Statens haverikommission
Swedish Accident Investigation Board

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Report RL 2010:08e

Aircraft incident to LN-RRX in airspace over Östergötland county, Sweden on 5 October 2009

Case L-17/09

SHK investigates accidents and incidents with regard to safety. The sole objective of the investigations is the prevention of similar occurrences in the future. It is not the purpose of this activity to apportion blame or liability.

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Statens haverikommission
Swedish Accident Investigation Board

2010-05-26 L-17/09

The Swedish Transport Agency
SE-601 73 NORRKÖPING, Sweden

Report RL 2010:08e

The Swedish Accident Investigation Board has investigated an incident that occurred on 5 October 2009 in airspace over Östergötland county, Sweden, to an aircraft registered as LN-RRX.

In accordance with section 14 of the Ordinance on the Investigation of Accidents (1990:717) the Agency herewith submits a report on the investigation.

Göran Rosvall Roland Karlsson

Report RL 2010:08e

L-17/09
Report finalised 2010-05-26

Aircraft; registration and type	LN-RRX, Boeing B737-600.
Class, airworthiness	Normal, valid ARC[1]
Registered owner/Operator	FGL Aircraft Ireland No. 3 Ltd/Scandinavian Airlines
Time of occurrence	5 October 2009, at 12:45 in daylight Note: All times are given in Swedish daylight saving time (UTC + 2 hours)
Place	In airspace over Östergötland county, Sweden, at flight level (FL) 410 (approx. 12 500 m above sea level)
Type of flight	Scheduled flight
Weather	Visual Meteorological Conditions, daylight
Persons on board:	
crew members	5
Passengers	83
Injuries to persons	None
Damage to the aircraft	None
Other damage	None
Commander:	
Age, licence	43 years, ATPL-A
Total flying time	7656 hours, of which 723 hours were on type
Flying hours previous 90 days	110 hours, all on type
Number of landings previous 90 days	41, all on type
Co-pilot:	
Age, licence	44 years, CPL-A
Total flying time	3841 hours, of which 1291 hours were on type
Flying hours previous 90 days	117 hours all on type
Number of landings previous 90 days	41 hours, all on type
Cabin crew members	3 persons

The Swedish Accident Investigation Board (SHK) was notified on 26 October 2009 that an aircraft of Boeing 737-600 type with registration LN-RRX had an incident at 12:45 hours on 5 October in the airspace over Östergötland County, Sweden.

The incident has been investigated by SHK represented by Göran Rosvall, Chairperson, Roland Karlsson, chief operations investigator, and Henrik Elinder, technical investigator.

The investigation was followed by Nicklas Svensson, Swedish Transport Agency.

Summary

During cruise flight at flight level 410 (approximately 12 500 m), a caution light appeared on the flight deck about a malfunction of one of the air-condition systems on the aircraft. The cabin pressure started to decrease and a rapid descent was initiated after receiving clearance to descend. During the descent the checklist items were performed, and the cabin pressure was restored. There were no injuries, nor to passengers or aircraft.

[1] ARC – Airworthiness Review Certificate

The incident was caused by a technical malfunction in the bleed air system of the right hand engine.

Recommendations

None.

1 FACTUAL INFORMATION

1.1 Sequence of events

The aircraft, a Boeing 737-600, with flight number SK 2548, was in the course of a scheduled flight from Manchester in Great Britain to Stockholm/Arlanda in Sweden.

While it was in level flight at flight level FL 410 (41,000 ft, or 12 500 m), which is the highest permitted flight altitude for this type of aircraft, a Master Caution[2] was activated and shown in front of both pilots. In front of the pilot in the right hand seat an amber text warning was also shown, and on the overhead panel a warning sign with the text “BLEED TRIP OFF” in amber colour for the right hand engine. The Master Caution was acknowledged by the pilots in accordance with the standard procedure. The warning indicated a fault in the engine air bleed system, which among other things supplies the pressure cabin with compressed air via the air conditioning system.

