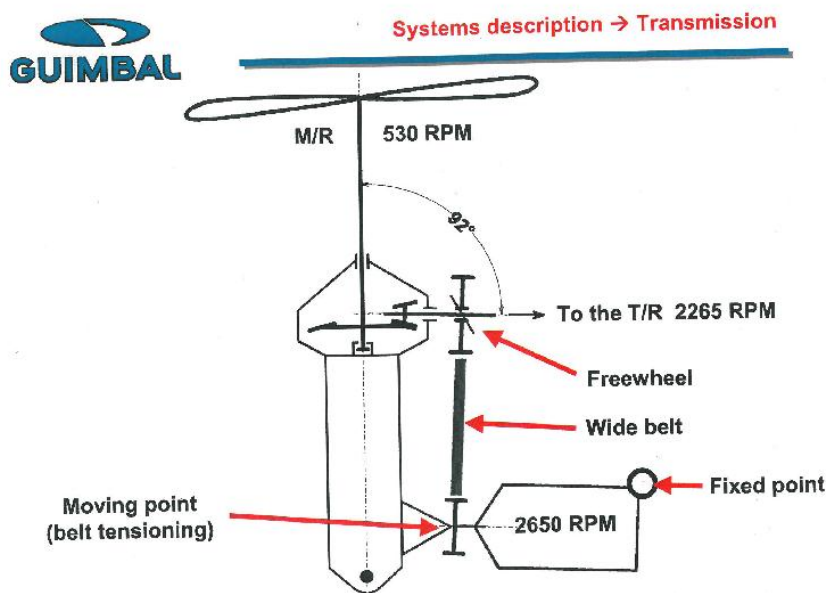
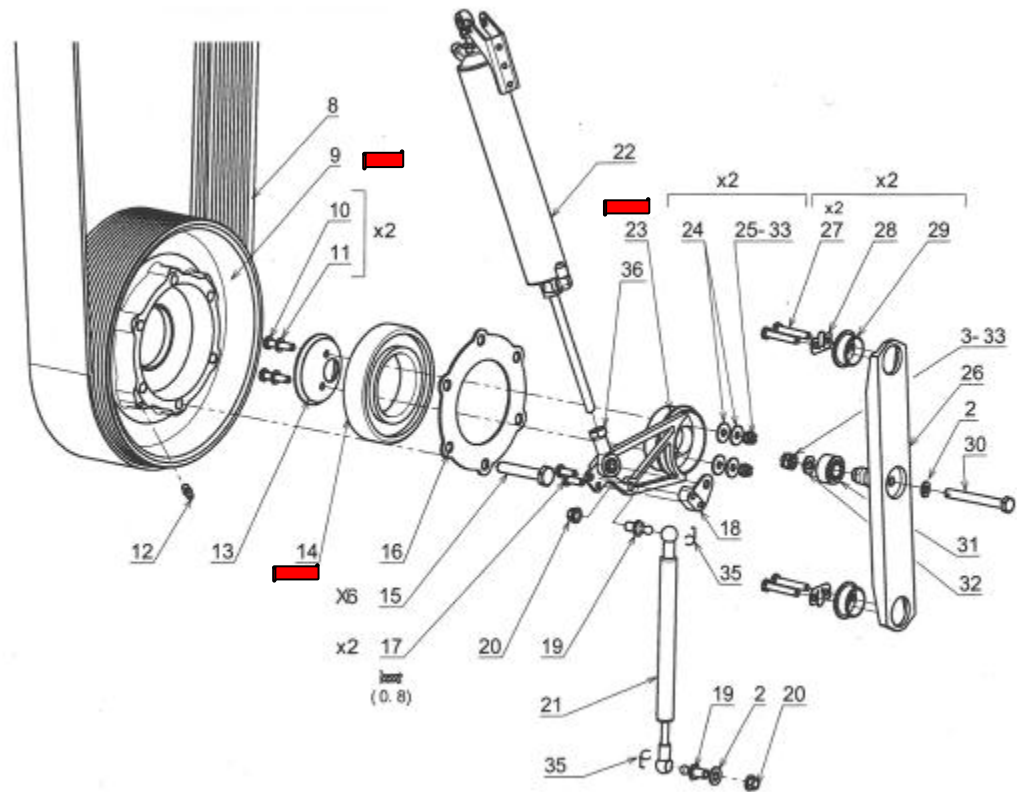


