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

AVIATION INVESTIGATION REPORT
A00P0010

POWER LOSS

TURBOWEST HELICOPTERS LIMITED
EUROCOPTER LAMA SA 315B (HELICOPTER) C-FJJW
GOLDBRIDGE, BRITISH COLUMBIA
20 JANUARY 2000

Canada

Aviation Investigation Report

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Summary

The Eurocopter Lama SA 315B helicopter (C-FJJW), serial number 2658, was climbing through 5000 feet above sea level, with the pilot and two passengers on board, when it experienced a partial loss of engine power resulting in a decay of the rotor rpm. The pilot attempted a force landing without entering autorotation, on the shore of Downton Lake, British Columbia. As he flared the helicopter to arrest its forward speed, the tail boom contacted the ground and separated from the fuselage. The helicopter rolled end-over-end and came to rest, with the cabin section relatively intact and the engine separated from the airframe. The fuel reservoir was breached, and fuel escaped, but no fire occurred. The passenger sitting in the left forward seat suffered a punctured lung; the pilot and the other passenger escaped with minor injuries. None of the occupants were wearing shoulder harnesses, although shoulder harnesses were available to the two forward cabin occupants.

Ce rapport est également disponible en français.

Other Factual Information

At the time of the accident, 1230 Pacific standard time,[1] the skies were reported as clear. The temperature at the surface was minus 15 degrees Celsius; at 5000 feet above sea level it was minus 5 degrees Celsius.

The pilot was certified and qualified for the flight in accordance with existing regulations. He had flown a total of approximately 10 200 hours, of which approximately 300 hours were on the Lama. During his last two pilot proficiency checks, the pilot had demonstrated his ability to perform autorotations with an MD 369D helicopter. He had obtained a type rating for the Lama in December 1997 but had not recently performed autorotations with this type of helicopter.

The aircraft maintenance engineer (AME) was licensed to perform maintenance on this type of helicopter. There are only about seven Eurocopter Lama SA 315B helicopters operating in Canada. AMEs with extensive experience on this type are limited.

The journey and technical logbooks contained no indication of uncorrected deficiencies relevant to the circumstances of the occurrence. The weight and balance of the helicopter were within the normal ranges at take-off.

The helicopter had been slinging logs and performing normally. A power assurance check had been carried out two days before the accident, with satisfactory results. The day before the accident, the pilot had reported to the AME that, during a flight to pick up a logging crew, he had noticed that the engine seemed to be lagging and that the rotor rpm (revolutions per minute) was decreasing. The AME installed an air-flow reduction plate on the engine oil cooler to increase the oil temperature. This oil is also used to lubricate the fuel governor system. He went along for a test flight, and the pilot indicated that, although the oil temperature had increased and was in the green (proper operating range), the engine was still lagging. The power would increase in cruise flight with no power setting change, but the engine rpm would not reach its normal operating speed of 33 500 rpm; however, it stayed above 33 000 rpm. Engine operation was normal when the power setting was decreased on approach for landing.

On the day of the accident, after the helicopter had been operating for some time, the AME and an apprentice AME were to be flown to Pemberton, British Columbia, for time off work. When the pilot attempted a start, the engine failed to self-sustain, and he aborted the start. On the next attempt to start the engine, the micro-pump indicator light remained illuminated until the starter cut out and the engine was self-sustaining. This sequence was not normal, and it was the first time the pilot had seen this. He lifted off and immediately observed that the engine rpm was low. The pilot commenced a slow climb-out with a power setting of 0.8 degree pitch;[2] the engine recovered to 33 500 rpm, and the engine oil temperature was 35 degrees Celsius (normal). Shortly after the helicopter climbed through 5000 feet, the engine rpm decreased by 500 rpm with no change in the power setting. The pilot decided to return to the service landing, reduced the power setting to 0.7 degree pitch, and initiated a normal turn. The engine speed

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1 All times are Pacific standard time (Coordinated Universal Time minus eight hours).

2 This helicopter type (Lama) determines power values by a collective pitch indicator.

decreased by an additional 100 rpm and was holding. The pilot then reduced pitch slightly to commence a slow descent to the service landing area. The engine started to decelerate rapidly, down to about 27 000 rpm, and the pilot landed on the shore of a frozen lake, where the accident occurred.

The pilot and the apprentice engineer, who was seated next to the pilot, were wearing helmets; however, the apprentice AME's helmet was lost during impact. Their seats were equipped with a shoulder harness, but they were not being worn. In accordance with Canadian Aviation Regulation (CAR) 605.27, the pilot should have been wearing his available seat harness, and in accordance with CAR 605.25, he should have directed the passengers to fasten their available seat harnesses. The apprentice was seated in the left forward seat and was the most seriously injured. The emergency locator transmitter activated at impact.

