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## Pressurization emergency, Boeing 737-800 EI-CSC, October 7, 2000

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**Micro-summary:** A pressurization system operation problem on climb results in the Boeing 737 returning to origin.

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**Event Date:** 2000-10-07 at 1300 UTC

**Investigative Body:** Air Accident Investigation Unit (AAIU), Ireland

**Investigative Body's Web Site:** <http://www.aaiu.ie/>

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*AAIU Report No. 2001/0018*  
*AAIU File No. 2000/0061*  
*Date Published: 30 November 2001*

<b>Aircraft Type and Registration:</b>	Boeing 737-800, EI-CSC
<b>No. and Type of Engines:</b>	2 x CFM 56 – 7B
<b>Aircraft Serial Number:</b>	29918
<b>Year of Manufacture:</b>	1999
<b>Date and Time (UTC):</b>	7 October 2000, at 1300 hours approx
<b>Location:</b>	During climb-out from Stansted Airport, UK
<b>Type of Flight:</b>	Public Transport, (Scheduled)
<b>Persons on Board:</b>	Crew - 2 Pilots, 4 - CCM's    Passengers - 177
<b>Injuries:</b>	Crew - Nil                                  Passengers - Nil
<b>Nature of Damage:</b>	None
<b>Commanders Licence:</b>	Airline Transport Pilot's Licence (UK)
<b>Commanders Age:</b>	44 Years
<b>Commanders Flying Experience:</b>	6392 hours
<b>Information Source:</b>	Report submitted by Operator AAIU Investigation

## **SYNOPSIS**

During climb-out from Stansted Airport (EGSS), the flight crew experienced an illumination of the “Master Caution” indicating “Overhead” on the main instrument panel. A short time later, the “Master Caution” (Overhead) illuminated again, followed by an additional warning light on the rear overhead panel, indicating that the passenger oxygen masks had automatically deployed in the cabin. Having reached FL 143, the aircraft was descended to and levelled at FL 100, where further analysis by the flight crew determined that the pressurisation system had not been properly configured for flight. The aircraft returned to the airport of departure, where it landed without further incident. There were no reported injuries to passengers or aircrew.

## **NOTIFICATION**

No emergency was declared by EI-CSC during the incident on the 7 October 2000. The Stansted Air Traffic Control (ATC) Occurrence Log reported that EI-CSC was returning with a failure of the air supply system and possible bird strike.

Post analysis of the incident by the Operator determined that the perceived sequence of events, as reported by the flight crew, differed somewhat from that which was contained on the Cockpit Voice Recorder (CVR) and the Digital Flight Data Recorder (DFDR). The Operator commenced a full internal investigation into the incident and sent an Incident Report to the Irish Aviation Authority (IAA) on the 10 October 2000. Follow-up action by the IAA included recovery of both the CVR and the DFDR downloads from the Operator and notification of the incident to the AAIU on the 12 October 2000.

As the United Kingdom (UK) was the State of Occurrence, an inspector from the AAIU contacted the information room of the UK Air Accident Investigation Branch (AAIB) and was advised that the AAIB were aware of the incident and that they would be carrying out an investigation.

Subsequent follow-up between the AAIU and the AAIB determined that in fact neither the AAIB nor the UK Civil Aviation Authority (CAA) had been notified of the incident by the Operator or EGSS ATC and consequently most of the evidence such as radar, RT recordings and aircraft data recorders were no longer available. On foot of this information, the State of Occurrence (UK AAIB) agreed to delegate the investigation to the State of Registry (Ireland). On the 17 November 2000, the AAIU commenced its investigation of EI-CSC. The Chief Inspector of Accidents appointed Mr J. Whyte as Investigator-in-Charge (IIC).

## **1 FACTUAL INFORMATION**

### **1.1 History of the Flight**

#### **1.1.1 Pre-departure**

The flight crew reported for duty in EGSS at 1145 hours and arrived at the aircraft 35 minutes prior to the Scheduled Departure Time (STD) of 1240 hours. It was a fine day with light winds and a temperature of 18°C.

The Captain, who was the designated Pilot-Flying (PF), carried out the aircraft pre-flight walk-around whilst the First Officer (F/O) proceeded to the cockpit and carried out the safety checks. Some minutes later the Captain arrived on the flight deck, checked the flight log and commenced preparation of the aircraft for departure. The aircraft pushed back at 1245 hours. A total of 177 passengers (4 infants) and 6 crew members were on board for the scheduled public transport flight to Knock International Airport (EIKN). Engine start was reported as normal and while taxiing to the holding point of Runway (RWY) 23, the Senior Cabin Crew Member (SCCM) confirmed to the Captain that the cabin was secure for take-off.

### 1.1.2 Post-departure

EI-CSC was airborne at 1255 hours. Shortly after departure, the flight crew, who had just carried out their “After Take-off” checklist, were advised by Stansted Radar that their aircraft may have suffered a bird-strike on take-off. The aircraft was cleared to, and maintained, FL 70 whilst details of the possible bird-strike were established.

The SCCM was called to the flight deck and was advised by the Captain that the aircraft may have suffered a bird strike and that she should report any abnormalities in the cabin, such as a burning smell. On receipt of information from Stansted Radar that a lapwing carcass was found intact on the departure runway and as the cabin and all engine parameters were observed to be normal, the Captain decided to continue the flight. Climb clearance was received from Stansted ATC for FL 090, FL 110, FL 120 respectively and onwards from London ATC for FL 190.

