AVIATION OCCURRENCE REPORT

LOSS OF TAIL ROTOR AUTHORITY - TAIL ROTOR DRIVE TRAIN FAILURE

CAMPBELL HELICOPTERS LTD.
BELL B205A-1 (HELICOPTER) C-FJTF
EDSON, ALBERTA 48 nm S
24 SEPTEMBER 1993

REPORT NUMBER A93W0159

Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

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.

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Synopsis

The pilot was moving a basket of drilling equipment on the end of a longline. As the basket cleared the top of the trees, the helicopter developed a severe vibration. As the pilot attempted to set the load down, the helicopter began to pitch violently and rotate as it descended. The pilot was thrown about in his lap-belt, and was unable to operate the load release mechanism. The helicopter crashed into tall trees on its left side. The helicopter was substantially damaged, and the pilot sustained serious chest injuries.

The Board determined that the pilot lost tail rotor authority because the input bevel gear of the 42-degree intermediate gearbox fractured due to a high-cycle, low stress fatigue mode of progressive cracking, disconnecting the drive shaft power from the main transmission to the tail rotor.

Ce rapport est également disponible en français.

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OCCURRENCE NUMBER:	A93W0159
TYPE OF OCCURRENCE:	Loss of Tail Rotor Authority - Tail Rotor Drive Train Failure (Accident)
DATE OF OCCURRENCE:	24 September 1993
LOCAL TIME:	1400 MDT
LOCATION:	Edson, Alberta 48 nm S
TYPE OF AIRCRAFT:	Bell B205A-1 (Helicopter)
REGISTRATION:	C-FJTF
TYPE OF OPERATOR:	Air Carrier
TYPE OF OPERATION:	Heli-slinging
DAMAGE CATEGORY:	Substantial
PILOT LICENCE:	Commercial

PILOT-IN-COMMAND

PILOT HOURS:	Last 90 Days	Total
All Types:	297	12,000
On Type:	297	2,000

INJURIES:	Crew	Passengers
Fatal:	-	-
Serious:	1	-
Minor:	-	-
None:	-	-

1.0 Factual Information

1.1 History of the Flight

The pilot of the Bell 205A-1 was flying the helicopter in support of a seismic drilling operation, and was performing external cargo operations using a longline to transport drill equipment. He had just moved the seismic drill about 1,000 feet east along a cutline to another site, and had returned to move a basket full of drill rods and support equipment.

As the 2,500-pound basket on the end of the 110-foot longline cleared the 60-foot pine trees, the helicopter developed a severe vibration. As the pilot attempted to set the load down, the helicopter began to pitch violently and rotate as it descended. The pilot was thrown about in his lap-belt, and was not able to operate the load release mechanism. The helicopter descended to the forest floor and came to rest on its left side with the load still attached to the helicopter. The pilot sustained serious chest injuries.

The drill crew used their hand-held radios to transmit a "MAYDAY" call to notify the base camp that the Bell 205 had crashed. The drillers then removed the seriously injured pilot from the wreckage, and he was immediately flown to medical facilities by another helicopter which had responded to the distress call.

1.2 Vertical Reference/Longline Operations

Vertical reference is the technique of moving external cargo sling loads by direct observation of the load, where the pilot looks downwards vertically out of an open door, or through a specially designed bubble window in the pilot's door. In some cases, the sling load requires the use of an extra long lanyard of sufficient length to allow the helicopter to clear any obstructions as the load is hooked up to the extended hook.

At the time of the occurrence, the pilot was flying the helicopter from the left side using a Transport Canada approved vertical reference kit. Part of this kit is the cargo release arm switch, which has identical installations on the left and right side collective controls. The switch is activated by lifting it out of its detent and moving it upwards to arm the external cargo release hook, located on the bottom of the helicopter. Should an urgent situation require the load to be released from the external cargo hook, the pilot merely depresses a red button, located on the cyclic control, with his right thumb. External cargo can also be mechanically released from the helicopter cargo hook by depressing the foot-operated cargo release pedal, located between the directional control pedals. During external load operations, the cargo release arm switch is sometimes left in the OFF position, in order to prevent inadvertent electrical release of external cargo.

In this helicopter, the cargo release arm switch installation on the left collective was different from that on the right collective. The switch had been removed and reinstalled on the left collective control column so that moving the switch to the UP position disarmed the system, or turned the system OFF instead of ON. The pilot was aware of the new installation on the left side; it allowed him to conveniently arm the cargo release mechanism by simply pulling outward on the cargo release arm switch with his left thumb and wiping it downward.

