Transportation Safety Board of Canada
Bureau de la sécurité des transports du Canada

# AVIATION INVESTIGATION REPORT
# A06Q0091

## ENGINE FAILURE

## HÉLI STAR INC.
## BELL 206L-3 HELICOPTER C-GDTM
## LA TUQUE, QUEBEC, 26 nm NE
## 07 JUNE 2006

Canada

# Aviation Investigation Report

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## *Summary*

The Bell 206L-3, registration C-GDTM, serial number 51366, operated by Héli Star Inc., was on a visual flight rules flight from La Tuque, Quebec, to Val-d'Or, Quebec. Approximately 20 minutes after take-off, at about 0810 eastern daylight time and at 2000 feet above sea level, the needle on the engine oil pressure gauge started to fluctuate. As a precaution, the pilot landed the aircraft in a marsh and shut down the engine. After conducting a pre-flight inspection, the pilot started the engine and took off with the intention of landing on a road one kilometre away. Just before the helicopter reached the road, there was a fluctuation in the engine oil pressure and engine torque. Right after that, there was an explosion and the engine stopped. The pilot did an autorotation that ended with a hard landing on the road. The helicopter was heavily damaged. The pilot was alone on board and was not injured.

*Ce rapport est également disponible en français.*

# *Other Factual Information*

On the morning of the accident, the pilot carried out a pre-flight inspection of the helicopter. No oil leaks were observed and the oil level in the tank was within the allowable limits. The pilot was alone on board and took off from La Tuque Airport, Quebec, around 0750 eastern daylight time[1] for Val-d'Or Airport, Quebec, where the helicopter was to undergo a 100-hour inspection. The weather conditions were favourable and the flight was conducted in accordance with visual flight rules.

About 20 minutes after departure, the needle in the engine oil pressure gauge was observed to be fluctuating within the limits. The engine oil temperature was normal, there were no other abnormal conditions, and the engine chip detector light was not on. The pilot decided to land in the nearest area he felt was safe. The pilot landed the helicopter in a mosquito-infested marsh about one kilometre from a road he had just flown over. After shutting down the engine, an unusual amount of bluish smoke was observed coming out of the exhaust pipe. A quick inspection of the engine compartment revealed no oil leaks or damage.

The pilot called Val-d'Or and spoke with an aircraft maintenance engineer (AME) working for the company responsible for maintaining the aircraft. The AME recommended checking that there were no oil leaks in the engine compartment and that the oil was at an appropriate level. The AME also asked the pilot to do an engine run-up before contacting him again. The pilot did the checks and then started up the helicopter. Bluish smoke was still coming out of the exhaust pipe; however, the engine oil pressure was stable, in the lower limits of the gauge. The pilot did an engine run-up for some time, and then hovered. Rather than contacting the AME as agreed, the pilot headed to the adjacent road after concluding that the engine oil pressure gauge was defective.

At about 50 feet above the road, the engine oil pressure gauge needle and the engine torque indicator needle began fluctuating. Right after that, there was an explosion and the engine failed. The pilot entered an autorotation, and on landing, the rear part of the skids touched the ground and the nose of the helicopter tipped forward. The main rotor cut off the tail boom, and the helicopter came to rest about 30 feet from that point. Shortly thereafter, the pilot notified search and rescue by satellite telephone.

The pilot was certified and qualified for the flight in accordance with existing regulations. He owned Héli Star Inc. since December 1997. He had about 5800 flying hours on helicopters, including 780 hours on type. On 08 December 2005, he had passed the pilot proficiency check flight test.

The aircraft was registered for commercial use and its certificate of airworthiness was valid. The aircraft was maintained and operated in accordance with existing procedures and regulations. The helicopter was equipped with an emergency locator transmitter (ELT), Pointer Sentry, model 4000 10, which activated at impact.

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[1] All times are eastern daylight time (Coordinated Universal Time minus four hours).

The Bell 206L-3 has a gauge that allows the pilot to determine the status of the engine oil system (see Figure 1). It shows the engine oil pressure and temperature. However, there is no caution light to warn of low engine oil pressure or high engine oil temperature. When an abnormal condition occurs, the pilot must determine how serious it is based on the engine oil temperature and pressure. The pilot must then follow the appropriate procedure recommended in the helicopter's flight manual. Engine oil pressure outside the prescribed limits indicates either a fault in the engine oil circulation system, a low engine oil level, or a system indication problem. Since the engine oil temperature sensor is located directly at the oil tank outlet, it is possible for the oil temperature to indicate normal even when the oil level is low. Three limiting ranges for engine oil pressure are defined according to the rpm of the engine's low-pressure compressor (N1 RPM), with N1 being proportional to the engine power delivered.

