Statens haverikommission
Swedish Accident Investigation Board

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Report RL 2006:23e

Aircraft accident to helicopter SE-HVY, south-west of Lundsbrunn, O county, on 4 October 2005

Case L-37/05

SHK investigates accidents and incidents with regard to safety. The sole objective of the investigations is the prevention of similar occurrences in the future. It is not the purpose of this activity to apportion blame or liability.

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Translated by Peter Langsdale from the original Swedish at the request of the Swedish Accident Investigation Board.

In case of discrepancies between the English and the Swedish texts, the Swedish text is to be considered the authoritative version.

Statens haverikommission (SHK) Swedish Accident Investigation Board

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2006-12-14 L-37/05

The Swedish Civil Aviation Authority

SE-601 73 NORRKÖPING, Sweden

Report RL 2006:23e

The Swedish Accident Investigation Board has investigated an aircraft accident that occurred on 4 October 2005 south-west of Lundsbrunn, O county, involving a helicopter with registration SE-HVY.

In accordance with section 14 of the Ordinance on the Investigation of Accidents (1990:717) the Board herewith submits a report on the investigation.

The Board will be grateful to receive, by 15 June 2007 at the latest, particulars of how the recommendations included in this report are being followed up.

Carin Hellner Göran Lilja

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Report finalised 14-12- 2006

Aircraft; registration and type	SE-HVY, Hughes 369D
Class/airworthiness	Normal, valid Certificate of Airworthiness
Owner/Operator	HT Helikoptertransport AB, Mälby gård, SE-740 81 GRILLBY, Sweden
Time of occurrence	4 October 2005 at 16:24 in daylight *Note.*: All times are given in Swedish daylight saving time (UTC + 2 hours)
Place	South-west of Lundsbrunn, O county, (position N 5827.0, E01323.4; 150 m or 492 feet above sea level)
Type of flight	Commercial flight, inspection of power lines
Weather	According to the SMHI (Swedish Meteorological and Hydrological Institute) analysis: Wind south-west 5 knots, good visibility, temperature/dew point +18/+10 °C, QNH 1031 hPa.
Persons on board:	
crew members	1
passengers	None
Injuries to persons	None
Damage to aircraft	Substantially damaged
Other damage	None
Pilot:	
Sex, age, licence	Male, 44 years, BH (Commercial Helicopter) licence
Total flying time	6700 hours (all on helicopters), of which 3000 hours on type
Flying hours previous 90 days	150 hours, of which 50 hours on type
Number of landings previous 90 days	Approx. 250, of which 40 on type

The Swedish Accident Investigation Board (SHK) was notified on 4 October 2005 that a helicopter with registration SE-HVY had an accident at 16:24 hours on that day at O county. The accident was investigated by SHK represented by Carin Hellner, chairperson, and Göran Lilja, chief technical investigator aviation. The investigation was followed by Gun Ström, Swedish Civil Aviation Authority.

Summary

The helicopter SE-HVY was being used on 4 October 2005 for inspection of an electrical power line. After completing work for the day the pilot interrupted the return flight at a farm south-west of Lundsbrunn in O county. He took off at 16:24 with the intention of continuing the flight. The take-off was from a grass field. This was an open area with no obstacles. The weather and visibility were good. There were no known technical problems.

The pilot was in good health. Immediately after take-off a loud bang was heard from the engine, which stopped immediately. The helicopter came down in a field of loose soil. Flames briefly appeared from the engine but the fire did not spread. The helicopter was extensively damaged. The pilot exited unhurt. The engine stoppage was been determined as due to a total failure of the compressor, which in turn led to the breakage of a compressor blade as a result of fatigue. This was very probably initiated by corrosion of the compressor wheel material.

Recommendations

The Swedish Civil Aviation Authority recommends that:

- suitable measures are taken to inform operators using this type of engine of the risk of blade corrosion and the importance of regularly washing the compressor in accordance with the manufacturer's recommendations *(RL 2006:23e R1)*.

