**SERIOUS INCIDENT**

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| **Aircraft Type and Registration:** | Boeing 767-332ER, N1608 |
| **No & Type of Engines:** | 2 General Electric CF6-80C2B6F turbofan engines |
| **Year of Manufacture:** | 2000 (Serial no: 30573) |
| **Date & Time (UTC):** | 13 August 2017 at 1225 hrs |
| **Location:** | London Heathrow Airport |
| **Type of Flight:** | Commercial Air Transport (Passenger) |
| **Persons on Board:** | Crew - 11 Passengers - 208 |
| **Injuries:** | Crew - None Passengers - None |
| **Nature of Damage:** | None |
| **Commander's Licence:** | Airline Transport Pilot's Licence |
| **Commander's Age:** | 61 years |
| **Commander's Flying Experience:** | 16,239 hours (of which 5,619 were on type)[1]<br>Last 90 days - 177 hours<br>Last 28 days - 72 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the operator and further AAIB investigation |

## Synopsis

On departing London Heathrow Airport, the cabin altitude reached 15,900 ft. The crew donned their oxygen masks, commenced an immediate descent and returned to Heathrow. The cause of the cabin failing to maintain the required pressure could not be established.

## History of the flight

The aircraft was scheduled to fly a return flight between Hartsfield-Jackson Atlanta International Airport and London Heathrow Airport. Shortly after departing Atlanta, the advisory message, R ENG PRV displayed on the Engine Indication and Crew Alerting System (EICAS), and remained on for the duration of the flight. On arriving at Heathrow, the operator's maintenance personnel examined the aircraft and found that the right engine pressure regulating valve (PRV) was worn, which they replaced.

A different crew consisting of the commander, co-pilot, and relief pilot were scheduled to fly the return flight to Atlanta and on arriving at the aircraft were asked by the maintenance personnel to carry out a ground run to check the operation of the PRV. No anomalies were noted during the ground run and the warning message on the EICAS did not reappear.

**Footnote**

[1] Commander's hours are at this operator.

During the departure from Heathrow, the advisory message, R ENG PRV, again displayed on the EICAS. As the aircraft passed FL100, the commander and the relief pilot actioned the R ENG PRV checklist in the Quick Reference Handbook (QRH) while the co-pilot handled the aircraft and radios. As the warning message was still present after the checklist had been completed, the crew sent a message to their maintenance staff via the Aircraft Communication Addressing and Reporting System (ACARS) seeking advice. The maintenance staff suggested that the crew should repeat the QRH checklist actions once they reached their cruise altitude, when the required engine power would be lower.

The crew reported that, at the planned cruise altitude of FL320, the cabin pressure was slightly higher than normal but was steady at about 7,000 to 7,500 ft. As they started to action the QRH the audio warning sounded, the master warning light illuminated, the CABIN ALTITUDE message appeared on the EICAS and the AUTO INOP warning light illuminated on the cabin altitude control panel (CACP). The commander also noticed that the cabin pressure was rapidly rising and recalled it reaching 15,000 ft. He attempted to close the outflow valve manually but noted that the position indicator showed that it was nearly at the closed position.

The passenger oxygen masks automatically deployed; the flight crew donned their oxygen masks and informed London ATC of the emergency and requested an immediate descent to FL250. The crew were instructed to squawk 7700 and were initially cleared to FL250. Once clear of Danger Area D203 the crew requested, and were given, clearance for a continuous descent to FL100. The crew also informed their maintenance staff at Heathrow that they were returning and discussed landing approximately 20,000 lbs over the maximum landing weight.

The commander and relief pilot actioned the QRH checklist for the CABIN ALTITUDE message, while the co-pilot continued as the handling pilot. The check list actions, which included moving the cabin pressurisation selector to manual, were unsuccessful in clearing the EICAS message. Once the aircraft reached FL100 the flight crew removed their oxygen masks and coordinated with London ATC to establish a holding pattern in order to jettison fuel from the centre fuel tank before making an uneventful approach and landing at Heathrow. The landing weight was 341,900 lbs which was 21,900 lbs above the maximum landing weight of 320,000 lbs. The crew reported that throughout the emergency they followed the appropriate check lists in the QRH.

The commander reported that the lenses in his oxygen mask were in poor condition, which affected his visibility, whereas the lenses in the masks of the co-pilot and relief pilot were clear.

