Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A06A0115

LOSS OF CABIN PRESSURE

AIR CANADA JAZZ
CANADAIR CL600-2B19 C-FSJJ
FREDERICTON AIRPORT, NEW BRUNSWICK, 100 nm NW
03 NOVEMBER 2006

Canada

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

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Summary

An Air Canada Jazz Canadair CL600-2B19 (serial number 7058, registration C-FSJJ) being operated as JZA8954 was on a scheduled flight from Toronto, Ontario, to Fredericton, New Brunswick. While in cruise at flight level 330, the flight crew observed the cabin altitude climbing at a rate of approximately 1000 feet per minute. A descent clearance to flight level 250 was requested from Moncton Area Control Centre and, after the aircraft was level at flight level 250, a continued increase in cabin altitude was observed. The crew requested and received clearance for further descent to 9000 feet. The pilots donned their oxygen masks during the descent as the cabin altitude climbed through 10 000 feet. When the cabin altitude reached 14 000 feet the passenger oxygen masks automatically deployed. The aircraft was leveled at 9000 feet where it remained until descent for final approach was initiated. The aircraft landed at Fredericton without further incident at 2115 coordinated universal time. There were no injuries to the 50 passengers and 3 crew members.

Ce rapport est également disponible en français.

Other Factual Information

Modern commercial aircraft that are designed to conduct sustained flight above 10 000 feet are pressurized. The pressurization systems are automatically controlled to maintain cabin altitudes below 10 000 feet in order to provide a safe and comfortable environment for the passengers. As the aircraft climbs, its pressurization system pumps air into the fuselage to maintain a cabin pressure altitude below 10 000 feet. This results in a higher pressure inside the aircraft than that of atmospheric pressure outside. The resulting pressure differential is regulated by the aircraft system.

Before the pressure loss started, C-FSJJ was level at flight level (FL) 330 while maintaining a cabin altitude below 10 000 feet. The aircraft had been established in level cruise flight for approximately 16 minutes before the crew detected a cabin pressure variation. Although there were no aircraft system warnings or caution messages present on the engine indicating and crew alerting control system (EICAS), the crew noticed that the cabin altitude was climbing at approximately 1000 feet per minute. On checking the air conditioning control panel, it was observed that the left air conditioning unit (ACU) pack was on-line. However, the right ACU pack was off-line. The bleed air control panel was indicating that the right 10th stage bleed shut-off valve (SOV) was also off-line. Therefore, the left ACU pack was the only available source of pressure for the air conditioning and pressurization demands of the aircraft.

If one of the two ACU packs goes off-line, the remaining pack will automatically switch to Hi flow as a normal function of the system. This should ensure cabin pressure can be maintained at an altitude below 8000 feet. The maximum aircraft altitude for single-pack operation is 25 000 feet.

After receiving clearance from Moncton Area Control Centre (ACC), the crew expedited descent with the intent of leveling off at FL250 before the cabin altitude could reach 10 000 feet. During the descent, the crew attempted to reset both the right 10th stage bleed SOV and the right ACU pack but neither would come back on-line.

Once the descent from FL250 was initiated, the captain made an announcement informing passengers that one of the ACU packs was not operating and that the flight was continuing on to destination. Approximately one minute after descent was initiated, the master warning illuminated for two seconds and the cabin altitude warning came on. The crew then observed "DISPLAY COOL" and "AIRINC COOL" messages on the EICAS primary display.

During the descent from FL250, the cabin altitude warning activated indicating that the cabin altitude had reached 10 000 feet. At this time the flight crew donned their oxygen masks. Despite an average rate of descent of 4000 feet per minute, the cabin altitude climbed steadily until it reached 14 000 feet. At that point the passenger oxygen masks deployed automatically.

The cabin altitude warning extinguished after the aircraft descended below 10 000 feet. After the aircraft was level at 9000 feet, the flight crew ran through the associated checklists and noticed that the pressurization fault light was illuminated on the pressurization panel. The crew then selected manual pressurization mode.

Seven days earlier, the aircraft was reported to have had poor airflow. Ground runs were completed by the maintenance personnel; the airflow was reported as normal.
Following the occurrence flight, a maintenance inspection revealed several separate anomalies related to both the left and right air conditioning systems:

- The left system, air supply duct (part number 601R95211-113), was found detached from its flange at the water separator joint. The duct is located in the unpressurized tail section of the aircraft, aft of the pressure vessel. The detached flange created a leak through which an undetermined percentage of air pressure was lost.
- The right system pressure regulating shut-off valve (PRSOV) sense line was found detached, which effectively caused that system to go off-line.
- Both the right and left system bulkhead check valves (part number 92E20-4) were missing a return spring. The missing return springs would permit the check valves to remain open and allow cabin air to backflow and escape through the duct system in the event of a breach in the respective ducts between the PRSOV valves and the pressure bulkhead. The missing springs were not located.

The duct flange failure observed in the left system was similar in nature to previous duct failures experienced in the air supply systems of the CRJ 100/200 series aircraft. Those duct failures are the subject of an airworthiness directive (CF-2003-05R1). However, those ducts are of a different part number and location within the air supply system than the duct that was found detached on C-FSJJ.

