Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A07W0150

POWER LOSS

KANANASKIS MOUNTAIN HELICOPTERS LTD.
BELL 206B HELICOPTER C-GFQZ
CLINE RIVER HELIPORT (CCR5), ALBERTA
12 AUGUST 2007

Canada

Aviation Investigation Report

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Summary

The Kananaskis Mountain Helicopters Ltd. Bell 206B Jet Ranger helicopter (registration C-GFQZ, serial number 2436) was over Abraham Lake, Alberta, on final approach to the Cline River heliport (CCR5), at approximately 1420 mountain daylight time when the engine (Rolls-Royce/Allison 250-C20B) decelerated and flamed out. The pilot entered autorotation and the helicopter descended into the lake, rolled onto the right side, and sank close to shore. The pilot and the passenger in the left cabin seat evacuated the wreckage without assistance. The passenger in the right cabin seat required the pilot's assistance to release the lap belt and exit the wreckage after the cabin became submerged. All three occupants sustained minor injuries. The helicopter was substantially damaged and there was no post-impact fire.

Ce rapport est également disponible en français.

Other Factual Information

Weather

Visual meteorological conditions with unlimited visibility prevailed at Cline River at the time of the accident. The surface winds were from the south at an estimated speed of 15 to 20 mph.

The Company

Kananaskis Mountain Helicopters Ltd. operated one Bell 206 L-3 and two Bell 206B helicopters under Sections 702 and 703 of the *Canadian Aviation Regulations* (CARs). A large portion of the operator's work consisted of high frequency, short duration, tourist sightseeing flights over glaciers in the Cline River area. The operation was seasonal in nature, with the majority of each year's flying activities taking place during the months of April through October inclusive.

Abraham Lake

Abraham Lake was a large man-made glacial lake, formed by the construction of the Bighorn Dam, on the upper waters of the North Saskatchewan River. The water temperature in the lake was low, which increased the physiological risks associated with cold water immersion.

The Cline River Heliport

The Cline River heliport was located approximately 200 m inland from the west shore of Abraham Lake. The shoreline near the helipad was oriented north-south. In strong south winds, final approaches to the heliport were usually carried out crosswind, heading east to west, due to the risk of encountering terrain-induced mechanical turbulence to the north, and west of the heliport. As well, there was a noise abatement restriction in place that prohibited flight over a resort area to the northeast. Approaching the heliport from the east required the helicopter to be over Abraham Lake for a brief period of time.

The Accident Flight

The helicopter had been chartered by two European tourists for a 25-minute glacier sightseeing trip to the west of Cline River. The flight was returning to Cline River when the accident occurred. On final descent to the heliport, at about 250 feet above Abraham Lake, the engine slowly decelerated. The engine-out warning horn and light subsequently activated, and the pilot observed that the rotor rpm was low. He immediately entered autorotation and turned about 90 degrees to the left to avoid a section of high, steep shoreline. A few seconds later, the helicopter was ditched into wind, parallel to the water's edge, about 20 feet from shore. It quickly rolled onto the right side and sank in about eight feet of water.

Wreckage Examination

The helicopter was recovered from Abraham Lake two days after the accident and transported to the TSB Western Region wreckage examination facility in Edmonton, Alberta, for examination. The wreckage was relatively intact. Damage to the lower fuselage indicated that the helicopter had contacted the water at a high rate of descent. The battery switch was found selected to the ON position, and the engine auto relight switch was in the OFF position. It was not determined if the auto relight switch was off before impact, or if it had been displaced to the OFF position by impact forces. The boost pump circuit breakers were engaged, and the collective twist grip was in the ground idle position.

The engine was examined in situ on the airframe before removal of any components. Water immersion precluded an engine test cell run, due to concerns over the effect of rapid cooling of the turbine wheels. There was no visual indication of external or internal mechanical damage to the engine. The engine controls showed no signs of discontinuity, gas turbine (N1) and power turbine (N2) turned freely when rotated by hand, and all engine accessory drives also showed no signs of discontinuity. There was no evidence of metallic contamination in the engine oil filter. The compressor, combustion, turbine and accessory gearbox assemblies were not disassembled during the examination.