During the emergency, the cabin crew informed the flight crew that all but two of the passenger oxygen masks had automatically deployed and that a passenger had fainted and was being attended by a passenger with a medical background. Medical personnel were requested to meet the aircraft on its arrival at Heathrow. Throughout the emergency, the flight crew communicated with the cabin crew and passenger announcements were made to inform passengers of the emergency and that the aircraft was returning to Heathrow.

## Recorded information

The operator provided the AAIB with the DFDR data from which the salient parameters are presented at Figure 1.

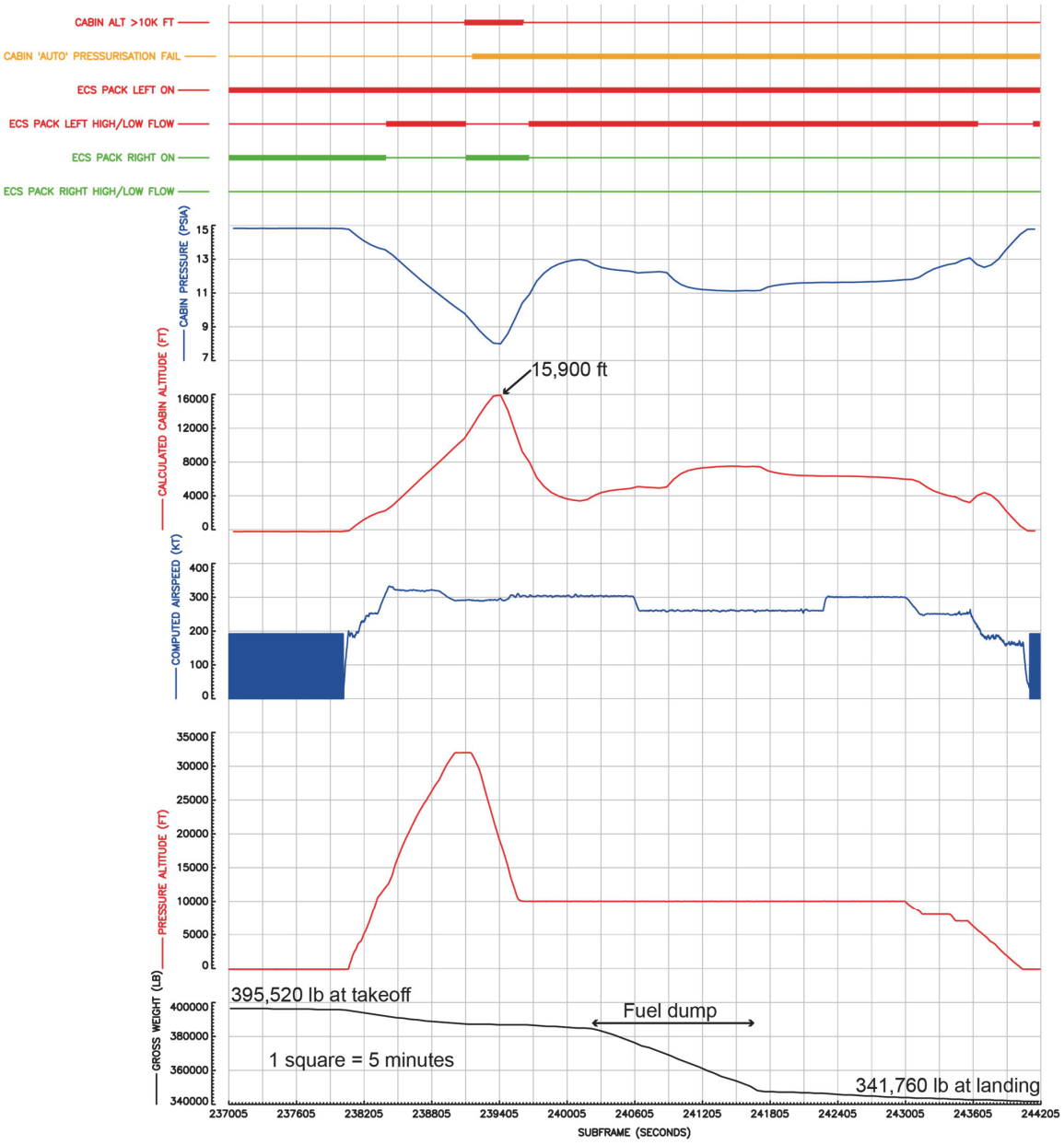


**Figure 1**

DFDR data at the time of the event – N1608, 13 August 2017

The DFDR data shows that the profile of the calculated cabin altitude followed the aircraft altitude and reached a height of 15,900 ft before reducing as the aircraft descended. There was no evidence of the cabin altitude stabilising between 7,000 to 7,500 ft before this point. The profile of the cabin altitude during the remainder of the flight was consistent with the cabin altitude being manually controlled by the crew. The position of the outflow valve is not recorded on the DFDR.