**Captain’s Report.** As reported by Captain in his Captain’s Special Report to the Operator’s Duty Operations Controller, on passing FL 100 and as the normal Standard Operating Procedures (SOP’s) were being carried out, the “Master Caution” illuminated advising “Overhead.” Further analysis identified that the passenger oxygen system had deployed in the cabin. The cabin altitude aural warning horn, (which alerts the flight crew that the cabin altitude is 10,000 ft above mean sea level) did not sound on the flight deck. Having reached FL 113, the aircraft was descended with clearance from ATC down to FL 100. The SCCM was called to the flight deck to report on the status of the cabin and she confirmed that the passenger oxygen masks had in fact deployed. The SCCM was then informed by the Captain that the pressurisation system had failed and that the aircraft would be returning un-pressurised to EGSS. The Captain then made a public address (PA) announcement to the passengers informing them of the situation.

Prior to the commencement of the descent from FL 100 to EGSS, the flight crew observed that the No 1 and No 2 Engine Bleed Air Switches were not selected to “On”. When both Engine Bleed Switches were configured correctly, the pressurisation system returned to a normal condition. It was also noted by the flight crew that the circuit breaker for the cabin altitude aural warning horn was found to be in the “Open” position. The pressurised aircraft then continued its descent to EGSS, where it landed without further incident at 1338 hours.

The airport rescue and fire fighting service were put on local standby for the landing. Upon arrival at the stand at EGSS, priority was given to expedite the transfer of passengers and crew to a spare aircraft. The crew of EI-CSC and all passengers departed EGSS on EI-CSI at 1515 hours for EIKN. All crew members completed their full rostered duty, finishing at 0020 hours on the following day.

**SCCM's Report.** Information provided by the SCCM in her In-flight Special Report Form, determined that approximately 5 minutes after departure from EGSS, she was called to the flight deck and was advised by the Captain that the aircraft may have suffered a bird strike on take-off and that she should report any burning smell in the cabin.

Some minutes later, while located in the forward galley, the SCCM heard a "click" and on looking into the cabin saw that the oxygen masks had deployed. All the Cabin Crew Members (CCM's) immediately went back to their stations and put on their oxygen masks. It was noticed by the SCCM that some passengers were not putting on their oxygen masks, so she pulled down the mask of the passenger sitting behind her, as did the No 2 CCM. Only then did the other passengers respond to the action of putting on the masks.

Approximately 2 minutes later the SCCM was called to the flight deck. The Captain asked if the passenger oxygen masks had deployed and she confirmed that they had. The Captain then informed the SCCM that the pressurisation system had failed and that the aircraft would be returning un-pressurised to EGSS. He also advised the SCCM that the passengers should stay on oxygen. While the SCCM was on the flight deck, she observed that neither flight crew member was on oxygen.

On returning to the cabin the SCCM saw that all passengers were on oxygen and that they all seemed calm. The SCCM returned to her station and went on oxygen. Approximately 2 minutes later, the SCCM was called to the flight deck once again and was advised by the Captain that the aircraft was now level at FL 100 and that the passengers could remove their oxygen masks. As the SCCM returned to the cabin to brief her fellow CCM's, she heard the Captain on the PA advising the passengers of the situation.

## 1.2 Personnel Information

1.2.1	<b><u>Commander:</u></b>	Male, aged 44 years
	<i>Licence:</i>	ATPL
	<i>Periodic Check (PC):</i>	21 July 2000
	<i>Type Rating:</i>	27 July 2000
	<i>Medical Certificate:</i>	2 October 2000 (Class I)
	<i>Flying experience:</i>	Total flying: 6392 hours
		Total P1: 3300 hours
		Total P1 on type: 192 hours
		Total on Type: 192 hours
		Last 90 days: 192 hours
		Last 28 days: 75 hours
		Last 24 hours: 4 hours
	<i>Duty Time:</i>	Up to incident: 1 hour 05 min
	<i>Rest Period:</i>	Prior to incident: 12 hours 45 min

<b>1.2.2</b>	<b><u>Co-pilot:</u></b>	Male, aged 35 years
	<i>Licence:</i>	CPL
	<i>Periodic Check (PC):</i>	10 September 2000
	<i>Type Rating:</i>	10 September 2000
	<i>Medical certificate:</i>	9 June 2000 (Class 1)
	<i>Flying experience:</i>	Total flying: 1957 hours
		Total on Type: 341 hours
		Last 90 days: 245 hours
		Last 28 days: 94 hours
		Last 24 hours: 6 hours
	<i>Duty Time:</i>	Up to incident: 1 hour 05 min
	<i>Rest Period:</i>	Prior to incident: 15 hours

### **1.3 Aircraft Information**

#### **1.3.1 Leading particulars**

Registration:	EI-CSC
Manufacturer:	Boeing
Model:	737 – 8AS
Serial No:	29918
Year of Manufacture:	1999
Engines:	2 x CFM 56 – 7B
Certificate of Registration:	Valid
Certificate of Airworthiness:	Valid

#### **1.3.2 Aircraft Systems Description**

##### **1.3.2.1 Bleed Air System**

Air for the bleed air system can be supplied by the engines, the auxiliary power unit (APU), or by an external air cart/source. The APU or external cart supplies air to the bleed air duct prior to engine start. After engine start, air for the bleed air system is normally supplied by the engines. Both bleed air switches are located on the forward overhead pressurisation panel. The following systems rely on the bleed air system for operation:

- Air conditioning/pressurisation
- Wing and engine thermal anti-icing
- Engine starting
- Hydraulic reservoirs pressurisation
- Water tank pressurisation

### 1.3.2.2 Air Conditioning

Conditioned air for the cabin comes from either the aircraft air conditioning system or an external ground source. The air conditioning system provides temperature-controlled air by processing bleed air from the engines, APU, or a ground air source, in the air conditioning packs. The flow of bleed air from the main bleed air duct through each air conditioning pack is controlled by the respective pack valve. Normally the left pack uses bleed air from engine No 1 (left engine) and the right pack uses bleed air from engine No 2 (right engine). A single pack is capable of maintaining pressurisation and an acceptable temperature throughout the aircraft up to the maximum certified ceiling.

