AVIATION OCCURRENCE REPORT

A98P0022

LOSS OF ROTOR RPM AND FORCED LANDING

BIGHORN AVIATION INC.

EUROCOPTER AS-350D (HELICOPTER) C-GBRC

CRANBROOK VOR SITE, BRITISH COLUMBIA

19 JANUARY 1998

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Summary

Following a 15-minute shutdown at the helipad at the Cranbrook VOR site, at about 7,500 feet above sea level (asl), the pilot of the ski-equipped Eurocopter AS-350D helicopter, serial number 1150, loaded his two passengers and started the helicopter. After an unremarkable starting sequence, at about 1710 Mountain standard time (MST), the pilot lifted the helicopter into a five-foot hover for about 30 seconds and verified that flight control responses and all engine, transmission and rotor indications were normal. The pilot then turned the helicopter to the left and transitioned into climbing, forward flight. At about 80 feet above ground level (agl), the pilot experienced a sudden and uncommanded rotor revolutions per minute (rpm) decay and the helicopter began to descend. The pilot pushed forward on the cyclic stick and lowered the collective lever in an attempt to regain rotor rpm. He was unable to recover the rotor rpm, however, and, with a forced landing on the downward-sloping surface inevitable, the pilot flared the helicopter at about 30 feet agl, levelled the helicopter, and landed straight ahead into deep snow. The helicopter touched down at about 10 knots, but it slid forward over a steeper area and rolled over onto its right side. The three occupants escaped through the left door without injury or difficulty. The helicopter was substantially damaged but there was no fire. Although armed for flight, the onboard emergency locator transmitter (ELT) did not activate. The pilot and passengers then walked back to the VOR site and reported the accident; about two hours later, they were rescued by volunteers on snowmobiles from Cranbrook.

Ce rapport est également disponible en français.

Other Factual Information

On the preceding flight, the pilot had taken off from Cranbrook airport at about 1615 [1] and flown to the VOR site to pick up the two passengers. He arrived at the helipad, kept the helicopter running at flying rotor rpm, and the two passengers boarded the helicopter. When the pilot attempted to lift off into the hover, the torque and engine temperature rose, but the main rotor rpm decayed and the helicopter would not take off. The pilot tried twice more but with the same result. He then shut the helicopter down and examined the three main rotor blades for ice contamination. He found an ⅛-inch layer of clear ice on the 20-inch inboard section of each blade; he cleaned the ice off with alcohol and confirmed visually that all the blades were free of ice. In his inspection for airframe ice, the pilot did not include the engine air intake, although he noted that the air intake screen at the top of the engine cowling was clear.

During his attempt to regain rotor rpm, the pilot recalls that the reading on the engine exhaust gas temperature (EGT) gauge was increasing and had entered the red band on the gauge. The red band begins at 749 degrees Celsius. The AS-350D helicopter is equipped with an aural low rotor warning system that is activated when the main rotor speed falls below 335 rpm; normal in-flight speed is 385 rpm. During the attempted take-offs before shutting down, the pilot heard the low rotor warning horn come on each time the rotor rpm drooped. The pilot did not recall, however, if the warning horn had activated during the accident sequence. An examination of the cockpit after the accident revealed that the circuit breaker for the warning horn was out, and the pilot does not recall if he had pushed the circuit breaker in before the last take-off.

Another pilot who had flown the helicopter before it departed Cranbrook for the VOR site reported that the engine seemed to be running about 100 degrees Celsius hotter than normal. On the 18-minute flight from Cranbrook to the VOR site, the accident pilot reported that he had flown through an area of thin, low cloud or mist; he also reported that he felt that the helicopter's performance was slightly lower than he had expected. The pilot reported that during the 15 minutes on the helipad before the last take-off, the temperature was about minus one degree Celsius, and that at the time of take-off, light snow or ice crystals were falling.

At the time of the loss of rotor rpm, the helicopter was climbing in a high power demand situation, at about 7,500 feet asl, at an estimated all-up-weight of about 3,800 pounds, and in an outside air temperature of minus one degree Celsius. According to the AS-350D rotorcraft flight manual, the maximum helicopter weight for an out-of-ground-effect hover (HOGE) in these conditions would have been about 4,100 pounds.

An inspection of the helicopter at the accident site on the day after the accident found no ice on the rotor blades, on the engine air intake screen, or in the engine air intake chamber. Snow had fallen during the period of time between the accident and the site examination, and the upper surfaces of the helicopter were coated with a one-inch layer of soft snow. The rotor head and blades, however, became buried in deep snow at the time of the roll-over, and it is likely that

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[1] All times are MST (Coordinated Universal Time (UTC) minus seven hours) unless otherwise noted.

the blades surfaces had been protected from any change in their pre-impact condition. Investigators found that the engine compressor turned freely by hand. Although the aircraft was significantly damaged when it rolled over, the initial impact was not violent enough to set off the ELT.