Approximately five minutes after the aircraft took off, the right Environmental Control System (ECS) pack was switched OFF and the left ECS pack changed to high-flow mode. Eleven minutes later the right ECS pack was switched ON and the left ECS pack returned to low-flow mode. At the same time, the CABIN ALT > 10K FT illuminated followed shortly afterwards by the CABIN AUTO PRESSURISATION WARNING FAIL. After a further nine minutes, when the aircraft had descended to an altitude of approximately 10,000 ft, the right ECS pack was switched OFF, the left ECS pack changed to high-flow mode and the warning CABIN ALT> 10K FT cleared. The right pack remained OFF and the left pack remained in the high-flow mode for the remainder of the flight.

**Aircraft information**

*General*

Three separate aircraft systems were involved in this event: Engine bleed air, air conditioning and cabin pressurisation.

*Engine bleed air*

Engine bleed air is provided from either the high-pressure or low-pressure sections of the engine compressor and is provided through ducting to other aircraft systems such as the ECS packs. The flow of bleed air into the ducts is controlled by a high-pressure shut off valve (HPSOV) and a PRV. An advisory message L (R) ENG PRV is displayed on the EICAS when the PRV is open when it has been commanded to close. In such a situation, the QRH procedure directs the crew to turn off the pack associated with the malfunctioning PRV.

*Air conditioning system*

The air conditioning system is equipped with two identical air conditioning (ECS) packs, which in flight are provided with bleed air from the associated engine to provide pressurised, conditioned air into the cockpit and cabin. The ECS packs are controlled by two identical controllers and the airflow into the cabin is automatically changed by the controller from low to high-flow when the other ECS pack fails or is selected off. This is to ensure there is adequate airflow into the cabin when one ECS pack is inoperative.

*Cabin pressurisation*

Cabin pressurisation is controlled by adjusting the discharge of conditioned air through the outflow valve. Positive pressure relief valves and negative pressure relief doors protect the fuselage against excessive differential pressure. The controls, indicators and warning lights for the cabin pressurisation system are located on the cabin altitude control panel (CACP) (Figure 2).

In automatic mode, the 'MODE SELECT' (7) on the CACP can be set to either the AUTO 1 or AUTO 2 position. Manual mode is selected by moving the 'MODE SELECT' to the MAN position and the cabin pressure is then controlled by moving the spring loaded 'MANUAL' control (1) to either the CLIMB or DESCEND position. This action moves the outflow valve towards either the open (OP) or closed position (CL).