### 1.3.2.3 Pressurisation System

Cabin pressurisation is controlled during all phases of aircraft operation by the cabin pressure control system. The cabin pressure control system includes two control modes, which are available by selecting automatic AUTO/STANDBY mode or a manual (MAN) pilot-controlled mode. The system uses bleed air supplied by the engines and distributed to the air conditioning system. Pressurisation and ventilation is controlled by modulating the outflow valve and the overboard exhaust valve.

Cabin altitude is normally rate-controlled by the cabin pressure controller up to a cabin altitude of 8,000 ft at the aircraft maximum certified ceiling of 41,000 ft.

An amber “Auto Fail” light on the forward overhead pressurisation panel provides an indication to the flight crew that a failure has occurred in the automatic pressurisation control. The “Auto Fail” will come on if any of the following conditions occur:

- Loss of DC Power
- Controller fault in the operational Controller
- Excessive rate of cabin pressure change (2,000 sea level ft/min)
- High cabin altitude (above 15,800 ft)

A diagram of the forward overhead panel is presented as **Appendix A** to this report.

### 1.3.3 Technical

A technical inspection, carried out on EI-CSC after the incident, determined that the pressurisation system was fully serviceable.

A test of the cabin altitude aural warning system determined that once the circuit breaker (D18 on the P6-3 panel) was re-set to the “pushed in” position, the aural warning functioned correctly. Following a search through the maintenance records of EI-CSC, it was found that no maintenance had been carried out on the aircraft in the days prior to this incident which would necessitate the pulling out of the cabin altitude aural warning horn circuit breaker. Discussions between the aircraft manufacturer and the AAIU determined that the operation of the cabin altitude aural warning system is independent of the bleed and pack selection/operation. The only input is from the cabin altitude sensor, which is located on the ceiling of the forward electrics and electronics (EE) compartment.

In addition, a test was carried out on both the cabin altitude alert switch/system and the automatic oxygen deployment switch/system. Under simulated altitude conditions, the cabin altitude warning system was found to be within the specified limits, as the aural alert sounded at 9,350 ft and it silenced at 8,850 ft.

With regard to the activation switch for the automatic deployment of the oxygen masks, it was found that, under simulated altitude conditions, deployment occurred at approximately 12,300 ft. The designed range is between 13650 ft and 14350 ft. Discussions between the operator, the supplier of the switch and the aircraft manufacturer revealed that the aircraft manufacturer was aware of the problem of the pressure altitude switch activating at a slightly lower than expected deployment altitude, typically within 2000 ft of the expected deployment. As a result, a fix had already been put in place and this was identified on the new switch with the letter “B” at the end of the serial number, in lieu of the letter “A” which is present on the original switch.

The aircraft manufacturer confirmed to the operator, that it had no technical objection for them to continue normal operations with the currently installed (“A” switch), provided that the switch deploys at a cabin altitude equivalent to below 15,000 ft.

## **1.4 Flight Recorders**

### **1.4.1 Cockpit Voice Recorder (CVR)**

The Operator down-loaded the CVR and a copy of the recording was provided to the AAIU. The recording covers the period starting from just after take-off (approximately 2,000 ft to when the aircraft arrives back onto the stand. A number of communications between the flight crew could not be deciphered from the recording and were deemed unintelligible. The reason for this was that the ATC Channel volume was high, the cockpit area microphone volume was low and headsets were in use without intercom.

The CVR did give the general impression that both flight crew members worked and communicated in a professional matter, in particular during their analysis of the suspected bird strike, and afterwards, when it was confirmed that the cabin oxygen masks had automatically deployed. The CVR did not cover the “Before Start/Cleared for Start/After Start/ and After Take-off” checks. During the climb, checks were being requested by the PF and were being called by the PNF. It was not possible to confirm from the recording as to whether or not the flight crew had carried out the “Passing 10,000 ft” check for pressurisation.

Comments and background noise on the CVR did reveal that no cabin altitude aural warning horn sounded on the flight deck at anytime during the course of the recorded flight. In addition, on becoming aware that the cabin oxygen masks had automatically deployed the Captain called to the F/O to request immediate descent from ATC to FL 100 due pressurisation problems. The Captain also advised the F/O, that *“Theoretically at this point we should both be on oxygen..... but as we have only 1500 ft to go we will skip it”*. No emergency was declared.



## 1.4.2 Digital Flight Data Recorder (DFDR)

The Operator down-loaded the DFDR and a copy of the data was provided to the AAIU. An extract of the DFDR covering the pertinent events, from push back to landing, is presented in table form as **Appendix B** to this report.

The DFDR was considered to be in good working order as all the declared parameters were recorded. Cabin altitude and the automatic deployment of the cabin oxygen system are not recorded as a parameter on the DFDR. However, a deployment does cause a “Master Caution”, which is recorded on the DFDR (2nd Master Caution).