Figure 2 - Schematic of the transmission and engine (Hélicoptères Guimbal)

When starting up for flight, the engine is started, and when the engine parameters have stabilized, the engine is connected with the rotor system. The connection takes place through a hydraulic cylinder (unit 22 in Figure 3) being pressurized with pressure from the engine oil system. The upper end of the hydraulic cylinder is secured to the structure, and the lower end to the eccentric. Unit 23 in Figure 3.

The entire front end of the engine is then moved downwards and slightly to the left, whereby the drive belt is tensioned and the engine's moment is transmitted to the gearbox. Should the engine stop or otherwise reduce rpm (so that the rpm is lower than the rpm of the transmission's input shaft), the freewheel mounted in the upper pulley on the gearbox input drive shaft disengages, see Figure 2. The rotor is then not braked, but can continue to rotate due to its kinetic energy. There is no system to monitor or record the vibration levels during operation of the rotorcraft.

Access for lubrication of the bearing that has caused damage is achieved via a grease nipple mounted on the engine pulley, found between the firewall and the belt pack, see Figure 6.



**Figure 3** - Diagram of belt tensioning from the parts catalogue (Hélicoptères Guimbal)

### Maintenance of the ball bearing

The lubrication of the bearing originally took place in connection with the inspection designated B5 every 500 flying hours or every 60 months (whichever comes first). According to instructions in AMM 51-A-03, issue 4,<sup>5</sup> that were applicable at the time, the grease gun was to be weighed before and after lubrication, and a normal quantity of injected grease was 10 to 20 grams. There is no visual means of inspecting that the grease really has filled the volume available in the bearing. The seal covers the bearing and acts as a dust cover, see unit 16 in Figure 3.

The only means to visually inspect the area around the grease nipple is with the aid of a mirror.

Hélicoptères Guimbal reacted quickly to the SHK investigation finding, which showed, among other things, that the bearing had failed, and issued a Mandatory Service Bulletin (MSB) numbered BS 12-004 A on 16 February, in which the interval between lubrications was shortened. After revision of the interval, the first time lubrication takes place shall be no later than at the next 50-hour inspection and subsequently every 100 flying hours.

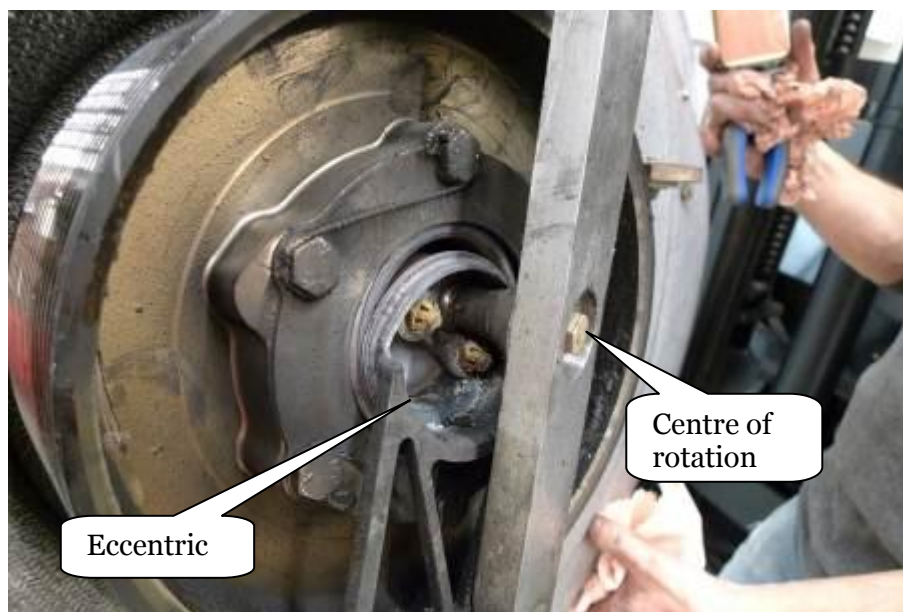
According to the type certificate holder the MSB BS 12-004A ensures that there is margin for enough greasing and that the amount does not exceed the quantity that leads to leaking on to the belt. Excess grease would also slightly overheat the bearing.