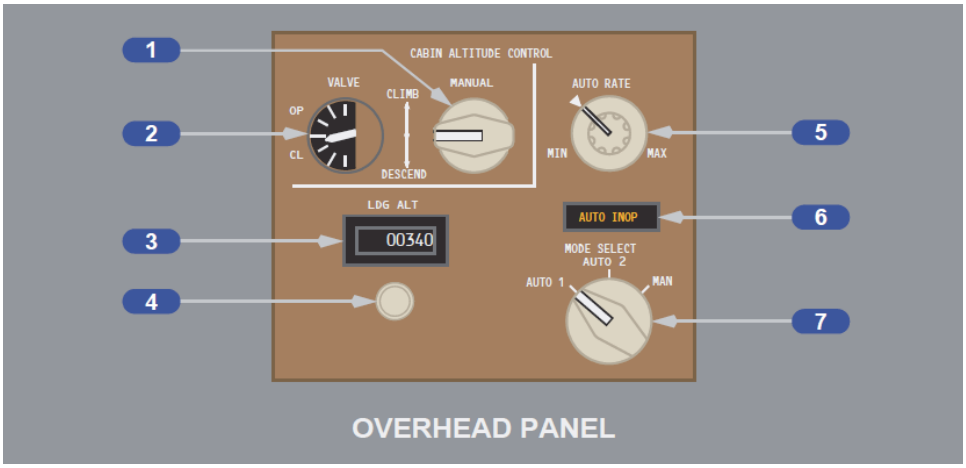


**Figure 2**
Cabin Altitude Control Panel

If the cabin altitude climbs above 10,000 ft, the red CABIN ALT warning light located on the centre forward panel, and the red CABIN ALTITUDE warning light on the equipment cooling overhead panel, illuminate and the message CABIN ALTITUDE is displayed on EICAS. The warning lights extinguish and the EICAS message clears when the cabin altitude descends below 8,500 ft. The amber AUTO INOP light illuminates (6) and the EICAS caution message CABIN INOP displays when automatic pressurisation control fails, or when the cabin altitude mode is selected to manual. In the event of a reduction in cabin airflow into the cabin from the ECS packs, the expectation is for the outflow valve to move to fully closed to retain or increase the pressure in the cabin.

*Passenger oxygen masks*

Passenger oxygen masks are stowed in Passenger Service Units (PSUs) located above the passenger seats. The oxygen masks can be deployed by the flight crew operating a switch, or by an aneroid switch that operates when the cabin pressure altitude is more than 14,000 ft.

**Engineering actions**

The operator reported that their maintenance personnel at Heathrow inspected the aircraft and identified a fault on the 'auto pressurisation control' that caused a low air flow into the cabin. The right engine PRV controller (PRVC), both cabin pressurisation controllers, the right engine high-pressure Controller and the outflow valve were all replaced. Wear was also found on the right engine HPSOV, which was also replaced. A leak check was carried out on the right PRV and PRVC sense lines and found to be satisfactory. Following the replacement of the components, an engine ground run was carried out and the cabin was pressurised using the left and right systems. No anomalies were found and the aircraft was released for flight.

The aircraft was flown to Atlanta on a non-revenue flight where the passenger oxygen system was inspected and it was discovered that the passenger masks at seat 5B/C and

18 F/G had not deployed. The oxygen generators were replaced, the passenger masks were cleaned and stowed, and a 'drop test' was carried out during which all the passenger masks deployed.

The operator returned the components that had been removed from the aircraft to an overhaul organisation for examination and testing. The right engine PRVC failed the preliminary inspection (bench check) due to a blown internal diaphragm; this fault would explain the R ENG PRV message on the EICAS. Inspection of the right engine PRV revealed that the position switches, bushings and internal link were all worn. Inspection of the other components did not establish a reason why the cabin failed to maintain pressure when the mode select was in the AUTO position.

**AAIB comment**

Data from the DFDR showed that during the departure from Heathrow the cabin altitude increased until it reached 15,900 ft when the crew commenced their descent. The flight and cabin crew acted appropriately throughout the emergency and the decision to land slightly overweight was made to ensure prompt medical treatment for a passenger with a medical condition.

The fault on the right engine PRVC would have generated the EICAS message R ENG PRV, which would have required the crew to turn off the right ECS pack. This action would have caused the left ECS pack to automatically switch to the high-flow mode. It can be seen from the DFDR data, presented at Figure 1, that the left pack automatically switched between low and high-flow mode on two occasions, which is consistent with the crew actioning the QRH. The cabin pressure was also maintained at a satisfactory level during the inbound flight when only the left pack was operating. This indicates that the air conditioning system worked correctly and the flow from the left pack should have been sufficient to pressurise the cabin.

For the cabin pressure to decrease as the aircraft climbed there would have had to have been either insufficient airflow into the cabin or excessive leakage from the cabin. The commander reported that the indicator on the CACP showed that the outflow valve was near to the CLOSED position when they commenced their descent to 10,000 ft. Examination of the aircraft at Heathrow and Atlanta, and inspection and testing of the components removed from the aircraft, could not identify a fault that would have restricted the airflow into the cabin or resulted in an excessive leakage. However, since the components were replaced the aircraft has flown more than 2,000 hours and 240 cycles with no further reported faults with the cabin pressurisation.

The two passenger oxygen masks that failed to deploy were located in separate areas of the aircraft and seat aisles. The aircraft manufacturer was unaware of any other occasions when the masks had failed to deploy on a Boeing 767 aircraft. Should some of the passenger oxygen masks not automatically deploy, then the cabin crew can provide the affected passengers with portable oxygen or mechanically release the oxygen masks.