Fuel samples were retrieved from the refuelling gear, the airframe filter bowl, the refuelling bowser, and a Kamax helicopter operating from the same staging area. These samples were analyzed by gas chromatography for make-up and to check for water content.[3] The refuelling gear samples were near the water saturation level. An anti-icing additive had been added at the fuel supplier.

The Lama is powered by a Turbomeca Artouste 111B1, 870-shaft-horsepower turbine engine. The accident aircraft's engine, serial number (S/N) 1561, was manufactured in 1983. At the time of the accident, the engine had accumulated about 8385 hours total time since new (TTSN). The last repair of the engine, carried out on 16 December 1998 at 7494.1 hours TTSN, was carried out at Heli-Support Inc., the only North American facility approved by Turbomeca to repair and overhaul the Artouste turbine engine. The engine had been reported to be "making metal", and a bearing was found to be disintegrating.[4] The repair facility performed "deep maintenance" to replace the defective bearing.[5] It is not a requirement that the wheels/rotors be disassembled or that a borescope inspection be accomplished when performing this maintenance or that the repair facility carry out an engine performance/test run after; however, a performance run was carried out satisfactorily.

After the accident, the engine was sent to the Turbomeca engine manufacturing facility in France to be tested and inspected.[6] The Bureau Enquêtes-Accidents (BEA)—the French civil aviation accident investigation agency—supervised these activities on behalf of the TSB. Further tests on some components and oil samples were conducted at the French governmental engine

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[3] Powertech Labs Inc. Project 99M191

[4] "Making metal" describes the generation of metal particles due to engine wear.

[5] The Turbomeca Artouste 111B and 111B1 maintenance manual, Chapter 72-00-0, page 1, lists operations that are identified as "deep maintenance" that may be carried out by the operator in addition to routine maintenance work.

[6] Turbomeca Technical Report No. T00/CR0231A

testing facility and laboratory (ministère de la Défense, Centre d'essai des propulseurs).[7] The engine operated erratically during the run-up test. It was subsequently disassembled and inspected along with its ancillary systems. A warranty seal was found to be missing from the adjustment of the maximum flow and the fuel pump bypass nozzle; warranty seals are installed to preclude unauthorized adjustments. Radiographic pictures showed significant deposits throughout the length of the injection tube and partial obstruction of the axial passage of the injection wheel. Deposits were found in many locations of the injection assembly. Subsequent extraction by flushing (repeated cleaning with a petroleum ether solution and compressed air) produced more than 400 milligrams of maroon/amber-coloured deposits shaped in a way that suggests that these were pressed or glued to the injection tube walls by centrifugal force. The deposits were non-magnetic. These deposits were analyzed by infrared (IF) and fluorescent X (FX) spectrometric tests; the results resembled the spectrum of a polymer-type urea formaldehyde cellulosic resin. A gas chromatography and mass spectrometer (GC/MS) test confirmed the presence of an amino composite in the deposit.

During this investigation, it was reported by Turbowest Helicopters Limited that another of its Lamas, S/N 2549, experienced a similar loss of engine power but was landed without incident. The engine, S/N 1772, from this second Lama was inspected locally; deposits were obstructing the injection tube. The deposits were analyzed and compared to the deposits from the first engine, S/N 1561, and from its fuel filter bowl.[8] Remarkable similarities were found. A fuel sample was retrieved from the airframe reservoir of the second Lama and was found to contain a gelatinous substance in suspension. Further analysis of the deposits from engine S/N 1772 was performed. The amber-coloured deposit recovered from the injection tube was solvent-washed to remove residual fuel and then dissolved in water, in which it formed a gel. The gel was dried to a thin film, which was examined by fourier transform infrared spectroscopy (FTIR). The dried film has an IF spectrum resembling that of carboxymethylcellulose (CMC). CMC is a water-soluble powder, commonly used as a moisture content regulator, thickener, and stabilizer and to increase the viscosity of many water-based products. CMC is available in many grades.