1 FACTUAL INFORMATION

1.1 History of the flight

The pilot was performing electricity power line inspections from the air using a helicopter and on the day of the accident had flown for about 2 ½ hours. The aerial inspection for the day had been completed and he was to fly the helicopter back to the temporary base at Skövde. On the way back to base the pilot landed in a field near a farm to visit an acquaintance. After a brief stay there, he started again in order to continue the flight. The pilot was alone on board.

After a climbing hover, which was completely normal, the pilot accelerated the helicopter forward while climbing, in a north-westerly direction. When the helicopter reached approximately 30 knots of forward speed and at a height of 5-10 metres above ground level a loud bang was heard and the engine suddenly stopped.

Before the pilot had time to initiate autorotation the helicopter hit the ground and fell on its left side. Witnesses on the ground heard the bang and saw flames emerging from the engine exhaust. The fire quickly extinguished and caused no damage beyond the engine.

The pilot was unhurt and could exit the helicopter without assistance. The helicopter sustained extensive damage, but its cabin was largely intact. The accident occurred at location N 5827,0, E01323,4[1]; 150 m above sea level

1.2 Injuries to persons

	Crew members	*Passengers*	*Others*	*Total*
Fatal	–	–	–	–
Serious	–	–	–	–
Minor	–	–	–	–
None	1	–	–	1
Total	1	–	–	1

1.3 Damage to aircraft

Substantially damaged.

1.4 Other damage

None.

1.5 Personnel information

1.5.1 Pilot in command

The pilot in command was 44 years old at the time and had a valid BH (Commercial Helicopter) Licence.

[1] Read as degrees, minutes and decimal parts of minutes

Flying hours			
latest	*24 hours*	*90 days*	*Total*
All types	5	150	6700
This type	5	50	3000

Number of landings this type previous 90 days: 40.
Flight training on type concluded on 27 April 2005.
Latest PC (Proficiency Check) carried out on 27 April 2005 on S350.

1.5.2 The crew member's duty schedule

The night before the accident, the pilot had slept 8 hours. At the time of the accident he had been awake for 8 hours, of which he had been on duty for 6 hours. He had taken a break immediately before the accident.

1.6 Aircraft information

AIRCRAFT	
Manufacturer	Hughes Helicopters
Type	369D
Serial number	970188D
Year of manufacture	1977
Gross mass	Max. authorised start mass 1360 kg, actual 900 kg
Centre of mass	Within permitted limits
Total flying time	Approx. 7010 hours
Flying time since latest inspection	1612 hours
Fuel loaded before event	Jet A1
ENGINE	
Manufacture	Rolls-Royce Corporation (Allison)
Model	250 C20B (serial number CAE 830753)
Number of engines	1
Engine	
Total operating time, hrs	6856
Compressor	
Serial number	CAC-37348
Total flying time	6643
Operating time since overhaul	3359
Operating time since inspection	1612
Compressor stages 2 and 3:	
Serial number	KR 75090
Total flying time	3359
Operating time since inspection	1612
ROTOR	
Rotor manufacturer	Hughes Helicopters
Rotor operating times since overhaul	
Main rotor	437 hours
Tail rotor	890 hours

The aircraft had a valid Certificate of Airworthiness

1.7 Meteorological information

According to the SMHI (Swedish Meteorological and Hydrological Institute) analysis: Wind south-west 5 knots, good visibility, temperature/dew point +18/+10 °C, QNH 1031 hPa. It was daylight.

1.8 Aids to navigation

Not applicable.

1.9 Communications

Not applicable.

1.10 Aerodrome information

Not applicable.

1.11 Flight recorders

Not required and not installed.

1.12 Accident site and aircraft wreckage

1.12.1 Accident site

The helicopter came down in an open field near to the farm premises located approx. 4 km south-west of Lundsbrunn. At the time the land consisted of loose soil that had been autumn seeded.

1.12.2 Aircraft wreckage

The landing gear was destroyed and extensive damage occurred to the helicopter structure. The tail boom was detached and all the main rotor blades were damaged.