The helicopter was manufactured in 1979 by Eurocopter (formerly Aerospatiale Helicopters) and, at the time of the accident, it had accumulated almost 11,100 hours of service. The Allied Signal (Lycoming) LTS-101-600A-3 turbine engine (serial number LE43525CE) had accumulated 2,621 hours total since new (TSN) at the time of the accident. The engine was a “lease” unit from Allied Signal and had been installed in C-GBRC on 01 November 1997 at 2,578 hours TSN, temporarily replacing the operator’s own engine, which was undergoing overhaul at Allied Signal in the United States of America.

The wreckage was recovered from the accident site and examined for defect; none was found. The engine was removed for visual examination and test-cell performance evaluation, and then disassembled for internal inspection. The visual examination of the engine, its components, and systems revealed no defect or anomaly that could have caused a loss of engine performance.

Investigators examined C-GBRC’s Canadian journey and technical logbooks and found nothing remarkable. The Allied Signal engine logbook, however, recorded that during two previous engine rentals, the power turbine governor (PTG), the fuel control unit (FCU), and the fuel pump had been replaced several times. The PTG had been replaced twice at 2,189 hours TSN as a result of engine surging, with the recorded comment that the helicopter could not get off the ground; the fuel pump and FCU had both been removed from the engine at 2,429 hours, and were reinstalled at the end of the rental period at 2,488 hours; they were still installed on the engine at the time of the accident. The PTG was replaced by Allied Signal at 2,488 hours. The engine manufacturer had installed a zero-time airflow modulator at 2,189 hours at the time of the test-cell run; it was replaced 52 hours later with an airflow modulator that already had 906 hours of service. The replacement airflow modulator was on the engine at the time of the accident, 380 hours later.

At the time of the accident, the engine was fitted with the following engine components:

Engine Components	Part Number	Serial Number
Fuel Pump	4-301-128-10	3AFP816B
Fuel Control Unit	4-301-288-04	238938
Power Turbine Governor	4-301-289-03	23184
Overspeed Controller	4-301-235-04	30353
T1 Sensor	4-301-099-02	16987
Airflow Modulator	4-301-102-12	2527

With the exception of the fuel pump and the airflow modulator, the above components were tested for specification performance; although the tests found slight deviation from specification data in three of the units, no condition was detected that would have caused a loss of engine performance.

Records show that the engine had twice been run in Allied Signal’s engine service centre test cell since the fuel pump, PTG, FCU, and airflow modulator were replaced. After the most recent test-cell run, the engine was installed in C-GBRC and flew for 43 hours before the accident.

A summary of recent engine maintenance activities follows:

Date	Engine TSN	Maintenance Action	Reason for Maintenance Action
31 Mar 96	2,189	Test cell run - Allied Signal Airflow modulator (#1516) installed	
25 April 96	2,189	Installed in AS-350D (#1255) Failed test flight - engine surging PT Governor (#18534) removed PT Governor (#21279) installed	Trouble-shooting Engine surging
26 May 96	2,189	Engine power checked Engine still surging	Trouble-shooting Engine surging
16 June 96	2,189	PT Governor (#21279) removed PT Governor (#28561) installed Test flight - engine still surging	Trouble-shooting Engine surging
4 July 96	2,241	Airflow modulator (#1516) removed Airflow modulator (#2527) installed Satisfactory test flight	Trouble-shooting Engine surging
24 Mar 97	2,429	Fuel pump (#3AFP816B) removed Fuel pump (#203G) installed FCU (#238938) removed FCU (#335225) installed Satisfactory test flight	Unknown
unknown	2,488	Engine removed from AS-350D (#1255)	
29 July 97	2,488	Fuel pump (#203G) removed Fuel pump (#3AFP816B) installed FCU (#335225) removed FCU (#238938) installed PT Governor (#28561) removed PT Governor (#23184) installed Test cell run - Allied Signal	Return loaner Return loaner SB 73-20-0177
31 July 97	2,488	Engine installed in AS-350D (#1555)	
21 Aug 97	2,578	Engine removed from AS-350D (#1555)	
8 Sep 97	2,578	Test cell run - Allied Signal	
1 Nov 97	2,578	Engine installed in C-GBRC	

19 Jan 98	2,621	Accident flight C-GBRC	

Under the scrutiny of the TSB Engineering Branch and a representative from the Canadian helicopter operator, Allied Signal carried out extensive engine performance tests on the subject engine in their engine test-cell facility in Phoenix, Arizona. The engine operated normally during all cell tests, and no conditions were identified that would have interfered with normal engine operation. In summary, the engine test-cell run found no anomalies that would have led to a loss of engine performance. Similarly, none of the engine components examined exhibited any anomalies that would have led to a loss of engine performance.

The TSB forwarded a copy of the Allied Signal engine test-cell results to an independent engine facility for discrete verification and review. Their review of these test results concurred with the conclusions made by Allied Signal and confirmed that the slight anomalies identified would not have caused a change in engine power.

The pilot held a valid Commercial Pilot Licence - Helicopter (CPLH) and a current medical certificate, both issued by Transport Canada (TC). The licence was endorsed for the AS-350 helicopter and had a restriction for “daylight flying only”; this limitation did not contribute to the accident circumstances. The pilot had accumulated about 1,100 flying hours, of which about 100 hours were on the AS-350 helicopter, and about 700 hours on similar-sized turbine helicopters.

