Air conditioning misconfiguration resulting in cabin depressurization, Ryanair Boeing 737-204 (ADV), EI-CJE

Micro-summary: **Inadvertent turning off of the packs on this Boeing 737 results in a pressurization crisis.**

Event Date: **2002-09-28 at 0820 UTC**

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

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

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FINAL REPORT

AAIU Formal Report No: 2003/010
AAIU File No: 2002/0050
Published: 6th Aug 2003

Operator:	Ryanair
Manufacturer:	Boeing
Model:	B737-204 ADV
Nationality:	Irish
Registration:	EI-CJE
Location:	During climb out from Derry Airport.
Date/Time (UTC):	28 September, 2002, 08.20 hours.

SYNOPSIS

The scheduled passenger flight departed Derry (EGAE) at 08.10 UTC with 108 passengers and 6 crew for Stansted (EGSS). The Captain who was the pilot flying (PF), elected to perform a "Bleeds Off" take-off for which the First Officer (FO), the pilot not flying (PNF), configured the air conditioning panel for "Bleeds Off" at the pre take-off holding point.

After take-off, the PNF reconfigured the air conditioning panel while performing the after take-off checks and turned the air conditioning packs OFF, in error. The flight then continued up to Flight Level (FL) 270, during which both pilots recall hearing warning horns.

At this level the PF levelled the aircraft, passenger oxygen masks had already deployed, and, in a panel scan, he noticed that the packs were selected to OFF and immediately switched them to ON. Cabin pressurisation returned to normal, aural warnings shortly ceased and the flight continued to Stansted, where it landed without further incident. ATC were not made aware of any onboard problem with this flight.

NOTIFICATION

The incident was notified to the Air Accident Investigation Unit (AAIU) on Monday 30 September 2002 and the UK Air Accident Investigation Branch (AAIB) on 3 October 2002. While the incident occurred in UK airspace the UK AAIB agreed, after consultation with the AAIU, to delegate the investigation to the State of Registry (Ireland).

Mr J.J. Barnett, Principal Inspector of Accidents, AAIB, is the UK Accredited Representative to the investigation.

The Chief Inspector of Accidents, Mr. Kevin Humphreys appointed Mr. Frank Russell, Inspector of Accidents, as Investigator-In-Charge (IIC). Formal notification of the investigation was then transmitted to the Chief Executive Officer of the Irish Aviation Authority (IAA), the Chief Executive Officer of Ryanair, the Chief Inspector of the Air Accident Investigation Branch (AAIB), UK, and the Boeing Company.

1. FACTUAL INFORMATION

1.1 History of the Flight

FR 611 arrived in Derry at 07.24Z following an uneventful flight from Stansted (STN). The FO had been PF for this leg. The Captain would be PF for the return flight to STN, now designated FR 612. Passenger boarding was completed, paperwork signed off, the aircraft was closed up, and the cockpit door locked. Following the completion of the transit checks the Captain advised the FO that he would be carrying out an engine, "Bleeds Off" take-off, even though there was no performance requirement to do so on this occasion. The FO told the Captain that his only experience of this procedure was during his simulator training and had not carried out one on line. The Captain told the FO that there was nothing to worry about, that the demonstration would be beneficial. He then described the procedure to the FO in simplified form, the basis of the configuration and reconfiguration was the scan flow pattern of the letter C forward and reverse. The Captain promised to revisit the procedure prior to take-off. While holding for Runway 26 departure, the FO configured the system for a Bleeds Off take-off, under the Captains guidance. When this was completed the FO asked the Captain when the after take-off reconfiguration should be accomplished? The Captain responded saying that it was the first item in the "After Take-Off" checklist. This answered the FO's query. The FO then asked the Captain to go over the actions that he would carry out. As the Captain was explaining he received his ATC clearance, followed immediately by a line up clearance. The Captain then called for the entering runway checks. At this point the FO was aware that the reconfiguration briefing had been interrupted by ATC but that he was satisfied with the briefing, up to that point. His only unstated reservation at that moment was over the use of the terms "scan flow pattern of the letter C forward and reverse", whereas he was used to the terms "squeeze spread squeeze" from his relatively recent Simulator training days. Take-off clearance was received and FR 612 was airborne at 08.04Z, with a left turn to the BEL VOR and initial clearance to flight level (FL) 170.

