INCIDENT

Aircraft Type and Registration:	DHC-8-402 Dash 8, G-ECOC
No & Type of Engines:	2 Pratt & Whitney Canada PW150A turboprop engines
Year of Manufacture:	2007 (Serial no: 4197)
Date & Time (UTC):	13 December 2018 at 2105 hrs
Location:	En route from Aberdeen to Birmingham
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 4 Passengers - 77
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	46 years
Commander's Flying Experience:	7,655 hours (of which 7100 were on type) Last 90 days - 204 hours Last 28 days - 49 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

During the climb to cruising altitude the flight crew took the precautionary action of using the fixed oxygen system following a pressurisation event. The aircraft pressurisation system was reset and functioned normally, however the oxygen system failed to provide the pilots with oxygen. The oxygen cylinder regulator was later disassembled, and the crew oxygen supply port was found blocked with a piece of debris. It is suspected that the debris was the tip of a screw extraction tool, but no evidence could be found to explain how it came to be in the regulator. The operator has changed the 'first flight' checks to ensure the flight deck emergency oxygen system is functioning correctly.

History of the flight

Prior to departure from Aberdeen Runway 16 for Birmingham Airport, the flight crew completed the safety checks satisfactorily, including verification that the flight crew oxygen system was pressurised. The altimeter checks and cabin pressure were indicating normally as the aircraft climbed through 10,000 ft (FL100) but at approximately 18,000 ft (FL180) a loud noise was heard on the flight deck which the pilots associated with a decompression event. They checked the cabin altitude, which showed normal, but saw that the MAX DIFF (maximum differential) cabin pressure warning was displayed. The aircraft was levelled off at FL190 and ATC were informed of the situation. Due to the MAX DIFF being reached the aircraft was slowly depressurising and as a precautionary measure the pilots decided to don their oxygen masks. When the oxygen supply was activated the headbands did not inflate and no oxygen was available, which startled the pilots and delayed the completion of the QRH card. There were no standard operating procedures which covered the failure of the crew oxygen system. The pilots decided to continue without their masks and actioned the QRH, resetting the pressurisation system which functioned normally for the remainder of the flight.

As a precautionary measure, the rest of the flight was made at FL190 and they requested portable oxygen from the cabin to be made available. The cabin crew were unaware of any pressurisation issues until informed by the flight crew.

On arrival at Birmingham Airport, the pilots re-checked their masks and found that although the pressure gauge showed normal, when oxygen was demanded the pressure reduced to zero.

Aircraft information

The De Havilland Canada (DHC) Dash 8 Q400 is a high-wing regional airliner type powered by twin turboprop Pratt and Whitney Canada PW150A engines.

Crew fixed oxygen system

The flight crew fixed oxygen system consists of a single pressurised oxygen cylinder assembly in the lower nose fuselage, three full-face oxygen masks, equipped with microphones and oxygen diluting regulators, a pressure gauge and the associated connecting pipes (Figure 1). Further portable oxygen cylinders are stored in the passenger compartment for cabin crew.

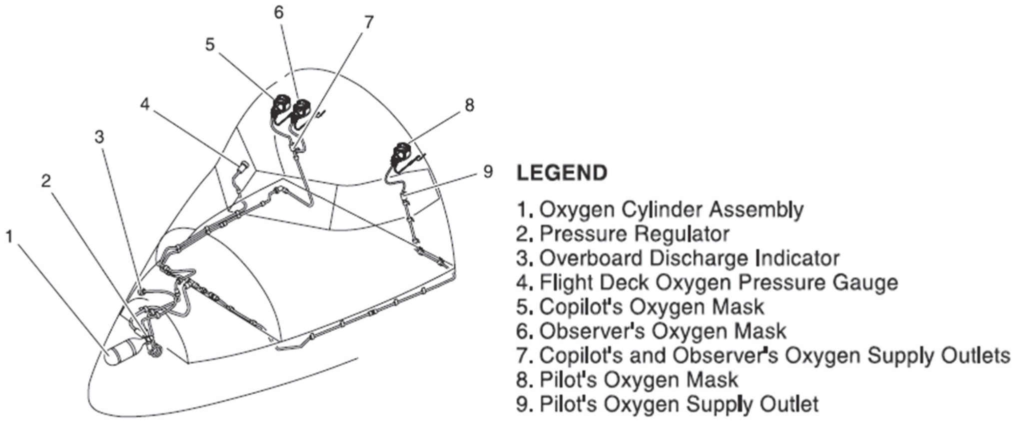

Figure 1

Crew fixed oxygen system

The oxygen cylinder assembly (Figure 2) has sufficient capacity for a descent to FL140 in 4 minutes followed by continued flight at FL140 for a further 116 minutes. The cylinder assembly consists of a composite bottle and a regulator assembly attached to the outlet (Figure 3).

