Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A07C0114

POWER LOSS - COLLISION WITH WATER

EXPEDITION HELICOPTERS INC.
EUROCOPTER AS 350 B-2 C-FLUK
BERNICK LAKE, SASKATCHEWAN
01 JULY 2007

Canada

Aviation Investigation Report

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Expedition Helicopters Inc.
Eurocopter AS 350 B-2 C-FLUK
Bernick Lake, Saskatchewan
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Report Number A07C0114

Summary

The pilot of the Eurocopter AS 350 B-2 helicopter (registration C-FLUK, serial number 2767) was ferrying the helicopter, with one passenger, to Points North Landing, Saskatchewan, from a fuel cache located approximately 42 nautical miles (nm) southwest. An electronic flight notification was sent by the passenger to another member of his survey company based at Points North Landing, indicating an arrival time of 1905 central standard time. When the helicopter did not arrive, the survey company initiated emergency procedures at 1945. Debris was found the following day in Bernick Lake, approximately 25 nm southwest of Points North Landing. The helicopter was found at the bottom of the lake with extensive damage and both occupants sustained serious injuries at water impact, but drowned when the helicopter sank.

Ce rapport est également disponible en français.

Other Factual Information

The helicopter was based at Points North Landing, Saskatchewan and was internally modified with equipment to conduct survey flights for a geological survey company. On the day of the accident, survey flights had been delayed by a weather system moving through the area from the west. When the weather cleared, the pilot flew several barrels of fuel to a fuel cache about 42 nautical miles (nm) southwest of Points North Landing and returned. The pilot and survey specialist then flew a survey flight with a sensor array towed underneath the helicopter. The survey flight was conducted in an area between Points North Landing and the fuel cache. The survey flight was complete upon arrival at the fuel cache and the towed array was removed. Some fuel was taken from one barrel to complete the flight back to Points North Landing.

After about 15 minutes on the ground at the cache the helicopter departed. At 1845 [1] the survey specialist sent a message from the helicopter to a member of his company at Points North Landing indicating a take-off time of 1843. At 1847 the survey specialist sent a second message indicating an expected time of arrival (ETA) of 1905 at Points North Landing. Neither message indicated a problem with the helicopter or weather. No other messages or transmissions were received from the helicopter. At 1945 the company initiated emergency procedures, as the helicopter had yet to arrive. Two locally-based helicopters searched along the track in visual flight conditions from about 2200 until darkness. Debris from the helicopter was found on Bernick Lake the following day by a search and rescue aircraft. Bernick Lake is located about 25 nm southwest of Points North Landing and was near the mid-point of the track from the fuel cache (See Appendix A - Planned Route).

An extensive underwater search was commenced by police divers. Eight days later, the helicopter was located in the eastern half of the lake, about 950 feet from shore at a depth of 69 feet. The helicopter was extensively damaged; however, the wreckage was found in one piece with both occupants strapped in their seats.

The autopsy revealed that both occupants of the helicopter sustained serious injuries at water impact and drowned when the helicopter sank. Toxicological tests for the presence of alcohol and common drugs were negative.

The helicopter was not equipped with an approved emergency floatation kit; however, personal floatation devices were carried on board [2]. There were no witnesses to the accident.

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1 All times are central standard time (Coordinated Universal Time minus six hours).

2 *Canadian Air Regulation* 703.23, applicable to the flight, specifies that no air operator shall, except when conducting a take-off or landing, operate a land aircraft over water beyond a point where the land aircraft could reach shore in the event of an engine failure, unless the air operator complies with the *Commercial Air Service Standards*. Standard 723.23 required the helicopter to be equipped with an approved emergency floatation kit if it was to be operated over water.

The air operator used a self-dispatch system for the operation of the helicopter. Under the guidance of the company operations manual, the pilot, in conjunction with the geological survey company, would decide how the day's survey operations would be conducted, including the establishment and use of the fuel caches, the routes flown to and from the areas of operation, and the suitability of the weather.

The Environment Canada prairie region clouds and weather map valid for 1800 local on 01 July 2007 indicated that the helicopter would have been operating in visual flight conditions. This map indicated scattered cumulus clouds based at 4000 feet above sea level (asl) with a visibility of six statute miles. The 1800 weather at the Cigar Lake Mine, located 17 miles to the northwest of the accident site, was as follows: light winds from the south; smoke from forest fires visible; temperature 20°C. Similar temperature and wind conditions were recorded by the Collins Bay autostation 22 miles northeast of the accident site.