At the same time the cabin pressure began to fall at about 1,000 feet (approx. 300 m) per minute, and the pilots carried out the items on the checklist for Rapid Depressurization[3], where the first item prescribed that they should don their oxygen masks. After having contacted the air traffic control and received a clearance to descend to FL 110 (3 400 m) the pilots carried out the procedure for Emergency Descent[4] and began to descend.

The loss of cabin pressure at high altitude is very serious from a flight safety viewpoint, and requires immediate actions from the pilots. If the overpressure in the cabin is lost at FL 410 (12 500 m) it is only a matter of seconds before the people on board fall into unconsciousness. Unless oxygen is supplied to persons on board, the altitude must be immediately reduced so that the cabin pressure can be maintained at a level where normal human functions can be maintained.

During the descent the items on the “BLEED TRIP OFF” checklist were carried out, which caused that the air bleed system could resume its normal operation when the aircraft had descended to FL 290 (approx. 8 800 m). At its lowest the cabin pressure fell to an altitude equivalent to about 11,000 feet (approx. 3 400 m). The passenger oxygen masks did not drop down, which should not happen until the cabin pressure altitude reaches 14,000 feet (approx. 4 200 m), or higher.

According to the commander the descent was gentle and the passengers hardly noticed anything abnormal, except for the instruction to fasten their seat belts.

The flight then continued at FL 110 (approx. 3 400 m), to the destination, and a normal approach and landing took place at Stockholm/Arlanda airport.

The incident occurred in daylight in the airspace above Östergötland county, Sweden, at FL 410 (approx. 12 500 m).

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[2] Master Caution – Primary warning signal with aural warning and text on a yellow/red background
[3] Rapid Depressurization – Rapid loss of cabin pressure
[4] Emergency Descent – Repid reduction of altitude in an emergency situation

1.2 Injuries to persons

	Crew members	Passengers	Others	Total
Fatal	–	–	–	–
Serious	–	–	–	–
Minor	–	–	–	–
None	5	83	–	88
Total	5	83	–	88

1.3 Damage to the aircraft

None.

1.4 Other damage

None.

1.5 The crew

1.5.1 The commander

The commander was 43 years old at the time and had a valid ATPL-A.

Flying hours			
previous	24 hours	90 days	Total
All types	2:16	110	7656
This type	2:16	110	723

Number of landings this type previous 90 days: 41
Skill test on type carried out on 18 February 2009.
Latest OPC (Operator´s Proficiency Check) was carried out on 10 July 2009.

1.5.2 Co-pilot

The co-pilot was 44 years old at the time and had a valid CPL-A.

Flying hours			
Previous	24 hours	90 days	Total
All types	2:16	117	3841
This type	2:16	117	1291

Number of landings this type previous 90 days: 41.
Flight training on type carried out on 24 April 2001.
Latest PC (Proficiency Check) carried out on 22 February 2009.

1.5.3 Cabin crew members

3 persons.

1.5.4 The crew members' duty schedule

Both the commander and co-pilot were on their third day in the roster period and was preceded by a rest period of 18:55.

1.6 The aircraft

1.6.1 General

The aircraft	
Manufacturer	Boeing
Type	B737 -600
Serial number	28296
Year of manufacture	1999
Gross mass	Max. authorised take-off/landing mass 59,874/54,657 kg, actual 52,210 kg
Centre of mass	Within permitted limits
Total flying time	24453 hours
Number of cycles	18008
Flying time since latest inspection	2,778 hours (P1-check)

Engine		
Manufacture	CFMI	
Engine model	CFM56-7B	
Number of engines	2	
Engine	*No. 1*	
Total operating time, hrs	10,737	*No. 2*
Operating time since		17,024
overhaul	N/A	
Cycles since overhaul	N/A	
		5,896
		4,259

The aircraft had a Airworthiness Review Certificate, ARC.