After clean up was completed the Captain continued to hand-fly the aircraft and called for the After Take-Off checks. The FO then methodically reconfigured the three bleed valve switches in sequence, stating each action aloud to the Captain, however, the subsequent switching of the Pack switches to OFF was not stated aloud and went unnoticed by the Captain. The FO then completed the other five items in the After Take-Off checklist. Subsequently, the standard call and checks passing FL100 and FL150 failed to detect any misconfiguration or abnormalities in the aircon/pressurisation system. At 08.12Z ATC cleared FR 612 from FL170 to FL250. ATC activity at this time was low. Nothing unusual was noted by either pilot in the FL200 "altimeter" check.

At approximately FL240 the crew heard what they understood to be the configuration warning horn sounding. Checks on the aircraft take-off configuration and reference to the Quick Reference Handbook (QRH) failed to detect the cause of the warning. At 08.18Z, 612 asked ATC could he hold at FL 260? FL 270 was given, with a slight heading change. Cabin service continued normally during this time, with the No 1 CCM attending the cockpit on call from the Captain. However, the crew were engrossed in the problem and the Captain told her he would call her again shortly when the situation was sorted. Trouble shooting continued, the FO was concerned that the QRH held no rectification measures, the Captain initially thought that there might be a micro-switch problem on the thrust lever quadrant, closing the thrust levers had no effect on the warning horn, which continued to sound. Further re-assessment led the crew to check the overhead panel where the Captain noticed that the Packs were OFF. He immediately switched both Packs ON and controlled the rate of repressurisation in Standby Mode. A check on the cabin altitude showed approx 14,000 ft. The Captain instructed oxygen masks on and as the FO read out the Rapid Decompression checklist from the QRH, he had some difficulty in establishing clear communications with the Captain. The cabin altitude horn silenced shortly afterwards. The passenger oxygen masks had earlier automatically deployed. While cabin pressurisation quickly returned to normal, neither Captain or FO could recall with any degree of certainty the maximum cabin altitude reached during this incident.

The No. 1 CCM was then called to the cockpit and, on arrival, confirmed that the passenger masks had deployed in the cabin and that the cabin crew had carried out their required drill. The Captain informed her that they had experienced a technical problem, that all was now normal and that they were continuing to Stansted. A P.A. to that effect was made by the Captain. At 08.24Z, FL 612 was recleared to FL 310 and continued to STN where it landed at 09.01Z. ATC were not advised of the incident at any stage.

1.2 Injuries To Persons

No injuries were reported to the investigation.

1.3 Personnel Information:

1.3.1 (Commander)

Personal Details	Male, Age 34
Licence	AT/255632/A
Last Periodic Check	31 May 02
Medical Certificate	Class 1, 15 February 02

Flying Experience:

Total all types	6800	hours
Total all types PI	2300	hours
Total on type	4000	hours
Total on type PI	2000	hours
Last 90 days	276	hours
Last 28 days	98.7	hours
Last 24 hours	On Duty	

Duty Time:

The Captain, when queried in his debrief, made reference to the fact that his own lapse of concentration may have been due to a degree of fatigue on his part, following a poor sleeping pattern during the days leading up to the incident. He mentioned that he was expecting the results of an important medical test earlier in the week, but that these results had not arrived up to the day of the incident. His preoccupation with these results and the resultant restless nights may have added to his fatigue, he felt, with hindsight.

The Captain was operating on the 5th of five consecutive roster days for September, with three days off to follow.

1.3.2 (First Officer)

Personal Details	Male, Age 22
Licence	CPL 343263 G/A
Last Periodic Check	25 July 02
Medical Certificate	Class 1, 18 July 02

Flying Experience:

Total all types	382.25	hours
Total all types PI	UNK	hours
Total on type	148.19	hours
Total on type PI	N/A	hours
Last 90 days	148.19	hours
Last 28 days	UNK	hours
Last 24 hours	On Duty	

Duty Time:

The first officer was operating on the third of five consecutive roster days for September.

1.4 Aircraft Information

Boeing 737.200, fully serviceable and certified for CAT II operations.