The weather system that had passed through the area earlier in the day and which had delayed the survey flight was about 30 nm to the east of Bernick Lake at the time of the accident. The weather in the area of this system was as follows: visual flight conditions with patchy ceilings at 1500 feet above ground level (agl), rain showers, and isolated thunderstorms.

The pilot held a commercial helicopter pilot licence validated by a Category 1 medical certificate and endorsed for the Aerospatiale AS 350 series helicopter. He had completed a pilot proficiency check on the AS 350 five months prior to the accident. The pilot's total time on the AS 350 was not determined; however, in the last five months he had primarily flown the AS 350 and had flown the accident aircraft exclusively for the last 30 days. His last training in autorotations was done at the time of his pilot proficiency check. The pilot had approximately 6620 hours of total flying time.

In the last 30 days, he had flown approximately 78 hours, flying two hours in the last 24-hour period. He had retired early the prior evening and appeared well rested on the morning of the accident. Information indicated that he was respected for his ability to fly survey grids accurately and that it was not his practice to accept requests to divert flights to sightsee or observe wildlife.

The certificate of registration and certificate of airworthiness issued by Transport Canada identifies C-FLUK as a Eurocopter AS 350 B2. The helicopter had been modified by a Transport Canada approved Soloy Aviation Ltd. supplementary type certificate (STC) number SR01647SE. The STC authorizes the replacement of the originally supplied Turbomeca Arriel engine with a Honeywell LTS-101-700D-2 engine. The helicopter can be referred to as an AS 350 SD2. The helicopter was recovered from the lake ten days after the accident and was taken to the TSB regional wreckage examination facility. Examination indicated it had struck the water heavily and with a high descent rate. Damage to the structure indicated that the helicopter had entered the water with some forward speed, nose-down, and banked to the right.

The teardown and inspection of the transmission and tail rotor gear box did not reveal any pre-impact anomalies. Inspection of the main rotor blades, tail rotor blades, engine controls, and flight controls indicated only post-impact damage. The examination of the rotor blades and the elastomeric bearings indicated that the rotor system had little kinetic energy when the rotor blades made water contact.

The tail rotor front shaft was found sheared and was sent to the TSB Engineering Laboratory. Examination revealed the tail rotor front shaft had failed as the result of shear overload from the sudden stoppage when the tail rotor contacted the water.

Continuity of flight controls was established from the pilot's cyclic, collective, and tail rotor pedals to the hydraulic actuators. An inspection of the hydraulic system revealed that the hydraulic pump V-belt was intact and still in place. During an autorotation the hydraulic pump is driven by the V-belt from the output shaft of the transmission, providing hydraulic pressure to the flight control servos. The hydraulic system was pressurised and the four flight control servos were tested while still installed on the helicopter and then individually bench tested. Both tests revealed no pre-existing anomalies that would have affected normal flight control.

Each servo is equipped with an accumulator that provides limited use of the flight controls in the event of a hydraulic system failure. The accumulators assist the pilot in maintaining control of the helicopter if hydraulic pressure is lost at airspeeds above 60 knots. The four accumulators were tested and all were found to contain less than the required pressure. This unserviceability would not have contributed to the accident because the hydraulic system was pressurized by the hydraulic pump throughout the crash sequence. The helicopter's flight manual requires the pilot to check the accumulators before the first flight of the day. However, concerns have been raised about the effectiveness of the required check and the TSB has issued Safety Advisory A06P0123-D3-A1 to Transport Canada urging a review of the flight manual accumulator check. There was no information as to the results of the pilot's hydraulic accumulator check on the day of the occurrence.

Fuel samples taken from the engine fuel filter contained contamination that consisted primarily of sand particles. It was considered likely that the contamination of the fuel occurred after the occurrence while the helicopter was submerged. The fuel control lever was found in the fully-forward or flight position. The aircraft's engine instruments and flight instruments were inspected at the TSB Engineering Laboratory and no anomalies were found.

Visual inspection of the engine oil filter revealed no contamination; however, the oil had a strong burnt odor. The engine (Honeywell LTS101-700D-2, serial number LE-46040C) was removed from the airframe and sent to the TSB Engineering Laboratory for teardown. The teardown of the engine revealed that the elbow assembly, power turbine retention – pneumatic, commonly referred to as the Py line or Py elbow, was cut. When the engine gearbox was removed, the power turbine shaft rotated with some resistance. Further disassembly revealed the failure of the number three power turbine shaft bearing. When the number three bearing fails, there is a rearward movement of the power turbine shaft that allows contact with the Py line. This is a design feature of the engine, which results in the cutting of the Py line and the consequent loss of metered air pressure. The loss of metered air pressure reduces fuel flow to the minimum fuel flow stop in the fuel control, which is approximately 38 pounds per hour, to minimize subsequent damage to the engine. The engine rotational speed decreases and should stabilize at about ground idle speed setting, which is insufficient to sustain flight. An engine power loss resulting from the cutting of the Py line presents indications which may be similar to those of a fuel governor failure in which there is a large drop in fuel flow rate.

