AVIATION INVESTIGATION REPORT
A02C0161

DRIVE SHAFT FAILURE AND COLLISION WITH TERRAIN

HELICOPTER TRANSPORT SERVICES

BELL 205 C-FPAZ

CHITEK LAKE, SASKATCHEWAN

11 JULY 2002

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

Aviation Investigation Report

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Summary

A Helicopter Transport Services Bell 205 helicopter, C-FPAZ, serial number 30016, was on contract to the Province of Saskatchewan's forest fire suppression program. At approximately 2000 central standard time, the provincial fire coordinator requested the pilot of C-FPAZ to resume water bucketing on a small fire approximately five miles east of Chitek Lake, Saskatchewan. While manoeuvring to the drop point, at less than 40 knots and approximately 150 feet, the pilot saw the reflection of a yellow caution light in the door window and heard an associated low-rotor-rpm warning. The corresponding N2 (main rotor rpm) indication was 97 to 98 per cent. The pilot released the water load and reduced the torque. The rotor rpm did not recover and the pilot prepared to make a forced landing. He kept power on until the bucket was clear of the trees below and then reduced collective in an attempt to regain rotor rpm. There was no resultant rotor rpm increase and the helicopter descended rapidly over a short distance, struck an earthen brush pile, and rolled onto its side. The accident occurred during daylight hours at 2010.

The pilot of another helicopter saw C-FPAZ go down, called the Chitek Lake Fire Base for emergency medical personnel, then landed adjacent to the crash site. The pilot of C-FPAZ was walking unsteadily away from the aircraft, and there were flames emanating from the exhaust stack. The engine was still running. Neither pilot attempted to extinguish the flames. The engine stopped several minutes after the two pilots exited the crash site. On receipt of the second helicopter's call, the fire coordinator at the Chitek Lake Fire Base dispatched emergency medical personnel and a water bomber aircraft to the site. The accident pilot, who had sustained serious injuries, was stabilized and evacuated to Saskatoon. The water bomber dropped water and retardant on the area immediately surrounding the crash site.

Ce rapport est également disponible en français.

Other Factual Information

The pilot held a valid Canadian commercial helicopter pilot licence, which was endorsed for several helicopter types, including the Bell 205. Available information indicated that the pilot was adequately rested, in accordance with company and Transport Canada requirements, on the day of the accident.

The observed weather at 2000 central standard time[1] at the Vimy Fire Base, approximately five miles from the accident site, was as follows: temperature at 28°C, with light winds out of the south.

On 08 July 2002, three days prior to the accident, a grease seal on the forward main input drive shaft coupling of the helicopter had failed. The failure was detected during a daily inspection, after the helicopter had operated for 6.1 hours. The grease seal was replaced and installed with Bell 204 grease, as recommended by the Bell 205 Component Repair and Overhaul manual. As part of the seal replacement procedure, the aircraft maintenance engineer (AME), disassembled, cleaned, and inspected the splined components of the forward coupling on the drive shaft. This inspection did not reveal any indication of wear or overheating of the splined components. The aft coupling assembly for the drive shaft was not disassembled. Temperature-sensing "temp-plates", installed on the outside of both coupling assemblies, were inspected and did not show that either coupling had experienced an over-temperature condition. Although the AME completed his work report and appropriate tag entries for the replacement of the forward coupling grease boot, there was no certification statement entered in the helicopter journey log for the accomplished work.

On 10 July 2002, C-FPAZ was returned to service and was engaged in fire-suppression operations, which involved several water bucketing trips and two crew moves. There were no reported abnormal vibrations or engine indications, with the exception of a slight main rotor rpm loss (droop) during the water pickups. Because of the high ambient temperatures, this was not considered abnormal by the pilot. A daily inspection was completed following that day's flying activities, during which the drive shaft couplings and temp plates were inspected with no apparent grease leakage or overheating of either coupling being detected.

On the day of the occurrence, C-FPAZ was again dispatched on fire-suppression operations, which initially involved a crew move, followed by approximately six hours of water bucketing and another crew move. During the bucketing operations, the main rotor rpm drooped slightly while picking up water with the bucket. There was no reported main rotor rpm droop while manoeuvring to the water drop position, until the time of the occurrence.

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

Examination of the wreckage and surrounding area yielded the following information:

- The helicopter had sustained substantial damage from deceleration forces on impact. The main rotor, tail boom, and cabin areas were bent and sheared from the resulting overload forces. Damage to the main rotor and transmission mounts was consistent with a low rpm impact with the ground and subsequent contact with the fuselage.

- The transmission mounting structure had been bent forward, which allowed the free-floating main input drive shaft to spin out of the forward coupling and eventually disengage from the engine and transmission.

- The splined end (forward transmission side) of the main input drive shaft showed extensive wear and heat damage. There was helical scoring from the drive shaft coupling teeth into the plastic-state metal of the splined drive shaft. The inside teeth of the coupling showed indications of high heat and wear, but had remained relatively intact. The corresponding teeth on the shaft were almost completely ground off. The damage to this end of the shaft was so extensive that a determination of the pre-failure condition of the shaft was not possible.

