Statens haverikommission
Swedish Accident Investigation Authority

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Incident with aircraft LN-RRR in the airspace near Kristianstad, Skåne County, Sweden on 20 October 2010

Case L-141/10

2012-02-27

Translated by Järva Tolk from the original Swedish at the request of the Swedish Accident Investigation Board.

In case of discrepancies between the English and the Swedish texts, the Swedish text is to be considered the authoritative version.

The report is also available on our Web site: www.havkom.se

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Statens haverikommission
Swedish Accident Investigation Authority

Swedish Transport Agency
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The Swedish Accident Investigation Authority (Statens haverikommission, SHK) has investigated an aircraft incident that occurred on 20 October 2010 in the airspace north of Malmö, Skåne County, Sweden involving an aircraft with the registration LN-RRR.

SHK hereby submits under the Regulation (EU) No. 996/2010 on the investigation and prevention of accidents and incidents in civil aviation, a report on the investigation.

On behalf of the SHK investigation team

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General observations

The Swedish Accident Investigation Authority (Statens haverikommission – SHK) is an independent government authority with the task of investigating accidents and incidents with the aim of improving safety. SHK accident investigations are intended to clarify, as far as possible, the sequence and causes, as well as any damages and other consequences, of such events. The results of an investigation shall provide the basis for decisions aiming at preventing similar events from occurring again, or limiting the effects of such an event, as well as for an assessment of the operations performed by the emergency services and, when appropriate, for improvements to these emergency services.

SHK accident investigations thus aim at answering three questions: *What happened? Why did it happen? How can a similar event be avoided in the future?*

SHK does not have any supervisory role and its investigations do not deal with issues of guilt, blame or liability for damages. Accidents and incidents are, therefore, neither investigated nor described in the report from any such perspectives. Issues of that kind may on the other hand be dealt with by judicial authorities or, for example, by insurance companies. The task of SHK also does not cover how persons affected by an accident or incident have been cared for by hospital services, once an emergency operation has been concluded. Measures in support of such individuals by the social services, for example in the form of post crisis management, also are not the subject of the investigation.

Investigations of aviation incidents are governed mainly by Regulation (EU) No 996/2010 on the investigation and prevention of accidents and incidents in civil aviation. The investigation is carried out in accordance with Annex 13 of the Chicago Convention.

The investigation

On 20 October 2010 SHK was informed that an incident involving one aircraft with the registration LN-RRR had occurred in the airspace near Kristianstad, Skåne County, on the same day at 14.25.

The incident has been examined by an SHK investigation team, consisting of Ms Carin Hellner as Chairperson until 31 January 2012, thereafter Mr Jonas Bäckstrand, Mr Stefan Christensen as Investigator in Charge until 15 August 2011, thereafter Mr Nicolas Seger, and Mr Staffan Jönsson as Technical Investigator (aviation).

The investigation team of SHK was assisted by Mr Inge Steven Arnesen as accredited representative of AIBN.

The work of the investigation team has been followed by Mr Nils Björner of the Swedish Transport Agency.

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Aircraft: registration, model	LN-RRR, Boeing 737-600
Class/Airworthiness	Normal, airworthiness certificate with current airworthiness review certificate (ARC)
Operator	SAS Structure Skand KB/SAS (SK)
Time of incident	20/10/2010 at 14.25 in daylight Note: All times refer to Swedish summer time (UTC+ 2 hours)
Place	Near Kristianstad, Skåne County, Sweden (pos 56.00N 13.50E; 6,700 m above sea level)
Type of flight	Scheduled flight
Weather	According to the Swedish Meteorological and Hydrological Institute (SMHI) analysis: light winds, good visibility, no clouds over 6000 metres
Persons on board:	
Crew members	5
Passengers	69
Injuries to persons	None
Damage to aircraft	None
Other damage	None
Commander:	
Age, licence	45, Airline Transport Pilot License (Airplane)
Co-pilot:	
Age, licence	44, Commercial Pilot License (Airplane)

History of the flight

The aircraft with the registration LN-RRR was performing a scheduled flight from Malmö/Sturup airport to Stockholm/Arlanda. The aircraft had been released for the flight with passengers in accordance with the minimum equipment list, MEL. This meant that only one of the two air conditioning systems were in use and that the flight altitude was limited to 25,000 feet equivalent to 7,600 metres.