1.6.2 Engine air bleed system

The engine air bleed control system, Fig. 1, in this particular type of aircraft is an older design and consists of a number of pneumatic and electrical components which to a certain extent work together in an "analogue" fashion. The system is located in the space between the engine compressor casing and the engine cowl. The engine air bleed system operates in a demanding environment, with large pressure and temperature variations, both within the system and its surroundings.

Each engine has a Bleed Air System, which among other things supplies the air conditioning system with bleed air. Air is bled from the engine compressor via two Bleed Valves located on the compressor casing at compressor stages 5 and 9. The air bleed valve at stage 9 is called the High Stage Valve (HSV).

Before bleed air is pumped into the air conditioning system it must be cooled and have its pressure regulated. The pressure is regulated by a Pressure Regulating and Shutoff Valve, which is controlled by an electro-pneumatic control unit, the Bleed Air Regulator. The Bleed Air Regulator receives its information from a number of pressure and temperature sensors in the system.

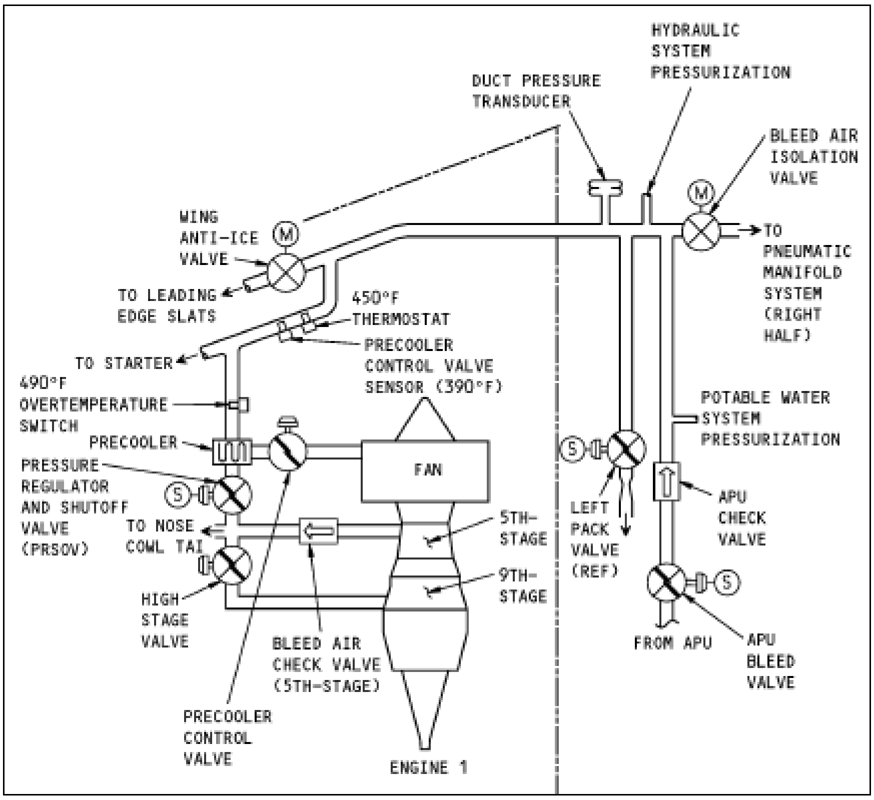

Fig. 1. Air bleed system (left engine)

The air bleed systems are operated by the pilots via a control panel located on the overhead panel roof above the windscreen, Fig. 2.

