Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT

A02W0178

TAIL ROTOR DRIVE SHAFT COUPLING FAILURE

ALPINE HELICOPTERS LTD.

BELL 212 C-FHDY

PINK MOUNTAIN, BRITISH COLUMBIA, 20 NM WEST

11 SEPTEMBER 2002

Canada

Aviation Investigation Report

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Summary

The Bell 212 helicopter, C-FHDY, serial number 30594, had been working on a seismic contract in the Pink Mountain area of northeastern British Columbia for the previous 26 days, flying about 77 hours. On the day of the accident, the pilot departed from Mae's Kitchen, a motel at Mile 147 on the Alaska Highway, at 0624 Pacific daylight time to fly to the Pink Mountain staging area to pick up seismic crews. From the staging area, the pilot flew the seismic crews into seismic drill sites located about eight miles to the west of the staging area. Nine hours later, after flying about four hours on various jobs, the pilot was completing a series of vertical reference sling operations with a 2700-pound compressor on a 100-foot longline equipped with a pilot-operated remote hook. As the pilot was hovering at 50 to 100 feet above the intended drilling site, located on a mountain ridge about 5600 feet above sea level, a loss of tail rotor authority occurred and the helicopter began rotating to the right. After dropping the load and clearing a ridge, the helicopter continued to rotate as it descended into a mountain cirque, and crashed on a slope at the 5200-foot level of the mountain at about 1615 Pacific daylight time. The pilot sustained fatal injuries and the helicopter was substantially damaged; there was no post-crash fire.

Ce rapport est également disponible en français.

Other Factual Information

The weather was reported to be good visual meteorological conditions with a high broken cloud layer, unlimited visibility, and winds from the west at about 15 knots. Weather was not considered to be a factor in this occurrence.

The pilot was certified and qualified for the flight in accordance with existing regulations. He had about 11 000 hours total time of which 2700 hours was in the Bell 212. His last pilot proficiency check in the B212 was on 02 October 2001. The pilot had been sitting in the left seat on a pillow, with his lap-belt fastened, and not using his shoulder harness. He was found partially outside the aircraft, pinned between the door frame and the ground, with his helmet in place. It is common practice for pilots flying vertical reference operations to leave the shoulder harness unfastened, since considerable upper body flexibility and movement is required in order to lean into the "vertical reference" bubble window for visibility during longline operations. Autopsy and toxicology results did not reveal any abnormal medical conditions which may have contributed to the occurrence.

The Transportation Safety Board of Canada (TSB) database contains eight occurrences since 1985 where pilots conducting vertical reference/longline operations were not using the available shoulder harnesses. Studies have shown that approximately 70 per cent of all serious and fatal injuries in helicopter accidents occur primarily to the head, spine, torso, and neck. An analysis of helicopter crash dynamics[1] showed that, of the personnel who experienced a helicopter crash, only 9 per cent of those who were wearing a shoulder harness had severe injuries compared with 34.3 per cent of those who wore only a lap belt.

The manufacturer's flight training contractor indicated that in a situation involving a complete loss of tail rotor thrust, the helicopter will swing to the right, with the severity of the initial reaction depending on airspeed, and the power being used. The pilot's upper body would be thrown to the left by centrifugal force, and in this case, into the bubble window. After three rapid rotations to the right, the pilot would be disoriented. Maintaining control of the helicopter would be difficult.

Records indicate that the helicopter was certified and equipped in accordance with current regulations and approved procedures, and was within the weight and balance limits before and after the load was released. The last scheduled inspection was a Phase 1 inspection which was completed on 05 September 2002 at 16 164.7 hours airframe time, about 15 hours prior to the accident.

Wreckage examination revealed that the fuselage was relatively undamaged and undistorted, and that the engines, main transmission, mast, and main rotor head were intact. Both main rotor blades were broken and twisted. Both throttles were at or near the FULL-OPEN position. The front left side of the left-hand seat was bent downward by the impact, and the door with the bubble window had separated from the aircraft. The tail boom was intact and had separated from the main fuselage. All tail-rotor drive components and the tail-rotor blades were intact, with damage to the blade tips from contact with the vertical fin. Marks on the fin indicated that the tail rotor was rotating in a reverse direction at impact.

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[1] J. W. Coltman, *Analysis of RotorCraft Crash Dynamics for Development of Improved Crash-worthiness Design Criteria*. DOT/FAA/CT-85/11. U.S. FAA, 1985

The main transmission tail-rotor forward coupling (transflex coupling), comprising inner coupling part No. 204-040-603-009, serial No. A-FS412418, and outer coupling part No. 204-040-604-005, serial No. A13-115799, was found to have separated in a condition not consistent with impact damage. Both couplings exhibited worn splines with sections broken away, and discoloration consistent with over-heating . The splines were coated with a reddish powder and no grease was evident on either coupling. Examination at the TSB Engineering Branch confirmed that the working surfaces of the splines were devoid of grease, had noticeable heat tinting, and that there was metal smearing from rotation or override following failure.

