

SERIOUS INCIDENT

Aircraft Type and Registration:	Boeing 737-86N, SE-RHX	
No & Type of Engines:	2 SNECMA CFM 56-7B turbofan engines	
Year of Manufacture:	1999	
Date & Time (UTC):	9 May 2010 at 0034 hrs	
Location:	Vienna, Austria	
Type of Flight:	Commercial Air Transport (Passenger)	
Persons on Board:	Crew - 7	Passengers - 189
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Left wing firewire failed insulation check, ruptured flexible duct on right air conditioning pack	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	50	
Commander's Flying Experience:	11,660 hours (of which 985 were on type) Last 90 days - 93 hours Last 28 days - 9 hours	
Information Source:	AAIB Field Investigation	

Synopsis

During the departure from Sharm el Sheikh, the left WING-BODY OVERHEAT caption illuminated and the crew shut down the left air conditioning pack in accordance with the non-normal checklist. After approximately 3.5 hours, the right air conditioning pack failed and cabin pressurisation was lost. The crew performed an emergency descent and diverted to Vienna.

An engineering investigation determined that the left WING-BODY OVERHEAT indication was spurious and the failure of a hose in the right pack had caused the loss of pressurisation.

History of the flight

The aircraft departed Manchester Airport at 1411 hrs on a charter flight to Sharm el Sheikh arriving at 1928 hrs. The flight was uneventful and following a short delay during the turnaround and refuel, it departed at 2054 hrs on the return flight to Manchester. The takeoff was from Runway 04R, in good weather with a radar vectored departure and climb initially to FL320 before a further climb to the final cruising level of FL360. The aircraft commander was seated in the right seat and was carrying out line training for the captain in the left seat who was the pilot flying for the sector.

As the aircraft passed an altitude of 6,500 ft, the master caution illuminated and a left WING-BODY OVERHEAT

caption illuminated on the air conditioning control panel. The crew performed the non-normal checklist items which required them to close the isolation valve, select the pack valve to OFF and close the engine bleed valve. Having confirmed that the checklist was complete, the crew reviewed their options whilst continuing the climb and satisfied themselves that there was no likelihood of structural heat damage occurring. There were no limitations imposed by the non-normal checklist or the Minimum Equipment List for operating with a single pack once airborne. They elected to continue to Manchester following the flight planned route and levels with regular checks of the pressurisation system.

Approximately 3.5 hours into the flight, the commander noted that the cabin differential pressure had reduced to 7 psi and the cabin altitude had risen to 9,000 ft with the outflow valve indicating fully closed. The commander was the handling pilot at this time because the captain had left the flight deck on a comfort break. As the captain returned to his seat, the master caution caption illuminated and the CABIN ALTITUDE audio warning sounded. The commander checked the position of the outflow valve which indicated closed and the cabin altitude which was climbing past 9,000 ft. Both crew members donned their oxygen masks and as the commander was still the pilot flying, he initiated an emergency descent, declared a MAYDAY and deployed the passenger oxygen masks. The descent was made straight ahead using the level change and heading modes of the autopilot with speed brakes deployed. Control of the aircraft was passed to the captain whilst the commander established that the Minimum Sector Altitude (MSA) was 8,700 ft. The crew agreed to set an initial level off altitude of 12,000 ft on the Vienna QNH of 1010 mb, which the captain selected using the altitude selector on the mode control panel.

During the descent the commander made an announcement to the cabin crew using the public address system notifying them of the emergency descent. He also reviewed the cabin altitude warning and emergency descent procedures and checked the pressurisation panel to see if he could manually control the pressurisation, but this was not possible. The aircraft was levelled off at 10,000 ft and the commander and the captain removed their oxygen masks. Following a short discussion, they requested a diversion to Vienna. ATC provided radar vectors for an ILS approach to Runway 34 and descended the aircraft in order to position it.

The commander called the Senior Cabin Crew Member (SCCM) to the flight deck and having established the wellbeing of the passengers and cabin crew, explained the nature of the problem, his intentions, the time scale for arrival in Vienna and that there were no special requirements. This is commonly referred to as a NITS briefing. The SCCM had no questions and returned to brief her colleagues and prepare the cabin for landing.

The weather at Vienna at 0020 hrs was 310°/05 kt, visibility 30 km, cloud few at 4,100 ft, broken at 5,000 ft with an OAT of +12°C and a dew point of 9°, QNH of 1009 hPa. The aircraft made a straight-in-approach and normal landing on Runway 34 at Vienna before taxiing to the parking stand and closing down.

