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

AVIATION INVESTIGATION REPORT
A05P0137

IN-FLIGHT ENGINE SHUTDOWN

CASCADE AEROSPACE INC.
BOMBARDIER DHC-8-402 C-FBAM
ABBOTSFORD, BRITISH COLUMBIA, 15 nm N
15 JUNE 2005

Canada

Aviation Investigation Report

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Summary

The aircraft departed Abbotsford International Airport at 1853 Pacific daylight time, under visual meteorological conditions, for the sixth flight of the day, and proceeded to uncontrolled airspace about 15 nm north of Abbotsford. There were two pilots and two company flight test engineers on board. A certification flight testing program was being conducted by Cascade Aerospace Inc. with the Bombardier DHC-8-402 (registration C-FBAM, serial number 4040) modified for air tanker operations. At about 1930 Pacific daylight time, during a rate-one turn in cruise flight at 4500 feet, the No. 1 engine (PW150A, serial number PCE-FA0020) shut down without warning. The auto-feather system was disarmed, in accordance with normal procedures, and the alternate feather system was used to complete feathering of the propeller. The flight returned to Abbotsford at 1950 Pacific daylight time with one engine inoperative.

Ce rapport est également disponible en français.

Other Factual Information

Operation

The aircraft was being operated under the authority of a Transport Canada (TC) Flight Permit – Experimental. At the time of the incident, the Q400 Airtanker conversion of the initial Bombardier DHC-8-400 design was undergoing supplemental type certificate (STC) certification flight testing for the fire-fighting role. The conversion included the installation of a 10 000 litre retardant delivery system. The pilot crew was employed by the Conair Group Inc. Both pilots had completed the Dash 8 Q400 initial pilot course at the FlightSafety International Toronto Learning Centre in November 2004.

Flight Recorders

The aircraft was equipped with a Honeywell solid-state cockpit voice recorder (CVR) and an Allied Signal solid-state flight data recorder (FDR). Information was recovered from the FDR but not from the CVR. The pertinent information from the CVR was overwritten while external electrical power was applied to the aircraft following the incident flight.

Powerplants

The PW150A engine consists of a free-turbine turbo machine (TM) module driving a Dowty Aerospace model R408 six-bladed propeller through a two-stage reduction gearbox (RG) module. The TM module includes the low-pressure (LP) compressor and its LP turbine, the single-stage centrifugal high-pressure (HP) compressor and its HP turbine, and the two-stage power turbine (PT) and its PT shaft, which drives the RG module. The three rotating assemblies are not connected together and rotate at different speeds and in opposite directions. The LP compressor case houses the LP compressor, an integral oil tank at the bottom, and an accessory gearbox (AGB) at the top. The AGB is driven by the HP turbine shaft through a vertical tower shaft and angle gearbox. The AGB drives the fuel metering unit (which incorporates the fuel pump), the starter/generator, and other accessories.

Maintenance and Aircraft Records

Aircraft records indicate that the left engine, serial number (s/n) PCE-FA0020, had about 1978 flight hours of total time since new (TTSN) and that the right engine, s/n PCE-FA0015, had about 2016 flight hours of TTSN. In summary, the engine logs for the incident engine (s/n PCE-FA0020) recorded about 1874 hours in the first 19 months after manufacture and about 104 hours in the following 35 months. It had not been operated for two extended periods. From October 2003 until June 2004, the aircraft was stored at the Bombardier West Virginia Air Center, and from October 2004 to May 2005, it was undergoing the air tanker conversion at Cascade Aerospace Inc. facilities.

A copy of the Engine Service and Maintenance Record contains a Bombardier Maintenance Work Card from the West Virginia Air Center dated 30 October 2003. The work card contains an instruction to perform weekly engine idle runs in accordance with DHC-8 Q-400 aircraft maintenance manual (AMM) Chapter 71-00-00. A single entry on that sheet dated 01 May 2004 recorded that this instruction had been complied with.

A Cascade Aerospace Inc. non-routine maintenance card, dated 24 November 2004, contained a requirement to carry out an AMM task regarding preparation of the aircraft for storage of 91 to 180 days, including suggested action of weekly and monthly recurring inspections. The Corrective Action section of the maintenance card stated that the aircraft was prepared for storage and returned to service in accordance with the applicable AMM tasks, dated 14 May 2005. Additional worksheets recorded that weekly inspections were completed between 19 January and 16 February 2005. On 22 February 2005, preparation of the aircraft for return to service commenced and was completed on 14 May 2005.