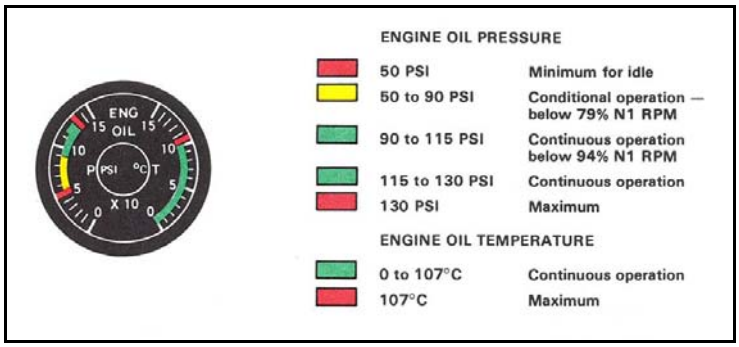


**Figure 1.** Engine oil pressure and temperature gauge (extract from the flight manual, section 1)

Section 3-13 of the Bell Helicopter flight manual (see Figure 2) stipulates that, when engine oil pressure is below the minimum or above the maximum, the pilot must land as soon as possible. This means that it is recommended that the pilot land without delay at the nearest suitable area that allows a safe approach and landing.

**3-13. ENGINE OIL PRESSURE LOW, HIGH, OR FLUCTUATING**

If engine oil pressure is below minimum or above maximum, land as soon as possible.

If engine oil pressure fluctuates but does not exceed a limit, monitor engine oil pressure and temperature and land as soon as practical.

**3-14. ENGINE OIL TEMPERATURE HIGH**

Land as soon as possible.

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|---|---|
| LAND AS SOON AS POSSIBLE | Land without delay at the nearest suitable area (i.e., open field) at which a safe approach and landing is reasonably assured. |
| LAND AS SOON AS PRACTICAL | The landing site and duration of flight are at the discretion of the pilot. Extended flight beyond the nearest approved landing area is not recommended. |

**Figure 2.** Extracts from the Bell 206L-3 flight manual

However, if engine oil pressure fluctuates without exceeding the limits, the pilot must monitor the engine oil pressure and temperature, and land as soon as practicable. In such a situation, the landing site and flight duration are at the pilot's discretion. Extended flight beyond the nearest approved landing area is not recommended.

Section 3-14 of the manual stipulates that, when engine oil temperature exceeds the allowable limit, the pilot must land as soon as possible.

The Rolls-Royce 250 C-30P engine, serial number CAE 895434, had accumulated 1590.5 hours since its last overhaul. The oil system includes a pressure pump and four scavenge pumps; they are all located inside the accessory drive gearbox. The Rolls-Royce engine has nine main bearings numbered 1 through 8. The third bearing is numbered 2½.

The aircraft had flown for about 15 hours since the last time oil had been added. The oil consumption could not be precisely determined because it had not been entered in the aircraft logbook, and it was not required to be by the Canadian regulation. However, Section 8 of the Rotorcraft Flight Manual (RFM) requests that an appropriate entry be made in the helicopter logbook when oil has been added to the engine, transmission, or tail rotor gearbox. According to the information gathered, oil consumption was approximately one litre per 100 hours, which is within the manufacturer's oil consumption limit for the C-30 engine. No significant changes had been observed since the last 100-hour inspection. After the aircraft was imported into Canada in May 2004, the operator had observed that the engine emitted slightly bluish smoke on start-up. A change in the brand of oil being used remedied the problem. Bluish smoke coming from exhaust pipes is usually a sign that engine oil is entering the power turbine section of the engine and is being burnt due to the high temperatures within this section.

The engine was torn down at the TSB Engineering Laboratory. Examination of the controls and external lines of the engine did not identify any anomalies. A large amount of carbon deposits had accumulated in the accessory drive gearbox and in the power turbine section. Bearings 6 and 7, composed of iron and silver, were destroyed. The area adjacent to bearings 6 and 7 had overheated and exceeded a temperature of 900°C.[2] Oil residue found in the external tank of the oil sump suggested that bearings 6 and 7 had been lubricated at the time they disintegrated. Because of the major damage to bearings 6 and 7, it was not possible to determine the cause of their failure.

The high internal temperature of more than 900°C melted the turbine compressor connection tie bolt, resulting in an overspeed and a disconnection that caused turbine wheel number 1 to disintegrate. The number 8 bearing sump nut had multiple dents where the fractured tie bolt made contact. According to Rolls-Royce, a lack of lubrication first causes bearing 8 to fail. Bearing 8 was not lacking oil, but it was on the verge of failing. None of the bearing components showed any evidence of severe thermal distress that would suggest that the No. 8 bearing had operated without oil. The two magnetic chip detectors located on the accessory drive gearbox showed no chips.