Following the incident, the aircraft was flown unpressurised by a ferry crew, without passengers, to the maintenance organisation at Lasham Airport.

Flight Recorders

The aircraft was equipped with a flight data recorder (FDR) and cockpit voice recorder (CVR) capable of recording a minimum duration of 25-hours of data

and 120 minutes of audio respectively. Recorded information relating to the left and right air conditioning system included the pack on/off status, pack flow mode and engine bleed air switch positions.

FDR data was available for the entire flight, with the CVR record commencing one hour twenty minutes prior to the activation of the cabin pressure warning and ending shortly after the aircraft had landed. The CVR record did not include the time period when the left wing body overheat warning had occurred. In addition to the incident flight, the FDR also contained records of four previous flights and the subsequent positioning flight from Vienna to Lasham Airport. A time history of the relevant parameters during the incident flight is provided in Figure 1.

The takeoff was uneventful, but as the aircraft climbed through 6,500 ft, the master caution was activated. Shortly after, the number one engine bleed air switch was selected OFF, in accordance with the QRH left wing-body overheat procedure. The QRH procedure also required that the left air conditioning pack be selected OFF. The left pack flow mode parameter subsequently changed from the low flow to the high flow/off indication, as would be expected if the pack had been selected OFF, but the left pack on/off parameter continued to indicate that the left pack was still ON; a defect was subsequently identified in the left ECS, whereby the pack falsely indicated that it was ON when set to the OFF position.

During all six flights, the right pack had continually indicated that it was in the high flow mode, but this was later confirmed as being an indication fault.

System description

The aircraft is equipped with two air conditioning packs, which are independently controlled and provide conditioned, pressurised air to the cabin. The cabin pressure is regulated by the position of the outflow valve, which allows air in the cabin to vent to atmosphere. This valve, and hence the cabin pressure, is controlled by one of two redundant Cabin Pressure Controllers when the automatic mode is used and directly by flight crew when the manual mode is used.

Each pack is provided with bleed air taken from the 5th and 9th stages of the engine compressor, with the 9th stage providing compressed air at low engine speeds and the 5th stage at high engine speeds. The High Stage Regulator (HSR) automatically opens a valve to switch between the two sources of air. The air then passes through the Pressure Regulating and Shutoff Valve (PRSOV), which controls the flow of air to the pneumatic manifold (duct). An Isolation Valve in the duct isolates the left and right side of the duct such that in normal operation the left engine provides air to the left pack and the right engine to the right pack. A Flow Control and Shutoff Valve (FSOV) allows pressurised air in the duct to enter each pack.

The air conditioning packs can operate in one of two modes, 'low' and 'high flow'. Normally the packs are selected on auto and will operate in 'low flow'. If one pack fails, or is selected OFF, then the remaining pack will automatically switch to 'high flow' provided the flaps are not extended. The flight crew can also switch each pack manually to 'high flow'.

The pneumatic manifold runs from each engine, along the wing leading edge to the air conditioning packs, which are located at the bottom of the fuselage, outside

