Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A00A0176

ENGINE FAILURE

CANADIAN AIRLINES INTERNATIONAL
BOEING 737-217 C-GKCP
FREDERICTON, NEW BRUNSWICK
13 NOVEMBER 2000

Canada

Aviation Investigation Report

Engine Failure

Canadian Airlines International
Boeing 737-217 C-GKCP
Fredericton, New Brunswick
13 November 2000

Report Number A00A0176

Summary

The Boeing 737-217 aircraft was landing on runway 15 in Fredericton, New Brunswick, on a flight from Québec, Quebec. When thrust reversers were deployed, the No. 1 engine (Pratt & Whitney JT8D-17A) spooled down, and flames were observed coming from the tail pipe. The crew secured the No. 1 engine and brought the aircraft to a stop on the runway. After a visual inspection by airport firefighters, the aircraft taxied to the ramp, where the passengers and the crew deplaned normally.

Ce rapport est également disponible en français.

Other Factual Information

When the flight service station specialist observed flames on the left side of the aircraft during the landing roll, he advised the crew and asked if they required further assistance. When they replied in the affirmative, he activated the crash alarm. The airport firefighters were on the scene in approximately 1 minute 10 seconds.

Initial examination of the engine revealed that the 4th-stage low-pressure turbine (LPT) wheel had shed all of its blades. This was a contained failure, but because the thrust reversers were deployed, some metal fragments from these shed blades were deflected against the side of the fuselage, denting and gouging the fuselage skin. (A few of these dents and gouges were found to be beyond serviceable limits when dressed out.) Several windows also had to be replaced.

An engine teardown, carried out under the supervision of the TSB, confirmed that the damage had been confined to the LPT. The 3rd- and 4th-stage LPT turbine wheels and the 2nd-, 3rd-, and 4th-stage LPT guide vanes were forwarded to the TSB Engineering Laboratory for failure analysis. The engine (JT8D-17A, serial number 709396) had a total of 45 647 hours in service, and the LPT installed on this engine had 14 569 hours since overhaul.

Examination of the LPT turbine components revealed that one 4th-stage blade showed a combination of fatigue and overstress fracture topography. The fatigue crack initiated at the trailing edge and propagated along the chord for 14 millimetres (mm). The fatigue crack was about 15 mm outboard of the platform. Scanning electron microscope examination of the fatigue portion of the fracture revealed a smooth oxidized surface, with the crack arrest markings clearly discernible. The crack initiated at or very near the trailing edge; there were no metallurgical or mechanical precursors found at the origin. The position and the length of the crack were similar to those found in previously investigated 4th-stage turbine blade failures, which had formed due to blade shroud cross notch (BSC) wear. In these failures, the fatigue crack was typically about 19 mm outboard of the platform and propagated to approximately one-third of the chord from the trailing edge before becoming unstable.

Airworthiness Directive (AD) 94-20-09, applicable to Pratt & Whitney engine models JT8D-15A, -17A, and -17AR, called for the installation of containment rings around the 3rd- and 4th-stage LPT to prevent engine debris from damaging the aircraft after failure of an LPT blade or shaft. In accordance with Pratt & Whitney Alert Service Bulletin (ASB) A5913, initial and repetitive inspections of the BSCs on 3rd- and 4th-stage LPTs were required until such time as containment rings were installed. Containment rings had been installed on the occurrence engine. The operator had also incorporated repetitive BSC inspections into its maintenance program, and these inspections had been carried out on the occurrence engine.

According to the ASB, normal engine operating stresses produce wear to the cross notch contact hardface surfaces, resulting in reduced blade damping and changes to the blade vibratory modes. Excessively worn and loose shroud contact surfaces result in increased blade operating stresses that can cause fracture of the blade. The ASB called for torque readings to be taken at six locations on the turbine disc. The interval between the BSC inspections was predicated on the torque readings obtained. For example, if torque readings of 10 inch-pounds (the highest value called for) are obtained at all six locations, the next inspection would be due in 1000 hours. A torque reading of 2 inch-pounds in any one of the six locations would dictate that the LPT be removed within 20 hours.

A review of the operator's BSC inspection sheets for the occurrence engine revealed that an inspection had been carried out 56 hours before the occurrence and that torque readings of 10 inch-pounds were recorded at all eight locations. (The operator takes readings at eight locations rather than at six locations called for in the ASB.)

The operator had experienced a 4th-stage LPT turbine wheel failure on another JT8D-17A engine (serial number 709378) on 19 July 2000.[1] BSC wear was cited as a causal factor in that failure as well, even though the BSC inspection had been carried out 952 hours before the failure and torque readings of 10 inch-pounds were obtained.

The operator indicated that it carries out the BSC inspection on all the JT8D engine models (-9A, -17, and -17A) in its fleet and has found this inspection program to be very effective in detecting 3rd- and 4th-stage LPT cross notch wear with all models, except the -17A. The operator indicated that it would see a gradual reduction in the torque readings obtained and would thus be able to remove the engine from service before failure. However, the operator indicated that the gradual reduction in torque reading trend does not always develop on the -17A engines, as evidenced by this occurrence and the one on 19 July 2000.

Analysis

BSC wear and the onset of vibrations resulted in fatigue failure of the 4th-stage blade. When this blade failed, it precipitated the overload failure of the remaining 4th-stage blades.

ASB A5913 and AD 94-20-09 were issued to mitigate the risk of blade LPT failures by measuring the BSC wear and removing LPT wheels from service before they reach the critical wear limit. To prevent engine debris from damaging the aircraft, the documents prescribed installing containment rings around the 3rd- and 4th-stage LPT wheels. However, from the operator's experience with the -17A engine, and as evidenced by the 4th-stage blade failure in this occurrence and in the 19 July 2000 occurrence, it appears that measuring the BSC wear is not an accurate method of predicting when an LPT blade may fail on a -17A engine. Nevertheless, the steps taken to contain the debris from an LPT blade failure have been successful.

The following Engineering Laboratory Report was completed:

LP 125/00—Low-Pressure Turbine Examination.

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

---

1 TSB Investigation report No. A00W0150 and TSB Engineering Laboratory report LP 82/00.

Findings as to Causes and Contributing Factors

1. A single 4th-stage turbine wheel blade failed as a result of an extension of a fatigue crack propagating through the chord from the trailing edge.

2. The position and the length of the crack were similar to cracks due to blade shroud cross notch (BSC) wear found in previous 4th-stage turbine blade failures.

Other Findings

1. Measuring the BSC wear does not appear to be an accurate method of predicting when a low-pressure turbine blade may fail on a -17A engine.

Safety Action

Transport Canada has written a letter to the Federal Aviation Administration (FAA) asking if other operators had experienced similar difficulties accurately predicting low-pressure turbine blade failures despite their complying with AD 94-20-09 and ASB A5913 and/or if there are any additional actions being considered to address low-pressure turbine blade failures. Transport Canada has stated that it will take appropriate actions following receipt of comments from the FAA.

Air Canada has instituted a limit of 12 500 hours on low-pressure turbine blades in its -17A engines in light of the failure of current inspections to accurately predict turbine blade failures on this engine model.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 04 December 2001.