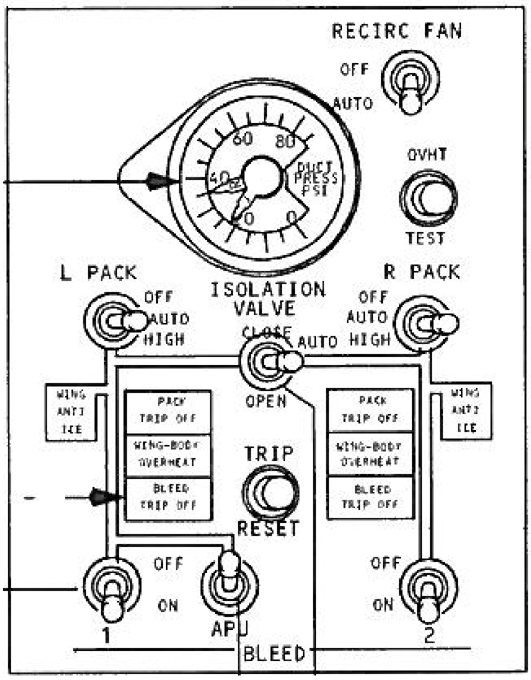

Fig. 2. Air bleed system control panel

The respective systems are equipped with sensors which activate a warning light on the control panel with the text “BLEED TRIP OFF” if the temperature or the air pressure in the system becomes too high. If this takes place the HSV closes automatically.

The components of the air bleed system, most of which are located inside the engine cowl in the respective engine nacelles, have no specified operating time limits, but may remain in operation as long as they operate normally.

1.6.3 Air bleed system – fault history

Over the years, the fleet of aircraft of this type has suffered a relatively large number of cases of faults in the air bleed system. Many times, the faults have been of an intermittent character and have therefore been difficult to troubleshoot and repair.

The aircraft manufacturer has produced special instructions to facilitate troubleshooting of the system, which have been introduced into the aircraft type's Fault Isolation Manual (FIM).

Several modifications have been made to components in the system, but according to the operator the fault rate of the system is still high.

1.6.4 Actions performed by the operator

In the interest of prevention, the operator has, on its own initiative, introduced a special periodic check, known as a Health Check, on the air bleed system (called EO-B737-360004R03/4) with the aim of detecting and repairing possible deficiencies before faults arise during operation. Evaluation of this action is not yet complete.

1.6.5 Air conditioning system

This type of aircraft is equipped with two separate air conditioning systems which supply the cabin with air for ventilation and pressurisation. The system also ensures that the cabin air has the desired temperature and humidity.

Within the air conditioning system external air and recirculated cabin air are mixed with heated air at high pressure from the aircraft engines (bleed air) and pumped into the cabin after pressure, temperature and humidity regulation. The system switches for the air conditioning packs respectively have three positions, "OFF", "AUTO" and "HIGH". According to the checklist, the switches should be set to the "AUTO" position before the flight.

The air bleed system for each engine has, according to the flight manual, the capacity to maintain an air pressure in the cabin equivalent to about 7,000 feet (approx. 2 100 m) altitude above sea level during flight at FL 410 (approx. 12 500 m), if the system is set to the HIGH mode. A cabin pressure altitude of about 7,000 feet or lower is generally regarded as being harmless and comfortable from the passengers' viewpoint.

With only one air bleed and air conditioning system in operation and the switch in the "AUTO" position, the capacity is insufficient to maintain a cabin pressure altitude of 7,000 feet at the maximum flying altitude; the pressure will drop due to air ventilation and normal leakage from the pressure cabin.

The checklist for BLEED TRIP OFF advises that a restart of the air conditioning system should be tried first, by pressing the TRIP RESET switch. If this action fails, the checklist states that the faulty air conditioning system, on the side where the BLEED TRIP OFF warning is shown, should be switched off. This action also causes the operating air conditioning system to automatically switch to the "HIGH" mode. According to the flight manual this would enable the cabin pressure to be maintained, even at the maximum permitted flying altitude for the aircraft, providing the operating air conditioning system had switched over to the "HIGH" mode.

1.6.6 Warning system in the cockpit

The most important systems and functions in the aircraft, in terms of flight safety, are monitored by a warning system. In the case of a fault in any of these the warning system is activated, providing a master warning in the form of a visible and aural signal to be seen and heard by the pilots, and also a brief text message on an annunciator panel placed next to the master warning, see Fig. 3. The annunciator panel is located on the instrument panel glareshield, see Fig. 4.