<sup>5</sup> AMM – Aircraft maintenance manual

### Damage to the aircraft

The tail skid on the lower part of the fin exhibited the only externally visible damage. The tail skid was bent upwards, and the distance to the lower fin was reduced to 11 cm. Nominally, this distance is to be about 13 cm.

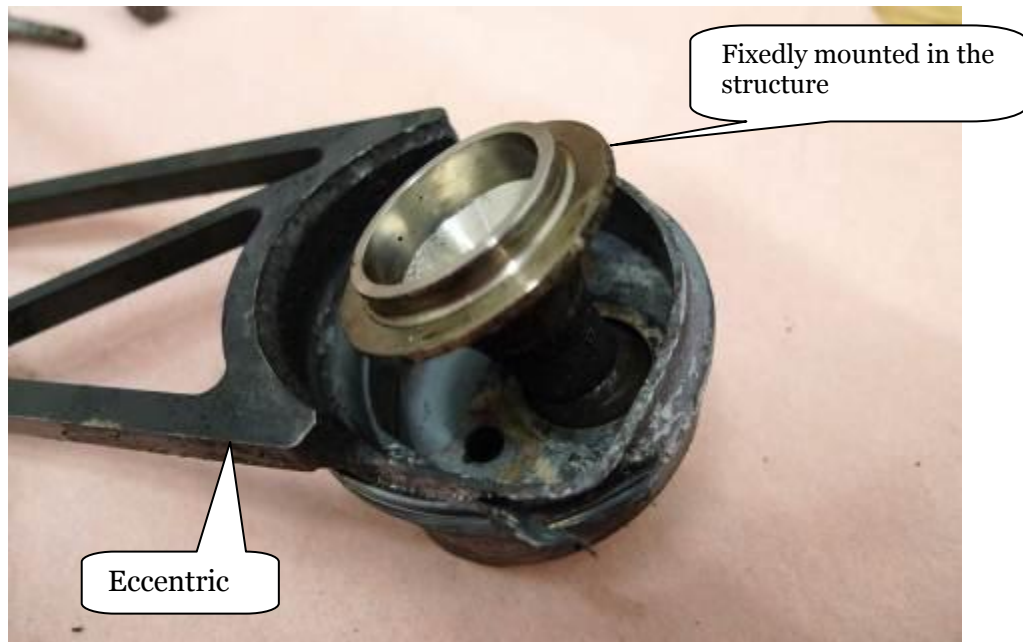
A more detailed examination of the helicopter's drive line demonstrated that the avant-garde front engine mount point had serious damage. The single row deep groove ball bearing that constitutes the engine's front mount had failed. The ball race had been compressed, see Figure 6.



**Figure 4** - The engine pulley with front engine mount and eccentric for the fitting of the drive belt. The vertical bar is fixed in the structure; when the belt is fitted, the entire engine rotates around a point in line with the hexagonal bolt head.

When the bearing had failed, the outer bearing race began rotating in the bottom (engine) pulley. At the same time, the eccentric's support in the inner bearing race began to rotate. The force increased and reached a level so great that the hydraulic cylinder failed to keep the drive belt in tensioned position. The drive belt loosened and started to slip on the drive wheels.