During the climb to flight level 220, corresponding to 6,700 meters altitude, the warning for cabin altitude was activated. The pilots carried out the measures under the checklists for cabin altitude warning and emergency descent, which includes the use of oxygen masks. The flight then continued to its destination at 3,300 metres altitude, followed by a normal approach and landing at Stockholm/Arlanda airport. After landing, the commander held a debriefing with the crew and passengers.

The engines' air bleed system

The control system in the engines' air bleed system (see fig. 1) consists of a number of pneumatic and electrical components, which are controlled by analogue input signals.

Each engine has a Bleed Air System which provides the cabin with the correct pressure and the air conditioning system with air (bleed air). Air is taken from the engines' compressors via two bleed valves located on the compressor housing at compressor stages 5 and 9. The air bleed valve at stage 9 is called the High Stage Valve (HSV).

Before bleed air is ducted into the air conditioning system, it must be cooled and the pressure regulated. Pressure regulation takes place through a Pressure Regulating Shutoff Valve (PRSOV) which is controlled by a pneumatic/electrical control unit, referred to as the Bleed Air Regulator. The Bleed Air Regulator receives its information from a number of pressure and temperature sensors in the system.

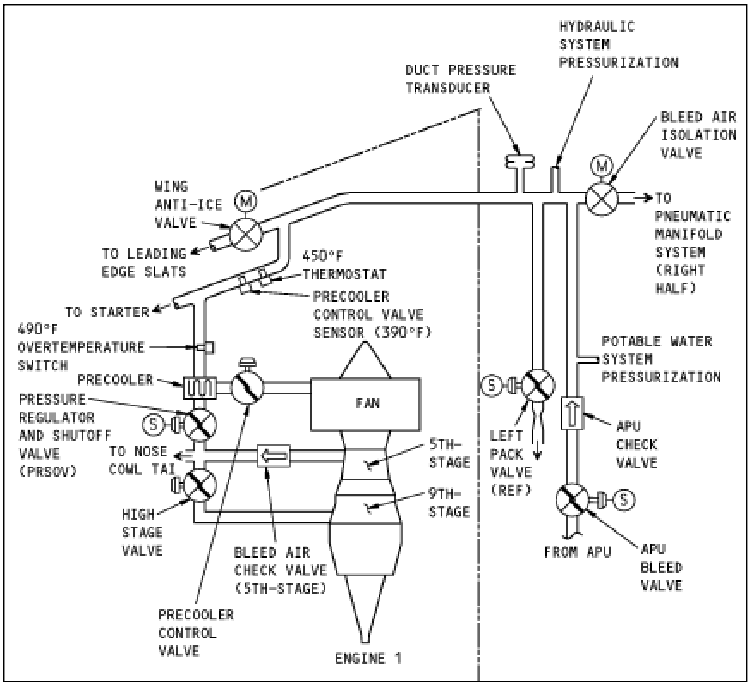

Fig. 1. Air bleed system (left engine)

The air bleed systems are operated by the pilots via an overhead control panel (see fig. 2).