The DFDR readout confirms that the Engine Bleed Air Switches were not switched “On” prior to engine start-up and remained in the “Off” position until the problem was identified by the flight crew during their descent/return to EGSS.

With regard to the configuration of the air conditioning pack(s), the DFDR recorded the left pack as “Off” during the initial climb. However, the right pack was recorded as being cycled “On/Off”, on four separate occasions during the climb and included, from take-off run to 2,842 ft (“On”, 1 min 52 sec) from 3,425 ft to 6,984 ft (“On”, 1 min 20 sec) from 11,576 ft to 11,826 ft (“On”, 8 sec) and from 13,334 ft to 14,307 ft (“On”, 21 sec). Outside of these selections the right pack was recorded as “Off”. (*See Note 1.*)

### 1.4.2.1 DFDR Air Conditioning “pack” indications

Initial analysis of the cycled right pack on the DFDR gave the appearance of some flight crew involvement. However, during a debriefing session, the F/O Pilot-Not-Flying (PNF) reported to the Operator that when they commenced the descent they began to search for the cause of the problem and found the Engine Bleed Air Switches in the “Off” position. Once these switches were reconfigured the pressurisation was restored.

Discussions between AAIU and the Boeing Company regarding the recorded cycled indications of the right pack determined the following. The DFDR parameter “Right Environmental Control System (ECS) Pack On” represents the state of the right pack flow control valve (FCV). This valve is electronically commanded from the flight deck but pneumatically powered. If no bleed air is provided, spring pressure will keep the valve closed, regardless of the electronic command. As duct pressure increases, the valve will begin to open by the time duct pressure reaches 8 pounds square inch gauge (psig.) For reference, nominal operating duct pressure is 42 psig. When the FCV begins to move away from the closed position, the DFDR parameter will change from “Pack Off” to “Pack On”. The actual point at which a specific FCV begins to open can vary from unit to unit within specification limits.

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#### Note 1.

*This report uses the generic term “Pack On”. It is recognized that actual pack selection is from “Off” to “Auto” or “High”.*

Duct pressure is supplied by bleed air from the engines. The pressure is regulated by the pressure regulating and shut-off valve (PRSOV). Like the FCV, the PRSOV is electronically commanded but pneumatically powered. Engine bleed air pressure at the PRSOV is a function of engine speed, altitude, airspeed, temperature, and the use of engine thermal anti-ice. When the PRSOV is closed, it is normal for a small amount of air to leak past the PRSOV and pressurise the bleed duct up to 10 psi. If the PRSOV is commanded closed and the FCV is commanded open, it is possible for the FCV to be either closed or slightly open. The actual state of the FCV (and thus the DFDR “Pack On” parameter) depends upon the actual leakage rate past the closed PRSOV and the individual characteristics of the FCV.

In order to determine the actual leakage rate past the closed PRSOV the engine bleed pressure upstream of the PRSOV was calculated. A graph presented as **Appendix C** to this report shows engine bleed pressure and recorded FCV position at several discrete altitudes selected from the DFDR data. The graph shows that when the engine bleed pressure is above approximately 109 psig, the FCV was recorded as open. Below that pressure, the FCV was recorded as closed. Therefore, the recorded positions of the FCV are very likely the result of expected system operation with the PRSOV commanded closed and the FCV commanded open.

The above scenario presumes that the right pack switch was selected “On” throughout the climb. The close correlation between the engine bleed pressure and FCV position suggest that this assumption is correct. It is possible that the left pack switch was also selected “On”, but that the left FCV didn’t open due to variability in operating characteristics of the left and right FCV.

## **1.5 Organisational and Management**

### **1.5.1 Oxygen Requirements**

The Operator’s Operations Manual (Part A) – (Chapter 8, Section 8.8) covers operating procedures for oxygen requirements. Under Para 8.8.1, (Conditions Requiring Provision and Use), the following is stated:

*“The Commander shall ensure that the flight crew members engaged in performing duties essential to the safe operation of the aeroplane in flight use supplemental oxygen continuously whenever cabin altitude exceeds 10,000 ft for a period in excess of 30 minutes and whenever the cabin altitude exceeds 13,000 ft”.*

### **1.5.2 Reporting of Accidents and incidents**

Chapter 11 of the Operator’s Operations Manual (Part A) covers extensively the handling and reporting of Accidents and Occurrences. Throughout this chapter, no reference is made for the requirements to report accidents and incidents to the AAIU, as laid down in the Statutory Instruments (S.I.) No 205 of 1997 Air Navigation (Notification and Investigation of Accidents and Incidents).

## 1.6 Additional Information

### 1.6.1 Conduct and use of Checklists

#### 1.6.1.2 General

Chapter 8, Section 8.05 of the Operator's Operations Manual (Part A), covers the use of both normal and non-normal checklists. One of the most important factors in good flight deck management is the proper utilisation of the checklist. Reliable normal operations and repeatable success in dealing with abnormal and emergency situations are clearly attributed to the checklist system. The checklist system does, however, depend absolutely on the command being given for the checklist, the correct checklist being used and ensuring its completion.

#### 1.6.1.3 Checklists (Normal)

The Operator's Normal Checklists are based on verification that routine action and procedures have been accomplished with flight crew using a challenge and response philosophy. Where the checklist is challenge and response, the responder will verify and answer each item. Any item omitted or incomplete will be accomplished at the time of the challenge before continuing with the checklist. It is the reader's responsibility to visually check that the action taken agrees with the response. If a response is incorrect, that item must be corrected and the proper response given. Where a checklist is interrupted, the check must be put on hold and when called for again, the challenge should begin again at the last item previously called. If any untoward situation should develop or discrepancy arise while a checklist is being carried out causing distraction, then the complete checklist should be re-read. Following the completion of each normal checklist, the Pilot-Not-Flying (PNF) will call "Checklist Complete".