The vibrations emanated from the failed ball bearing.



**Figure 5** - Severely heat-affected eccentric; the material has reached the yield point. The black lower part should be circular and lie flush with the ball bearing's inner bearing race.



**Figure 6** - The pulley mounted on the engine; note that the ball bearing's inner bearing race is elliptic. The bearing's ten balls have been compressed in a part of the bearing. The ball cage has been damaged, allowing the balls to move so that the distance between the balls is not evenly distributed.

The ball bearing had ceased to function as a bearing. The temperature rise was severe due to the considerably increased friction and the stability of the front engine suspension being breached. According to CS 27X602<sup>6</sup>, the integrity of the engine and the belt drive is, in an extension of the incident, to be classed as hazardous. For this class of critical parts, a “Critical parts plan” is produced.

The three parts that SHK has investigated; the lower pulley, bearing and coupling arm (eccentric), are all listed as critical details; in Figure 3 these are marked in red. In the certification process, a number of tests are carried out to

<sup>6</sup> CS-27 – Certification standard for small rotorcraft, construction provisions for small helicopters. X – indicates that paragraph 602 is not part of FAA Part-27.

ensure that redundant load paths are available in the event of fractures in these primary units.

### **Fractographic examination of the pulley, ball bearing and eccentric**

An independent laboratory (Exova) has investigated the pulley pos. 9, ball bearing pos. 14 and eccentric pos. 23, the references to each part relating to Figure 3. The purpose of the examination was to determine, if possible, the origin of the damage. Initially, it was suspected that the ball bearing had been subjected to axial forces of a magnitude that had not been taken into account in the design of the belt tensioning mechanism. The examination did not prove this theory.

The bearing's inner bearing race has begun to slide towards the centre of the eccentric. The frictional heat has yielded a temperature of over 800 °C, and the microstructure of the material has disintegrated and phase transformation has taken place. The material had been so soft that it had been plastically deformed and pressed radially, outwards over the balls. The temperature has also reduced the hardness of the inner bearing race from about 700 HV to 320 – 370 HV<sup>7</sup>.