The engine was fitted with a Bendix fuel control system. The power turbine governor (PTG), fuel control unit (FCU), engine-driven fuel pump, fuel nozzle, fuel line check valve, and bleed valve were removed and bench tested. A fuel nozzle that had been removed from the engine approximately nine hours before the accident was also bench tested. The bench testing was accomplished in consultation with the engine and fuel control system manufacturers, at a facility that provided maintenance, repair and overhaul (MRO) services for Rolls-Royce model 250 series engines. No anomalies that would have likely prevented normal operation of the engine were identified during the bench tests.

The fuel check valve assembly, which is located in the fuel line between the FCU and the fuel nozzle, leaked internally at 0.6 pounds per square inch gauge (psig) pressure. The purpose of the check valve assembly was to prevent any build-up of raw fuel in the combustion case if the burner drain valve remained in the closed position when the engine was not operating. Raw fuel build-up in the combustion case can result in a hot start. The check valve also prevented fuel nozzle drip at shutdown, to reduce the risk of afterfire. The check valve assembly is required to have zero leakage at 17 psig.

The engine fuel system components were disassembled following bench testing. Although the bench tests had not identified any anomalies that could have contributed to a loss of engine power, minute amounts of unidentified solid contamination were found in the FCU, the screen of the fuel nozzle that was installed at the time of the accident, and the screen of the fuel nozzle that had been replaced before the accident. The stem of the FCU bypass valve was worn undersize, and there was a small perforation in the bleed valve diaphragm. A small amount of unidentified solid contamination was also found in the fuel system check valve.

Maintenance Irregularities Found During the Investigation

The following maintenance irregularities, some administrative in nature, and others potentially more safety-critical, were identified during the course of the investigation.

The engine data plate was missing from the engine. The accessory gearbox assembly had recently been changed, and the engine data plate, which is normally mounted on the accessory gearbox assembly, had not been transferred from the old assembly to the new.

The company was in the process of implementing an electronic maintenance tracking system. At the time of the accident, no current engine technical record meeting the requirements of Section 605.92 of the CARs, and Schedule II of CAR 605 was available. Section 605.92 of the CARs requires the owner of every aircraft to keep a separate technical record for each engine installed on an aircraft. Schedule II of CAR 605 identifies the particulars to be entered in the record, the time frames within which the entries must be completed, and the persons responsible for the entries. Section 625.96 of the CARs requires the technical records, other than the journey log or technical records pertaining to repetitive inspections, to be kept until such time as the aircraft is no longer registered.

The PTG, part number 23070101, which was installed on the engine, was designed for Rolls-Royce/Allison 250 C30 series engines.

A small air leak was found in the compressor discharge pressure (Pc) tube at the “B” nut at the aft side of the PTG tee-fitting. The leak was found by pressurizing the Pc system with air and applying a liquid soap solution to the fittings before removal of any fuel system components. Breakaway torque measurement indicated that the “B” nut had been tightened to a value within the low end of the prescribed range of 80 to 120 inch-pounds. Torque paint is required to be applied to rigid tube “B” nuts on Rolls-Royce/Allison 250 series engines. The torque paint allows the “B” nut to be inspected for indications of slippage. The presence of old torque paint on the “B” nut was noted, although no continuation was noted on the adjacent surface of the governor tee-fitting. The Rolls-Royce/Allison 250 series Operation and Maintenance Manual (OMM) required the old torque paint to be removed and fresh paint applied across the connection following maintenance. The leak rate could not be quantified. The TSB Engineering Laboratory examination indicated that the leak may have occurred due to solid contamination between the cone on the tee-fitting and the flare on the Pc tube.

A crack was found in the end flare on the main fuel line in the fuel cell, where the line attached to the reducer tee-fitting on the aft boost pump. The TSB Engineering Laboratory examination indicated that the flare had failed initially as a result of an overload applied by overtorquing of the connection. The continued presence of either high imposed or residual stresses would appear to have allowed the crack to propagate further by stress corrosion cracking.

