Statens haverikommission
Swedish Accident Investigation Board

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Report RL 2007:09e

Aircraft accident to helicopter SE-JHD at Södra Åsjön, Blekinge county, Sweden on 1.March 2006

Case L-04/06

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Swedish Accident Investigation Board

2007-07-09 L-04/06

Swedish Civil Aviation Authority

601 73 NORRKÖPING

Report RL 2007:09e

The Swedish Accident Investigation Board has investigated an accident that occurred on 1 March 2006 at Södra Åsjön, Eringsboda, Blekinge county, involving a helicopter with registration SE-JHD.

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

The Board will be grateful to receive, by 10 January 2008 at the latest, particulars of how the recommendations included in this report are being followed up.

Åsa Kastman Heuman Henrik Elinder

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Report finalised 9 July 2007

Aircraft; registration and type	SE-JHD, Eurocopter AS 350 B3
Class/airworthiness	Normal, valid Certificate of Airworthiness
Owner/Operator	SEB Finans AB, SE-167 81 Bromma, Sweden/Laroy Flyg AB, Enoch Thulin's airfield, SE-261 92 Landskrona, Sweden
Time of occurrence	1 March 2006, at 08:02 in daylight *Note:* All times are given in Swedish standard time (UTC + 1 hour)
Place	Södra Åsjön, Eringsboda, Blekinge county, (posn. N 56°27', E 015°22'; 91 m (299 feet) above sea level)
Type of flight	Utility flight
Weather	According to SMHI's analysis: Wind south-east 5-10 knots, visibility 1500-4000 m in snowfall, cloud 8/8 stratus with base 500-1000 feet, temperature/dew point -1/-1 °C, QNH 995 hPa
Persons on board:	
Crew	1
Passengers	0
Injuries to persons	None
Damage to aircraft	Substantially damaged
Other damage	Small trees cut down
Commander:	
Sex, age, licence	Male, 33 years, valid CPL(H) licence
Total flying time	4186.7 hours, of which 3032.0 hours on type
Flying hours previous 90 days	67.6 hours, of which 65.3 hours on type

The Swedish Accident Investigation Board (SHK) was notified on 1 March 2006 that a helicopter with registration SE-JHD had an accident at 08:02 hours on that day at Södra Åsjön, Eringsboda, Blekinge county.

The accident was investigated by SHK represented by Åsa Kastman-Heuman as Chairperson. The chief technical investigator was Dan Åkerman until 2 April 2006, Agne Widholm until 1 June 2007 and Henrik Elinder thereafter. SHK was assisted by Lars-Peter Peltomaa as a technical expert.

The investigation was followed by Ulrika Svensson, Swedish Civil Aviation Authority.

Summary

The helicopter was to be used to spread powdered limestone over a partly ice-covered lake. After having started the engine and warmed it up for about six minutes, the pilot took off, with a relatively low engine power setting. When the helicopter had climbed to about 40 metres (130 feet) height and the speed was just over 50 knots, the engine stopped without any warning.

At that moment the helicopter was above the lake, and the pilot immediately started an auto-rotation, at the same time beginning a steep right turn into wind towards land. The helicopter came down on to the ice, about 20 metres from the shore, at low forward speed but at a high rate of descent. The pilot was unhurt and could exit the helicopter without assistance.

Apart from the fact that three compressor blades had FOD damage from a “soft” object, no other technical malfunctions could be found in the helicopter. Before the flight it had been parked outdoors in falling snow. This type of helicopter has no Auto Ignition System.

The accident was probably caused by undetected ice build-up during the time it was parked, being drawn into the engine and causing a flame-out. A contributory factor was that this type of engine is sensitive to water ingress and did not have an Auto Ignition System.

Recommendations

The Swedish Civil Aviation Authority is recommended to:

- in a suitable manner point out to operators of this particular type of helicopter the importance of ensuring that ice, packed snow and water cannot be drawn into the engine, since even small amounts can cause the engine to stop *(RL 2007: 09e R1),* and to

- make efforts to have the Auto Ignition System introduced as standard in this type of helicopter *(RL 2007: 09e R2)*.

1 FACTUAL INFORMATION

1.1 History of the flight

The helicopter was to be used to spread powdered limestone over a partly ice-covered lake. The day before the accident the helicopter was parked, at the end of its day's work, outdoors close to the lake, and a tarpaulin was placed over the engine air intake.