The master warning can be provided at two different levels, which have different priorities. Either a Master Warning[5] which has a red background, or a Master Caution shown on an amber background, see Fig. 3. The red warning requires immediate action by the pilots, whilst the amber warning requires a response as soon as possible. A Master Warning thus has a higher priority than a Master Caution. The Master and Caution warnings are activated by the faulty system.

The text on the annunciator panel shows which system has activated the warning. The respective pilots' annunciation panels monitor different systems, and a particular fault will only be shown on one of the panels, in front of either the left or right pilot. The pilots must acknowledge the warning message by pressing on the annunciator button, which is spring loaded and can move a few millimetres inwards from its neutral position. This extinguishes the warning text, which can however be restored by pressing once more on the button. Acknowledgement of a warning reactivates the warning system, so that any new faulty functions can be shown.

In the case of certain faults a sign on the operating panel for the system with the fault lights up.

Fig. 3. Warning and annunciator panel on the glareshield in front of the left seat.

When a warning appears it is normal procedure for one of the pilots to call out "Master Warning", or "Master Caution", which must be confirmed by the other pilot, after which the warning is acknowledged by pressing the button on the annunciator panel. After this, the actions are taken in accordance with the checklist for the faulty system.

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[5] Master Warning – Primary warning signal with sound and text on a red background

Fig. 4. Instrument panel in the Boeing 737-600.

1.6.7 Actions in the case of a "BLEED TRIP OFF" warning

The checklist for "BLEED TRIP OFF" prescribes that among other things the switch called "RESET" should be operated. This may cause the system to return to normal operation, which took place in this particular case. The checklist also states that if the system cannot be restored to operation by means of "RESET", the switch for the air conditioning system on the faulty side should be set to "OFF". In the subtext for this action it states that this also leads to the air conditioning system on the operational side automatically switching over to "HIGH".

1.6.8 Actions in the case of loss of cabin pressure

In the case of a possible fall in cabin pressure at high altitude, the altitude must immediately be reduced. At the same time the pilots must put on their oxygen masks and ensure that they can leave the altitude without risk of collision with other aircraft at lower levels.

In the Rapid Decompression and Emergency Descent Checklist are instructions for how such a manoeuvre should be carried out. The most important actions should be performed by the pilots from memory ("by heart" items) and checked against the checklist. Resetting of the air conditioning switches is not included in these checklists.

If the cabin pressure falls to an equivalent altitude of 10,000 feet (approx. 3 000 m) or less, a warning light is lit on the instrument panel in front of the pilots and an aural warning sounds intermittently. If the cabin pressure falls to an equivalent altitude of 14,000 feet (approx. 4,300 m) or lower, oxygen masks for the passengers are automatically released and a caution text is shown on the instrument panel in cock-pit.

1.7 Meteorological information

Visual Meteorological Conditions, daylight

1.8 Aids to navigation

Not applicable.

1.9 Radio communications

When the pressure fell the pilots contacted the air traffic control and requested clearance to a lower altitude. The aircraft was given immediate clearance to FL 110 (approx. 3 400 m).

1.10 Aerodrome information

Not applicable.

1.11 Flight recorders and voice recorders

1.11.1 Flight Data Recorders (FDR, QAR, GPS)

The recordings were retrieved.

1.11.2 Cockpit Voice Recorders (CVR)

This incident was made known to SHK three weeks after the date it occurred. The recorded audio was not recovered, as the CVR only contains the latest two hours of audio recording.

1.12 Incident site

1.12.1 Incident site

In the airspace over Östergötland county, Sweden, at FL 410 (approx. 12 500 m).

1.12.2 Aircraft wreckage

Not applicable.

1.13 Medical information

Nothing was discovered to indicate that the psychological or physical condition of the pilots was degraded before or during the flight.

1.14 Fire

There was no fire.

1.15 Survival aspects

Not applicable.

1.16 Tests and research

1.16.1 Previous distrurbances in the right engine air bleed system

Four days and seven flights before this particular incident this aircraft was affected by a similar type of disturbance in the air bleed system from the right engine. After the system had been restarted while in the air it operated normally for the rest of the flight.