The Operator's Normal Checklist covers the normal checklist for all phases of flight. With specific regard to pressurisation, the following checklist actions are required to be completed by the flight crew:

**Cockpit Safety Inspection.....CIRCUIT BREAKERS.....CHECKED**  
**Before Start.....AIR COND & PRESS.....PACK(S), BLEEDS ON..... SET**  
**Cleared for Start.....AIR CONDITIONING PACKS.....OFF**  
**After Start.....AIR COND & PRESS.....PACKS ON**  
**After Take-off.....AIR COND & PRESS.....PACKS SET**

#### 1.6.2 Checklist (Non-normal)

The Operator's Quick Reference Handbook (QRH) covers, among other things a checklist for use by flight crew to cope with non-normal situations, for example, failures/warnings of particular systems. The non-normal checklists begin with steps to correct the situation or condition. It also assumes that system controls are in the normal configuration for the phase of the flight, prior to the initiation of the non-normal procedures. The non-normal checklist covers a number of Air Conditioning and Pressurisation failures, including:

Emergency Descent - with the condition that the flight crew are unable to control cabin pressure with the aircraft above 14,000 ft Mean Sea Level (MSL);  
Rapid Depressurisation - with the condition that a rapid loss of cabin pressure occurs when the aircraft altitude is above 14,000 ft MSL; and  
Auto Fail – the Auto Fail light illuminated indicates a controller fault or loss of power in the operational controller.

With regard to the use of crew oxygen regulators, the non-normal checklist for emergency descent requires that: *“Flight crew must use oxygen when the cabin altitude is above 10,000 ft MSL. To conserve oxygen, position the regulator to NORMAL”*.

**1.6.3 Standard Operating Procedures (SOP’s)**

**1.6.3.1 General**

The Operator’s SOP’s emphasise that normal checklists are considered reference checklist and therefore require that the checklist will be used on every flight and phase of operation for which a checklist exists. Normal operations dictate that the PF will initially pre-position the switches to their required selection. The checklist is then called for by the PF and the PNF reads out the checklist using the challenge and response method. Both the PF and the PNF are required to verify switch position or status. In addition, the checklist will only be called complete when all items have been accomplished and the required responses given. At that time, the pilot reading the checklist will announce, *“(Checklist name) complete”*. If any item has not been completed when challenged, the checklist must be held until that item has been accomplished.

**1.6.3.2 SOP’s for Pressurisation**

The Operator’s SOP on pressurisation states:

Climb to Cruise

*Checks of the aircraft pressurisation system are desirable every 5,000 ft.*

*Passing 10,000 ft the PF will perform a complete panel scan.*

In addition the following will be carried out from memory.

*Challenge: PNF: “Altimeters”*

*Response: PF: “Passing Flight level 100 for Flight level XXX”*

The PNF does the following actions from memory:

*Fixed landing and Turnoff lights.....OFF*  
*Recall.....CHECK*  
*Rear Belt Sign.....OFF (unless not safe to do so)*  
*Pressurisation Panel.....CHECK (switches in correct position*  
*and differential pressure and cabin altitude checked).*

## 2. ANALYSIS

### 2.1 The Incident

The DFDR readout confirms that the Engine Bleed Air Switches were not switched “On” prior to engine start-up and remained in the “Off” position until the problem was identified by the flight crew on their return to EGSS. With no engine bleed air supplied to the air conditioning packs, the aircraft was unable to pressurise and no source of warm air was available for the air conditioning system. The non-pressurisation of the aircraft thus caused the cabin altitude to rise with the aircraft altitude.

The recorded switching of the right pack was consistent with expected system operation with the engine bleeds configured “Off” and the right pack selected “on”. The investigation recognizes that a single pack is capable of maintaining pressurisation and an acceptable temperature throughout the aircraft up to the maximum certified ceiling. It is also possible that the left hand pack was on for the initial climb, but that the left FCV didn’t open nor was it recorded as open, due to variability in operating characteristics of the left and right FCV.

The normal checklist requires that the engine bleeds are switched “On”, “Before-Start”. Both the Engine Bleed Air switches and the air conditioning pack(s) should (normally) remain “On” for the entire duration of the flight. In addition, normal checklist requires flight crew action for pressurisation/air conditioning on four separate occasions, namely “Before Start/Cleared for Start/After Start/ and After Take-off”. (See Section 1.6.1.3)

It is clear that both flight crew members did not adhere to the Operator’s SOP’s with regard to completion and verification of the normal checklist. The PF failed to correctly configure the aircraft pressurisation and air conditioning for flight. The PNF failed to visually confirm that the checklist responses were in agreement with the actual switch position. Neither flight crew member confirmed that the pressurisation was functioning correctly.

No illumination of the “Auto-Fail” occurred during the aircrafts un-pressurised climb. Any one of four conditions (See Section 1.3.2.3) will generate this warning, with the more common one being the excessive rate of cabin pressure change through the controller (2000 sea level ft/min). As no “Auto-Fail” warning was recorded on the DFDR, it is considered that the average cabin rate of change did not exceed the threshold of 2000 ft/min during the un-pressurised climb. The levelling at 3000 ft and FL 7000 respectively, may have contributed to this outcome.