The PTG had been replaced approximately 36 flight hours before the accident. The Kananaskis Mountain Helicopters Ltd. aircraft maintenance engineer (AME) had verbally ordered a PTG for an Allison 250 C20B engine from Eagle Copters Maintenance Ltd. Eagle Copters was an approved distributor for aeronautical parts. A written purchase order had not been submitted. The AME was advised that a newer version PTG would be shipped. The wrong part was inadvertently picked from the parts shelf, and because there was no written order that referenced a specific part number, the sales order was generated based on the data plate on the new PTG. The PTG was shipped with paperwork that identified it as a C30 series PTG. The AME observed that the PTG he received was similar, but not identical to the one he had removed from the helicopter. He attributed the visual differences to the new governor being the newer version. A part number verification was not completed as part of the receiving inspection at Kananaskis Mountain Helicopters Ltd. The governor arm on the old PTG was installed on the new PTG, and the new PTG was installed and rigged without difficulty. A C30 series PTG operates through a different range of Pc pressures than a C20 series PTG.

The PTG was bench tested and found to have met C30 calibration parameters. Communication with the engine manufacturer and detailed review of the bench test data by the fuel control manufacturer indicated that, while incorrect, the installation of a C30 series PTG on the C20B engine would not likely have contributed to the loss of engine power.

A fuel control system pneumatic leak check had not been accomplished following the PTG change. The pneumatic portion of the Bendix fuel control system must be checked for leaks using a liquid soap solution if any pneumatic component is removed or installed, or if any pneumatic line is opened during maintenance of the control system. No leaks are permitted. Pc pressure modifies fuel flow during certain phases of engine operation, such as start, acceleration, and deceleration. While it is known that a large leak in the Pc system will result in engine deceleration, communication with the engine manufacturer indicated that, since the Pc line was not broken, the flare was not cracked, and the “B” nut was not loose, the leak rate was likely insufficient to have contributed to the loss of power. The Rolls-Royce Allison 250 C20B engine has no provision to manually control fuel flow to the engine in the event of a Pc system air leak.

The Bell 206 airframe fuel system uses two boost pumps submerged in the main fuel cell to transfer fuel from the main fuel cell to the engine. Both boost pumps operated normally following the accident, and there was no report of a boost pump failure during the flight. With both boost pumps operating, the crack in the end flare, on the main fuel line in the fuel cell, would have resulted in a minor fuel leakage back into the fuel cell. The crack was therefore not likely a factor in the engine deceleration. Leaks in fuel cell plumbing become problematic when both boost pumps are inoperative, and the leak is above the fuel level in the fuel cell. In this situation, air can enter the fuel system due to the engine-driven fuel pump drawing air up from within the fuel cell.

The Refuelling and Flight Turnaround Process at Cline River

Passengers for ice field sightseeing flights often arrived at the Cline River heliport in groups on large tour buses. In these cases, numerous 20- to 30-minute flights involving two or more helicopters would take place within a short period to accommodate the tour bus business. Kananaskis Mountain Helicopters Ltd. had a regimented procedure in place to facilitate quick turnarounds. Pilots would remain in the cockpit for several flights in a row, and then switch to ground support duties. Passenger safety briefings were provided to waiting passengers by ground crews, and the helicopters were hot-refuelled (engine running and the rotor turning), between flights.

On a typical turnaround, disembarking passengers were assisted out of and away from the helicopter by ground crews before refuelling. During refuelling, the pilot would observe the fuel gauge in the cockpit, and signal to the refueller when the gauge indicated the required fuel level. The refueller would then open the cockpit door and check the reading on the fuel gauge himself. Embarking passengers were then assisted into the helicopter, harnesses and doors were checked for security by the ground crews, and the pilot was given the signal to depart.

The flight departed with 35 to 37 US gallons of fuel, and it was estimated that there was between 20 and 25 US gallons of fuel on board at the time of the accident. It was not determined who had refuelled the helicopter, or how much fuel was added on the turnaround before the accident flight. The company did not require the amount of fuel added or the time of each refuelling to be recorded. The fuel cell had been breached during the accident, as evidenced by a fist-sized hole in the cell, below the cabin seat. The fuel cell was drained following recovery of the wreckage, and found to contain 70 litres of water and 3 litres of fuel. This was considered to be an unreliable indication of the fuel quantity at the time of the accident due to the impact damage to the fuel cell and the possible loss of fuel through the hole in the cell when the aircraft was submerged and during recovery. The fuel quantity indication system could not be tested to verify calibration following the accident due to impact damage to the system.

