

AVIATION OCCURRENCE REPORT

MAIN TRANSMISSION FAILURE - FORCED LANDING

UNIVERSAL HELICOPTERS NEWFOUNDLAND LTD.

BELL 206L C-GJBC

GOOSE BAY, LABRADOR 27 NM N

10 AUGUST 1997

REPORT NUMBER A97A0157

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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### *Summary*

The Bell 206L, serial number 45096, was returning from a forest fire mapping flight north of Grand Lake, Labrador, with the pilot and two forestry employees onboard. The pilot was following the north shore of Grand Lake eastwards at 400 feet above ground (agl) towards the forestry centre, located at North West River, at a cruising speed of 130 miles per hour (mph). A few minutes before the occurrence, the pilot recalls feeling a very slight, high frequency vibration throughout the helicopter; he glanced at his instruments and caution panel but observed nothing out of the ordinary. The pilot and passengers then heard a loud bang and felt the helicopter yaw sharply to the left. The pilot warned his passengers to prepare for an emergency landing, lowered the collective, decreased the airspeed to 70 mph, and commenced an autorotation towards a spit of land along the shore. During the descent, the pilot believes he may have seen the Engine Out caution light illuminate briefly for about 3 or 4 seconds. He focussed his attention on his approach and landing and does not recall seeing any other lights, hearing any engine out or low rotor warning horns, nor does he recall noticing any readings of his engine or transmission instruments. Nearing the spit of land, the pilot initiated a flare at about 50 feet agl and commenced raising his collective to arrest the descent. He then observed that the intended landing spot was strewn with large boulders and warned his passengers to brace themselves. At about 5 feet agl, the pilot had raised full collective and the main rotor rpm had decreased; the helicopter landed hard. The helicopter then yawed uncontrollably to the left about 45 degrees and came to rest upright, with a 5 degree list to the right. The pilot noted that the engine was still running and he could hear unusual 'hissing' sounds. He rolled the throttle from the full open to the OFF position and completed the remainder of the engine shutdown. All occupants exited the helicopter uninjured.

*Ce rapport est également disponible en français.*

## *Other Factual Information*

The helicopter was substantially damaged during the hard landing. Damage included a downward bending deformation of the tail boom and the tail rotor drive shaft as well as some serious structural deformation of the aft fuselage. The helicopter was slung by air to the operator's base of operations where the engine, main rotor, and transmission were removed. The removal of the mast shaft was particularly difficult and gear fragments were found inside the transmission case.

The engine and main transmission were forwarded to the TSB Engineering Branch for examination. The engine was partially disassembled and no signs of internal damage were observed. The engine was subsequently ground run in a test cell and was found to be satisfactory in all respects.

During the examination of the transmission, the sun gear splines were found damaged in the area of engagement with the main ring gear shaft internal spline. When the internal splines of the main ring gear were examined, it was noted that the sun gear had been operating with about 0.30 inches of engagement. A slight wear pattern was observed on the internal spline indicating that a sun gear had previously been installed having a much greater engagement into the main ring gear shaft. The damaged sun gear (part number 206-040-122-103, serial number AFS 004575) removed from the transmission was determined to be a sun gear designed exclusively for use in the Bell 206B helicopter transmission. The overall length of the damaged sun gear was 4.8200 inches. The correct sun gear required for the occurrence Bell 206L helicopter transmission was part number 206-040-122-005. This sun gear, although similar in appearance to the damaged sun gear, is considerably longer at 6.010 inches.

Engine power is input to the transmission by a spiral bevel gear that engages and turns the transmission first reduction stage ring gear. Inner splines of the ring gear assembly drive a sun gear that engages the four planetary gears of the second stage reduction gear assembly. Since the second stage ring gear is permanently fixed to the transmission case, rotation of the planetary gears causes the planetary gear case to turn. The upper gear of the planetary gear case turns the mast shaft which completes the engine power transmission to the main rotor blades. Of note, the first reduction stage ring gear also drives the main rotor tach generator, the transmission oil pump and the system hydraulic pump. The low rotor rpm warning light and horn receive information from the rotor tachometer and activate at  $90 \pm 2\%$  rpm.