1.5 Communications

Normal VHF comms made. ATC transcript shows that traffic in the relevant Control Sectors was light, up to the issuance of clearance of FR 612 to FL 310.

1.6 Aerodrome Information

Londonderry Eglington, licenced public aerodrome. Runway 26/08, is 1852 metres long.

1.7 Flight Recorders

The aircraft was fitted with a Cockpit Voice Recorder (CVR) and a Flight Data Recorder (FDR), as standard. However, as the aircraft continued in service, CVR recordings relevant to the incident were overwritten and were of no benefit to the investigation. The particular FDR installed on EI-CJE contains twelve parameters, none of which were pertinent to the investigation. In particular, the FDR does not record cabin altitude.

1.8 Organisation and Management

1.8.1 SOP's for Pressurisation

The Operator's SOP on pressurisation states:

Climb to cruise

Checks of the aircraft pressurisation system are desirable every 5000 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:

Turnoff lights……OFF
Seat belt sign……OFF (unless not safe to do so)
Recall……CHECK
Pressurisation Panel……CHECK (switches in correct position and differential pressure and cabin altitude checked).

1.8.2 Oxygen Requirements

The Operators Operations Manual (Part A), Chapter 8, Section 8.2.1 states:

"The Commander shall ensure that 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 thirty minutes and whenever the cabin altitude exceeds 13,000 ft".

1.8.3 The Operators Operations Manual (Part A), Chapter 8, Section 8.9.3 (c) states, inter alia:

"Any aircraft malfunction or system failure which significantly or potentially degrades the normal levels of safety for the continuation of the flight should be reported to ATC either on an advisory basis or because facilitation or assistance may be required"

1.8.4 Incapacitation of Crew Members

The Operators Operations Manual (Part A), Chapter 8.3.14 addresses the problem of pilot incapacitation, including recognition of causes in general terms, action to be taken by the remaining pilot and intervention criteria in various operational phases of flight, including the use of cabin crew to aid an incapacitated pilot in his seat (One such cabin crew aided incident occurred near Dublin in July 1999 and was published in AAIU Report No. 1999/0019).

However, this Section implies *individual* pilot incapacitation and does not refer to the real threat posed by *both* pilot incapacitation, caused by Hypoxia, for example.

1.9 Medical Information

Hypoxia

The amount and pressure of oxygen delivered to the tissues is determined by arterial oxygen saturation, by the total oxygen – carrying capacity, and by the rate of delivery to the tissues. Hypoxia, *defined as an insufficient supply of oxygen,* can result from any one of the above three factors.

Two serious pressurisation incidents were reported to the AAIU in late 2000 and were the subject of extensive investigations which resulted in AAIU Report Nos. 2001/014 and 2001/018, respectively. The Report 2001/014, in particular, gives detailed information on the causes and development of Hypoxia and can be found at http://www.aaiu.ie/upload/general/3504-0.pdf

In addition, the US Naval Flight Surgeon's Manual, Third Edition 1991: Chapter: Physiology of Flight, "Hypoxia", gives invaluable information on the reality and the misconceptions on the onset of Hypoxia.
http://www.vnh.org/FSmanual/01/03Hypoxia.html

1.10 Additional Information

The investigation notes that the cockpit door was locked in compliance with the Operator's Flight Crew Instruction of 14 October 2002 "Amended Cockpit and Cabin Crew locked Door Procedures". The cockpit door was unlocked on the two occasions when the No 1 CCM went to the cockpit.

Such Procedures were introduced throughout the aviation industry as a result of the events of 11 September 2001. In addition the ICAO (International Civil Aviation Organisation) Council adopted an ICAO Annex 6 amendment, on 14 March 2002, applicable to aircraft heavier than 45,500 kg. or with 60 or more passengers:

- Cockpit door satisfying intrusion and penetration resistance requirements, and lockable from either pilot's station required.
- Doors must be closed and locked at all times except for access and egress by authorised persons.
- Requirement for monitoring of entire door area outside the cockpit.

This amendment is proposed as mandatory for worldwide fleets by 1November 2003.

2. ANALYSIS

The Operators Manual states that the Pilots Standard Operating Procedures (SOP's) fall into two categories, the first of which identifies a core of mandatory actions or procedures which must always be performed because the failure to do so has a direct adverse impact on the safety of the operation. These SOP's include formal items such as Standard Callouts, altimeter setting and checking procedures, emergency drills, and the non-exceedence of limitations.