The engine chip-detection system was found to be serviceable. Because the metal particles that were produced by the wearing of the number three bearings were extremely fine and few in number, the engine chip-detection system produced no warning of the impending failure. Examination of the oil supply system and related components did not indicate a lack of oil supply to the bearings prior to the failure of the number three bearing.

The number two bearing was examined visually and localized areas of corrosion were noted. Rub marks were found in the corrosion and the pit edges on the rollers and inner ring were burnished and plastically deformed, indicating that the number two bearing was operated for some time subsequent to the formation of the corrosion pits (see Photo 1). The number three bearing was destroyed (see Photo 2 and Photo 3); however, examination of the less damaged portions of the number three bearing's outer ring revealed corrosion pits and spalls similar to those observed on the number two bearing.

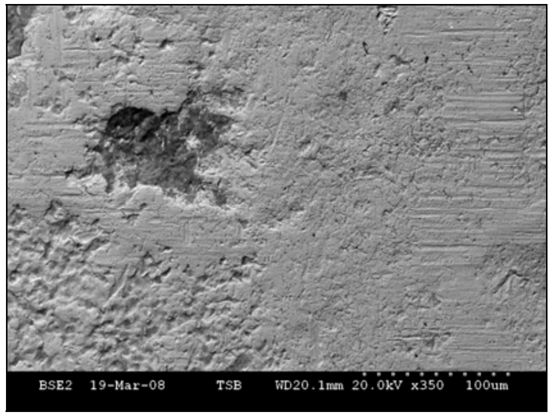

Photo 1. Scanning electron micrograph of a representative roller of the No. 2 bearing

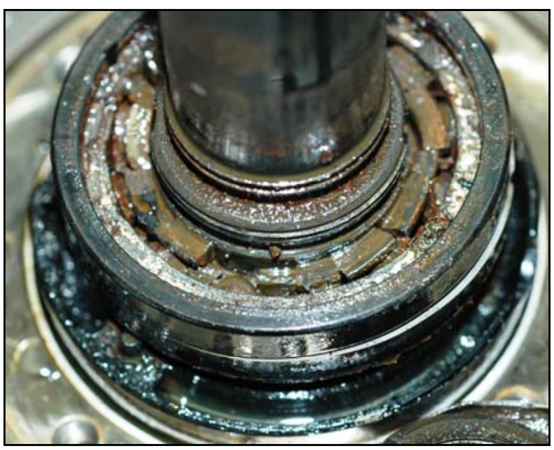

Photo 2. No. 3 bearing as-received condition

Photo 3. No. 3 bearing components disassembled

The engine was a rental engine and had been installed on 17 June 2007. At the time of installation the engine had zero time since overhaul and 6728 hours since new. At the time of the accident, the engine had flown an additional 74.5 hours. There were no reports of engine magnetic chip-detector actuation in the period before the accident. The engine had been in storage and was not operated during the period from 28 May 2004 to 06 June 2007. Both the number two and number three bearings examined were in the engine during this period of time. When an engine is stationary over a period of time in the presence of moisture, corrosion pitting can occur. To prevent corrosion, the manufacturer's engine maintenance manual identifies the degree of preservation based on the length of time the engine will be idle. When the engine is to be idle for more than 180 days, the permanent storage procedures are to be followed.

If the engine is also to be installed in a shipping container, then additional procedures must be followed. The manufacturer could not provide any records as to whether the engine had been preserved during the time period from 28 May 2004 to 06 June 2007.

The helicopter was equipped with two global positioning system (GPS) receivers, one of which transmitted data to a ground-based tracking facility. Information from this tracking facility indicated that, on the day of the accident, the survey flight was flown at an average altitude of about 1800 feet asl. This would have resulted in a height above ground of 500 feet or less for most the flight.

The basic flight manual for the helicopter contains a Soloy Aviation Ltd STC supplement for the Honeywell LTS101-700D-2 engine installation. The supplement indicates that the symptoms for governor failure are the same symptoms as for a complete engine failure, but the supplement does not indicate that the engine rpm will stabilize at a low rpm value. Information provided by the manufacturer of the engine indicated that the rpm would stabilize just under the ground idle speed setting. The flight supplement for the engine indicates that ground idle is in the range of 50 to 70 per cent.