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[2] Turbine outlet temperature (TOT) is 716°C in continuous operation, up to 768°C for 5 minutes in the take-off range and a maximum of 927°C for 1 second on start-up.

Two oil samples were taken; one from the engine and one from the oil tank. Analysis of the samples established that they contained twice as much iron and eight times as much silver as new oil.

# *Analysis*

Analysis by the TSB Engineering Laboratory determined that the area around bearings 6 and 7 had exceeded a temperature of 900°C. At this temperature, it is normal for oil to dissipate rapidly, by evaporation and burning. The oil that burned away did not return to the tank and, after a short time, the oil level became very low, causing the engine oil pump to cavitate and the engine oil pressure to fluctuate. Furthermore, since the oil did not return to the tank, the oil temperature did not change, or at least not significantly, and the pilot falsely deduced that the engine oil pressure gauge was displaying an incorrect indication.

A lack of lubrication is characterized primarily by major damage to bearing 8. Yet, although this bearing had been damaged, none of the bearing components showed any evidence of severe thermal distress that would suggest that the No. 8 bearing had operated without oil. In addition, none of the lines that lubricated bearings 6, 7 and 8 was obstructed, or at least, was not at the time of examination. The damage to bearings 6 and 7 was so severe that it was impossible to determine conclusively, based on the results of the metallurgical examination, the cause of their failure.

The pilot's decision to land before reaching his destination was justified considering the abnormal fluctuation in engine oil pressure. The pilot must have felt that the situation required landing as soon as possible as indicated in the RFM, when the engine oil pressure is beyond the stated limits. Nevertheless, since the oil pressure was fluctuating within the allowable limits but the oil temperature was normal, an immediate landing was not required according to the RFM. The procedure recommended by Bell Helicopter allowed the pilot to extend the flight to the nearest location suitable for landing. It would thus have been preferable to land on the road one kilometre away from the marsh because of the accessibility to the road.

During the visual examination of the engine, there were no abnormal conditions detected. Because the engine defect was internal, no oil leak was visible. Since the surface of a marsh, which is naturally soft, does not offer level bearing capacity, it is probable that the aircraft was not level, thereby altering the apparent oil level in the tank. The procedure recommended in the flight manual regarding engine oil fluctuation within the limits led the pilot to believe that the abnormal condition was not very serious since the oil temperature was normal. In reality, a major internal engine defect is not always associated with an abnormal engine oil temperature.

Based on the above, the pilot mistakenly concluded that the fluctuating engine oil pressure was possibly caused by a defective gauge. However, before taking off from the marsh, the following signs could have suggested that a defect other than the gauge was the source of the fluctuation:

- abnormal bluish smoke was coming out of the exhaust pipe;
- after starting up in the marsh, the oil pressure fluctuated before stabilizing within the allowable limits, but at a pressure that was lower than normal.

The fact that the pilot moved the aircraft one kilometre rather than going to his destination or returning to La Tuque suggests that he suspected something more serious than an instrument problem. Considering the circumstances, it was reasonable to anticipate an engine failure. Consequently, it would have been prudent to wait until a qualified AME examined the helicopter before taking off from the marsh. It appears that the marsh's inaccessibility and the infestation of mosquitoes influenced the pilot's decision to move the helicopter to the road.

The rear part of the skids touched the ground during autorotation, indicating that the helicopter was not levelled at the time of the landing. Consequently, the helicopter nose tipped forward after landing, causing the tail to lift, which was then damaged by the main rotor.

The following TSB Engineering Laboratory reports were completed:

LP 055/2006 — Engine Oil Analysis;
LP 056/2006 — Engine Examination.

These reports are available from the Transportation Safety Board of Canada upon request.

## *Findings as to Causes and Contributing Factors*

1. The area adjacent to bearings 6 and 7 had exceeded a temperature of 900°C. The bearings were destroyed for undetermined reasons, causing an engine failure.

2. Moving the helicopter towards the road when the engine was showing signs of malfunction contributed to the failure of bearings 6 and 7.

3. During the autorotation, the helicopter was not levelled at the time of the landing, which resulted in a hard landing.

## *Finding as to Risk*

1. The procedure recommended in the flight manual suggests a less serious problem if engine oil pressure is fluctuating within the limits and the gauge is showing a normal oil temperature. Consequently, a pilot could decide to continue the flight with a defective engine oil circulation system, which could cause the engine to fail or malfunction.

*This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 30 May 2007.*

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