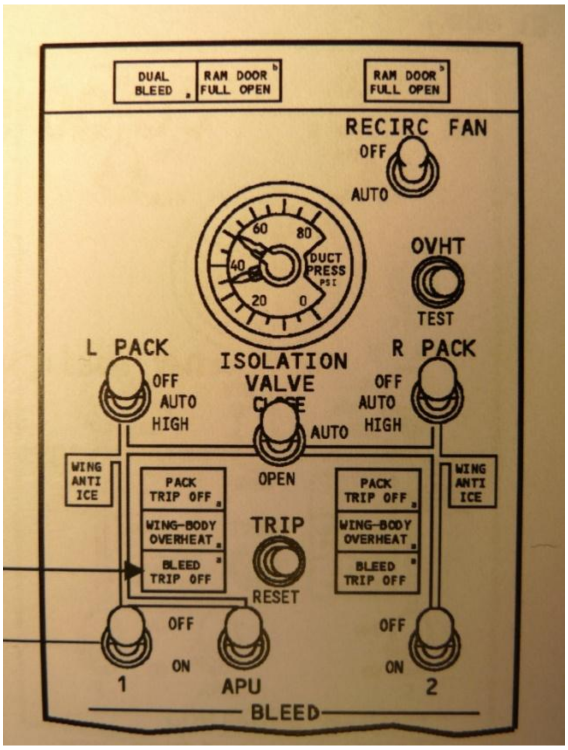

Fig. 2. Overhead control panel for air bleed systems, Bleed module

The components included in the air bleed system, most of which are located inside the engine cowlings in each engine housing, have no fixed lifespan limits, but may be in operation as long as they operate normally.

Air bleed system - fault history

The fleet of this particular aircraft model has had a relatively high number of faults in the air bleed system over the years. These errors have often been of an intermittent nature and have therefore been difficult to diagnose and rectify.

The type-certificate holder and the OEM[1] (Honeywell) of the air bleed system has produced specific instructions to help troubleshoot the system, which have been included in the aircraft type's Fault Isolation Manual (FIM).

Several modifications have been introduced to components in the system, but according to the operator the fault frequency (MTBF[2]) of components in the system remains high.

It should be noted that according to the MSG-3[3] analysis in which fault frequency in the air bleed system is evaluated and the emergency measure required is an emergency descent, this is not classified as safety related for this model of aircraft.

The operator's actions

For preventive purposes the operator, on its own initiative, has introduced a specific repetitive check to detect and correct any faults before these lead to a disruption in operation. An evaluation of those activities has shown that the updates of fault-sensitive components as recommended by the manufacturer of original equipment has not increased the average time between faults.

At the end of 2011 the operator introduced an updated repetitive check of the air bleed system, which has less than a 2-year frequency, to ensure that every part of the system is able to withstand the prescribed pressure. The test is performed to verify that a system can produce the cabin altitudes as required when the aircraft is approved for operation under MEL 21:01.

Air conditioning system

The aircraft model is equipped with two separate air conditioning systems, one for each engine, that provide the cabin with air for ventilation and pressure. The systems also govern the cabin air temperature.

In the air conditioning systems, external air and recirculated cabin air are mixed with heated air under high pressure from the aircraft's engines (bleed air) and then ducted into the cabin after regulation of pressure and temperature. The switch for each air conditioning system has three positions: "OFF", "AUTO" and "HIGH". According to the checklist, the switches shall be set to the "AUTO" mode before the flight.

Each engine’s air bleed system, according to the flight manual, has the capacity to maintain air pressure in the cabin equivalent to approximately 7,000 feet

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[1] OEM - Original Equipment Manufacturer
[2] MTBF - Mean Time Between Failure
[3] MSG-3 – Maintenance Steering Group 3

(approximately 2,100 m) altitude when flying at FL 410 (approx. 12,500 m), if the system is set in the HIGH mode. A cabin height of about 7,000 feet or below is generally considered to be comfortable from a passenger's point of view.

With only one air bleed and air conditioning system in operation and the switch in the "AUTO" mode, there is not sufficient capacity to maintain a cabin altitude of 7,000 feet at the maximum flight level since the pressure decreases due to air circulation and normal leakage from the pressure cabin.

Warning systems in the cockpit

The most important systems and functions in an aircraft from the flight safety point of view are monitored by a warning system. A malfunction in any of these systems activates a main warning in the form of a light and sound signal in front of the pilots, as well as a short text message on an annunciator panel next to the master warning display (see fig. 3) The annunciator panel is located on the instrument panel's glare shield (see fig. 4).