Water was found throughout the airframe and engine fuel system, including in the airframe fuel filter, the engine-driven fuel pump housing, and the line between the FCU and the fuel nozzle. Post-occurrence checks by the operator found no evidence of water contamination in the fuel supply system at the heliport. The airframe filter had been drained before the first flight of the day, and no anomalies had been observed. With the battery switch ON, it is probable that the boost pumps would have continued to operate after the helicopter became submerged, until the battery was fully discharged. With the collective twist grip in the ground idle position and the check valve leaking internally in the fuel line between the FCU and the fuel nozzle, water that entered the impact-damaged fuel cell may have been distributed all through the fuel system by the boost pumps.

Engine Data Acquisition Unit

The engine was fitted with an engine data acquisition unit (DAU). DAU data indicated that the accident flight was the fifth flight since the engine had last been shut down. The data also indicated that the five flight turnarounds had each been accomplished in approximately four minutes.

The engine DAU recorded 11 parameters. The values were recorded once per minute. The value for each parameter represented an average value for the parameter for each minute of engine operation. The DAU was successfully downloaded following the accident. The data indicated that the accident flight was airborne for approximately 22 minutes. No parameters were exceeded and no anomalies were recorded during that flight.

Previous Recent Incidents with the Helicopter

On 26 July 2007, at 3003.0 airframe hours, the helicopter had sustained damage to the transmission striker plate and isolation mount during a landing at a remote site. The incident was attributed to degradation of rotor rpm and landing on sloped terrain. On 10 August 2007, following repairs to the upper deck and transmission mounts, the helicopter had experienced three episodes of start problems: a hung start, an uncommanded shutdown after reaching 40 per cent N1 rpm, and an uncommanded shutdown after reaching 60 per cent N1 rpm. Troubleshooting had been carried out, the engine fuel system had been bled, and the fuel nozzle, part number 23077068, had been changed. The helicopter had subsequently been test flown and returned to service. The accident occurred 9.3 flight hours after the fuel nozzle had been changed.

The Pilot

The pilot was licensed in accordance with existing regulations. He held a valid commercial helicopter licence, endorsed for Bell 206 and Hughes 300 helicopters. He had approximately 300 hours of total flight time with less than 30 hours on Bell 206. He had recently been hired by Kananaskis Mountain Helicopters Ltd. and the accident occurred on his first day of revenue flying. The pilot was well rested and fatigue was not considered to be a factor in this occurrence.

The Approved Maintenance Organization

Maintenance on company helicopters was being carried out under the provisions of a maintenance contract with Avipro Helicopters Ltd. Avipro Helicopters Ltd. was an approved maintenance organization (AMO) authorized to perform all non-specialized maintenance work on a variety of aeroplanes weighing less than 5700 kg, and on numerous helicopters, including the Bell 206 series. The Avipro Helicopters Ltd. Maintenance Policy Manual (MPM) contained information to ensure the efficiency of the AMOs maintenance policies, including those relating to quality assurance, as required by Section 573 of the CARs. The MPM reflected the means of compliance with the CARs and described the standards and procedures that were to be adhered to in the performance of maintenance work.

The Aircraft Maintenance Engineer

The Kananaskis Mountain Helicopters Ltd. AME had 28 years of helicopter maintenance experience. He was licensed in accordance with existing regulations and endorsed on several helicopter types including the Bell 206. He had been employed by Kananaskis Mountain Helicopters Ltd. for the past two years. His signing authority was under the Avipro Helicopters Ltd. AMO, and his recent maintenance training met all of the training requirements set out in the Avipro Helicopters Ltd. MPM.

The AME was maintaining three Bell 206 helicopters at the Cline River base. He was working alone most of the time. Due to the high utilization of the company helicopters at that time of year, he was putting in long hours each day, often for several days in a row.