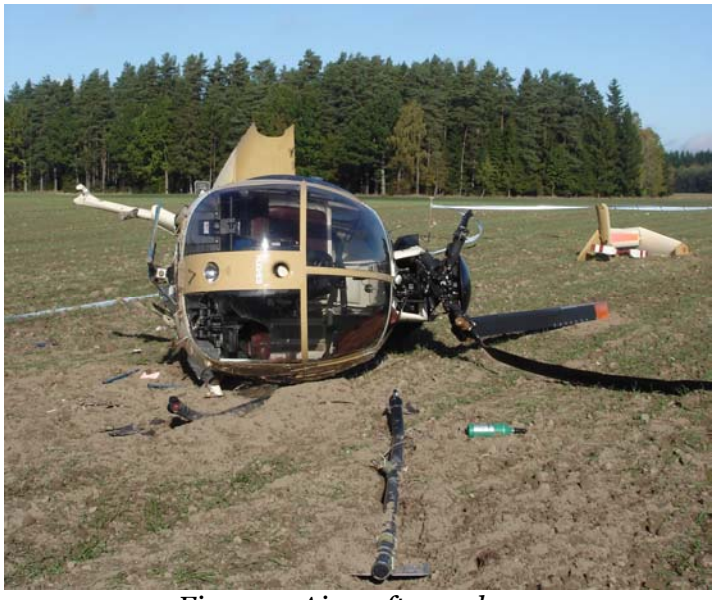

Figure 1. Aircraft wreckage

1.13 Medical information

Nothing indicates that the mental and physical condition of the pilot was impaired before or during the flight.

1.14 Fire

According to reports from the pilot and observers on the ground, flames were seen briefly coming from the engine after the crash. The fire went out by itself and caused no further damage. The information about the fire was reinforced by observations made during the engine examination. The pilot had switched off the fuel supply to the engine.

1.15 Survival aspects

The Emergency Locator Transmitter (ELT), of type and manufacture Artex 200, was activated by the impact. The internal fittings in the helicopter were mainly intact. The safety belt and seat showed no signs of damage. The right hand door was unaffected and used as an exit (the left hand door was resting on the ground). The fact that the fire did not spread must be considered as important for survival.

1.16 Tests and research

1.16.1 Technical examination of the helicopter

SHK performed a detailed technical examination of the entire helicopter in conjunction with the operating company's technical manager. Apart from damage caused by the impact, no faults or abnormalities were found in the helicopter or its engine installation. This examination did however point to clear signs of damage in the area of the compressor. This damage was visible from the exterior, in the form of small dents in the air ducting between the compressor and the combustion chambers.

1.16.2 Technical examination of the engine

The engine was later dismantled at an authorised engine maintenance facility in the presence of representatives of the SHK and of the engine manufacturer, Rolls-Royce (advisor for the NTSB – National Transport and Safety Board – accredited representative). This revealed a failure in the engine compressor, with major damage to both the blades and the guide vanes, see Figure 2. In addition extensive resultant damage could be seen in the direction of flow. Slight traces of impacts by foreign objects on the front guide vanes and rotor blades could also be seen. Selected parts of the compressor were later subjected to metallurgical examination in a materials laboratory under the guidance of SHK and in the presence of the manufacturer's representatives. The results showed that the failure began with a fatigue fracture present at the root of one of the blades in the third compressor stage, see Figure 3.

