AVIATION OCCURRENCE REPORT

COLLISION WITH TERRAIN

CANADIAN HELICOPTERS LIMITED
EUROCOPTER AS-350BA (HELICOPTER) C-GRGK
REVELSTOKE, BRITISH COLUMBIA, 50 NM NORTH
26 APRIL 1996

REPORT NUMBER A96P0064

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Summary

The pilot departed the operator's Revelstoke base in the AS-350BA helicopter at 0750 mountain daylight time (MDT) on Friday, 26 April 1996, and flew to the operator's base at Golden, British Columbia, to refuel and pick up two passengers. The three then departed Golden at 0900 MDT to begin a planned visual flight rules (VFR) flight to undertake snow-sampling operations at various locations in the mountainous area between Golden and Revelstoke. The helicopter did not return to Golden at the expected time, and the operator's base-pilot in Golden commenced an aerial search in the other company helicopter. The Kamloops flight service station specialist contacted the Rescue Coordination Centre in Victoria to advise them of the overdue aircraft. Search and rescue aircraft were dispatched from Canadian Forces Base Comox shortly thereafter and flew to the search area. After an extensive civilian and military search, the wreckage of the missing helicopter was found at about 1030 MDT the following day. The helicopter had crashed in mountainous terrain at about 6,200 feet above sea level; the three occupants were fatally injured and the helicopter destroyed. There was no fire.

Ce rapport est également disponible en français.

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[1] All times are MDT (Coordinated Universal Time minus six hours) unless otherwise noted.

Other Factual Information

The pilot was on the fifth day of his tour at the Revelstoke base, and had last flown on Wednesday, 24 April 1996. The pilot was said to be a happily married man, and a quiet, compassionate, and meticulous individual. He was regarded as a conscientious pilot, well-respected by his peers and supervisors in the company, and had a positive, professional manner with a pro-active attitude towards flight safety. He had no significant outside pressures. There was no evidence that incapacitation or physiological or psychological factors affected the pilot's performance.

The pilot was licensed and qualified in accordance with existing regulations. He had considerable experience in both mountain flying and winter operations, as well as field-camp operations. His flying career included about 4,500 helicopter hours with the Canadian Forces in both Canadian and German operational and training spheres. Since joining Canadian Helicopters, he had accumulated about 1,500 hours on the AS350 helicopter, bringing his total helicopter experience to about 6,000 hours. His last operational and pilot proficiency examinations and flight tests were conducted in February 1996, and, as on previous occasions, were of a consistently high standard.

The pilot refuelled the helicopter himself, but the precise amount of fuel he added is not known. Had he refuelled the tank to its capacity of 540 litres, or about 940 pounds, at Golden, the aircraft weight at take-off would have been no more than 4,200 pounds. The maximum certificated weight for the helicopter is 4,630 pounds. Given that the pilot had recorded the journey's cumulative flight time up to the last landing as 1 hour and 35 minutes, the fuel consumed would have been about 490 pounds; the estimated take-off weight from Goldstream, the last landing site recorded in the pilot's flight log, would have therefore been less than 3,700 pounds. The longitudinal and lateral positions of the centre of gravity would have been within limits, regardless of the fuel load. Investigators at the accident site drained about 90 litres, or about 160 pounds, of fuel from the fuel tank. A test for water in the fuel revealed no contamination. Fuel quantity, quality, or delivery were considered not to have been factors in this accident.

The helicopter had a set of snow covers designed to cover the engine inlet, exhaust, and the main rotor blades. The pilot did not take this protective equipment from the Revelstoke base when he departed on Friday morning, nor was he required to have done so.

The pilot had not made any comment to the engineering personnel at Golden that morning about any deficiencies with the helicopter. A review of the aircraft maintenance documents revealed that the helicopter was certificated and maintained in accordance with existing regulations, and no evidence was found of any outstanding defects.

The helicopter was equipped with an emergency locator transmitter (ELT) beacon, mounted in the forward section of the instrument pedestal, near the pilot's left anti-torque pedal. This particular installation did not provide convenient access to the ELT. No ELT signal had been received; first responders at the accident site found the ELT switch in the OFF position. The TSB Engineering Branch examined the ELT and found no evidence that the switch had been struck, despite considerable case damage. It was therefore concluded that the switch had not been jarred off during impact, and that the ELT had not been armed before the accident

flight. Engineering laboratory tests revealed that the internal 'g-switch' in the ELT had been triggered, but that the transmitter crystal had been recently split, presumably by the impact forces of the accident; such damage would have immediately rendered the unit unserviceable. It could not be determined when, or why, the ELT was turned OFF, or why the pilot did not set it to ARMED before the flight.