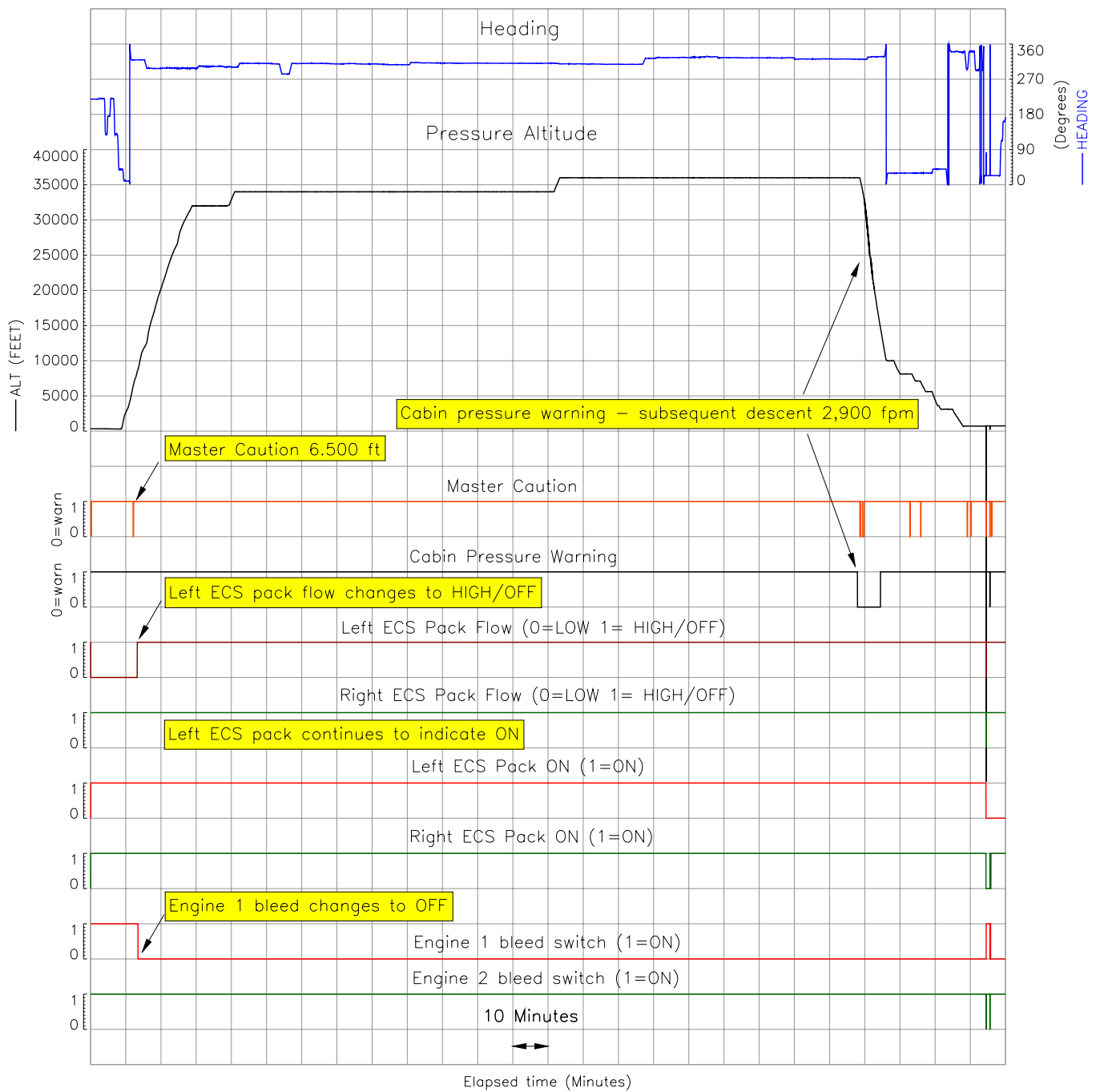


Figure 1
Salient FDR parameters (SE-RHX 9 May 2010)

the pressure hull. A firewire, routed alongside the duct, provides the flight crew with an overheat warning.

Engineering examination

Passenger and crew oxygen

The AAIB undertook an initial examination when the aircraft landed at Lasham. All the oxygen masks in the cabin had deployed and all the oxygen generators had activated. The 'Pass Oxygen' switch on the flight deck had been operated. The 'crew oxygen' contents gauge read 1,400 psi.

Fault finding

An engineering investigation undertaken by the operator identified the following faults in the cabin pressurisation system:

- BITE check on the CPC showed fault Code 30 appearing on alternate legs over the last 20 flights. The Boeing fault-finding chart attributes the possible cause to '*low pack flow, low pneumatic pressure, or excessive fuselage leakage*'.
- BITE check carried out on the Wing Body Overheat Module showed fault Code 14. Firewire M268, located along the left wing leading edge, failed the insulation check. The fault was cleared by replacing the firewire.
- An air leak was found from a split in a flexible hose (AS1505-18A0042) located on the right pack between the Air Cycle Machine and the Condenser. The fault was cleared by replacing the flexible duct.
- A confidence check carried out on each air conditioning pack (AMM 21-00-05-780-801)

found that the duct pressure was outside the published limits. With the engines at idle, the minimum duct pressure should have been between 18 and 20 psi, but was found to be 8 psi and 15 psi for the left and right engines respectively. At an engine speed of 72% N_R (33% N_2), the minimum duct pressure should have been 26 psi, but was found to be 15 psi and 24 psi. The left engine PRSOV and the HSR on both engines were replaced and the aircraft passed the confidence check.