The Owner

The owner of Kananaskis Mountain Helicopters Ltd. was operations manager, chief pilot, director of maintenance/maintenance manager, and safety officer for the company. He had started flying in 1973, and had acquired over 10 000 hours of helicopter flying experience. Although highly familiar with helicopter operations, he had no maintenance qualifications. He had informally delegated all administrative responsibilities pertaining to maintenance to the AME.

The Kananaskis Mountain Helicopters Ltd. Maintenance Control Manual (MCM) contained information to ensure the efficiency of the maintenance control system, in accordance with Section 706.08 of the CARs. The MCM reflected the means of compliance with the CARs and described the standards and procedures that were to be adhered to in the performance of maintenance work.

Flight Recorders

The helicopter was not fitted with a flight data recorder (FDR) or cockpit voice recorder (CVR), and neither was required by regulation. The engine DAU provided limited flight data; however, the usefulness of that data was diminished due to the low capture rate of one value for each parameter each minute. A higher data capture rate would have provided an increased level of usefulness of the DAU data for accident investigation purposes. An available, lightweight, comparatively inexpensive alternative to an FDR in non-FDR-equipped helicopters is a cockpit video digital recorder (CVDR). There is currently no regulatory requirement to install a CVDR in light-fixed wing aircraft or helicopters that are not otherwise fitted with flight recorders.

Occupant Survivability

The pilot's head was struck by the windshield at impact. He was wearing a shoulder harness and a helmet with a visor. The helmet and visor likely reduced his level of injury.

The passengers were given a passenger evacuation briefing before departure by a pilot performing ground crew duties. The pilot and the passenger in the left cabin seat evacuated the wreckage unassisted. The passenger in the right cabin seat was unable to release her seat belt after the cabin became submerged, even though the belt was fully functional. The pilot provided critical emergency assistance by reaching underwater, through the left cabin door, and releasing the lap belt buckle. The trapped passenger was subsequently lifted above water, and assisted to shore by the pilot and the other passenger.

The following TSB Engineering Laboratory reports were completed:

LP 117/2007- "B" Nut Analysis
LP 118/2007- Rear Boost Pump Reducer Tee Failure

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

Analysis

The weather conditions were suitable for visual flight and were not considered a factor in the occurrence.

The engine lost power and flamed out for undetermined reasons. While no discrepancies that would have prevented normal operation of the engine were identified during bench testing of the Bendix fuel control components, small amounts of unidentified solid contamination were found in several components after disassembly. While small amounts of solid contamination were present, the fuel system components functioned satisfactorily during bench testing; therefore, the possibility that contamination contributed to the loss of power could not be proven or ruled out.

The fuel load on the helicopter at the time of the occurrence could not be determined with certainty, and water contamination was present throughout the engine and airframe fuel systems when the wreckage was recovered. The fuel cell was breached during the accident, which would have allowed water to flow into the fuel cell after the wreckage became submerged. With collective twist grip in the ground idle position and the engine fuel check valve leaking at low pressure, water may have been distributed throughout the fuel system by the boost pumps after the fuel cell filled with water, before the battery became discharged.

Several maintenance-related anomalies were identified during the examination of the engine and airframe. The missing engine data plate, the absence of a current engine log, and the installation of an incorrect PTG were indicative of administrative deficiencies, specifically maintenance tracking and record keeping, within the company maintenance program. The leaking Pc tube, the lack of continuous torque paint on the PTG "B" nuts, the crack in the reducing-tee in the fuel cell, and the internal leak in the check valve assembly in the FCU to fuel nozzle fuel line were further indications of weak maintenance practices. While none of these anomalies could be linked directly to the loss of engine power, their presence indicated that maintenance on the helicopter was not being accomplished fully in accordance with the Avipro Helicopters Ltd. MPM or the Kananaskis Mountain Helicopters Ltd. MCM.

The pilot had modified his approach to the helipad due to the south wind, and the approach carried the helicopter over Abraham Lake. The helicopter was over water, heading toward a steep shoreline when the engine lost power. Both topographies exposed the helicopter and occupants to an adverse forced landing environment. The pilot's decision to ditch the helicopter near the shore, rather than attempt to set down on the steep shoreline, likely reduced the crash forces and the impact damage to the helicopter.