Transport Canada Airworthiness Directive (AD) CF-2003-05 "Air Supply Ducts and Bulkhead Valve – Inspections" was issued on 04 February 2003; this was later superseded by CF-2003-05R1 issued on 31 March 2006. The background section of the AD indicates the following:

> The manufacturing procedure used to attach the flanges to the air supply ducts has resulted in bonds that may lose shear strength at elevated temperatures. This condition could potentially cause the duct to disconnect and in combination with the failure of a bulkhead check valve, result in the in-flight loss of aircraft pressurization.

Technical records indicated that no recent maintenance had been carried out on the PRSOV line. The investigation could not determine how the line became loose and detached.

It should be noted that as part of AD CF-2003-05R1, Bombardier added a new task to the CRJ maintenance program. The task calls for a repeat check valve inspection at an interval of 4000 flight hours. Prior to this incident, the check valves (part number 92E20-4) were last inspected at the operator facilities on 08 August 2005; the springs were present and deemed serviceable.

Analysis

The most plausible initiating event related to the reduction in cabin pressure was the loose PRSOV line serving the right air conditioning pack. Once the line had detached completely, the actual duct pressure for the right ACU pack could not be sensed accurately and the PRSOV valve likely closed. The closed PRSOV valve effectively caused the right pack to go off-line. When either of the two packs goes off-line, the remaining pack will automatically switch to Hi flow as a normal function of the system. In this case the left pack did switch to Hi flow, which increased the pressure in that respective duct system.

The additional pressure from the Hi flow may have caused an already weak flange-to-duct joint to fail completely. It is also possible that the duct had deteriorated over time and was already partially detached from the flange. Normally, one air conditioning pack operating at Hi flow is adequate for aircraft pressurization, provided a maximum aircraft altitude of 25 000 feet is maintained. However, once the flange failed, duct pressure was reduced as the air escaped into the unpressurized tail section.

The "DISPLAY COOL" and "ARINC COOL" EICAS messages the crew observed were most likely triggered by a low airflow condition in ducts that supply cooling air to the instrument panel and the avionics bay of the aircraft. The caution messages do not necessarily indicate a higher than normal duct temperature. They do indicate the fact that a low airflow supply to the instrument panel and to the avionics bay was resulting in an increased operating temperature of those particular components. It is also possible for messages to be triggered by flow sensors in the system that are sensitive to changes in air density as cabin altitude increases.

After the right air conditioning system had gone off-line and the left air conditioning system became the sole source of air pressure to the cabin, the right bulkhead check valve should have closed. However, the check valve remained open due to the missing spring. This allowed cabin air pressure to backflow through the inoperative right system ducting up to the PRSOV valve which had closed due to the detached PRSOV line. Had the bulkhead check valve spring been in place, the valve would have closed when the duct pressure opposing it decreased. This would have prevented backflow of the pressurizing air to the PRSOV valve. Since there was no breach in the right system between the bulkhead check valve and the PRSOV valve, the cabin pressure loss to ambient from the right side would have been negligible. The left bulkhead check valve spring was also missing but in this case it had little effect on the rate of cabin pressure loss since some supply air was likely available from the left ACU pack. The missing check valve springs were not recovered and it could not be determined how long they had been missing. The effect of a missing check valve spring would go unnoticed during normal operation of the system and, therefore, could go undetected for some time. The left system duct had detached at the water separator which effectively allowed the majority of supply air from the left ACU to escape from the ducting.

Although the left air conditioning system continued to operate and supply the cabin/cockpit with air pressure, the pressure supplied was insufficient to overcome the rate of pressure loss created by the left system duct leak. Therefore, the cabin altitude could not be controlled and continued to climb.

The combined effect of the independent technical failures across both independent ACU pack systems resulted in a loss of cabin pressurization. This loss of pressurization was not easily detected as one pack remained on-line and in Hi flow mode. However, the majority of the supply air pressure coming from the left pack was escaping through the dislodged duct flange before it could enter the cabin. According to Bombardier analysis from other incidents, the rate of pressure loss in this case was the same as what could be expected if there were little or no air pressure entering the aircraft cabin, provided the following conditions are met: there is no significant breach in the pressure vessel or the systems that supply pressure to the cabin, and the aircraft pressure vessel has nothing more than the normal leak-down rate expected.

It is unusual for a flight crew to be faced with multiple, unrelated failures at the same time. In this case the crew attempted to resolve the problem but it could not be rectified in flight. Due to the lack of any other significant pressurization warnings and because the aircraft can normally operate on one pack, the crew's initial plan to descend to 25 000 feet was reasonable.

The following TSB Engineering Laboratory report was completed:

LP 109/2006 – FDR Analysis

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

Finding as to Causes and Contributing Factors

1. The combined effect of the detached left air conditioning unit pack system air supply duct, the detached right system pressure regulating shut-off valve line, and the missing return spring on the left system bulkhead check valve resulted in the loss of cabin pressurization.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 13 March 2008.

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