When the engine loses power, the pilot must transition to autorotation using the same procedures as specified in the basic flight manual and then must close the fuel control lever to shut down the engine. The flight manual requires the pilot to lower the collective and establish airspeed at approximately 65 knots. At approximately 65 feet above the surface, the pilot is required to flare to a nose-up attitude and, at 20-25 feet, to apply collective pitch gradually. Just prior to touchdown, the helicopter is placed in a level attitude by the pilot and any side-slip is eliminated.

There are risks inherent in an autorotative landing in water by a land helicopter, in addition to the risks for helicopters equipped to land in water. During the landing, the pilot's estimation of the helicopter's height above the water surface is difficult, particularly in calm conditions [3]. The judgement of height above the landing surface is critical to the success of an autorotation. Flaring and application of collective at the correct height ensures that the kinetic energy of the blades is used to transition from a high descent rate at the autorotation speed to a low descent rate with zero forward speed as the helicopter touches down. If the kinetic energy of the blades is expended too soon, the ability to control the helicopter will be reduced and the helicopter will enter a high rate of descent and crash. Underwater egress is difficult when a helicopter sinks. If the egress is successful, the risk of hypothermia or drowning before the shore is reached increases with the distance from the shore.

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[3] *Aeronautical Information Publication*, *Airmanship*, sections 2.11.2 and 2.11.4.

There is no information provided in the helicopter flight manual with respect to gliding distance in autorotation. Information from the manufacturer indicated that the descent rate in autorotation is approximately 1800 feet per minute. With this rate of descent, the helicopter could sustain flight for about 13 seconds from entry into an autorotation at 450 feet agl until the landing flare at 65 feet agl. Turning the helicopter would increase the rate of descent and decrease the distance travelled and the time to touchdown. Time and distance may be increased by the conversion of any excess airspeed into altitude at the time the engine power loss is recognized.

In autorotation, the recommended airspeed of the AS 350 is 65 knots. Because of the angle of descent, the helicopter travels over the ground at 62 knots or 105 feet per second with no wind. The distance that the helicopter was found from shore was equivalent to nine seconds of flight time in a straight-ahead autorotation.

The helicopter was equipped with a warning horn that sounds a continuous warning tone if the rotor speed drops to 360 rpm or if the hydraulic pressure is lost. Examination of the warning system indicated that it was functional and was switched on at the time of the accident. On 09 August 2006, the TSB issued Aviation Safety Advisory A060031-1 to Transport Canada concerning the ambiguity of the same warning horn for both low main rotor speed and low hydraulic system pressure in the AS 350 B2.

Analysis

The pilot was able to fly to the fuel cache earlier in the day and then conduct a survey flight. Additionally, search helicopters were able to fly along the route to the fuel cache in visual flight conditions after the accident. Consequently, it is likely that the weather was substantially as forecast along the route flown and was not a factor in the accident.

The engine's number three bearing failed, resulting in a rearward movement of the power turbine shaft which cut the engine's Py line. As a result, the engine's rotational speed decreased to about ground idle speed, which is insufficient to sustain flight. Since there was no message from the helicopter by the survey technician indicating any emergency condition, it is likely that the power loss occurred quickly and that there was little advance warning of the impending bearing failure.

The burnishing and plastic deformation of the corrosion pit edges on the number two bearing indicate that the number two bearing was operated subsequent to the formation of the corrosion pits. Consequently, the corrosion pitting of the number two bearing occurred prior to the engine being submerged in the lake. Since the number two and number three bearings are located close to each other and share the same lubrication system, the number two and number three bearings would have been exposed to the same environmental conditions. Consequently, since the corrosion pitting of the number three bearing is similar, the corrosion pitting of the number three bearing also occurred prior to the engine being submerged in the lake. Therefore, it is likely that corrosion pitting caused the failure of the number three bearing.

The corrosion had to occur when the engine was idle for a period of time and was not stored in accordance with the manufacturer's procedures. Because both bearings were installed in the engine and as there are no records indicating that the engine had been preserved in accordance with the maintenance manual from 28 May 2004 to 06 June 2007, the corrosion likely occurred during this period.