The Operator’s SOP’s are written procedures, which afford maximum safety and protection to the aircraft, passengers and crew. The application of SOP’s, provide flight crews with the best means of ensuring that the possibility of error is minimized, thereby reducing the likelihood of an error chain developing. General airmanship should also provide for the monitoring of all aircraft instrumentation and on board systems during flight. With regard to pressurisation it is necessary to confirm from time to time the on-going integrity of the pressurisation system, but in particular (and as required for in the SOP’s) as the aircraft climbs through FL 100.

Analysis of the CVR failed to determine whether the flight crew had carried out the “Passing 10,000 ft” check as the aircraft climbed through FL 100. Had the flight crew confirmed the status of the pressurisation system (actual cabin altitude and cabin rate of climb) at that point, it is likely that the non-pressurised state would have been detected.

Climbing through FL103, the first “Master Caution” (Overhead) illuminated. Approximately 23 seconds later, the DFDR records a cabin altitude warning, however, as the circuit breaker was in the “Open” position, the associated aural warning horn did not sound on the flight deck. A review of the aural warning system indicates that it is unlikely that the circuit breaker tripped in-flight (before the aircraft reached FL 100). It is therefore considered more likely that the circuit breaker had been manually tripped sometime prior to the preparation for this particular flight. While the investigation was unable to determine how this occurred, it does recognise that failure to identify this condition during the pre-flight cockpit safety inspection denied the flight crew of a vital safety element of the pressurisation system.

Had the circuit breaker been correctly set for flight, the flight crew would have been more clearly alerted to the pressurisation condition at the time of the first “Master Warning”, and most probably would have reacted accordingly. As it was, neither flight crew member identified the pressurisation problem on illumination of the first “Master Caution” with the result that the aircraft was allowed to continue its un-pressurised climb. The second “Master Caution” (Overhead), illuminated as the aircraft climbed through FL 127. This provided the flight crew with an additional warning light on the overhead panel, indicating that the passenger oxygen system in the cabin had automatically deployed.

When the actual deployment was confirmed to the Captain by the SCCM, the Captain advised the F/O to request immediate descent from ATC for FL 100, due pressurisation problems. The aircraft was cleared down to FL 100 by ATC where it remained level for approximately 4 minutes. While level at FL 100, further analysis by the flight crew determined that both engine bleeds had not been correctly configured for flight.

## **2.2 Operating Procedures/Use of Oxygen**

The non-normal checklist for emergency descent and rapid depressurisation provides for a condition whereby a pressurisation failure occurs above 14,000 ft MSL. While no specific non-normal checklist provides for the failure of the cabin to pressurise, the non-normal checklist does require that flight crew must use oxygen when the cabin altitude is above 10,000 ft. The Operator’s Operating Procedures for oxygen requirements (Conditions requiring provision and use) are in conflict with the non-normal checklist (See Section 1.6.2) as they specify that: *“The Commander shall ensure that the flight crew members engaged in performing duties essential to the safe operation of the aeroplane in flight use supplemental oxygen continuously whenever cabin altitude exceeds 10,000 ft for a period in excess of 30 minutes and whenever the cabin altitude exceeds 13,000 ft”*. The investigation considers that operating procedures should reflect the requirements of the non-normal checklist.

The time difference between the flight crew identifying the pressurisation problem and the aircraft descending to and levelling at FL 100 was relatively short. In addition, it is recognised that, as the Captain commenced the descent, he did acknowledge (but did not action) the requirement for the flight crew to go on oxygen. Notwithstanding this, the investigation is of the opinion that, due to the varying nature and effects of altitude/hypoxia on different individuals, it would be considered prudent for flight crews to be required to don their oxygen masks:

- i. Immediately after a cabin altitude warning system activates; and/or
- ii. When the cabin altitude exceeds 10,000 ft; and/or
- iii. When the integrity of the pressurisation system is considered suspect.

### **2.3 Situation Awareness/Cabin Environment**

Throughout the un-pressurised climb, none of the CCM's reported any problems with the cabin. In particular, when the Captain called the SCCM onto the flight deck to advise her of the suspected bird strike, she reported the cabin as normal.

When a cabin climbs un-pressurised in a non-air conditioned state, the environment inside the cabin will generally deteriorate. Poor air quality, increased noise levels, ear ache/popping, light headiness, reduction in temperature and even misting can be present in varying degrees. These prevailing conditions can be an indication to crew members, in particular the CCM's that a problem exists with the aircraft pressurisation/air conditioning system. Reporting on a significant change in the cabin environment could provide the flight crew with a vital source of information, which might assist them during their analysis of an emergency situation or a system failure.

### **2.4 Post-incident Operations**

On arrival back at EGSS after the incident, the crew of EI-CSC were re-assigned a replacement aircraft and then carried out their full rostered duty of four sectors, finishing at 0020 hours the following day, a total of 12 hours 30 minutes.

The duration of the incident was in itself relatively short and the subsequent duty carried out was within the prescribed Maximum Planned Flight Duty Period of 14 hours. However, in this particular case, the flight crew would have been acutely aware of the role that they had both played in the incident and it is quite possible that they were experiencing a number of mixed emotions (which could provide a source of distraction) as they prepared for their next flight.

As it was, the crew of EI-CSC completed their full rostered duty without further incident. Notwithstanding that, the investigation considers that greater concern should be shown towards the mental state and well being of individuals who have just been involved in an aircraft incident and that no additional flight should take place until all flight crew and CCM's have had the benefit of a full de-briefing session.