1.3 Height/Velocity Curve and External Load Operations

The height velocity (H-V) curve is a diagram which depicts the combinations of height above ground versus forward speed, including hover, under which a safe landing can be accomplished should a loss of power or directional control (that is, a critical emergency) occur.

The H-V curve is included in the operating limitations section of the approved BHT 205A-1 basic *Flight Manual* (see Figure 1)[1], which directs pilots to avoid operation in the shaded area of the H-V curve. Operating the helicopter at a combination of low height and low speed corresponding to the shaded area of the H-V curve will preclude performing a safe autorotative landing.

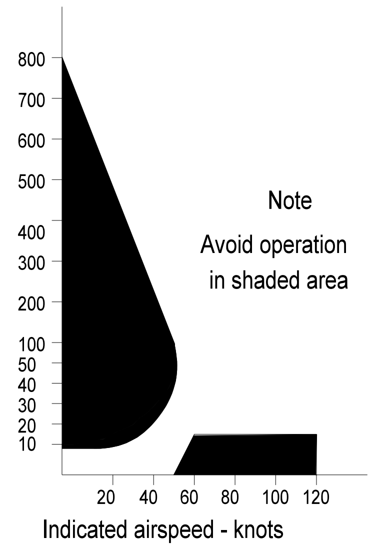

Figure 1
Height/Velocity Curve

The approved *External Load Operation Supplement (BHT-205A1-FMS-CAN-2)* to the basic flight manual, however, advises that the H-V limitations in the basic manual are not limitations for external load or hoisting operations.

1.4 The Accident Site

When the helicopter initially bounced, the left cockpit door opened; the door was forced inside the cockpit area on the second and final impact. The basket, containing the drilling equipment, was still attached to the longline and came to rest undamaged at the south edge of the east-west cutline, about 54 feet south of the helicopter. The left collective cargo arm

1 The height/ velocity curve depicted here is adapted from the approved Bell 205A-1 Flight Manual.

release switch was found in the OFF position.

The helicopter's main rotor blades had cut off several thick pine trees, resulting in damage to the main rotor blades representative of significant power being developed at initial impact. Some fragments from the main rotor blade strikes were found imbedded into trees as far as 200 feet from the main wreckage. The main rotor blades severed the tail boom just in front of the 42-degree (intermediate) gearbox. The tail rotor gearbox and blades were found about 27 feet north of the main wreckage. The tail rotor blades did not exhibit any rotational damage.

1.5 Forty-two Degree Gearbox Examination

On-site examination of the helicopter determined that the 42-degree gearbox in the tail rotor drive train had failed. The gearbox was broken open, and the failed condition of its internal gears was clearly evident. A section of the input bevel gear from the gearbox was found lying loose outside of the gearbox at the scene. The piece of input bevel gear found outside the gearbox, and the entire tail boom assembly, were examined at a metallurgical facility in Vancouver,
British Columbia, with TSB representatives in attendance.

The 42-degree gearbox (P/N 204-040-003-37) had accumulated a total of 7,480.8 hours since new, and 123.4 hours since overhaul. The input bevel gear (P/N 204-040-500-9) was original to the gearbox. There is no finite retirement life for the 42-degree gearbox as its components are replaced "on condition" during inspection.

Failure analysis of the input bevel gear determined that it had fractured and failed due to relatively high-cycle, low-stress fatigue. Fatigue cracking had initiated at a root fillet on the concave face or drive side of a tooth. There was no overstress precursor observed in the fatigue origin area. No material deficiencies were observed which could have contributed to the failure.

1.6 Forty-two Degree Gearbox - Previous Failures

In addition to this failure of the input bevel gear (P/N 204-040-500-9), there have been eight other failures of a similar nature since 1979 with gearbox P/N 204-040-003-37. The "total time in service since new" of the gears that failed varied from a

minimum of 2,186 hours to a maximum of 8,543 hours; known times since non-destructive testing and overhaul ranged from 124 to 1,985 hours. Another gearbox (P/N 204-040-003-23) with the same input bevel gear as the others also had an input bevel gear failure, bringing the total number of failures to ten.

In all but one case, for which no operational information is available, the failed gear had, at one time or another, been in service during repeated heavy-lift operations such as logging, fire suppression, or seismic support missions.

1.7 Safety Equipment

The helicopter was equipped with a shoulder harness restraint mechanism. However, the pilot chose not to wear it because he found that the harness restricted his movements and was uncomfortable when he had to lean to his left, over the collective control, to monitor the load at the end of the longline.

The pilot owned a safety helmet. However, he felt that while conducting vertical reference work within the bubble window, wearing a helmet jeopardized his field of vision, and he chose not to wear it.