The second category of standard operating procedure has the purpose of standardising procedures to make it possible to crew any two pilots together on a non-regular basis without lowering safety standards.

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 checklist begins 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.

It is clear from the pilots debriefing into this incident that the pressurisation system controls were not in the normal configuration, at least from after take-off at 08.03Z to the resolution of the problem between 08.18Z and 08.24Z, when permission to climb to FL310 was requested. While the Captain's decision to perform a "Bleeds Off" take-off was done in the interest of the relatively inexperienced FO, (this was his first such take-off), the Cross Cockpit Gradient of experience was quite steep in this instance. It was unfortunate that the additional switching prior and after take-off led to the FO describing retrospectively, in his own words, "mentally becoming overloaded with new information which potentially had serious effects". And this, in effect, is what transpired. The FO switched the pack switches to OFF and this went unnoticed by the Captain in subsequent checks and ignored by the FO, until the aircraft levelled off at FL270. That all was not well was brought to the crews attention by the sounding of what they understood to be the configuration warning horn.

Checks on the aircraft configuration and reference to the QRH failed to detect the cause of the warning. Some confusion on the cause of the warning existed. For instance, a faulty microswitch in the thrust lever quadrant was suspected by the Captain, based on a recent similar experience on another flight. However, Boeing are clear in this matter. The cabin altitude and take-off configuration warning horns have the same intermittent aural sounds. The take-off warning horn is a function of air/ground logic and once airborne will not sound unless a failure occurs in the air/ground logic (which is what the Captain initially suspected) …….. and the cabin altitude warning sounds when the cabin altitude reaches 10,000 feet.

Also, there are other indications available to crew to help to identify the cause of the warning horn. The AUTO FAIL annunciation will occur along with the attendant MASTER CAUTION light if the cabin rate of climb reaches 1800 fpm or the cabin altitude reaches 13,875 feet. There is a checklist for both AUTO FAIL or UNSCHEDULED PRESSURE CHANGE. The check list includes the cabin altitude horn as one of the "Conditions" to execute the checklist. The first two steps of the checklist is to check that Bleeds are ON and Packs are ON.

Both the Captain and FO recall, but not with any certainty, that the configuration warning horn sounded at perhaps FL240 and this is when they went into troubleshooting mode, unfortunately beginning their analysis with a non-existent take-off configuration problem. Independent of this cockpit activity, the passengers oxygen masks in the cabin deployed automatically, the No. 1 CCM stated that, up to the time of this deployment, she did not notice anything untoward and that cabin service was normal and progressing. With the subsequent levelling off, the pilot's donned their oxygen masks "for a short time", experiencing, when they did, communication problems between themselves. The crew cannot recall the maximum cabin altitude indicated during the incident nor could they recall whether the MASTER CAUTION light or any other light illuminated. There is also no pertinent FDR data available as none of it's twelve parameters relate to warning lights.

While the initial incorrect switching by the FO at low altitude initiated the chain of events, what occurred at high altitude, the misdiagnosis of the warning horn and the time it took both pilots to solve the problem, the inability to recall the maximum cabin altitude attained, the inability of both pilots to recall any warning lights, can only lead the investigation to conclude that both pilots were experiencing the onset of hypoxia. In the event, when the problem was solved, the decision to climb to FL310 without informing ATC of the onboard problem was perhaps, *in part*, the result of the crew's same hypoxic experience.

On landing at Stansted the Captain was stood down from duty as his next scheduled flight that Saturday morning was cancelled due to an ATC industrial dispute in Italian airspace. The Operations Department only became aware of the incident on the following Monday morning through their Engineering Department, who queried the deployed passenger oxygen masks on the previous Saturday's flight.

HYPOXIA

There is a commonly encountered perception among pilots that it is possible to learn all of the early symptoms of hypoxia and then to take corrective measures once symptoms are noted! This concept is appealing because it allows all action, both preventive and corrective, to be postponed until the actual occurrence.