It snowed during the night, and during the daily inspection before the first flight of the day about 10 cm of snow was removed from the helicopter. The weather conditions were marginal, and the pilot decided to first make a brief flight without any load, to check the visibility in the area, and at the same time receive by radio an updated weather forecast from the Ronneby control tower. After having started the engine and warmed it up for about six minutes, he took off, with a relatively low engine power setting. He accelerated and climbed gently downwind, noting that all the indicated engine values were normal.

When the helicopter had climbed to about 40 metres (130 feet) height and the speed was just over 50 knots, the engine stopped without any warning. At the same time one of the ground staff saw a momentary flash of light from the engine exhaust. At that moment the helicopter was above the lake, and the pilot immediately started auto-rotation, at the same time beginning a steep right turn into wind towards land. He reported by radio to the ground staff that the engine had stopped.

Since the pilot was in doubt about the strength of the ice, he tried to reach land, but was unable to prevent the helicopter striking the ice, about 20 metres from the shore, at low speed and a high rate of descent. On impact the tail boom detached and the helicopter then slid towards the shore and collided with several trees before it stopped.

The pilot was not injured and could exit the helicopter without assistance after switching off the main electrical power and shutting off the fuel supply.

The accident occurred at position N 56°27', E 015°22'; about 91 m (299 feet) 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

Two trees on the shore, about 20 cm diameter, were broken.

1.5 Personnel information

1.5.1 Commander

The commander, male, was 33 years old at the time and had a valid CPL (H) Licence.

Flying hours			
previous	*24 hours*	*90 days*	*Total*
All types	4.8	67.6	4186.7
This type	4.8	67.6	3032.0

Number of landings this type previous 90 days: 148.
Flight training on type carried out in 2000.
Latest PC (Proficiency Check) carried out on 14 May 2005 on an AS 350.

1.5.2 The pilot's duty schedule

The pilot had slept at least seven hours per night during the most recent seven day period before the accident. On that particular day he had been awake for over two hours, and came on duty about one hour before the accident occurred.

1.6 The aircraft

1.6.1 General

THE AIRCRAFT	
Manufacturer	Eurocopter
Type	AS 350 B3
Serial number	3612
Year of manufacture	2002
Gross mass	Max. authorised take-off mass 2250 kg, actual 1410 kg
Centre of mass	Within permitted limits
Total flying time	1673.4 hours
Number of cycles	Unknown
Flying time since latest inspection	59.5 hours
Fuel loaded before event	JET A1

ENGINES	
Manufacture	Turbomeca
Model	Arriell 2B
Number of engines	1
Total operating time, hrs	5013
Operating time since overhaul	1173
Cycles since overhaul	4378

ROTOR	
Manufacture	Eurocopter
Operating time since overhaul	150.5 hours

This type of helicopter is equipped with a turboshaft engine and has room for a total of seven people on board. It is often used for carrying passengers, but also used for other types of airborne task. The engine air intake is located above the cabin. The helicopter had a valid Certificate of Airworthiness.

1.6.2 DECU/VEMD

The helicopter engine is equipped with a Digital Electronic Control Unit (DECU). Data concerning selected engine parameters in the DECU is in certain conditions saved in a data display unit on the instrument panel, called the Vehicle and Engine Multifunction Display (VEMD). According to the operator, inexplicable fault warnings have appeared in this system.

1.6.3 Technical maintenance

The technical maintenance of the helicopter was carried out in accordance with applicable regulations.

1.7 Meteorological information

According to the SMHI (Swedish Meteorological and Hydrological Institute) analysis:
A low pressure area over the Skagerrack resulted in cloudy weather in Blekinge during the afternoon of 28 February, and the temperature rose to a few degrees below zero. During the evening, up to and including the time of the accident in the morning of 1 March, there was continuous snowfall, which was at times heavy.

At the time of the accident the weather was as follows:
Wind south-east 5-10 knots, visibility 1500-4000 m in snowfall, cloud 8/8 stratus with base 500-1000 feet, temperature/dew point -1/-1 °C, QNH 995 hPa.

The accident occurred in daylight.

1.8 Aids to navigation

Not applicable.

1.9 Communications

The pilot had obtained radio contact with ground staff at the site.

1.10 Aerodrome information

Not applicable.

1.11 Flight recorders

None. Not required.

1.12 Accident site and aircraft wreckage

1.12.1 Accident site

The accident occurred on the south shore of Stora Åsjön lake, which is about half a kilometre in diameter. A small grove of trees reaches down to the water's edge, and just south of the grove are a couple of open fields.

1.12.2 Aircraft wreckage

The helicopter suffered substantial damage. The landing skids were broken, the tail boom broke off, and all the main rotor blades and the main rotor hub were damaged.