Consultation with the industry provided information that had been transmitted from Transport Canada and issued by the US Federal Aviation Administration (FAA). This information was distributed in the form of an Aviation Maintenance Alert, issued in September 1999, and pertained to Special Safety Notice, Fuel Filters, FAA Advisory Circular AC 43-16A. The notice advised all those concerned with aviation safety that a product recall had been issued for Velcon filters. These filters use a polymer material as a water-absorbing media (similar to the media in baby diapers, incontinence pads, etc.) that will absorb free (undissolved) water from the fuel. The free water is normally removed to two parts per million or less. At standard flow rates, 50 per cent or higher of the element's rated flow, the differential pressure will rise across the cartridge as water accumulates. The cartridges are changed at 15 pounds per square inch differential pressure. A large amount of free water in the fuel (slug) will rapidly increase the differential pressure, shutting off the fuel flow as the water is absorbed. Velcon reported that, in testing trials, an undetermined number of cartridges have plugged in normal operation until

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[7] The Centre d'essai des propulseurs produced the following reports: No. 81-IP-2000, No. 61-IP-2000, and No. 53-IP-2000.

[8] Powertech Labs Inc. Project 14594-43-00

eventually the water-absorbing media was extruded through the media migration barrier in the element and flowed downstream. The refuelling gear filter used at the time of the occurrence was a Facet filter; it was retrieved and analyzed and was determined to incorporate a water-swellable material resembling a polyacrylate.[9] There are three classes of water-absorbent materials: aminoplast, CMC-based, and polyacrylates.

Analysis

There were early indications that the engine was operating abnormally. This was not recognized as important, and flight operations were continued.

The engine fuel injection tube and the wheel assembly contained a contaminant that obstructed the fuel flow, which would have caused the engine to lose power. The analysis of the contaminant substance showed that its chemical composition was similar to that of a compound/polymer found in the airframe fuel filter bowl of the same Lama, S/N 2658. The refuelling gear sample was near the water saturation level, and an anti-icing additive was added to the fuel at the supplier. Fuel filter manufacturers warn that water-absorbing cartridges are adversely affected by the use of anti-icing additives; the differential pressure specification across the filter is reduced. It is concluded that differential pressure across the filtering element caused the water-absorbing media to migrate out from fuel filters. The migration contaminated the fuel supply to the engine, obstructed the fuel flow, and caused a loss of power.

Since the installation of engine S/N 1561 (with a ground run, test flight, and power check performed) on this helicopter airframe S/N 2658 and after the last repair (7994.1 hours TTSN), 889 hours of flight time accumulated. It is probable that the aggregates had been accumulating since the engine's previous installation, on airframe S/N 2549. The deposits had likely been accumulating since the time of the last overhaul (31 March 1993 at 5432 hours TTSN) and before the last repair when the engine fuel pump may have been adjusted to compensate for obstructions in the fuel flow. The performance runs conducted after the deep maintenance failed to detect the contamination. The repair and overhaul facility and the operator missed the opportunity to identify and correct this problem.

It is unlikely that the air-flow reduction plate installed on the oil cooler to increase oil temperature affected the engine adversely, since the engine oil temperature gauge indicated normal operating temperatures after its installation.

It is known that a shoulder harness is a safety feature that greatly improves survivability in a crash. Accident investigation and research carried out by the TSB has consistently shown that the use of the shoulder harness portion of the seat restraint system is effective in reducing or preventing injury during moderate-impact forces. The injuries suffered by the apprentice AME would likely have been lessened had he been wearing the available shoulder harness.

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[9] Powertech Labs Project Nos. 12834-43-01 and 13086-43-01

Findings as to Causes and Contributing Factors

1. The pilot and the maintenance crew were not able to properly diagnose the problem with the engine and continued to fly the helicopter with a malfunctioning engine.

2. The helicopter lost engine power because an accumulation of water-absorbing material migrated out from refuelling gear fuel filters and subsequently obstructed the fuel passages to the combustion section of the engine.

Findings as to Risk

1. It is not a requirement that the wheels/rotors be disassembled or that a borescope inspection be accomplished when performing deep maintenance, nor is it mandatory for the repair facility to carry out an engine performance/test run following a repair termed as "deep maintenance".

2. Fuel filter manufacturers use water-absorbing materials that may be extruded and forced into aircraft fuel systems, causing fuel blockage and engine stoppage.

3. The injuries suffered by the apprentice aircraft maintenance engineer during the accident sequence would likely have been lessened had he worn the available shoulder harness.

Safety Action Taken

An article in the Transport Canada publication *Feed-Back* issued in the first quarter of 2000 reiterated the content of the FAA Advisory Circular AC 43-16A issued September 1999.

On 25 July 2001, the TSB issued Aviation Safety Advisory A010029 to Transport Canada. The thrust of the letter was that, through technical means and/or the dissemination of information to users, steps could be taken to reduce the risk of aircraft fuel system contamination caused by or related to the internal components of refuelling filters.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 19 December 2001.