### **3 CONCLUSIONS**

#### **(a) Findings**

- 3.1** Both flight crew members were medically fit, fully rested and licensed to undertake the flight.
- 3.2** A technical inspection of the aircraft after the incident determined that the cabin altitude warning system, the pressurisation system and the air conditioning system was serviceable.
- 3.3** The cockpit safety inspection carried out by the flight crew, failed to identify the “Open” condition of the cabin altitude aural warning horn circuit breaker.
- 3.4** Failure to correctly configure the Engine Bleed Switches for flight caused the aircraft to be operated without pressurisation and air conditioning.
- 3.5** The recorded indications of the right pack was consistent with expected system operation with the engine bleeds configured “Off” and the right pack selected “On”.
- 3.6** The flight crew did not confirm the status of the pressurisation system as the aircraft passed through FL 100. This was contrary to the Operator’s SOP’s
- 3.7** The cabin altitude aural warning horn, failed to sound on the flight deck because the associated circuit breaker was in the “Open” position. This denied the flight crew of a vital source of information with regard to the actual cabin altitude and the condition of the pressurisation system.
- 3.8** Both flight crew members failed to adhere to the Operator’s SOP’s regarding the completion and verification of the normal checklist.
- 3.9** Flight crew analysis of the first “Master Caution” failed to recognize that the pressurisation system was inoperative.
- 3.10** Neither flight crew member donned their oxygen masks when the cabin altitude was above 10,000 ft. This was contrary to the Operator’s non-normal checklist.
- 3.11** The Operator’s Operating Procedures for crew oxygen requirements were found to be in conflict with the Operator’s non-normal checklist.
- 3.12** None of the CCM’s reported any abnormalities with the cabin as the aircraft continued its un-pressurised/non-air conditioned climb.
- 3.13** Following their involvement in an aircraft incident, the crew members of EI-CSC were subsequently tasked to carry out their full rostered duty of four sectors, a total duty period of 12 hours 30 minutes.



3.14 The practice of tasking crews for continued duty, following an incident of this nature, is considered by the investigation to be an un-safe practice.

3.15 The Operator's Operations Manual (Part A) makes no reference for the requirements to report accidents and incidents to the AAIU, as laid down in the Statutory Instruments (S.I.) No 205 of 1997 Air Navigation (Notification and Investigation of Accidents and Incidents).

**(b) Cause(s)**

The incident was caused by the non-adherence, by the flight crew, to the Operator's SOP's for conduct and use of checklists.

Cabin Altitude Aural Warning Circuit breaker and the Engine Bleed Air Switches were not correctly configured for flight. This caused the aircraft to be operated without pressurisation and air conditioning.

**4. SAFETY RECOMMENDATIONS**

It is recommended that:

4.1 In order to prevent the possible on-set of insidious hypoxia, the Operator should reiterate to their flight crews, the need to fully don oxygen masks, when the cabin altitude exceeds 10,000 ft and/or where the integrity of the pressurisation system is in doubt. (SR 39 of 2001)

4.2 The Operator's program for pilot recurrent training should include scenario's providing for insidious pressurisation failures, such as failure of the aircraft to pressurise and insidious incapacitation. (SR 40 of 2001)

4.3 The Operator should review their emergency safety procedures and CRM training for CCM's, in order to ensure that cabin crew can fully recognise a deteriorating cabin condition and that emphasis be placed on the importance of vigilance and reporting in all matters relating to cabin pressurisation and air conditioning to the flight crew. (SR 41 of 2001)

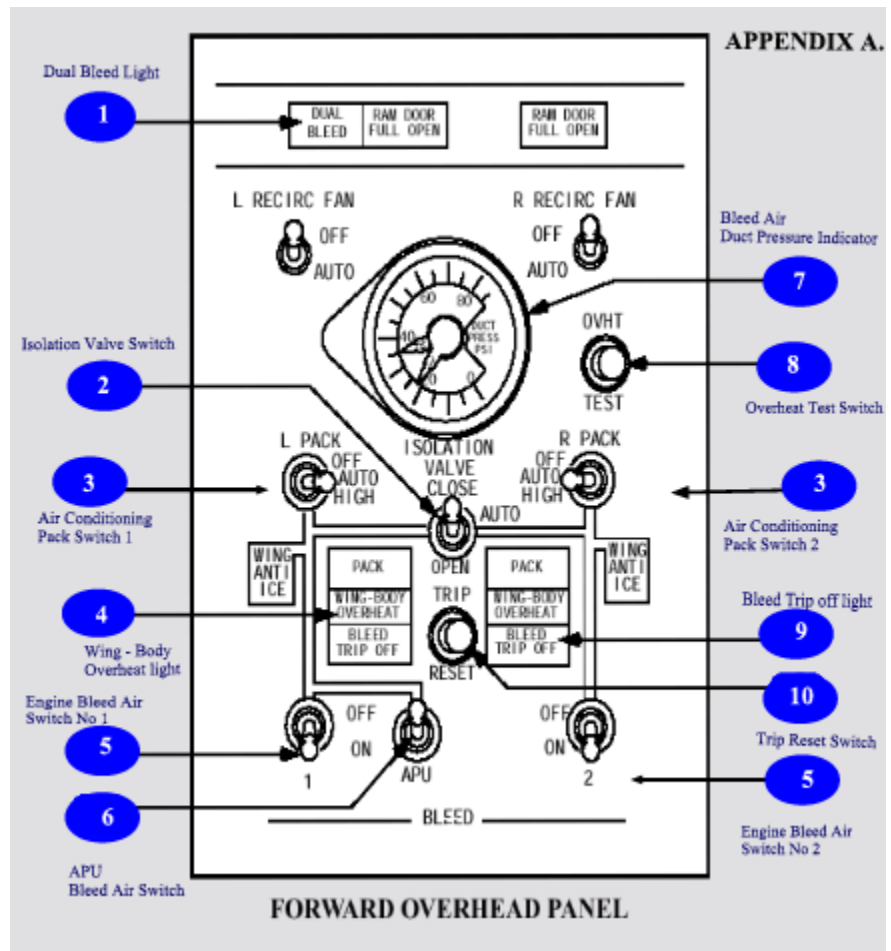
4.4 The Operator should review their policy regarding the tasking of crew members for duty, immediately following an aircraft incident. (SR 42 of 2001)