Figure 2

Oxygen cylinder assembly

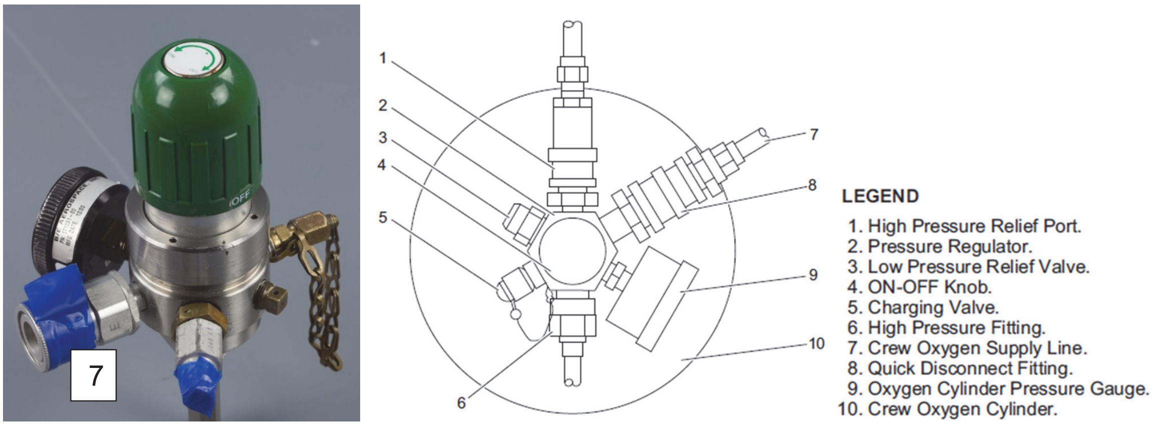

Figure 3

Oxygen cylinder regulator assembly

The operator had a contract with an equipment pool supplier to ensure that replacement cylinder assemblies were always available. The pool supplier had a contract with a maintenance and repair organisation (MRO) to replenish and re-certify depleted cylinder assemblies which could then be returned to service. The cylinder assembly from the incident flight was last certified in February 2015 and passed a flow rate test. It had subsequently been returned to the MRO on three separate occasions since then for minor rework and refill & leak checking. The operator's maintenance organisation is only authorised to attach the regulator outlet (crew oxygen supply line [7] in Figure 3) to the aircraft and are not authorised to remove or disassemble the regulator.

Aircraft examination

Following the incident on 13 December 2018, the oxygen cylinder assembly was removed from the aircraft and taken to a laboratory for further analysis. The regulator was removed from the bottle and a visual examination revealed debris blocking the crew oxygen supply line port (Figure 4).

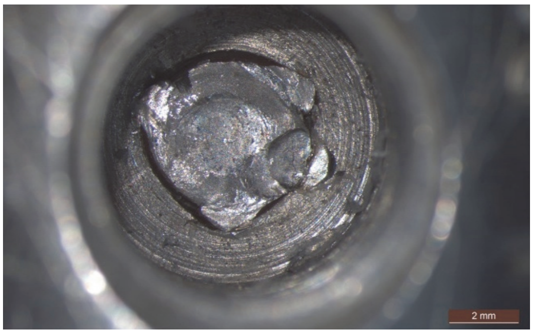

Figure 4

Debris blocking port with regulator partially disassembled

The regulator was fully dismantled, and abrasion damage was observed to the valve pin when viewed through the low-pressure relief valve port ([3] in Figure 3). The valve body was sectioned at right angles to the port and further visual examination of the debris revealed that it was threaded. Energy dispersive x-ray (EDX) analysis of the metal attached to the end of the debris confirmed that the debris had damaged the valve pin (Figure 5). EDX analysis of the debris showed it to be a low alloy steel containing chromium and molybdenum, whereas the valve pin and the regulator body are manufactured from a corrosion-resistant steel.