Unfortunately, this theory is both false and dangerous. One of the earliest effects of hypoxia is *impairment of judgement*. Therefore, even if the early symptoms are noted, a pilot may disregard them and often does, or he may take corrective action which is actually hazardous, such as disconnecting himself from his only oxygen supply.

Medical experiments have shown that at high altitudes hypoxia may cause unconsciousness as the *first* symptom. However, it is difficult to state precisely at what altitude a given individual will show symptoms. The threshold of hypoxia is generally considered to be 3,300 feet since no demonstrable physiological reaction to decreased atmospheric pressure has been reported below that height. In practice, however, a significant decrease in performance does not occur as low as that, but, as altitude increases above that level, the first symptoms of hypoxia begin to appear and a more realistic threshold would be around 5000 feet. What is of main concern is that the very nature of hypoxia itself is such that the pilot can become the poorest judge of when he or she is suffering from its insidious effects. However, operationally, commercial aircraft normally operate with cabin altitudes of 8,000 to 8,500 feet for prolonged periods.

Finally, it is worth noting that an often used adjective in describing hypoxia is insidious (Latin insidiae, *ambush*), meaning "working in a subtle or apparently harmless way, but nevertheless dangerous or deadly". Both that description and the threat from hypoxia is valid and ongoing. Crew vigilance and adherence to normal procedures is the first line of defence.

2.1 Cockpit Doors

The well documented events of 11 September 2001 in the USA have triggered off many changes in the aviation industry worldwide, not least among those is the new ICAO position on cockpit doors which, in essence, states "cockpit door and monitoring of outside cockpit area proposed as mandatory for worldwide fleet by November 1st, 2003".

Airlines have effectively applied the locked door policy for some time now, with the specifics of the ICAO proposal to be implemented by the due date.

However, with the locked door policy endeavouring to solve one specific problem, paradoxically, it may be creating another one or more problems that could impinge on aviation safety. In this regard it is reported that the acting Chairman of the US National Transport Safety Board (NTSB) Carol Carmody, said last year that the NTSB wants to determine whether new security precautions affect aircraft safety.As an example, she pointed to reinforced cockpit doors. She said that communication problems between cockpit and cabin crews have played a role in some accidents, and security improvements should not compromise crew communications, *including face to face discussions,* during emergency situations. She pointed out that access to the cockpit can be important during an emergency ……. that the changes to cockpit doors must be considered in the light of the impact they are having on the flightcrews ability to escape or be rescued following an accident.

The above reported comments are valid, up to a point. The onboard interaction between the cockpit crew and cabin crew has been part of the aviation industry culture for decades. The accessibility of cockpit and cabin crews to each other has indeed been an important and proven link in the matter of flight safety. There are references to Irish Reports in this investigation, not to mention other related International Reports, whereby the intervention of cabin crew in given situations was instrumental in preventing a possible accident occurring. However, in the subject investigation, the concern is not primarily about the medical incapacitation of <u>one</u> of the flight crew, which can be dealt with by the remaining cockpit/cabin crew, but with the possible incapacitation through hypoxia, for example, of <u>both</u> members of the cockpit crew while the cabin doors are locked. Airlines are addressing this problem by issuing instructions to crew on locked door procedures. The Operators in this investigation advises its cabin crew to call the flight deck at specified intervals via interphone, as a confidence check of the cockpit crew. This is an effective normal procedure but it does not address a non-normal situation that may have developed as a result of both pilots becoming hypoxic. As earlier described and discussed, hypoxia leads to pilot incapacitation, either by stealth or more quickly, and it's advent may not afford the luxury of two way conversations at specified intervals. So, while the locked door in this case did not affect the ultimate safety of EI-CJE the implications for flight safety in the specific scenario of flight crew hypoxia is not being addressed by a locked cockpit door policy. This is another problem.

3. CONCLUSIONS

(a) Findings

3.1.1 Both the Captain and First Officer were medically fit and licensed in accordance with IAA Requirements to undertake the flight.

3.1.2 The aircraft, a Boeing 737-200, was fully serviceable and maintained in accordance with IAA Requirements.

3.1.3 The Captain elected to conduct a Bleeds-Off take-off, and while not a performance requirement, this was done as a demonstration for the relatively inexperienced First Officer, for whom this was a first such take-off.