The French aviation regulatory agency, Direction générale de l'aviation civile (DGAC), had issued an Airworthiness Directive (AD), number 93-067-066(B), dated 12 May 1993, which limited flight in falling snow in all AS350 helicopters which do not have one of the approved, optional engine intake accessory kits installed. At the time of the accident, C-GRGK did not have either kit installed and, to avoid risk of engine flameout when flying in falling snow, the following limitations were applicable:

a. when visibility was greater than 1,500 metres, flight was authorized;
b. when visibility was less than 800 metres, flight was prohibited; and
c. when visibility was between 800 metres and 1,500 metres, the total flying time in falling snow was limited to 10 minutes. This time limit included the time required to leave all snowy conditions, irrespective of the visibility.

Transport Canada (TC) Continuing Airworthiness Branch issued a letter to all AS350 helicopter owners, dated 07 January 1994, which referred to the DGAC AD and which "clarifies the restrictions on flight in snow imposed by the subject airworthiness directive (AD)." The letter stated in part that;

> "The AD does not supersede any approved AFM *(Aircraft Flight Manual)* Supplements that allow in their Limitations Sections cancellation of the flight in snow limitations of the basic AFM."

The letter further stated that;

> "TC has accepted the DGAC approval for flight in snow with the Sand Filter kit, or with the Protection of the Air Intake Against Induction of Snow kit installed in accordance with the Flight Manual Supplements ..."

The TC letter made no further interpretation of the in-flight time restriction of 10 minutes.

During the course of the investigation, discussions with other Canadian operators of the AS-350 helicopter revealed fundamental differences in their interpretations of the in-flight time restriction imposed by the AD. The operator had interpreted the restriction to imply that the total of 10 minutes flight was inviolate, and that the helicopter had to be on the ground for engine intake inspection within that time; another operator deemed that the AD flight time restriction was cumulative in effect, and that the helicopter could fly in snow at various times during flight for a total of 10 minutes before landing for inspection; yet another interpretation was that the 10-

minute limit was on a per-instance basis and that, providing the 10-minute limit was not exceeded on any one occasion, the helicopter could fly in and out of snowing conditions indefinitely.

A witness, who was located at the 4,600-foot level in the same valley as the accident site, saw a helicopter flying low, moving slowly up the valley towards the Goldstream landing site at about 1320 MDT. He reported that the weather conditions at that level were poor, with heavy, falling snow, and low ceiling. These conditions reportedly did not improve significantly for several hours, until about 1700 MDT. The witness did not see or hear the helicopter subsequently take off. Without an observer, the weather conditions at the Goldstream landing site, about two miles away and 2,000 feet higher up the mountainside, are unknown. According to people familiar with the local weather circumstances and seasonal patterns, it is common at that time of the year for frequent and localized weather cells to move across the area, creating well-defined snow squalls in otherwise clear, sunny skies. Visibility in these rapid squalls is often reduced to less than 100 feet.

Recent human tracks were found at five of the seven proposed landing sites, indicating that the accident helicopter had recently landed there. An examination of the site notes taken by the snow-sampling team confirmed that they had worked at those sites, and established their sequence; the pilot's personal flight record notebook confirmed the flight times to the sites, and the landing sequence. A collective review of these records reveals that the helicopter had landed at the Goldstream site at 1325 MDT, after having landed at four other sites.

The three people on board the helicopter were experienced outdoor campers, had sufficient provisions to stay overnight in the field, and none had urgent or pressing requirements to return to Golden that Friday night. At the time of landing at Goldstream, they still had about seven hours of daylight at their disposal to work, wait if necessary, and depart for the remaining site, or to return to Golden.

The accident site is about 300 feet lower in elevation than the Goldstream landing site, and at a distance of about 1,500 feet down the valley. The terrain slopes at about 30 degrees and is moderately populated with tall conifers. Two large trees on the periphery of the accident site had been topped and exhibited clear evidence of rotor blade strikes at about 50 feet above the snow surface; a larger tree, about 18 inches in diameter, had been snapped off at the surface and had fallen back onto the helicopter at impact. Other smaller trees exhibited scrape marks and gouges consistent with helicopter fuselage and skid contact. There were areas that were clear of trees adjacent to the accident site which may have been suitable for an emergency landing.