While information from the survey flight indicated that the pilot was accustomed to flight at 500 feet agl or below, there was no information to indicate how the pilot flew the route from the fuel cache to Bernick Lake. As the pilot was respected for his businesslike approach to flying and was known to have refused requests to deviate for sightseeing, it is likely that he would have adjusted his flight path and altitude at Bernick Lake to remain within safe autorotational distance from shore. The judgement of the autorotational distance required by the helicopter from a given altitude by an experienced pilot accustomed to low-level flight would be expected to be adequate. However, the possibility that the pilot misjudged the height required for autorotation to shore could not be ruled out. It is also possible that the pilot, in responding to the first indication of the impending bearing failure, attempted to land near the shoreline in shallower water and was in the process of manoeuvring to land when the power loss occurred.

When the rapid power loss occurred, the pilot was required to follow the emergency procedures as outlined in the basic flight manual and the supplement for the Honeywell engine. To comply with those procedures, the pilot should have immediately entered an autorotation, turned towards the shoreline, closed the fuel control lever to shut down the engine, and completed an autorotational landing to shore. There are two possible scenarios in which the fuel control lever would not be moved to the closed position: either the pilot did not follow the procedure or the pilot was rushed and did not have time to do so. In either case there was no adverse consequence to not closing the fuel control lever because the helicopter landed in the lake so any post-impact fire would be quickly extinguished.

If the pilot was rushed, this could indicate that the helicopter's height above the lake was low at the time of the engine power loss, because time in autorotation reduces as height is reduced. This could have occurred either en route at too low an altitude over the lake or while manoeuvring to land near the shoreline.

If the pilot judged the required en route altitude to overfly the lake correctly and had sufficient time to complete the procedure, the position of the fuel control may indicate that the pilot's response to the emergency was incorrect. After the power loss, engine rpm would have stabilized at a low rpm value. This condition is not described in the Honeywell supplement and may have been confusing to the pilot; this may have distracted the pilot and slowed recognition of the engine condition. This distraction could have reduced the effectiveness of the turn towards the shore. The 950-foot distance from shore was equivalent to nine seconds of flight time in autorotation and the time could easily have been lost if the pilot was distracted during a critical flight manoeuvre.

Judgement of height above a water surface is difficult even for experienced pilots. Examination of the helicopter indicated that the aircraft should have been controllable during the autorotation. However, the low kinetic energy of the main rotor blades coupled with the high descent rate, forward speed, and bank on impact indicate that the pilot likely misjudged his height above the surface of the lake during the flare for landing. Initiating either the flare or collective pitch increase or both at higher-than-recommended heights would result in the loss of the kinetic energy of the main rotor blades. Without sufficient kinetic energy in the main rotor blades, the pilot would have been unable to control the water landing.

The pilot would have had an aural warning of the reduction in rotor rpm but because the same aural warning occurs for hydraulic pressure, the pilot would have had to differentiate between the two possibilities. This may have delayed the pilot's response and caused the pilot to be rushed. A delay in responding to the audible warning may have resulted in a large drop in rotor rpm, excessive altitude loss, or loss of control.

The severity of the impact likely contributed to the inability of the occupants to egress as the helicopter sank. The distance from shore would have decreased the occupants' chances of survival had they exited the aircraft.

The following TSB Engineering Laboratory reports were completed:

LP081/2007 – Engine Tear-Down and Analysis;
LP090/2007 – Tail Rotor Shaft Failure;
LP093/2007 – Instrument Examination;
LP094/2007 – Jet B Fuel Analysis; and
LP099/2007 – Servo Actuator Testing.

These reports are available from the Transportation Safety Board upon request.

Findings as to Causes and Contributing Factors

1. The number three bearing of the engine's power turbine failed and engine power was automatically reduced to about ground idle, requiring the pilot to conduct an autorotation. The bearing likely failed when corrosion pitting occurred during a period where the required storage procedures were not followed.

2. The pilot conducted a forced landing into the lake because the en route altitude selected was too low to permit an autorotation to shore, because the pilot's response to the engine power loss slowed the establishment of an effective autorotation toward the shore, or because he was attempting to land near the shoreline of the lake in response to the first indication of the impending bearing failure.

3. The pilot likely misjudged the height of the helicopter above the water and executed the flare and landing prematurely. Premature initiation of the flare would result in the loss of the kinetic energy of the main rotor blades at a height from which the pilot would have been unable to control the water landing.

Finding as to Risk

1. Although regulations require pilots to fly the helicopter at a distance and height that would enable an autorotation to shore, there is no information provided in the basic flight manual with respect to glide ratios.

Other Finding

1. Although not a factor in this occurrence, the pressure in the hydraulic accumulators was below specification.

Safety Action Taken

Honeywell Aerospace is reviewing its long-term storage procedures.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 07 October 2008.

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Appendix A – Planned Route