The passenger in the right cabin seat was unable to release her lap belt after the cabin filled with water. The quick actions by the pilot to release the lap belt and assist the passenger from the submerged wreckage likely reduced the level of injury.

The engine DAU data were being averaged each minute of engine operation, and recorded once per minute. This recording rate of one value per parameter per minute diminished the usefulness of the DAU for accident investigation purposes. A functioning crash-protected CVDR may have allowed investigators to reconstruct the flight sufficiently to better understand the circumstances that led to the accident.

Findings as to Causes and Contributing Factors

1. The engine lost power and flamed out for undetermined reasons on approach to the Cline River helipad and the helicopter ditched in Abraham Lake.

2. The approach was conducted over water, toward a sloping shoreline that exposed the helicopter to an adverse forced landing environment.

Findings as to Risk

1. Small amounts of unidentified solid contamination were found in several engine fuel system components after disassembly, creating the potential for fuel flow anomalies to occur within the engine fuel system.

2. A small air leak was present in the compressor discharge pressure (Pc) pneumatic tube, situated between the governor and the fuel control unit (FCU), at the “B” nut on the aft side of the governor tee. There was a risk of engine deceleration had the leak rate increased.

3. There was a crack in the end flare on the main fuel line in the fuel cell, where the line attached to the reducer tee-fitting on the aft boost pump. At low fuel levels, the engine-driven fuel pump can draw air into the system if the boost pumps become inoperative.

4. The wrong power turbine governor (PTG) was installed on the engine, creating a situation of potentially degraded engine performance.

5. The engine check valve assembly, located in the fuel line between the FCU and the fuel nozzle, had a substantial internal leak, increasing the risk of drainage of fuel into the combustion case when the engine was not operating.

6. The torque paint on the PTG “B” nuts was discontinuous, leaving no way to confirm visually any loosening of the “B” nuts.

Other Findings

1. The company did not maintain current engine technical records in accordance with the requirements of Section 605 of the *Canadian Aviation Regulations* (CARs).

2. Each parameter of engine data acquisition unit (DAU) data was being averaged and recorded once per minute, which reduced the amount and usefulness of the data for accident investigation purposes.

3. A functioning crash-protected cockpit video digital recorder (CVDR) may have allowed investigators to reconstruct the flight sufficiently to better understand the circumstances that led to the accident.

Safety Action Taken

Following the accident, Transport Canada completed a limited combined regulatory inspection of the Kananaskis Mountain Helicopters Ltd. field operation base at the Cline River Heliport. A more in-depth inspection was subsequently carried out by Transport Canada Aircraft Maintenance and Manufacturing (AMM). There were 10 inspection findings in total, most identifying administrative deficiencies. The specialty areas that had findings were quality assurance (QA), technical records, sample aircraft for conformance, maintenance planning, defect recording, rectification, deferral and control procedures, and technical dispatch procedures. Kananaskis Mountain Helicopters Ltd. responded immediately by implementing a comprehensive corrective action plan (CAP). An aviation consulting company was contracted to assist in dealing with and rectifying the deficiencies. There will be a Transport Canada AMM follow-up inspection in 2008.

As a follow-up to this occurrence, Eagle Copters Maintenance Ltd. conducted an internal review of the circumstances leading to the shipment of an incorrect power turbine governor (PTG) to Kananaskis Mountain Helicopters Ltd. The review employed a Maintenance Error Decision Aid (MEDA) process. The review resulted in four internal MEDA recommendations for error prevention:

- Encourage the customer to identify the part number required, and provide a purchase order when ordering parts.
- Ensure that parts requests are entered electronically, so as to provide an electronic trail to enable checking of parts prior to shipment.
- Ensure that the parts are correctly identified before removing them from inventory.
- Additional human factors training for the employee involved.

As a follow-up to this occurrence, Avipro Helicopters Ltd. provided additional individual staff training, in accordance with the Maintenance Policy Manual (MPM), as necessary to upgrade the knowledge and understanding of the requirements of the MPM with regards to receiving of parts. As well, an MPM amendment was generated to address the use of owner-supplied parts.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 22 May 2008.

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