The helicopter wreckage was contained to the impact point and all components were accounted for. Impact marks and aircraft wreckage characteristics revealed that the helicopter had struck the ground in a nose-low, right-side-down attitude with a high rate of descent and low main rotor rpm. At surface impact, the helicopter had collided head-on with the large tree, which then passed through the cabin area and struck the main transmission gearbox, breaking the front main transmission mounts and the forward hydraulic servo. The tail boom assembly had snapped off at the fuselage attachment bulkhead, and it exhibited damage consistent with separation at low rotor rpm; the tail rotor assembly exhibited similar low-rpm damage. The three main rotor blades were intact and attached to the head; the damage patterns were consistent with impact with the surface at low torque and low rotor rpm. None of the drive train components exhibited evidence of engine power at impact. Except for the known tail boom separation, flight control continuity was confirmed for the collective,

cyclic, and anti-torque controls.

The throttle lever in the cockpit was found in the "stop", or aft, position; the main fuel flow valve on the engine fuel control unit (FCU) was in the corresponding closed position; and the throttle cable fitting at the engine had been bent at impact. The TSB Engineering Branch examination of the bent end fitting on the fuel flow control cable revealed damage that was consistent with the cable having been forced into the fitting while the fitting was bending or after the fitting was bent. Since the bending occurred at impact, it was concluded that the throttle lever was forced into the aft, closed position as a result of the impact forces when the helicopter struck the ground. The fuel lever was found snapped off at the quadrant in the open, or normal in-flight, position but the frangible witness wire was intact; the associated fuel shut-off valve was found open.

The Turbomeca Arriel 1B engine was taken to an approved engine overhaul facility for a detailed examination and test cell run. The examination revealed no evidence of either mechanical deficiency or significant rotation at impact. The engine was test run and met the engine manufacturer's specifications. The engine FCU was examined, tested, and stripped down; it was unremarkable and met all specifications and tolerances.

The main rotor gearbox was disassembled and examined. With one exception, all components were unremarkable. When the main rotor shaft was removed from the gearbox upper housing unit, the locking key which couples the phonic wheel to the shaft fell out from the machined key-way. Closer examination revealed that the retaining roll-pin, which normally holds the key in place in the phonic wheel key-way slot, had been sheared. TSB Engineering Branch microscopic examinations of the key, the phonic wheel, and associated bearings determined that, although the key had been partly in place in the key-way slot, there had been no slippage between the components during service life. As a result, it was concluded that the mis-set key was not a contributing factor in this accident. It was, however, the focus of a study and review of the installation procedures for this component.

All three occupants were wearing seat-belts and shoulder harnesses; the pilot was also wearing a flight helmet. The impact forces at ground contact were high, and the occupiable volume of the cabin was compromised by the large tree which the helicopter struck at ground impact. The accident was not survivable.

Analysis

In general, in the event of an uncommanded engine deceleration in flight, the indications to the pilot would have been similar to those resulting from an engine flame-out, and would have given the pilot the same operational options. Such a deceleration would have been caused by a malfunction of the engine's fuel control unit (FCU). The engine run in the test cell after the accident repeatedly demonstrated consistent, specification engine performance, and normal function and performance of the FCU. The FCU examination and disassembly revealed no abnormalities, and demonstrated again that the FCU was functioning correctly. It is possible that foreign matter had entered the FCU at some time, caused it to malfunction, and yet became dislodged at impact; however, the undisturbed fuel samples taken before and during the first engine run contained no discernible contaminant, nor was any significant contaminant found at FCU disassembly. Given the success of the test cell runs and the FCU examinations, and in the absence of any contaminant found in the fuel system, it is unlikely that contamination of the FCU caused an uncommanded deceleration and led to the

accident. Since no causal mechanical deficiencies with the engine or helicopter were found, this analysis concentrates on the operational factors of this accident.

As a result of the engine examination, it was concluded that the engine was not delivering significant power at impact, although capable of doing so. As well, the damage to the rotor system is consistent with low torque and low rpm at impact. Although the engine throttle control was found in the closed position, there is evidence to conclude that it was moved by impact forces.