4.5 The Operator should amend their Operations Manual (Part A) in order to comply with the accident and incident notification requirements of S.I. No 205 of 1997. (SR 43 of 2001)

## Note 2

*Discussions between the aircraft manufacturer and the AAIU regarding this incident and a recent similar incident (EI-CDB - Report No. 2001/014, published 21/9/01) determined that Boeing were aware of other events around the world in which aircraft have failed to pressurise when the packs and/or engine bleed air systems have not been selected on.*

*After a review, the Boeing Company has now decided to revise the non-normal procedures to combine the Auto-Fail and Unscheduled Pressurisation Change checklist. The new checklist will contain specific steps to select engine bleed and packs to "On". The change will be incorporated at the next scheduled revision of the various manuals and should be completed within the next 6 months.*



**DFDR Readout EI-CSC De-Pressurisation out of Stansted Oct 2000**

**APPENDIX B.**

Event	Time UTC	Alt 1013 (Note.3)	Posn	Bleed L	Bleed R	ECS Pack L H/L	ECS Pack R H/L	ECS Pack L	ECS Pack R (Note 5)	Isol Valve	Master Warn	Cab Alt Warn	Remarks
Push back	1245	N/A	Grnd	Off	Off	High	High	Off	Off	Open			
R Pack selected on	1255.10	N/A	Grnd	Off	Off	High	High	Off	On*	Open			* 20 sec prior to airborne
Airborne	1255.36	N/A	Air	Off	Off	High	High	Off	On	Open			
Levelled 3000 ft R/Pack selected off	1257.02	2,842	Air	Off	Off	High	High	Off	Off*	Open			* Pack on 1 min 52 sec Level 3000ft for 24 sec Avg ROC 2000ft/min
Re-climb for FL70	1257.26	2,809	Air	Off	Off	High	High	Off	Off	Open			
R Pack selected on	1257.53	3,425	Air	Off	Off	High	High	Off	On	Open			
R Pack selected off	1259.13	6,984	Air	Off	Off	High	High	Off	Off*	Open			* Pack on 1 min 20 sec
Levelled FL70	1259.36	7,000	Air	Off	Off	High	High	Off	Off	Open			Level FL70 for 2 min10 Avg ROC 1850ft/min
Re-climb for FL190 (Note. 4)	1302.15	7,000	Air	Off	Off	High	High	Off	Off	Open			
Through FL 100	1303.36	10,000	Air	Off	Off	High	High	Off	Off	Open			
1st Master Warn	1303.43	10,307	Air	Off	Off	High	High	Off	Off	Open	On *		* Master Warn 3 sec
Cab alt warn above 10,000 ft	1304.06	10,718	Air	Off	Off	High	High	Off	Off	Open		On *	* 23 sec after Master Warn. No aural alarm
R Pack selected on	1304.50	11,516	Air	Off	Off	High	High	Off	On	Open		On	
R Pack selected off	1304.58	11,826	Air	Off	Off	High	High	Off	Off*	Open		On	* Pack on 8 sec
2nd Master Warn	1305.59	12,740	Air	Off	Off	High	High	Off	Off	Open		On	Auto Deployment of cabin masks
R Pack selected on	1306.24	13,334	Air	Off	Off	High	High	Off	On	Open		On	
	1306.26	13,427	Air	Off	Off	High	High	Off	On	Open		On	
R Pack selected off	1306.45	14,307	Air	Off	Off	High	High	Off	Off*	Open		On	* Pack on 21 sec
Max Level	1306.48	14,332	Air	Off	Off	High	High	Off	Off	Open		On	
	1307.30	12,221	Air	Off	Off	High	High	Off	Off	Open	On	On	
	1308.59	10,310	Air	Off	Off	High	High	Off	Off	Open	Off *	On	* Master Warn on 1 min 29 sec
Levelled FL100	1309.24	10,002	Air	Off	Off	High	High	Off	Off	Open		On	Level for 4 min. Cabin above 10,000 ft approx 5 min 48 sec
Bleeds/Packs On	1313.21	9998	Air	On	On	Low	Low	On	On	Closed		On	
Descent	1313.23	9998	Air	On	On	Low	Low	On	On	Closed		On	
All warnings off	1315.12	9839	Air	On	On	Low	Low	On	On	Closed	Off	Off *	From 1st Warn * 11 min 29 sec
Land on	1329.27	N/A	Grnd	On	On	Low	Low	On	On	Closed			Airborne 34 min

Note 3. DFDR readout on 1013 hPa, QNH 1019 hPa

Note 4. Aircraft cleared onward climb to FL90, FL110, FL120 and FL190.

Note 5. DFDR indication of right pack cycled "On/Off".

### 737-800 EI-CSC Engine Bleed Pressure and Right Pack FCV Indications

