SERIOUS INCIDENT

Aircraft Type and Registration:	Boeing 767-36N, G-POWD
No & Type of Engines:	2 General Electric Co CF6-80C2B7F turbofan engines
Year of Manufacture:	2003 (Serial no: 30847)
Date & Time (UTC):	19 March 2017 at 0900 hrs
Location:	En route from London Stansted Airport to Rzeszow-Jasionka Airport, Poland
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 9 Passengers - 262
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	52
Commander's Flying Experience:	8,965 hours (of which 2,635 were on type) Last 90 days - 24 hours Last 28 days - 24 hours
Information Source:	AAIB Field Investigation

Synopsis

Shortly after entering the cruise at FL370 the cabin altitude audio siren sounded and the CABIN ALTITUDE red warning caption illuminated. The crew carried out the depressurisation drills before commencing an emergency descent and subsequent diversion to Amsterdam Schiphol Airport. It was established that the aircraft failed to pressurise correctly due to a faulty positive pressure relief valve (PPRV)[1]. Both PPRVs had been replaced with overhauled valves during recent maintenance.

Testing and strip examination of the faulty valve proved inconclusive, with no obvious reason for the malfunction being found. The possibility of debris trapped in a metering section of the valve could not be ruled out, although no evidence of this was found.

History of the flight

This was the aircraft's first revenue flight following heavy maintenance, during which both PPRVs were replaced. A 1-hour post-maintenance check flight was completed the day before the incident, which included a climb to FL350. No pressurisation problems were reported on the check flight.

Footnote

[1] Positive and negative pressure relief valves are provided to protect the cabin from excessive pressure differentials. There are two PPRVs on the Boeing 767, mounted above one another on the left side of the fuselage, ahead of the wing.

On the day of the incident, the aircraft was planned to conduct a charter flight to Jasionka Airport (EPRZ) in Poland, then return to Stansted. The crew included the two pilots and a maintenance engineer who had conducted the check flight the previous day; the engineer occupied the jump seat. As neither pilot had been to EPRZ before, the commander flew the outbound sector, with the co-pilot acting as pilot monitoring (PM). All the flight preparations were normal.

The aircraft departed at 0921 hrs and was step climbed to its cruising level of FL370. As they approached abeam the 'TULIP' waypoint at FL370, the co-pilot answered an interphone call from the cabin service director (CSD) about the seat belt signs having illuminated. On checking the passenger sign switch, he noted that it was in the AUTO position. At that moment, the cabin altitude aural warning sounded and the CABIN ALTITUDE red warning caption illuminated. In accordance with the operator's emergency procedure for '*Rapid depressurisation*', the pilots and engineer donned their oxygen masks and established communication with each other. The co-pilot had to be assisted with his mask and he thought he may have been suffering some degree of hypoxia. They noted that the cabin altitude was about 10,000 ft and the cabin differential pressure indicator was at about the seven o'clock position, which equates to about 7 psi cabin differential pressure. The co-pilot transmitted a MAYDAY call advising Maastricht ATC of the depressurisation and the crew's intention to carry out an emergency descent. This was acknowledged by ATC and the crew were given a radar heading to fly. As the aircraft had just passed Amsterdam, the crew elected to divert there.

The passenger oxygen system was deployed and an emergency descent was commenced, first to 20,000 ft, then 10,000 ft and finally levelling at 7,000 ft. The commander removed his oxygen mask at 10,000 ft, but the co-pilot remained on oxygen until level at 7,000 ft. The crew programmed the FMS for an arrival for Runway 27 at Schiphol Airport, where an uneventful landing was completed at 1007 hrs.

External inspection of the aircraft revealed that the indicator flag on the upper PPRV upper door flap was visible (Figure 1, arrowed), indicating that the valve had operated in flight, allowing cabin air to leak overboard.