The outer coupling had two red-bordered TEMP-PLATE temperature indicators attached about 120˚ apart around the circumference, with a zinc chromate primer heat indicator stripe painted between the ends of the TEMP-PLATEs. Installation of the TEMP-PLATEs as a replacement for the primer strip was recommended by *Bell Helicopter Alert Service Bulletin, No. 212-93-89 Rev. A*, dated 04 March 1994, as a more reliable means of detecting over temperature conditions on grease lubricated couplings. Two red-bordered TEMP-PLATEs, part number 6000-1, are to be attached to the outer circumference of the transflex coupling and positioned 180˚ apart. The red-bordered indicators have white centres that change to black at a temperature of 370˚ Fahrenheit (F). The zinc chromate primer stripe should change colour from green to brown at 375˚ F. The TEMP-PLATEs had changed colour and were mostly burned away, and the primer stripe had changed colour, but the change was only discernable under close examination. Previous tests have revealed that zinc chromate primers may require temperatures as high as 500˚ F before the colour change is significant, and the change may be difficult to detect. The zinc chromate primer used in this application was *Plasti-kote 1249 Green*, which meets specification TT-P-1757A, for primers used for thermal indicators.

The *Bell Helicopter 212 Maintenance Manual* requires disassembly, inspection, and repacking of the tail-rotor transflex coupling at 600-hour or 6-month intervals. This coupling had been serviced during the 600-hour inspection on 08 May 2002 at 15 873.7 airframe hours, at which time the inner coupling was replaced because of excessive wear. Approximately 16 flight hours later, at 15 889.6 airframe hours, the coupling was found to be leaking grease because of a displaced seal, and it was repacked in the field on 13 June 2002. No logbook entry was found, but other records were accessed to determine the airframe time and date of service. Total time in service since this repack to the occurrence was about 300 airframe hours.

A daily inspection of the helicopter had been completed by an aircraft maintenance engineer the previous night. The section of the coupling visible from above as viewed by flashlight, looking past the main drive shaft and other structure, had only the zinc chromate stripe visible. No change in colour was noticed. The drive shaft was not rotated to inspect the TEMP-PLATE indicators. Inspection panels on both sides of the compartment, each fastened by eight bolts, could have been opened for a detailed inspection of the coupling, but neither was opened during the daily inspection. Neither rotating the drive shaft nor opening the panels are specifically part of the daily inspection.

A sample of the grease, Bell Helicopters 204-040-755, was burned at the Department of National Defense's Quality Engineering Test Establishment to determine the amount of residue that should have remained if the specified quantity of 17 grams of grease had overheated and been burned inside the coupling. The residue volume should have about 85 per cent of the volume of the original charge and the weight about 2.04 grams. Residue recovered was negligible as to volume, and weighed about 1.82 grams. The residue contained a large quantity of metallic

fragments and flakes of metal from the disintegrating coupling splines. The Quality Engineering Test Establishment 's conclusion was that the residues were not consistent with the presence of the specified quantity of grease at the time of failure.

The tail-rotor drive shaft transflex coupling is located directly below the main input drive shaft coupling on the main transmission. A grease leak in either coupling (both use the same specification grease) would sling grease over a large area in the main transmission compartment, and would require a careful inspection to determine which coupling was the source of the grease leak. A leak in the transmission compartment area on 31 August 2002 at 16 154 hours was detected and diagnosed as being from the main drive shaft coupling, since there was no grease on the tail-rotor drive shaft coupling. The main drive shaft assembly, with couplings, was replaced at that time, and no grease leaks were found in the compartment in the subsequent 34 flight hours prior to the occurrence.

Information from the manufacturer's database indicated that the operating life of the transflex coupling after lubrication failure could be from 14 to 410 airframe hours, depending on the type of operation, with demanding operations such as seismic slinging resulting in the earliest failures. In a similar previous occurrence (TSB Report No. A90W0148), investigators determined that the coupling had not been packed with grease prior to having been placed in service, and had failed after 62 hours of flight time.

Analysis

The analysis will examine three areas: the lack of lubrication in the tail-rotor drive shaft transflex coupling, the inspection of the coupling at the previous daily inspection, and the survivability aspects of this accident.