After landing, the system underwent troubleshooting in accordance with the FIM without any fault being found. The aircraft was then taken back into service for a maximum of 10 days in accordance with the MEL-Cat. C[6]. The purpose was to keep the system under observation.

Two days before this particular incident, the system underwent troubleshooting in accordance with the "Health Check" without any fault being found.

1.16.2 Troubleshooting of the right side air bleed system

After the incident the engine air bleed system was once again inspected in accordance with the "Health Check" whereupon it was found that the valve flap in the HSV for the right engine was not operating properly. When this unit was changed, the system operated without remarks and the aircraft was returned to service without any limitations.

On inspecting the removed HSV in a specialist workshop, it could be verified that as a result of jammed piston rings the unit would leak in its closed position.

1.17 Organisational and management information

Not applicable.

1.18 Other

1.18.1 Rescue services

Not applicable.

1.18.2 Equal opportunities aspects

Not applicable.

1.18.3 Environmental aspects

None.

[6] MEL-Cat. C – Minimum Equipment List – Category C – List of equipment that may be unserviceable in certain conditions and for a certain length of time. In the case of Cat. C a maximum of 10 days applies.

2 ANALYSIS

2.1 The flight

In the case of this incident the cabin pressure began to fall at about the same time as the pilots received a “BLEED TRIP OFF” warning. When the pilots observed the decreasing pressure in the cabin, the situation went from the “Caution” level to the “Emergency” level and the actions for the BLEED TRIP OFF warning were given lower priority relative to the emergency measures. The pilots acted quickly in accordance with practised procedures by immediately putting on their oxygen masks and starting to descend in accordance with the Rapid Decompression and Emergency Descent Checklists.

It turned out however that the cabin pressure was decreasing relatively slow, leaving the pilots time to request and obtain clearance to a lower flight level before they started to descend. There was therefore no need to declare an emergency.

During the descent, the pilots returned to the actions in accordance with the “BLEED TRIP OFF” checklist, which aims primarily to restoring the system with the RESET function. These actions enabled normal operation of the system to be maintained before the cabin pressure fell to such a low level that the passenger oxygen masks were released.

It is important to point out that falling cabin pressure at high altitude is always very serious, and from the flight deck crew’s viewpoint it must be assumed that even an initially slow event can quickly develop into a critical loss of pressure.

2.2 Faulty operation of the air bleed system

It appears that both the disturbance suffered by the air bleed system several days before this particular incident and the incident itself were caused by a jammed flap in the HSV. After this valve had been changed the system worked without remarks and a component fault was verified after the change.

Leakage through the valve probably resulted in an excessive flow of hot bleed air from the engine entering the system, which thus overheated and was automatically switched off. It is not unusual for this type of fault to be of an intermittent nature, which can explain why the system operated normally in between the complaints. The components are subjected to harsh internal and external environments in the form of such stresses as vibration and large temperature variations, which could explain the disturbances.

The frequency of this type of fault has still not reduced to an acceptable level, and SHK understands that the affected parties are still working towards this goal.

Since the consequences of problems in the air bleed system usually only cause certain operational difficulties, which normally do not seriously affect aviation safety, and improvement work is ongoing, SHK sees no reason to issue any recommendation in this respect.

3 CONCLUSIONS

3.1 Findings

a) The pilots were qualified to perform the flight.
b) The aircraft had a valid ARC
c) The cabin pressure fell while in flight at cruising altitude.
d) The pilots took actions in accordance with the emergency checklists.
e) The loss of pressure was caused by a disturbance in the air conditioning system.
f) The disturbance was caused by a technical fault in the right engine air bleed system.
g) After reducing altitude the air conditioning system could be reset to its normal operational state.
h) The frequency of complaints to the engine air bleed systems is high, which has been noted by both the operator and the aircraft manufacturer.

3.2 Causes of the incident

The incident was caused by a technical fault in the right engine air bleed system.

4 RECOMMENDATIONS

None.