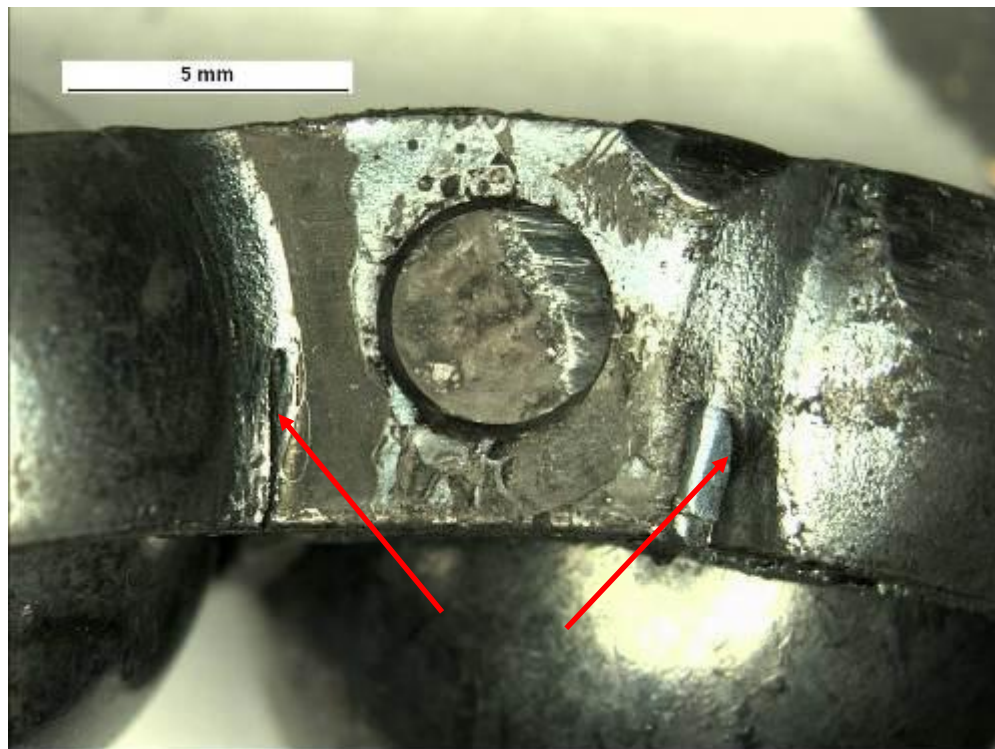


**Figure 7** - Reference ball and ball with friction damage (Photo: Exova)

A complete bearing should contain ten balls. All these remained, but one ball exhibited more extensive damage, see Figure 7. This ball has become jammed between the inner and outer bearing races and begun to slide towards the outer race (normally the balls roll). With increasing friction, this ball has gradually ground down the ball cage, allowing the balls to gather in one cluster along a little more than half the circumference of the bearing.

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<sup>7</sup> HV - hardness according to Vickers.



**Figure 8** - Cracks in the ball cage on the back of the rivet (red arrows); the damage is secondary. Note that there were primary fatigue cracks in parts of the ball cage (Photo: Exova).

The jammed ball has also caused the outer bearing race to rotate in the pulley. However, the damage to the outer bearing race is less pronounced than that to the inner race, and the hardness and microstructure of the bearing race have not been affected to the same extent as those of the inner race. Besides the damage mentioned, there are only fatigue cracks/fractures on the ball cage, see Figure 8. Neither typical bearing damage, such as “spalling<sup>8</sup>” in the bearing races, nor axial load, could be substantiated.

Remaining primary damage:

- the bearing had overheated due to insufficient lubrication
- the ball cage had failed due to fatigue fractures caused by vibrations
- the bearing had overheated due to excessive play between the bearing's inner race and the coupling arm's eccentric that caused the bearing race to slip and generate heat, the latter sequence, however, being less likely

### **Examination of the lubrication properties of the grease**

An independent materials laboratory has examined the batch (production batch) of grease that was used since the most recent lubrication of the bearing before the failure. The examination shows that the grease used met the specifications stated by the grease manufacturer according to current standards.

### **The rescue operation**

A distress call from the helicopter was received by air traffic control at Axamo Airport on tower frequency 118.250 MHz at 15.34 hrs. The helicopter pilot only had time to declare an emergency before the transmission was broken. After a few futile attempts to call the pilot via radio, the air traffic controller

<sup>8</sup> Spalling - small metal flakes are torn away from the bearing race

alerted the Air Rescue Coordination Centre JRCC<sup>9</sup> in Gothenburg and conducted a three-party conversation with SOS Alarm. At the same time, the airport rescue services were alerted.

Information was provided to JRCC by the air traffic controller at Axamo that a probable position for the helicopter was west of the airport between Gällstad and Dalstorp and that there were two persons in the helicopter. From JRCC, a rescue helicopter based in Gothenburg was alerted. The task of the rescue helicopter was to locate the site of the emergency landing and rescue those in distress.

Via the SOS centre in Jönköping, the emergency services, ambulance and police were alerted. When the probable area for the emergency landing had been narrowed down by the Air Rescue Coordinator at JRCC, the Södra Älvsborg Fire and Rescue Service, having the nearest fire station in Ulricehamn, was alerted instead of the Jönköping Fire and Rescue Service that had been alerted initially. The units were directed towards Gällstad.

The airport rescue services, which had also driven towards Gällstad, were withdrawn by JRCC when it became clear that the area in question was further away than the immediate vicinity of the airport. In this way, flight operations at Axamo Airport could be maintained.