- Most of the rubber portion of the forward coupling grease seal was missing. Only the seal mounting hardware remained. The inner teeth of the outer coupling were filled with carbon and remnants of teeth from the drive shaft. The carbon material was subsequently tested and found to be representative of a substantial quantity of grease that had carbonised due to excessive heat. There was no indication of grease leakage in the surrounding area.

- The aft drive shaft coupling failed as a result of overload forces, produced when the shaft spun out of the forward coupling. The grease seal on this end was in place, and there were indications of grease spatter on the forward side of the engine compartment.

- The tail boom was bent and the tail rotor drive shaft coupling had separated.

The water bucket was connected to C-FPAZ's cargo hook by a 60-foot long-line, cinched at the 80 per cent setting, which corresponded to a calculated total sling load weight of about 3060 pounds. The helicopter had approximately 800 pounds of fuel on board. The maximum permissible gross weight for the helicopter was 10 500 pounds. The estimated total weight of the aircraft and sling load at the time of the accident was 9622 pounds. The electric cargo release system arming switch was in the "armed" position.

The main input drive shaft in the Bell 205 does not have a finite service life. It is maintained on an "on condition" basis, with a 600-hour inspection and re-grease interval. The shaft in the accident helicopter had operated for 187.4 hours from the time of its last 600-hour inspection to the time of the grease seal failure on 08 July 2002. The shaft requires a continuous internal coating of grease to reduce frictional heat and premature wear, and the grease seals, which are inspected daily for damage and leakage, retain the grease within the shaft coupling.

The recommended pilot procedure following an engine failure or loss of main rotor rpm is to execute an autorotative descent.[2] Helicopters have critical flight regimes, from which the possibility of establishing a successful autorotation is extremely low.[3] The Bell 205 pilot flight manual limitations section specifies these conditions in its height/velocity diagram.[4] The height/velocity diagram directs pilots to avoid operating under specified conditions of altitude and airspeed. However, this direction does not constitute a regulatory limitation for external load operations.[5] Helicopters engaged in water bucketing (external cargo) operations routinely operate under these critical conditions.

Analysis

The carbon residue from the burned grease and the absence of grease spatter surrounding the failed end of the main input drive shaft, suggest that it is unlikely that there was a second grease seal failure prior to the accident. The TSB Engineering Branch determined that a failure of the main input drive shaft forward coupling was the lead event in the accident sequence. There are two possible scenarios as to why this forward coupling failed:

- There may have been a progressive failure occurring within the drive shaft coupling that was not or could not have been detected by visual inspection at the time of the grease seal replacement. Operation with less than the normal amount of grease at the time of the seal failure may have accelerated the progression of the coupling failure; or

- Operation with less-than-normal lubrication at the time of the seal failure may have damaged the drive shaft coupling to the extent that it subsequently failed.

The helical scoring and wear damage on the splined end of the main input drive shaft indicated that it had been spinning inside the coupling prior to impact, the result of which was a decoupled engine that was no longer driving the rotors. Because the engine was no longer driving the main rotor, the rotor rpm began to decay with a corresponding low rotor rpm warning and subsequent loss of lift.

Because the decoupling occurred at an altitude of 150 feet and at an airspeed of less than 40 knots, the helicopter was operating in a flight regime from which the likelihood of establishing a successful autorotation was low.

The height velocity diagram of the Bell 205 helicopter is contained in the limitations section of the pilot's flight manual, as are the conditions attached to the limitation. Helicopters engaged in external load operations are not

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2 Bell 205 Pilot's flight manual, Section 3, "Emergency Procedures".

3 *Dynamics of Helicopter Flight,* Saunders 1975.

4 Bell 205 Pilot's flight manual, Section 2, " Limitations".

5 Bell 205 Pilot's flight manual, *Supplement for External Cargo Operation*, Section 2, page 5, 3rd paragraph.

limited by the diagram. Consequently, pilots operating the Bell 205 helicopters in external load operations are exposed to a heightened level of risk because the potential to recover from a malfunction, such as power and drive train failure, is significantly reduced.

The following TSB Engineering Branch Report was completed:

LP 067/02 - Drive shaft Assembly Bell 205A-1, C-FPAZ.

Findings as to Causes and Contributing Factors

1. The main input drive shaft of the helicopter failed at the forward coupling, most likely as a result of a progressive failure or damage that was not detected at the time of the grease seal replacement.

2. Failure of the main input drive shaft decoupled the engine from the transmission, which resulted in a decrease in main rotor rpm and a rapid rate of descent that continued until the helicopter collided with the terrain.

3. The main input drive shaft failure and subsequent descent occurred at an altitude and flight regime from which a successful steady state autorotation could not be achieved.

Findings as to Risk

1. Helicopter pilots engaged in external load operations with Bell 205 helicopters are not limited by the restrictions specified in the height velocity diagram and are, therefore, exposed to a higher level of risk than are helicopter pilots who are not operating in this flight envelope.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 08 October 2003.

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