3.1.4 The First Officer had not performed a Bleed-Off take-off either on Line or during Line Training, his only exposure to the procedure was during his type conversion training on simulator earlier in 2002.

3.1.5 The First Officer configured the air conditioning panel for Bleeds-Off at the pre take-off holding point, as the Captain monitored his actions. The Captain's brief for the post take-off actions by the First Officer was not completed due to ATC clearances been given and acted on.

3.1.6 The different terminology used by the Operator and the Simulator training company for configuring the air conditioning panel confused the First Officer, causing him to turn the two air conditioning packs OFF, after take-off. During the First Officer's training the term "squeeze-spread-squeeze" was introduced to explain the scan and sequenced switching when configuring for a Bleeds-Off take-off. On the day of the incident, in his briefing, the Captain referred to the same procedure as "C" scan. This is the Operators normal terminology.

3.1.7 After take-off the Captain called for the after take-off checks, per SOP's. The First Officer then reconfigured the three bleed valve switches in sequence, stating each action aloud to the Captain. His switching of the pack switches to OFF was not stated aloud and went unnoticed by the Captain. The remaining items of the after take-off check list were then completed.

3.1.8 While the Captain briefed the First Officer on the ground on the Bleeds-Off take-off, he failed to monitor the procedure once airborne.

3.1.9 The incorrect positioning of the pack switches was not detected by the Captain or the First Officer during the after take-off checks nor at the subsequent altimeter and 10,000 feet checks.

3.1.10 The cabin altitude warning horn which activates at 10,000 feet, and the take-off configuration warning horn, which is a function of air/ground logic, are the same intermittent aural. In response to the warning horn, heard by both pilots, they misdiagnosed the cabin altitude warning horn as a spurious configuration warning horn.Valuable time was wasted trouble-shooting this non-existent problem, as the aircraft and cabin continued to climb.

3.1.11 While the passenger oxygen masks deployed automatically with the cabin altitude reaching at least 14,000 feet, none of the cabin crew personally noticed any signs or symptoms associated with an unpressurised cabin.They reported that all emergency equipment operated satisfactorily.

3.1.12 While the resolution of the problem was eventually effected on levelling out at FL 270 by the switching ON of the packs, continuing the climb to that level while trying to solve the problem was a poor use of Crew Resource Management (CRM), considering the steep experience gradient between the two Pilots.

3.1.13 Some six minutes were flown at FL 270.

3.1.14 The delay in isolating the problem over this period of time suggests that one or both of the crew were probably affected by hypoxia. It is known that the onset of hypoxia can adversely affect the speed and clarity of a flight crews analytical process.

3.1.15 The subsequent decision to continue the climb to FL 310 and not inform ATC of the incident, was contrary to the Operator's SOP's.

3.1.16 While the locked cockpit door, complying with ICAO standards and the Operators instructions, had no direct bearing on the outcome of this incident, the potential for a full scale accident is self evident in this type of emergency.

3.1.17 This is the fifth serious pressurisation incident reported by various Irish Operators of Boeing 737 aircraft to the AAIU since 2000.

(b) **<u>Causes</u>**

3.2.1 The initial misconfiguration of the air conditioning and pressurisation system, the non-adherence to SOP's and the failure of both pilots to monitor the pressurisation system resulted in the aircraft being operated unpressurised up to FL 270, at which level the diagnostic capability of both pilots may have been impaired by the onset of hypoxia. A contributory factor may also have been the Captain's recollected feeling of fatigue as a result of his poor sleeping pattern over the previous days.

4. SAFETY RECOMMENDATIONS

It is recommended that:

4.1 The Operator should add a new paragraph on "HYPOXIA" in the Operations Manual- Part A, Chapter 8 "Incapacitation of Crew Members", with a brief description, including the insidious threat it poses to aircrew. **(SR 20 of 2003)**

4.2 The Operator should add the Bleeds-Off take-off procedure to the pilots Line Training programme. (**SR 21 of 2003).**

4.3 The Operator should amend the QRH to include CABIN ALT warning in the Warning Systems Section. **(SR 22 of 2003)**

4.4 The Boeing Company should consider installing, in addition to the existing cabin altitude warning horn, a visual alert warning of excessive cabin altitude. **(SR 23 of 2003)**