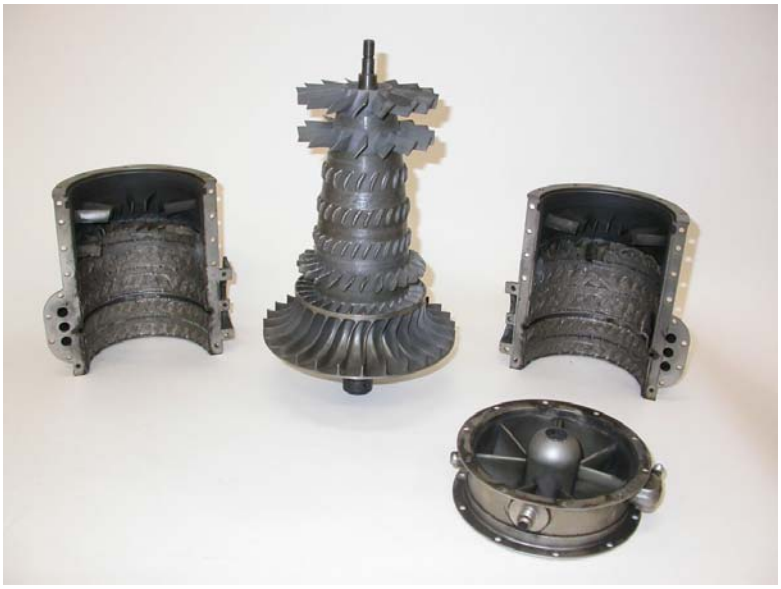

Figure 2. Principal parts of the compressor after dismantling.

Figure 3. The root of the third stage compressor blade showing the fatigue fracture.

Closer examination under an electron microscope revealed a small corrosion mark there and at other locations close to the blade roots. These appeared as very small holes in the aluminium-based coating on the surface of the rotor. In some cases they extended more deeply into the rotor base material. This coating is intended to act as a sacrificial anode and thereby protect the rotor material from corrosion. If necessary it can be replaced by a new coating.

Both the manufacturer and the materials laboratory documented their findings, which were unanimous, in writing.

Later information from the manufacturer (which is also the accredited advisor to the NTSB representative) showed that no Airworthiness Directives or Service Bulletins relevant to this event were issued for this type of engine. During the life of this type there have been 80 detected cases of corrosion damage in stages 2 and 3 (a common wheel) that have led to fatigue

cracks (but not necessarily to fracture). This would amount to a frequency of 1 event per million flying hours.

1.16.3 Review of technical documentation

The helicopter was acquired by the operating company in 1992 and at that time had flown approximately 1100 hours. It had previously been operated in Norway, among other locations. It had mainly been used after that for electricity power line inspections.

The engine had been installed in this helicopter since 16 June 1992. The compressor had been installed in the engine since 6 October 1997. The faulty compressor wheel (2nd and 3rd stages) had been installed in the compressor section since 6 December 1996. In respect of running hours, please refer to section 1.6.

The applicable maintenance and modification requirements had been met. The compressor was subjected to a 3500 hours inspection on 6 December 1996, at which time it had run 3284.4 hours. A 1750 hours inspection was carried out on 5 November 2001, after 5031.4 hours compressor running time. 100 and 300 hours inspections are not entered in the engine log, which the manufacturer pointed out, see below. According the operating company's technical manager it is usual for this not to be done on Allison engines, and these inspections are only documented in job orders. At 100 hour inspections the engine is washed with water. SHK has requested and been promised documentation of work done.

1.16.4 Information from the manufacturer

Compressor Safety Analysis

Rolls-Royce has placed at SHK's disposal an analysis of this type of compressor problem, issued in 2002 and updated in 2006.

In summary it states:

There are both coated and uncoated compressor wheels. The proportion is about 40 to 60. The coated version may either be supplied coated, or coated afterwards.

The probability of a blade failure due to corrosion and fatigue (as in this case) is, according to the R-R analysis concerning coated blades, about 1.3 per million flying hours.

Some relevant aspects are as follows.

- The failure rate for uncoated blades is about double.
- The choice between coated or uncoated is a "Customer Option".
- CEB[2] 1303 of 2002 "authorizes Wheel Coating". Patria Ostermans reported that they had implemented 10 such coating procedures.
- CSL-1135[3] of 1986 expresses the need for "Water Rinse"
- The O&M Manual[4] of 1999 "added 6 month calendar time to 300 hour inspection".
- Several problems have arisen in Salt Laden Environments.

Commercial Service Letter June 23 1986, Revised August 27, 2004

A CSL is not a "Mandatory" Document, but reminds in this case operators of the need for daily compressor cleaning with water, with the aim of avoiding corrosion in "corrosive environments", without a more closely defined statement of the degree of corrosivity. In respect of Sweden, the Stockholm area and all the islands are classified as Severe, the rest of the country being classified as a mixture of Mild and Moderate. It is not clear as to which de-

[2] CEB, Commercial Engine Bulletin
[3] CSL, Commercial Service Letter
[4] O&M Manual, Operations and Maintenance Manual

gree of corrosive environment the manufacturer considers that daily washing is needed, and in what areas it would be sufficient to clean at less frequent intervals. The present operator's technical organisation has interpreted this as needing to be carried out at intervals of 100 hours taking into account their actual use of the helicopter.