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

There was no fire.

1.15 Survival aspects

1.15.1 General

The Emergency Locator Transmitter (ELT) of type Artex DO-160 was not activated. The pilot was not injured, which can be interpreted as meaning that the helicopter's descent rate at the time of impact was not so great that the kinetic energy could not be absorbed by the deformation of the landing skids.

1.15.2 Actions by the rescue services

Not applicable.

1.16 Tests and research

1.16.1 The helicopter

After a preliminary inspection at the accident site, the helicopter was transported to a hangar where it was examined by SHK technical experts. Nothing abnormal and no technical faults were found in the helicopter or the systems that affect engine operation, that would explain the sudden stoppage of the engine. There were 107 kg of usable fuel remaining in the fuel tank.

The engine gas generator and free turbine could be rotated without restrictions or abnormal noises. It was noted that the outer sections of three of the first stage compressor blades were “gently” curved forwards and without sharp edges (see the photograph below).

First compressor stage

Damage to the compressor blade

1.16.2 The engine

The engine has been examined by the engine manufacturer, Turbomeca, in France under supervision by SHK representatives.

After the usual reception checks, the engine was installed in a test cell and functionally tested. The engine started without any problems and normal performance checks could be carried out without difficulty. Apart from the engine only delivering 94 % of the specified power at the operational speed of 50026 rpm, the other performance requirements were met.

During the subsequent dismantling and inspection nothing abnormal was found, considering the engine’s use and running time, apart from the damaged compressor blade.

1.16.3 Recorded VEMD information

Data from the VEMD has been analysed by the helicopter manufacturer Eurocopter, under supervision by SHK representatives. The engine stoppage was recorded as an error message at 5 minutes and 26 seconds after engine start. Apart from this there was no faulty operation or abnormal parameters recorded during the flight in question or during the flight time before the accident that could be associated with the accident.

1.16.4 Start switch

This type of helicopter is equipped with a Start switch, which is used in conjunction with starting and shutting down the engine. The Start switch has three positions; OFF, IDLE and FLY which represent shut down, idling and flying.

The Start switch in this particular helicopter had been changed several times due to faulty operation. After the accident the operation of the helicopter's Start switch was tested. The tests were carried out at different temperatures and with vibration at different frequencies to simulate flight conditions. The installation of the switch in the helicopter was also examined. No faults or other abnormalities could be found.

1.16.5 Examination of the engine tarpaulin

The helicopter was parked outdoors on the night before the accident flight, and the engine air intake above the cabin was at that time covered by a tarpaulin (see the photograph below).

Tarpaulin covering the engine air intake

Certain parts of the tarpaulin are porous, and an examination was carried out to establish its ability to retain free water and ice. The examination concluded that in certain circumstances the tarpaulin could absorb up to 300 grams of water that would not run off due to gravity.

1.17 Organisational and management information

The aircraft operating company is based in Landskrona and carries out various types of helicopter tasks, mainly concerned with adding lime to lakes, and similar kinds of operation. At the time of the accident there were five full-time employees operating two AS350B3 type helicopters.

1.18 Additional information

1.18.1 Equal opportunities aspects

This event has also been examined from the point of view of equal opportunities, i.e. against the background that there are circumstances to indicate that the actual event or its effects were caused by or influenced by the women and men concerned not having the same possibilities, rights or obligations in various respects. Such circumstances were however not found.

1.18.2 Environmental aspects

The accident did not have any consequences from the environmental viewpoint.

1.18.3 FOD

Unwanted objects that are drawn into an engine air intake can cause Foreign Object Damage (FOD), including to compressor blades. Hard objects, such as stones and pieces of metal, usually result in sharp-edged damage to the front edges of the blades, while easily crushed objects such as snow and ice result in “gentle” damage. At the time, the helicopter was equipped with a “sand filter” (a type of particle separator) located in the engine air intake, intended to prevent compressor damage as a result of FOD.

1.18.4 Engine stalling

If the air flow to a to a turbojet or turboshaft engine is disturbed for any reason, one or more compressor stalls can occur. The gas pressure in the combustion chamber then momentarily collapses, which can be apparent by, among other things, a jet of flame shooting out from the engine intake and exhaust, accompanied by a loud bang. The engine usually returns to normal operation as soon as the disturbance ceases.

1.18.5 Flameout

A sudden engine stoppage can occur in a turbojet or turboshaft engine as a result of the combustion of the air/fuel mixture in the engine combustion chamber ceasing, known as flameout. Flameout can be caused by various factors, including being the result of a compressor stall as outlined above, but also if sufficient amounts of ice, snow or water are drawn into the engine air intake. According to the manufacturer, flameout can occur in the particular type of engine if more than 40 grams of ice, snow or water are sucked in.