Consequently, snow ingestion remains as the most likely reason for the engine stopping in flight. It was not possible to determine either the time of take-off from Goldstream or the duration of the flight prior to the engine stoppage. It is possible that (a) the helicopter flew into adverse snow showers and accumulated sufficient snow to flame out the engine, or that (b) unseen by the pilot, snow had accumulated inside the engine intake while the helicopter was on the ground at Goldstream, and slipped into the engine during in-flight manoeuvring and caused the flame-out. It is also possible that a combination of the above occurred.

A sudden loss of engine power would have committed the pilot to conduct an autorotative descent and landing over inhospitable terrain, and possibly in adverse weather conditions. The in-flight circumstances immediately preceding the engine stoppage could not be determined; however, when the helicopter struck the trees during the last stage of descent, the main rotor rpm would have been reduced and, if the rpm had already decayed, likely would have rendered the helicopter uncontrollable, leading to inevitable impact with the surface.

The TC Airworthiness letter dated 07 January 1994 which sought to clarify the DGAC AD restrictions on flight in falling snow, did not either identify the possibility of, or resolve, the ambiguity in the AD, nor did it further interpret the in-flight time restriction of 10 minutes. That Canadian operators of the AS-350 helicopter independently interpreted the AD with fundamental differences in their application of the in-flight time restrictions indicates that the AD is ambiguous and unclear, that it leads to mis-interpretation, and is not applied uniformly.

The following Engineering Branch reports were completed:

LP 67/96 - Systems Examination;
LP 77/96 - Control and Drive Systems Examination.

Findings

1. Records indicate that the helicopter was certificated and maintained in accordance with existing regulations, and no evidence was found of any pre-impact failure or malfunction which could have contributed to the accident.

2. The actual weather conditions at the accident site or the last known take-off location are unknown.

3. Conditions of falling snow and reduced visibility were reported in the vicinity at about the time of the accident.

4. The helicopter engine flamed out in flight, likely as a result of snow ingestion.

5. The pilot was committed to an autorotative descent and landing into inhospitable terrain.

6. The helicopter struck trees during the final stage of descent for undetermined reasons .

7. The ELT was not ARMED for this flight for undetermined reasons.

8. The DGAC AD pertaining to flight in falling snow is ambiguous, and leads to misinterpretation.

9. The locking key which coupled the phonic wheel to the main rotor shaft had been incorrectly installed; it was concluded that this did not contribute to the accident.

Causes and Contributing Factors

The engine flamed out, likely as a result of snow ingestion. It could not be determined why the helicopter struck trees during autorotative descent. Contributing to the accident were the inhospitable terrain and likely adverse weather conditions.

Safety Action

On 20 May 1996, Eurocopter France, the manufacturer of the AS-350BA, issued a service letter, number 1270-00-96, to all operators of Eurocopter helicopters on the subject of "Protection and Operation of Helicopters in Snowy Conditions." The letter served to explain and emphasize the precautions to be taken to prepare for flight a helicopter that had been parked out in the open in (falling) snow.

Since the accident, the operator has installed the engine particle separator kit in all its AS-350 helicopters. As a result of this installation programme, the AD pertaining to flight in snow no longer applies to any of their AS-350 helicopters.

Since the anomaly concerning the drive shaft key was identified, the maintenance division of the operator has issued internal instructions to highlight the possibility of misalignment of the components at re-assembly, and to increase awareness of the potential danger of misalignment.

In December 1995, following a review of TSB data for occurrences from 1984 to 1995, the TSB forwarded an Aviation Safety Advisory to TC concerning the high incidence of ELTs being found in the unarmed position during accident investigations. The Advisory asked TC to consider emphasising the importance of arming ELTs prior to flight, and as well, for TC to consider a mandatory requirement for the arming of ELTs. In response, TC indicated that a rule requiring mandatory arming of ELTs was not appropriate. However, the former ELT ANO (Series II, Number 17) has now been replaced by the Canadian Aviation Regulation (CAR) 605.38, which in part requires the ELT to be armed if so specified by the flight manual, operating manual, or pilot handbook. Since the accident, TC has prepared articles on the importance of ensuring that ELTs are armed prior to flight, and they have appeared in the COPA, Vortex, Maintainer, and Aviation Safety newsletters.

An Aviation Safety Advisory letter was sent to TC advising of the ambiguity that exists in Airworthiness Directive 93-067-066(B) with respect to the limitations for flight in falling snow.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson Benoît Bouchard, and members Maurice Harquail, Charles Simpson and W.A. Tadros, authorized the release of this report on 17 September 1997.