Operations and Maintenance Manual
This document describes the measures to be taken where surface rust or "corrosion pitting" is indicated. It does not specify what should be done to avoid these.

SHK notes that there is no "Mandatory" regulation concerning the prevention of corrosion. On the other hand, there is a regulation for the measures to be taken if such corrosion is detected. This assumes that the effects have been detected. The technical inspection that was carried out showed that detection of this kind is not easy.

1.17 Organisational and management information

The company operated four Hughes 369 and 269 helicopters. The technical servicing and technical management was entrusted to another company.

1.18 Additional information

1.18.1 Equal opportunities aspects

Not applicable.

1.18.2 Environmental aspects

No known environmental effects.

2 ANALYSIS

2.1 The Accident

The engine stopped without warning at a critical phase of the flight. The speed and height of the helicopter were too low for the pilot to be able to perform an autorotational landing. Impact with the ground therefore took place without control and at a high sink rate, as a result of which the left side landing gear was broken and the helicopter fell onto its left side. The circumstances were fortunate in that only material damage was caused by the accident.

2.2 The engine failure

The technical inspection of the engine showed that the engine stopped due to compressor failure, probably as a consequence of a blade breaking in the third stage. The investigation indicates that the blade failure was in turn caused by high cycle fatigue originating from a fatigue crack that was initiated by corrosion close to the blade root. Extensive subsequent damage made it difficult to assess the status of the remaining blades.

Everything points to the engine and compressor being maintained in accordance with the applicable regulations, and no definitive explanation for the corrosion and blade failure could be made. According to the manufacturer operation in a salt-laden atmosphere increased the risk of corrosion.

It has not been possible to determine whether the recommended washing of the compressor had actually been carried out at every 100 hour inspection, during the full life of the compressor, since this type of work was documented separately. If such washing had not been carried out and the helicopter was operated in a corrosive environment, this could have contributed to the presence of corrosion. The compressor was installed in the helicopter while for a certain period it was in operation in Norway.

At the present time inspection of power lines involves high power operation much of the time and SHK cannot exclude the possibility that this may be at the upper edge of the load spectrum that the manufacturer originally used as a basis for determining the overhaul and inspection intervals.

As can be seen from the engine manufacturer's report, similar blade fractures have on a few occasions occurred in this type of engine before. Based on the previous occurrences, the probability of a blade fracture is estimated at 1.3 events per million flying hours. For a helicopter flying 300 hours per year, it would on average take 2500 years between such an event. Taking into account the low probability, SHK sees no reason for special measures to be taken as a result of this accident, except in a suitable way to inform operators using this type of engine of the risk of blade corrosion and the importance of regular compressor washing.

3 CONCLUSIONS

3.1 Findings

a) The pilot was qualified to perform the flight.
b) The helicopter had a valid Certificate of Airworthiness
c) The engine stopped due to a blade failure in the compressor.
d) The blade failure was caused by a fatigue crack initiated by corrosion damage.
e) It is known that there is a risk of corrosion damage to compressor blades resulting in blade failure.
f) Special maintenance procedures are recommended to reduce the risk of blade corrosion.
g) According to the available documentation the helicopter was being operated and maintained in accordance with the applicable regulations.
h) Completed compressor washing was not documented as normal in the maintenance log.

3.2 Causes

The following causal factors were identified. The engine stopped suddenly during flight at low speed and low height. The engine stoppage was caused by a fatigue failure in stage 3 of the compressor.

4 RECOMMENDATIONS

The Swedish Civil Aviation Authority recommends that:

- suitable measures are taken to inform operators using this type of engine of the risk of blade corrosion and the importance of regularly washing the compressor in accordance with the manufacturer's recommendations *(RL 2006:23e R1)*.