The operator also carried out an investigation to establish why the indications on the FDR showed the right pack at 'high flow' during both the accident flight and the five previous flights, and the reason why the left pack indicated ON after the crew stated that they had turned it OFF. The investigation discovered:

- There was an open circuit in the cable (W410-0489-24) between the No 1 Flight Management Computer and the right Air Conditioning Accessory Unit, which provides the signal to indicate if the right pack is in 'high' or 'low flow'. The fault was traced to a connection in the avionics bay where a pin had come out of its connector (Pin 3, DFD1002A). The fault was cleared by replacing the pin.
- With the left pack switched OFF, and the duct still pressurized, the pack would indicate ON and the indication would only change to OFF when the right pack, or APU, was turned OFF. The fault was cleared by replacing the left FSOV.

Examination of right duct flexible hose

The flexible hose from the right pack had evidence of abrasion on the top and sides of the folds (concertinas) where the failure had occurred, (Figure 2). There was also evidence that the reinforcement metal rings had cut through the hose.

The hose had been correctly fitted to the pack and there was nothing in the vicinity that might have caused the abrasions, (Figure 3). It is suspected that the some of the abrasions might have occurred as a result of the folds on the hose rubbing against each other.

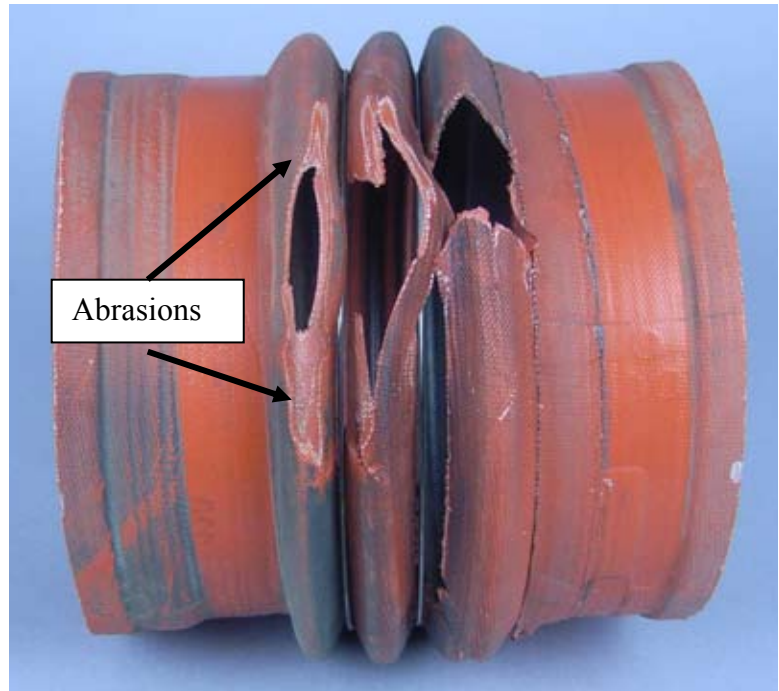


Figure 2

Failed flexible hose from right air conditioning pack



Figure 3

Flexible hose installed on the right air conditioning pack

Previous occurrences

The aircraft manufacturer advised the AAIB that there have been three reported failures of this hose since 2004. However, they were only able to inspect one of these hoses and attributed the failure to

'the reinforcement metal rings wearing away the silicone and reinforcing fibreglass at several locations in the hose.'

Analysis

The engineering investigation determined that the incident occurred as a result of two separate faults in the aircraft air conditioning system. As the aircraft reached 6,500 ft the left wing body overheat light, and the master caution,

illuminated as a result of a fault in the firewire. The crew acted in accordance with the QRH by shutting down the left air conditioning pack, which would have resulted in the right pack automatically changing to 'high' flow. The aircraft continued to climb to its cruising level and approximately 3.5 hours later, whilst at FL360, a flexible hose in the right pack failed. The leak was such that the single pack could no longer maintain the cabin pressure, which slowly dissipated. The investigation was unable to establish the initiating factor that caused the hose to fail.

Although the air conditioning pack confidence checks established that the duct pressures were below the specified minimum, the flow from the right pack was sufficient to maintain the cabin pressure for almost 3.5 hours. Therefore, the faults on the PRSOV and the HSR were not considered to be causal to this incident.

The flight crew successfully carried out the emergency descent actions in accordance with the non-normal checklist and the operator's Standard Operating Procedures resulting in an uneventful diversion and landing.