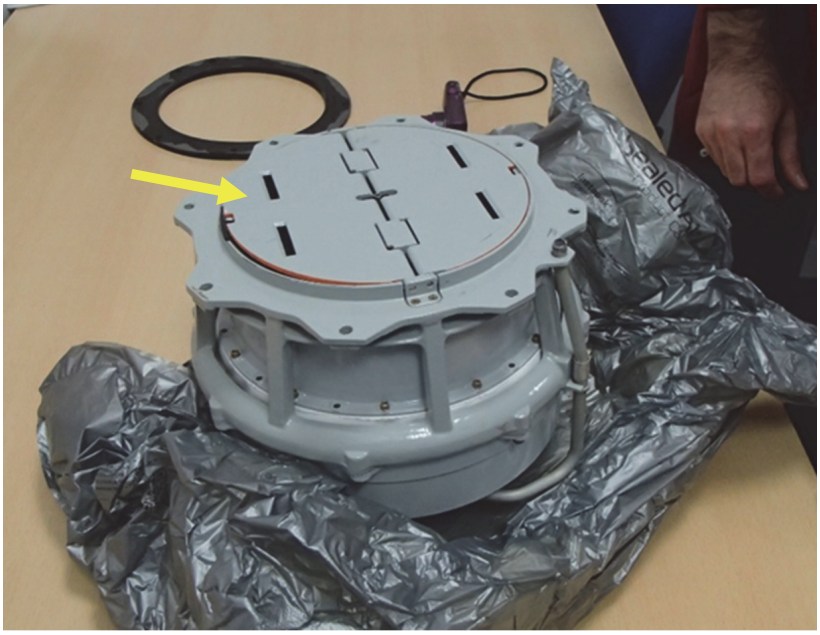

Figure 1

Defective positive pressure relief valve,
as removed from G-POWD

Recorded information

The aircraft was fitted with a solid-state Flight Data Recorder (FDR) and Cockpit Voice Recorder (CVR), both of which were downloaded at the AAIB.

Flight Data

The downloaded data showed that the seat belt signs were activated at 09:40:59 hrs with the aircraft in cruise at FL370, followed 38 seconds later by the display of a cabin altitude EICAS[2] message in conjunction with a Master Warning. The crew's oxygen system reduced in pressure 25 seconds later, indicating that it was being used by the flight deck crew, and an initial descent to FL200 was started after a further 60 seconds.

The passenger oxygen system was deployed as the emergency descent was commenced, two minutes after the seat belt signs had illuminated. The average rate of descent during the emergency descent was approximately 4,500 fpm.

The FDR installation on G-POWD does not record the cabin pressure differential or altitude, nor does it record the position of the cabin outflow valve.

CVR examination and testing

The CVR recorded pre-flight preparations on the ground at Stansted, up until the point that external power to the aircraft was removed. The recording then resumed on the ground at Amsterdam when the aircraft was parked on the stand.

Footnote

[2] Engine Indicating and Crew Alerting System.

Because the recorder stopped working after the external power had been removed from the aircraft, the CVR was subject to an examination at a manufacturer approved overhaul agent. This initial examination consisted of an external visual inspection of the CVR, a detailed visual inspection of the interior of the CVR and a full suite of functional checks using the manufacturer's approved acceptance test software. No defects were found during this examination.

The CVR which was fitted to the aircraft to ferry it back from Amsterdam to the operator's base at Stansted was also downloaded by the AAIB. This recorder was found to contain a complete recording of the ferry flight. Further testing was then carried out on the aircraft with a different CVR fitted, focussing on the routing of power to the CVR during removal of external power. No faults were identified during this testing.

The incident CVR was shipped to the manufacturer for a more detailed examination. Although this identified some anomalies with the operation of the unit, none of these anomalies were consistent with the unit stopping recording.

In consultation with the AAIB, the operator elected to introduce an additional CVR check which was conducted every flight, post-engine start. The aircraft was monitored over the next 100 days of operation and during this period no faults were recorded.

Recent maintenance history

The aircraft had recently completed a 'C' Check heavy maintenance input, during which both PPRVs were replaced with overhauled units. There was a scheduled maintenance requirement to test the PPRVs in situ on the aircraft, but the maintenance organisation's test equipment for this was unserviceable. These replacement valves were tested in accordance with a different procedure, contained in B767 Aircraft Maintenance Manual (AMM) Task 21-32-01-702-027, which details a procedure for conducting a leak check on the remote static pressure lines. The procedure states:

> *'… (3) If you replaced both positive pressure relief valves with two new valves which were successfully tested off-aircraft in the shop, you can use this procedure as an alternate test to the Positive Pressure Relief Valve – System Test ….'*

The PPRV involved in this incident had part number 103642-3 and serial number 69-A0674. It was removed from a Boeing 757 after being described as "inoperative". The valve had completed 25,270 hours and 16,162 cycles in service. The date of removal was not disclosed, but it was received at the manufacturer's UK facility on 3 January 2012, where it failed a bench test. Following an overhaul, it received its final inspection stamp on 26 January 2012, with its associated EASA Form 1, dated 27 January 2012. A note in the Component Maintenance Manual (CMM) for the PPRV stated that the unit should be re-tested if it was not fitted to an aircraft within twelve months. However, this instruction was not reproduced on the EASA Form 1 (which formed part of the release documentation), so maintenance personnel installing the valve on the aircraft would not have been aware of it. Until its fitment to G-POWD, the valve had not been fitted to an aircraft since being overhauled in 2012.

Positive Pressure Relief Valve

Figure 2 shows a schematic diagram of the PRPV, highlighting the principal components.