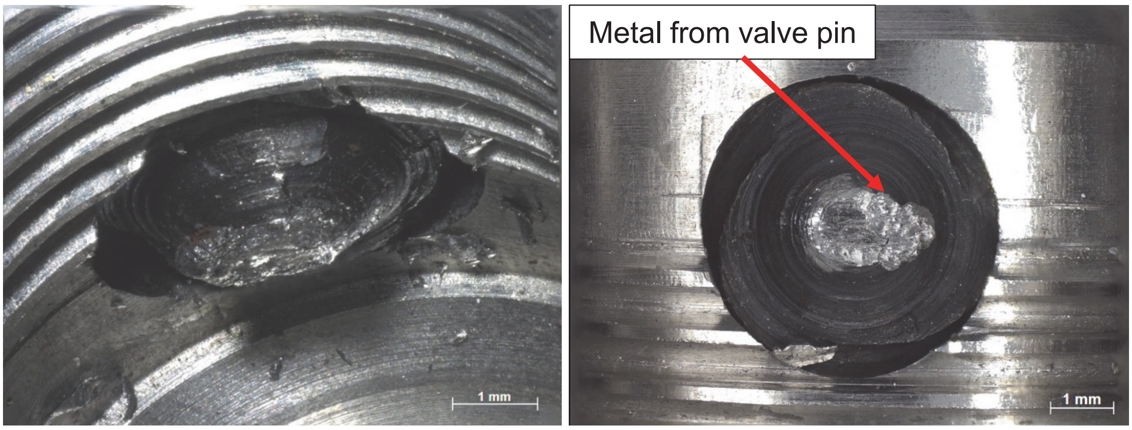

Figure 5

Debris blocking port (regulator sectioned)

Examination of the outer end of the debris using a scanning electron microscope (SEM) showed that the surface had been extensively mechanically damaged by contact with another body. Analysis of undamaged areas of the surface showed a fracture surface consistent with torsional overload in shear. An attempt was made to remove the debris using a screw extractor, however the debris was too hard to drill using a standard drill bit.

The regulator body was further sectioned along the axis of the port and revealed the debris to have a left-hand thread and that it had cut into the smooth bore section of the crew oxygen supply port (Figure 6). The debris was tapered and was approximately 6 mm in length.

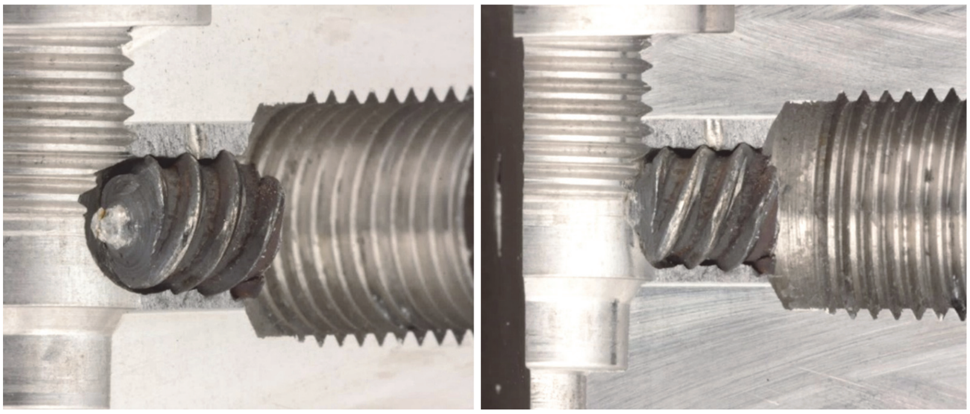

Figure 6
Debris blocking port [7] (regulator sectioned)

Analysis

The tapered geometry and left-hand thread of the debris is similar to a screw extractor tool (Figure 7) and these are typically manufactured from a steel with high hardness, which would explain the difficulty in drilling it during the examination process.

Figure 7
Example of screw extractor tool

It is possible that a screw extractor tool had been inserted into the crew oxygen supply port at some point and turned until it contacted the valve pin and cut into the wall of the port. If torque continued to be applied to the tool it would result in overload failure of the tool in shear. The subsequent damage to the fracture surface may have been the result of attempts to remove the debris. With the debris in place normal oxygen flow would have been restricted but it did not fully block the port therefore allowing, over time, for the system pressure to read normally on the flight deck gauge.

The equipment pool supplier and the MRO participated in the investigation and no evidence could be found to explain the presence of the debris. The acceptance test certificate was obtained demonstrating that oxygen flow was within limits when the cylinder assembly was last certified in February 2015. It would not have been possible to pass the test with the debris in position.

The crew oxygen system check, which is performed before the first flight each day, is to verify using the cockpit pressure gauge that the system is pressurised. Following this incident, the operator has changed the 'first flight' procedure to include a momentary flow of oxygen to ensure that the system can maintain pressure whilst supplying a flow.

Conclusion

For reasons unknown, a tapered screw extractor tool had been inserted into the flight crew oxygen supply port until it failed through torsional overload. Despite possible attempts to remove the debris from the cylinder assembly, the oxygen bottle was subsequently installed onto G-ECOC. The blockage was sufficient to restrict the flow of oxygen flow when demanded on the incident flight, however it did allow the cylinder pressure to register on the flight deck pressure gauge until the system was turned on.

No explanation could be found to explain the presence of the debris.

Safety action

The operator has taken the following safety action:

> The Operations Manual for the Flight Deck Fixed Oxygen Checks has been updated to include a one-second flow of oxygen to ensure that system pressure is maintained during the first flight check.