After a flameout caused by ice, snow or water, the engine can usually be restarted if the ignition is activated. Certain types of helicopter are equipped with a system called the Auto Ignition System that detects the occurrence of a flameout, and accordingly automatically activates the ignition system.

2 ANALYSIS

2.1 The Accident

The engine stoppage occurred without warning as the helicopter was flying at low speed and height over a lake, which placed the pilot in a difficult situation. Since he was unsure of the strength of the ice, it is understandable that he chose to turn back towards land to try to make a forced landing there. However it is doubtful that it was operationally possible in these circumstances to establish autorotation, turn back to land against the wind and there make a controlled landing. The result was that at the end of this manoeuvre the pilot lost control of the helicopter, which came down hard on the ice-covered lake before it reached land.

2.2 The engine stoppage

Apart from the damage to the compressor blades, nothing arose from the technical investigation to indicate that any fault or faulty function took place that would explain the engine stoppage. Except for the engine not fulfilling all the applicable performance requirements, it operated satisfactorily during test running in a test cell.

The operation of the engine is dependent on several different systems, and it can of course not be ruled out that the sudden engine stoppage was caused by a momentary fault in one of these systems, either in the DECU or the start switch which had previously been unreliable. Nothing in the technical investigations that were carried out on these indicates that this happened.

The damage to the compressor blades that was discovered does however tend to show that the engine was subjected to FOD. The appearance of the damage indicates that an easily crushed material, such as ice or packed snow, could have been drawn into the engine.

As was described in 1.18.5, flameout resulting in engine stoppage can occur in this particular type of engine if more than 40 grams of ice, snow or water is sucked into the engine, and there is a strong possibility that the engine stoppage was caused in this way.

This sequence of events is reinforced by the observation made from the ground of a momentary flash of light seen emerging from the engine exhaust. This flash of light probably derived from a compressor stall that was initiated by ice or packed snow being sucked into the engine and which, apart from damaging the blades, caused a brief disturbance to the air flow passing through the compressor.

2.3 FOD

Since the helicopter was equipped with a sand filter, such ice must have built up in the filter or in the space between the filter and the engine. How this could happen has not been determined with any certainty.

During the evening and night before the accident the helicopter had been parked outside in snowfall. It is possible that a certain amount of snow could have entered the engine air intake before the tarpaulin was fitted. Heat from the engine could also have melted snow, on the tarpaulin and the top of the engine housing, which then in the form of water passed through or past the tarpaulin. Water could in partly frozen form have collected in or under the sand filter, or alternatively somewhere in the space between the filter and the engine.

When the helicopter took off, the air temperature was below freezing and any such water that may have been present would have frozen. The presence of the sand filter makes it difficult to see such ice during the daily inspection. It could have been such ice that in connection with take-off came loose, due to vibration and heat from the engine, and been drawn into the engine.

SHK reviewed in report C 1999:35 the investigation into a similar accident that was caused by an engine stoppage as a result of snow being drawn into the engine. There is therefore a reason for the Swedish Civil Aviation Authority in a suitable manner to point out to operators of this particular type of helicopter the importance of ensuring that ice, packed snow and water cannot be drawn into the engine, since even small amounts can cause the engine to stop.

Considering how little water is required, according to the manufacturer, to cause a flameout in this type of helicopter, SHK considers that there is

reason for the Swedish Civil Aviation Authority to take steps to get the Auto Ignition System introduced as standard in helicopter types where this can practically be implemented.

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 helicopter had been parked outdoors in falling snow.
d) The helicopter was equipped with a sand filter.
e) Three compressor blades had FOD damage from a "soft" object.
f) Apart from this no technical faults were found in the helicopter.
g) This type of helicopter had no Auto Ignition System.

3.2 Causes

The accident was probably caused by undetected ice build-up during the time it was parked, being drawn into the engine and causing a flame-out. A contributory factor was that this type of engine is sensitive to water ingress and did not have an Auto Ignition System.

4 RECOMMENDATIONS

The Swedish Civil Aviation Authority is recommended to:

- in a suitable manner point out to operators of this particular type of helicopter the importance of ensuring that ice, packed snow and water cannot be drawn into the engine, since even small amounts can cause the engine to stop *(RL 2007: 09e R1),* and to

- make efforts to have the Auto Ignition System introduced as standard in this type of helicopter *(RL 2007: 09e R2)*.