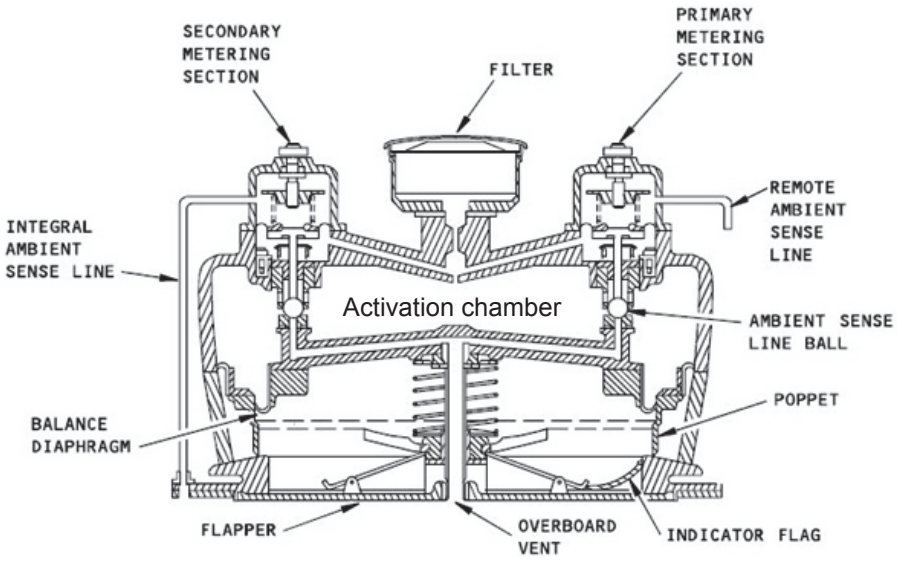

Figure 2

Schematic of the positive pressure relief valve

The PRPV uses two control metering sections, the primary and the secondary, which open at differential pressures of 8.95 and 9.42 psi, respectively. They are identical in construction, but the secondary unit is adjusted to the higher pressure so that it operates as a back-up in the event of a failure in the primary. One side of each metering section is supplied with an ambient pressure source: a remote line for the primary and an integral sense line for the secondary. Cabin pressure is applied to the opposite sides of the metering section and, at excess cabin pressures the ball valve attached to the metering section will lift, allowing air to pass into the activation chamber. This allows cabin pressure to open the poppet valve, which vents cabin air overboard. Associated movement of the flapper doors causes the spring-loaded indicator flags to pop out.

Testing and strip examination

The defective PPRV assembly was taken to the manufacturer's UK overhaul facility where it was tested and disassembled with the AAIB. The valve was installed in a test chamber that included a representation of an aircraft fuselage. A negative pressure was then applied to the 'outside', to simulate the aircraft climbing. With a correctly functioning unit there should be no flow through it until a pressure differential of at least 8.95 psi is reached. However, it was found that a flow became established at a pressure differential as low as 3.36 psi. This would result in cabin air being able to leak from the aircraft during a normal climb.

The tests pointed to a fundamental problem with the valve and a strip examination was performed. This proved inconclusive, with no obvious evidence found to explain the valve malfunction.

Whilst the reason for the PPRV's failure was not found, the manufacturer calculated that the valve would have opened at around 3.5 psi differential pressure if a piece of debris as small as 0.0033 inches in diameter had become trapped underneath the ball valve in either the primary or secondary metering section.

Analysis

The evidence shows that there was a failure of the cabin to pressurise correctly during the climb. The flight crew actioned the emergency procedure in a timely manner and, despite some difficulty experienced by the co-pilot in donning his oxygen mask, the crew successfully completed an emergency descent and diversion to Schiphol Airport.

The investigation concluded that there was a fault in one PPRV that would result in gradual cabin air leakage. The reason for the fault was not identified, despite testing and careful strip examination. The valve manufacturer surmised that a small piece of debris could have become trapped in a metering unit ball valve, thus propping it open. However, it was not established how such debris could have entered the valve after it was tested as serviceable following overhaul.

The valve had remained in storage for approximately five years before being fitted to G-POWD. The CMM states that the PPRV should be re-tested if it was not fitted to an aircraft within 12 months, but this information was not available outside the manufacturing organisation nor was it stated on the EASA Form 1.

During the recent maintenance and, in the absence of serviceable test equipment, the maintenance organisation had removed both PPRVs from the aircraft, replacing them with overhauled units. The AMM test of the replacement valves failed to detect any defect and it is likely that the aircraft departed for its first flight with the faulty valve leaking cabin air as soon as the cabin differential pressure exceeded approximately 3.4 psi. This would have led to a gradual loss of cabin pressure and the cabin altitude to climb to the level that triggered the cabin altitude warning.

It is not clear why the cabin pressurisation problem did not manifest itself during the post-maintenance check flight, during which the aircraft climbed to FL350 without any cabin pressure warning. However, it is possible that the leak rate may not have been enough for the cabin altitude to climb to a level that would have triggered the warning during this flight.

Conclusion

The failure of the cabin to pressurise correctly resulted from a faulty PPRV which was installed during recent maintenance. The maintenance checks of the replacement valves did not identify the defect with the faulty PPRV.

The event was a failure to pressurise correctly, rather than a sudden depressurisation and the crew's timely actions in identifying the problem and carrying out the appropriate emergency procedure ensured a safe outcome.