Although there was no logbook entry documenting the last servicing and repack of the tail-rotor drive shaft transflex coupling, it was determined that this was completed about 300 airframe hours prior to the failure. If the tail-rotor drive shaft transflex coupling was improperly lubricated at that time, it could have resulted in a failure, as the time is within the range of other documented failures. However, a grease leak, reported to have occurred in the transmission compartment 34 airframe hours prior to the accident, was more likely related to the failure of the tail-rotor drive shaft transflex coupling because the severe operating conditions of seismic slinging operations would have resulted in a relatively short time period before failure. The source of the grease found in the compartment was probably mis-diagnosed as being from the main drive shaft coupling, or possibly both couplings may have been leaking simultaneously.

Checking the tail-rotor coupling's zinc chromate stripe inside the transmission compartment with a flashlight on the daily inspection probably would not have detected any change caused by heat distress, since a colour change, if any, would have been very subtle. Checking the TEMP-PLATE indicators would have been more informative, but the drive shaft had to be rotated for them to be visible. Opening one or both inspection panels on the sides of the compartment would have allowed a more thorough inspection of the coupling and temperature indicators. If the coupling markings had been in conformance with *Bell Helicopter Alert Service Bulletin No. 212-93-89 Rev. A*, the zinc chromate stripe would not have been present, and the TEMP-PLATE indicators would have been the defining indicators.

In order for the pilot to more easily conduct the slinging and longline operations, he sat on a pillow in the left seat with his head and helmet in the bubble window and the shoulder harness unfastened. Sudden loss of tail rotor thrust would have violently pressed the pilot further into the bubble since the helicopter was in a high-power situation with no airspeed at the time of the failure. Elevating his body with the pillow would further increase the upper body migration to the left. This condition would be consistent with the pilot not being able to close the throttles, and the helicopter rotating until impact.

The accident appears to have been survivable as indicated by the lack of airframe destruction. Use of the shoulder harness, or some other form of restraint, could have allowed the pilot to retain control to the extent of stopping the rotation before impact, and to remain in the cockpit, thereby possibly averting a fatal injury. The number of occurrences since 1985 in which shoulder harnesses were not in use would indicate that the practice is widespread and likely systemic.

The following TSB Engineering Branch reports were completed:

LP 089/90 – Sect I, Analysis of Tail Rotor Drive Coupling
LP 092/02 – T/R Drive shaft Coupling
LP 101/90 – Sect II, Overheat Indicator Stripes Analysis

Findings as to Causes and Contributing Factors

1. The helicopter lost tail-rotor authority while in a hover at low altitude, positioning a heavy load. The pilot could not regain control before the helicopter crashed.

2. A loss of lubrication in the transmission compartment resulted in the failure of the tail-rotor drive shaft transflex coupling and, subsequently, the loss of the tail-rotor authority.

3. The tail-rotor drive shaft transflex coupling revealed signs of overheating and loss of lubrication, which were not detected during the daily inspection.

4. Because the pilot was not wearing the shoulder harness, or any form of upper body restraint, the forces of the rapid rotation of the helicopter prevented the pilot from closing the throttles and regaining control of the helicopter.

Findings as to Risk

1. The colour change on the zinc chromate overheat temperature indicator stripe was subtle and difficult to detect during the daily inspection in dim light.

2. The position of the TEMP-PLATE overheat indicator markings and the non-elimination of the zinc chromate stripe were not in accordance with the manufacturer's recommendations in *Bell Helicopter Alert Service Bulletin No. 212-93-89 Rev. A* resulting in an unreliable verification of coupling overheat.

3. Not wearing the available shoulder harness greatly increased the risk of the pilot being injured.

Other Findings

1. There was no logbook entry documenting the last servicing and repack of the transflex coupling.

Safety Action Taken

Immediately following this accident, the operator instituted a procedure whereby the daily inspection of the tail-rotor drive transflex coupling includes the opening of the inspection panels on the transmission compartment for a detailed inspection of the TEMP-PLATEs, and to check for grease leaks.

The operator will be removing the zinc chromate indicator stripes on all couplings as the couplings are overhauled and serviced, to be completed before 30 May 2003. The TEMP-PLATE indicators will be attached in compliance with *Bell Helicopter Alert Service Bulletin No. 212-93-89 Rev. A* by 30 May 2003.

On 20 February 2001, the TSB sent Aviation Safety Advisory A010006-1 to Transport Canada suggesting they may wish to consider investigating and requiring other means of personnel restraint for use during longlining/vertical reference operations. Transport Canada responded to the TSB's Aviation Safety Advisory A010006-1 on 02 May 2001 with the following statement. "Transport Canada has approved safe pilot restraint systems and has promulgated regulations regarding their installation and use. It is the responsibility of the industry to comply with the regulations, and if warranted, apply for an approval of a configuration to meet its operational needs."

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 21 August 2003.