The main warning can be given at two different levels, with different priorities: either a Master Warning[4] that has a red background, or a Master Caution[5] that appears with an amber background (see fig. 3). A red warning requires immediate action by the pilots, while the amber warning should be taken care of as soon as possible. A Master Warning has higher priority than a Master Caution. The main warning is activated by a warning in the faulty system.

The text on the annunciator panel shows which system activated the warning. Each pilot's information panel monitors different systems and certain faults only appear on one of the panels, either in front of the left or the right pilot. Pilots must acknowledge warning messages by pressing the panel, which is spring-loaded and can move a few millimeters inward from its neutral position. The warning text is then switched off, but may be recalled by pressing on the screen again. The acknowledgement of a warning reactivates the warning system, so that any new error functions can be displayed.

For certain faults an illuminated sign also lights up by the control panel for the system with the fault.

Fig. 3. Warning and annunciator panel on the instrument panel in front of the left pilot.

When a warning occurs, the normal procedure is that one of the pilots calls out "Master Warning", or "Master Caution", which must be confirmed by the other pilot, after which the warning will be acknowledged by pressing on the information panel. Actions are then carried out according to the checklist for the faulty system.

[4] Master Warning – Primary warning signal with sound and text on a red background
[5] Master Caution – Secondary warning signal with sound and text on an orange background

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

Measures for pressure drop in the cabin

In the event of a pressure drop in the cabin at high altitude, the flight altitude must be immediately reduced. At the same time, the crew put on their oxygen masks and ensure that flight altitude can be decreased without a collision risk occurring with other aircraft at a lower altitude. Air traffic control then clears the aircraft to a lower altitude.

There is a description of how such manoeuvres are to be carried out in the Rapid Decompression and Emergency Descent Checklist. The most important measures are to be performed by the pilots from memory (by heart items) and checked against the checklist. Resetting the switch for the air conditioning systems is not included in the by heart items.

If the cabin pressure drops to an altitude equivalent to 10,000 feet (approximately 3,000 m), a warning sign is lit up on the instrument panel in front of the pilots and an intermittent horn sounds. Should the cabin pressure fall lower than that corresponding to an altitude of 14,000 feet (4,300 m), oxygen masks are automatically released to the passengers in the cabin and a warning text for this is displayed on the instrument panel in the cockpit.

Troubleshooting

During the physical inspection of the components the technicians who began examining the aircraft found that the High Stage Valve was in a half-open position, although it should have been closed. It was also noted that the PRSOV, which should have been closed, was stiff in its movement. Both of these units were replaced. For identification of the units, see fig. 1.

After the functional check (engine bleed air health check), it was found that the bleed air regulator was not functioning as intended and the regulator was replaced.

Additional checks were made on the bleed module (overhead panel) and it was found that the right switch's system (2) indicated that it was closed, although the valve was open (see fig. 2), and this unit was also replaced.

At the same time oxygen masks were replaced as well as the oxygen generators in the cabin and the pilots' oxygen equipment.

Independently of the above, the right air-conditioning unit shut-off valve was later also replaced since it indicated that it was open irrespective of the position of the valve.

Fault results of tested components

The HSV, PRSOV and Bleed module have been to a workshop for examination and the fault results were verified.

Conclusion

The crew made a correct assessment of the conditions of the flight at the planning stage. In the stage of the flight when the climb had to be interrupted, they followed the company's established procedures for Rapid Decompression and Emergency Descent with the aid of checklists. The altitude could be reduced without any disruptions or time delay and it was stabilized at 3,300 m. The oxygen masks in the cabin were released in accordance with established procedure. After landing at Arlanda the commander held a debriefing with the crew and passengers. No report of discomfort to passengers was presented.

The type-certificate holder, Boeing, has implemented a number of controlled introductions of improved components since this aircraft model was introduced at the end of the nineties, but the result of this work has not extended operating time before faults occur.

The operator's maintenance actions after the incident have been changed to ensure that in the event of a failure of one air conditioning system, the second system has a verified capacity so that cabin pressure can be maintained when flying at 7,600 metres.

Statement

The incident was caused by faults in several components of the only air-conditioning pack in use.

Recommendations

None.