Analysis

Despite rigorous testing and examination of the engine and its ancillary systems, no defects were found that would have led to the sudden and uncommanded loss of main rotor rpm. Nonetheless, previous logbook entries record the removal and replacement of primary engine control components as a result of engine surging. Such component removal and replacement is characteristic of maintenance staff trouble-shooting engine performance-related problems. The components were not tested at that time, and no conclusions about their performance can be made.

The engine passed Allied Signal’s test-cell run on 31 March 1996; however, the engine failed to meet the engine manufacturer’s specifications immediately thereafter when it was installed in the AS-350D helicopter, serial number 1255. Records show that in June/July 1996 the engine was operated for another 52 hours before the airflow modulator was replaced on 04 July 1996. This operating overview is consistent with an intermittent problem with the airflow modulator. It is also possible that the original surging problems were caused by a combination of performance tolerance extremes of the engine fuel control system components, but that the airflow modulator may have had the most effect. At that time, the helicopter could not lift off the ground; the accident pilot experienced the same circumstance just before the accident. As a result, the possibility of mechanical malfunction of one or more of the engine control components being a contributing factor in the loss of rotor rpm cannot be discounted.

The ice that the pilot found on the main rotor blades had accumulated on the rotor disk hub which has no aerodynamic benefit and produces little lift, if any. As a result, it is unlikely that removing the ice from the blades’ roots had any significant effect on the aerodynamic efficiency of the rotor system, and certainly would not have been the principal factor for the rotor rpm recovering before the final take-off. In the three-minute period from start-up at the VOR site to rotation into forward flight, the reported weather conditions were likely not severe enough to accumulate sufficient blade ice to cause significant and rapid rotor rpm decay. Since post-accident information revealed no ice accumulation on the main rotor blades, blade ice would have been an unlikely factor in either instance of rotor rpm decay.

However, it could not be determined if an accumulation of snow or ice in the engine intake had occurred, or if such an accumulation would have led to an engine performance degradation sufficient to precipitate a loss of rotor rpm under the specific take-off conditions prevailing at the time of the accident.

There remain four possibilities to explain the two separate, but apparently similar, instances of rotor rpm decay, namely:

1 - engine air intake contamination and restriction;
2 - engine airflow modulator rigging or function;
3 - fuel volume delivery or scheduling restriction; or
4 - a combination of all three.

According to the pilot, the EGT exceeded 749 degrees Celsius during the loss of rotor rpm immediately before the accident; further, there is a report of the engine running hotter than usual. This high temperature is not consistent with fuel flow restriction, rather with engine airflow problems.

The possibility of airflow restriction/interference is further raised by the report from the pilots that the engine seemed to be lacking power. This lower-than-expected power is unlikely explained by the small amount of blade root ice found when the helicopter shut down on the VOR site pad. Another possible factor in the second instance of rotor rpm decay is the pilot's handling technique; without benefit of recorded flight data, however, this remains an undetermined factor.

Prior to the loss of rotor rpm, the helicopter was climbing with high power, and at a weight and density altitude that likely placed the helicopter near the maximum available flight performance. In this situation, the presence of adverse meteorological phenomena, such as freezing precipitation, or any type of mechanical malfunction leading to performance degradation, such as anomalies with the airflow or fuel control systems, could have resulted in a loss of rotor rpm. Such circumstances would have been demanding for the pilot, would have had incrementally deleterious effects on helicopter performance, and would have allowed little margin for handling error.

The pilot experienced a sudden decay of main rotor rpm at an altitude, airspeed, and power demand combination that did not permit him to effectively recover the rpm and continue flight. As a result, he was committed to perform a forced landing on a downward-sloping surface.

The impact forces were not great enough to activate the armed ELT.

The following TSB Engineering Branch report was produced:

LP 30/98 - Engine Examination (AS-350B C-GBRC)

Findings

1. Testing and examination of the engine and its ancillary systems found no defects that would have led to the loss of main rotor rpm.

2. The engine logbook records the removal and replacement of primary engine control components as a result of engine surging. The components were not tested at that time, and no conclusions about their performance can be made.

3. The possibility of mechanical malfunction of one or more of the engine control components being a contributing factor in the loss of rotor rpm cannot be discounted.

4. It could not be determined if snow or ice had accumulated in the engine intake.

5. When main rotor rpm decayed, the combination of altitude, airspeed, and power demand did not permit the pilot to effectively regain the rpm and continue flight.

6. From the location where the rotor rpm decayed, the only available landing area was a downward-sloping, snow-covered surface.

Causes and Contributing Factors

The main rotor rpm suddenly decayed at an altitude, airspeed, and power demand combination that did not permit the pilot to effectively recover the rpm and continue flight. As a result, he was committed to perform a forced landing on a downward-sloping surface. The cause of the loss of rotor rpm could not be determined.

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 23 June 1999.