TSB Engineering, Research, and Other Reports

This occurrence is recorded as file CF 20050621013 in TC's service difficulty reporting (SDR) database. A search of TC's SDR database did not produce any similar occurrences in Canada or the United States. At this time, the only civilian aircraft equipped with the PW150A engine is the DHC-8-400 model.

The TSB Engineering Laboratory participated in the engine teardown and produced report LP 065/2005. Pratt & Whitney Canada (P&WC) also produced an investigation report. Both reports presented the same information, but the P&WC report also included the metallurgical analysis that was completed at P&WC facilities. The reports noted that the No. 30 bearing had significantly deteriorated and fractured into multiple pieces. All eight balls, portions of the bearing's outer race, and portions of the bearing cage were found in the oil pump, scavenge oil screen, the scavenge oil tube, and the blow-down housing for the cavity containing the No. 3 and the No. 4 bearing. The No. 4 bearing is the thrust bearing for the HP compressor shaft. Portions of the bearing were also found on the AGB chip detector and the two magnetic speed sensors for the HP compressor rotor. Localized corrosion-related pitting and staining was noted on the No. 4 bearing balls, and inner and outer races, with the heaviest concentration at the six o'clock position. At the top of the tower shaft, localized rust-like stains were noted on the upper surface of the No. 29 bearing rollers and outer cage, the lower surface of the oil shield, and the outer surface of the shaft portion of the spiral bevel gear. The teeth on the spiral bevel gear (bottom of tower shaft adjacent to the No. 30 bearing) were smeared with metal, forced in the direction of rotation. Some of the teeth had fractured near the crown.

The TSB Engineering Laboratory report concluded that:

- It is likely that the corrosion pitting noted on the left engine's No. 4, No. 29 and No. 30 bearing components was due to the bearings being stationary while in the presence of moisture.

- It is likely that the No. 30 bearing failed due to corrosion pitting.

- The left engine flamed out because the AGB was not driving the fuel pump.

Additional Information

A chip detector fault code for the No. 1 engine TM module was recorded by the engine monitoring unit (EMU) at a time of 1559 on 15 June 2005, which coincided with the completion time of the third flight of the day. A fault code interrogation had been completed at the end of the previous day's flying with no faults detected. The next fault code interrogation was planned for the completion of the current day's flights. There is no chip warning or detection system available to the flight crew, although operators could make this information available to flight crews if they wish to. The No. 30 bearing failure occurred about two hours of air time following the chip detector fault.

During the time that engine s/n PCE-FA0020 was inoperative at Cascade Aerospace Inc. facilities, it remained on aircraft s/n 4040 along with engine s/n PCE-FA0015. Since both engines were stored under the same conditions, engine s/n PCE-FA0015 was also subjected to a preliminary inspection in the presence of TSB investigators at P&WC (without complete disassembly) for indications of corrosion in the AGB drive train area. The main and scavenge oil filters, main oil pump sump screen, engine oil sample, HP compressor rotor speed sensors, and the TM chip detector were visually examined with no irregularities noted. The cover of the angle drive gearbox was removed to expose the No. 29 bearing. The bearing itself could not be viewed due to the bearing/gear oil shield installation. However, nothing abnormal was observed as far as could be seen. P&WC later completely rebuilt this engine and no anomalies were reported to the TSB.

During the time that aircraft s/n 4040 was not in service at the West Virginia Air Center, it was equipped with engines s/n PCE-FA0020 and s/n PCE-FA0063. The No. 2 engine, s/n PCE-FA0063, was removed on 06 June 2004 and engine s/n PCE-FA0015 was installed in the No. 2 position on the same date. The condition of engine s/n PCE-FA0063 was given consideration for comparison. However, the engine was viewed as a serviceable engine (as s/n PCE-FA0015 had been) and neither a teardown nor inspection was completed. Engine s/n PCE-FA0063 was subsequently installed on aircraft s/n 4040 on 18 June 2005 and has since accumulated numerous hours without difficulties.

Also during the period that the aircraft was at the West Virginia Air Center, the No. 1 engine, s/n PCE-FA0020, was removed and sent to P&WC facilities where it underwent a hot section inspection and other repair work between February and May 2004. Part of the repair work included removal of the AGB cover plate enclosing the No. 29 bearing. It could not be determined how long the access cover may have been left off or if it could have been re-installed without its preformed packing during that period. During that period, roof leaks were experienced at the P&WC Service Center in the area where the subject engine had been worked on.