2.0 Analysis

2.1 Introduction

The analysis will address the effect of a loss of tail rotor authority while conducting longline operations within the shaded area of the H-V curve, and the reason why the input bevel gear of the 42-degree gearbox failed.

2.2 External Load Operations versus H-V Curve

Although the helicopter was operated at a low height and low speed combination within the shaded area of the H-V curve, the external load operation was conducted in accordance with the approved *External Load Operation Supplement* to the basic flight manual.

Longline, external load operations such as drill support require that helicopters be operated routinely at height and speed combinations within the shaded area of the manufacturer's H-V curve. Although such missions can be carried out in accordance with the external load supplement to the basic flight manual, operation within the shaded area of the H-V curve is nonetheless risky as a safe landing cannot always be accomplished should a critical emergency such as an engine or tail rotor failure occur.

Helicopter pilots who specialize in longline, external load operations routinely fly within the shaded area of the manufacturer's H-V curve, and are aware that such an operation is of a high-risk nature. However, during external load operations within the shaded area of the H/V curve, pilots should be prepared not only for a possible loss of power, but also for an unexpected loss of tail rotor authority, which is more likely to occur under high loads, such as during hover at maximum weights.

2.3 Release of External Cargo

When the input bevel gear failed, there was little time for the pilot to recognize that he had lost tail rotor authority. In this situation, above the trees, the pilot's response was to immediately attempt to release the external load from the external cargo hook and prepare for a crash landing. His intention was to arm the cargo release mechanism by pulling outward on the cargo release arm switch on the collective control column with his left thumb and wiping it downward, in accordance with the way the switch had been reinstalled. The pilot also attempted to kick the manual-release pedal located between the rudder pedals. However, in the presence of the gyrations of the helicopter following the loss of tail rotor authority, the pilot did not succeed in releasing the external cargo.

2.4 Input Bevel Gear Failure

Failure analysis of the input bevel gear of the 42-degree gearbox determined that the gear had fractured and failed due to relatively high-cycle, low-stress fatigue which happened during flight at a root fillet on the concave face or drive side of a tooth.

The failure of the input bevel gear occurred at a critical phase of flight, as the helicopter was flying over the trees at a low height and low speed combination which precluded the pilot from completing a safe autorotative landing.

2.5 Use of Available Safety Equipment

The pilot was not wearing his helmet, and was not using the shoulder harness. It was not determined to what extent this contributed to the severity of the pilot's injuries.

3.0 Conclusions

3.1 Findings

1. The external load operation was being conducted in accordance with the approved *External Load Operation Supplement* to the basic flight manual.

2. The input bevel drive gear failed due to a high-cycle, low-stress fatigue mode of progressive cracking.

3. The pilot lost tail rotor authority because the input bevel gear of the 42-degree gearbox fractured, which disconnected the drive shaft power from the main transmission to the tail rotor.

4. With existing gyrations of the helicopter following the loss of tail rotor authority, the pilot did not succeed in releasing the external cargo.

5. The loss of tail rotor authority occurred while the helicopter was operating over a forested area at a low height and low speed combination which precluded the pilot from performing a safe autorotative landing.

6. The pilot was not wearing his helmet, and was not using the available shoulder harness.

3.2 Causes

The pilot lost tail rotor authority because the input bevel gear of the 42-degree intermediate gearbox fractured due to a high-cycle, low-stress fatigue mode of progressive cracking, disconnecting the drive shaft power from the main transmission to the tail rotor.

4.0 Safety Action

4.1 Action Taken

Following receipt of a TSB Safety Information Letter concerning previous 42-degree gearbox failures, Transport Canada (TC) published an article in the 1/93 issue of *Maintainer*, advising operators involved in repeated heavy-lift operations of the history and risk of 42-degree gearbox failures. Additionally, TC issued a letter, dated 06 October 1993, to owners of Bell 204B and 205A-1 helicopters. The letter advises that the 42-degree gearbox on the referenced models of helicopter is prone to failure on helicopters used in repeated, external heavy-load lifting, even if the maximum load carried is within limits.

Transport Canada Aviation is monitoring the situation, and has been in contact with the Federal Aviation Administration and Bell Helicopter Textron Inc. regarding corrective action for the existing problem.

Bell Helicopter Textron Inc. has issued Operations Safety Letters OSN-205-93-31 and OSN-GEN-93-25, which caution operators about heavy lift operations.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson, John W. Stants, and members Gerald E. Bennett, Zita Brunet, the Hon. Wilfred R. DuPont and Hugh MacNeil, authorized the release of this report on 19 January 1995.