At 15.51 hrs, information from air traffic control was conveyed that there might only be one person in the helicopter. This was confirmed at 16.00 hrs by JRCC, which had overheard a conversation between the pilot and a private helicopter from the airport.

The pilot in the emergency-landed helicopter had telephoned the school at the airport and sent his position via a positioning tool on the phone. With that information, another of the flying school's helicopters found the site of the emergency landing and communicated the position to JRCC. At 16.08 hrs, the rescue units arrived at the site of the emergency landing.

Staff from the emergency and medical services made an initial assessment of the pilot's status and found the pilot to be uninjured.

The rescue operation was concluded at 16.30 hrs.

## **Conclusions**

The flight was completely normal until the loud bang was heard. The pilot's quick reaction and ability to adjust flying to the situation that had arisen allowed for a successful autorotation landing. The low flight altitude meant that the time from when the damage occurred until an autorotation landing had been executed resulted in the avoidance of a very serious incident

Due to the low rotor speed, the landing was executed as a glide landing with relatively high forward speed at touchdown on a snow-covered cultivated surface.

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<sup>9</sup> JRCC – Joint Rescue Coordination Centre; the direction of rescue operations takes place from the joint coordination centre in Gothenburg

The materials examination shows that the incident was caused by the failure of the single row deep groove ball bearing of the eccentric that tensions the drive belt and is also the front engine mount. The bearing failed as a result of insufficient lubrication or the ball race has failed due to fatigue fractures caused by vibrations. A factor contributing to this may be the design of, and difficulty in accessing, the lubrication point on the ball bearing and verifying that grease has penetrated into the bearing

The helicopter has no systems for monitoring vibration levels (accelerometers). It is therefore difficult to determine whether the load on the ball race was the result of prolonged operation with an adverse load on the bearing. Due to the extensive bearing damage, it is also not possible to demonstrate which of the failure sequences the primary one is.

The engine is attached to the engine mount at its rear, with free forward motion, preventing significant axial load on the front bearing. It was suspected that the single row deep groove ball bearing had been subjected to axial forces. The materials examination showed that the bearing had not been subjected to axial forces.

The bearing arrangement allows no opportunity to verify visually that the grease has penetrated into the bearing, and so the grease flow when applying lubrication is uncertain. The maintenance programme requirements for weighing the grease gun before and after lubrication of the bearing in order to determine a quantity of injected grease of 10 to 20 grams give great uncertainty. A standard grease gun weighs 2-4 kg depending on size and quantity of residual grease; ideally then, the recorded weight should be accurate to within ten parts per thousand. The probability is low that the right quantity of grease is injected, and there is a risk of insufficient lubrication. The proposed method of inspecting the quantity of injected grease with sufficient accuracy using scales is unsatisfactory.

The rotorcraft type certificate holder has issued a mandatory service bulletin in order to reduce the time between lubrications from 500 to 100 flying hours. This solution must, however, be viewed as temporary. Further work is in progress to improve the lubrication of the bearing and the seal around the bearing. In the long term, work is also being done on a change in the cage that would minimize the effect of insufficient lubrication. Improvement of the lubrication instruction of the bearing is also worked on.

The investigation regarding the rescue operation does not demonstrate any problems in terms of direction or coordination of the operation. With respect to the details of positioning and the late stage of securing the information about how many persons were affected, SHK considers this to be within the recommendations to the Swedish Transport Agency as presented in Report RL 2011:17 and whose response is considered to attend to these.

**The accident was caused by:**

- The deep groove ball bearing in the engine pulley failed. The underlying cause was that it is delicate to inspect with certainty whether grease has penetrated into the bearing when applying lubrication.

**Recommendation**

EASA is recommended to ensure that Hélicoptères Guimbal amends the procedure for the lubrication of bearings with part number HG61-0790 so that at inspections it is possible with certainty to determine that a sufficient quantity of grease has been injected into the ball bearing and at the correct position.

*(RL 2013: 01 R1).*