Analysis

Based on the nature of the in-flight engine shutdown (IFSD) and the observations and conclusions of the engine teardown and reports, it was concluded that the IFSD was ultimately caused by fuel starvation due to a loss of drive to the AGB. The AGB drives the fuel metering unit and integral fuel pump.

The No. 29 and No. 30 bearings support the tower shaft in a cavity above the No. 3 and No. 4 bearing cavity. The loss of drive to the AGB was caused by the failure of the No. 30 thrust bearing at the base of the tower shaft. Failure of this bearing allowed the driven spiral bevel gear shaft (tower shaft) to lift longitudinally and disengage from the driving spiral bevel gear on the HP compressor shaft. Although the balls of the No. 30 bearing were damaged to the point that surface material analysis was precluded, corrosion stains and pitting were noted in several places along this power train, including all three bearings (which lie in a vertical orientation). It was concluded that distress occurred to the No. 30 bearing as a result of instability due to spalling. The spalling was initiated by corrosion, and the resulting instability produced fatigue fractures in the bearing cage and outer ring, ultimately resulting in disintegration.

Records since July 2002 indicate that the aircraft had only flown 104 hours in the last 35 months and that there were two notable periods of time that it was not in service. Records for those periods indicate that engine idle runs or storage inspections were completed in accordance with the maintenance instructions specified. At some time, a contaminant was introduced into the engine and it is concluded that the most likely opportunity was between February and May 2004 when the engine was undergoing repairs. The cover plate of the angle gearbox enclosing the No. 29 bearing had been removed and may have been left off and/or re-installed without its preformed packing, allowing contaminant ingress at the cover plate when leaks in the building roof occurred. The contaminant migrated down this power train by gravity from the No. 29 bearing through the No. 30 bearing and onto the No. 4 bearing. The maintenance actions completed were not sufficient to prevent or detect contaminant ingress while the engine was in the shop. The system then remained stationary long enough for corrosion of the bearings along the AGB drive train to occur.

Although the TM chip detector recorded a fault due to metal in the engine oil, this warning was not available to the flight crew and, consequently, they had no prior indication of the impending failure and IFSD.

The following TSB Engineering Laboratory report was completed:

LP 065/2005 – Engine Examination

This report is available upon request from the Transportation Safety Board of Canada.

Findings as to Causes and Contributing Factors

1. While the engine was undergoing repairs, the cover plate of the angle gearbox enclosing the No. 29 bearing had been removed, and it is likely that contamination from a leaking roof entered the engine, allowing corrosion to take place.

2. Distress occurred to the No. 30 bearing as a result of instability due to spalling. The spalling was initiated by corrosion and the resulting instability produced fatigue fractures in the bearing cage and outer ring, ultimately resulting in disintegration.

3. The loss of drive to the accessory gearbox (AGB) was caused by the failure of the No. 30 thrust bearing at the base of the tower shaft. Failure of this bearing allowed the driven spiral bevel gear shaft (tower shaft) to lift longitudinally and disengage from the driving spiral bevel gear on the high-pressure compressor shaft.

4. The No. 1 engine in-flight shutdown was ultimately caused by fuel starvation due to a loss of drive to the AGB. The AGB drives the fuel metering unit and integral fuel pump.

Findings as to Risk

1. The engine maintenance actions completed during extended shop repairs were not sufficient to prevent the introduction or detection of a contaminant and resultant corrosion of the bearings along the AGB drive train.

2. Although the turbo machine chip detector recorded a fault due to metal in the engine oil, this warning was not available to the flight crew. Consequently, they had no prior indication of the impending failure and in-flight shutdown.

Other Findings

1. Information was not recovered from the cockpit voice recorder since it was overwritten while external electrical power was applied to the aircraft following the incident flight.

2. The aircraft had flown only 104 hours in the last 35 months and there were two notable periods of time that the engine/aircraft were not in service. Records for those periods indicate that engine idle runs or storage inspections were completed in accordance with the maintenance instructions specified.

Safety Action

Action Taken

Pratt & Whitney Canada engaged a contractor to provide a climate-controlled storage facility for inactive engines.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 23 August 2006.

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