The transmission had been removed on 6 October 1996 for a 1,500-hour inspection, at which time the sun gear was found to exceed maximum wear limits and was replaced. The helicopter had flown 391.0 hours since the replacement sun gear had been installed.

The Board examined how the incorrect sun gear was introduced into the operator's supply system and how the incorrect component could have been installed into the transmission without being recognized as the wrong part.

The operator ordered the sun gear on Sunday, 6 October 1996. During normal working hours, the operator uses a computer system dedicated to the Bell Helicopter parts warehouse network in Calgary. However, the part was ordered outside normal working hours and operator staff familiar with parts requisition using the computer system were unavailable. Therefore, maintenance management ordered the sun gear by calling the Bell Helicopter parts warehouse toll-free number in Calgary. The Bell Helicopter employee who received the call at home, accessed the Calgary warehouse parts inventory list (remote access) and confirmed that the part was in their stores. The sun gear was shipped the next day to the operator.

In order to satisfy the operator's record keeping requirements, the person who placed the order completed the purchase order form, identifying the part number of the sun gear that he wanted, the date the part was ordered and the date the part was required. There was no record found to indicate that the purchase order form had been mailed or faxed to the supplier. The supplier's invoice, which accompanied the sun gear, made reference to the operator's purchase order number and the invoice accurately quoted the part and serial numbers of the sun gear found in the occurrence transmission. It could not be determined if: 1) the operator's maintenance personnel had quoted the incorrect part number during the phone conversation; 2) whether the supplier's employee had inadvertently relayed the incorrect part number electronically to the stores in Calgary; or, 3) the personnel in the warehouse in Calgary had inadvertently introduced the incorrect part number in their internal shipping procedures.

When the sun gear arrived at the operator's main base of operations, the records clerk retrieved the original purchase order form, identified that the last three digits of the recorded part number (-005) did not correspond with the part number recorded on the invoice shipped (-103), and overwrote the purchase order part number to correspond with the invoice. The reason for this modification to the purchase order without apparently consulting company maintenance personnel could not be explained.

The sun gear was then shipped to the operator's satellite base in Goose Bay where an aircraft maintenance engineer (AME) installed the component in the transmission. The sun gear was shipped with a company release certification tag indicating the correct part number of the shipped sun gear. The AME, and his supervisor, apparently relied on the main base of operations to send the correct part. They did not physically compare the two components nor did they refer to the Bell Helicopter Illustrated Parts Catalogue (IPC) to verify that the correct part number was being installed.

The sun gear that was installed was about 1.2 inches shorter than the correct sun gear. When installed in the main ring gear shaft, the amount of gear engagement cannot be determined. In this case, the shorter sun gear end that engaged with the planetary carrier gears sat lower, physically contacting the main ring gear shaft face with the side of the sun gear. The gear engagement was minimal, roughly 0.30 inches.

## *Analysis*

The incorrect sun gear was inadvertently installed in the helicopter's transmission over 10 months prior to the occurrence. As a result of this relatively long time period since its installation, individuals directly involved could not recall specific details concerning the ordering, shipping, and installation of the component. It was evident; however, that at some point during the ordering and shipping process, a breakdown in communications occurred which resulted in the incorrect component being shipped to the operator. The specific time at which this breakdown in communication occurred or its cause could not be determined.

The normal supervisory checks and balances in place within the operator's maintenance practices for the reception and installation of the correct components into the operator's aircraft were ineffective in this case. There are two readily identifiable critical points during the events leading to the installation of the component by the operator's maintenance personnel during which the wrong component should have been identified. The first occasion was when the component was initially received at the main base of operations. The records clerk, noting the different part number of the sun gear, amended the part number in the purchase order to correspond with the part number of the part received apparently without consulting with maintenance personnel. The new number appearing on the amended purchase order then took on the appearance of being a legitimate part number for that specific transmission, possibly setting the scene for a later misidentification by the maintenance engineer. The records clerk could not recall amending the purchase order or the reason for doing so.

The second occasion at which the error could have been noticed occurred when the AME, and his supervisor, installed the sun gear into the transmission. Had the AME, or the supervisor, physically compared the two sun gears, it would have been apparent that, despite their similar appearances, the replacement sun gear was noticeably shorter than the sun gear which had been removed from the transmission. In addition, had they verified the part number of the replacement sun gear with the part number of the sun gear removed from the transmission or with the part number contained in the parts catalogue, they would have become aware of a discrepancy and the replacement sun gear would likely not have been installed.

In any case, the specific reason why the AME and his supervisor installed the replacement sun gear without first verifying its authenticity could not be determined. As previously suggested, they may have been misled by the amended part number on the purchase order, or they may have relied on the maintenance personnel at the operator's base of operations for having verified that the sun gear was in fact the correct component.

It was determined that, when the splines of the sun gear and the inner splines of the ring gear failed, the engine essentially became uncoupled from the main rotor. The main rotor rpm then began to decrease; this decrease was checked when the pilot lowered the collective and entered an autorotative descent. It is interesting to note that, since the ring gear was still being driven by the engine, the hydraulic pump and the main rotor tachometer generator were still being driven. In this instance, the main rotor rpm indicator may have produced a momentary indication above 100% but then the rotor rpm indication would have returned to 100% and remained at that reading as long as the throttle was kept in the full open position. Since the low rotor rpm warning light and horn are initiated by the rotor tachometer, there would have been no low rotor rpm warning regardless of the actual rotation speed of the main rotor.

The unusual sharpness of the left yaw which accompanied the uncoupling of the engine from the main rotor was a result of two factors: 1) at the time of the sudden failure, the tail rotor was in a trim position for powered flight and there was suddenly no torque; and, 2) the engine, which was still providing power to the tail rotor, surged due to the sudden loss of drive to the main rotor and the tail rotor rpm increased momentarily as a direct result of the engine power surge. The maximum increase in engine speed would have been controlled by the fuel governor.

The decrease in main rotor rpm and left yaw reported by the pilot is consistent with an engine power loss. The pilot's reaction to the apparent engine malfunction of lowering the collective was the correct response in this situation. The cause of the Engine Out light illumination observed by the pilot during the autorotative descent could not be determined.

### *Findings*

- . An incorrect sun gear was installed in the helicopter's main transmission by the operator's maintenance personnel.
- . It could not be determined why the incorrect sun gear was shipped to the operator by the supplier.
- . It could not be determined why the operator's maintenance personnel did not identify the sun gear as being an incorrect component for this helicopter's transmission.
- . The sun gear failed causing the failure of the main transmission after the helicopter had flown 391.0 hours since its installation.
- . The helicopter was substantially damaged during the autorotational landing.

### *Causes and Contributing Factors*

The cause of the transmission malfunction was the failure of the incorrect sun gear installed in the main transmission. Contributing to the occurrence was a breakdown in communications between the operator's maintenance personnel and the supplier with respect to the ordering, shipping, and receiving of the sun gear. Also contributing to the occurrence, was an inadequate degree of attention and supervision by the operator's maintenance personnel during the installation of the sun gear.

## *Safety Action*

Following this occurrence, at the operator's request, the Transport Canada Airworthiness District office in St. John's, Newfoundland approved an amendment to the Company Maintenance Control Manual. The amendment was designed to address the issue of proper supervision and record keeping for critical maintenance tasks performance by its maintenance staff. All maintenance staff have been briefed on these new procedures and all holders of the Company Maintenance Control Manual have been provided with a copy of the amendment to the manual.

*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 07 July 1998.*