Statens haverikommission
Swedish Accident Investigation Board

ISSN 1400-5719

Report RL 2010:12e

Aircraft incidents to SE-DZB in airspace near Malmö/Sturup airport, Skåne County, on 9 November 2008

Case L-27/08

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.

This report is also available on our web site: www.havkom.se

Statens haverikommission (SHK) Swedish Accident Investigation Board

Postal address	Visiting address	Telephone	Fax	E-mail	Internet
P.O. Box 12538	Teknologgatan 8 C	+46(0)8-50886200	+46(0)8-50886290	info@havkom.se	www.havkom.se
SE-102 29 Stockholm	Stockholm				

Statens haverikommission
Swedish Accident Investigation Board

2010-09-02 L-27/08

The Swedish Transport Agency
SE-601 73 NORRKÖPING, Sweden

Report RL 2010:12e

The Swedish Accident Investigation Board has investigated an incident that occurred on 9 November 2008 in airspace over Malmö/Sturup airport, Skåne County, Sweden, to an aircraft registered SE-DZB.

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

The Swedish Accident Investigation Board will be grateful to receive, by 1 April 2011 at the latest, particulars of how the recommendations included in this report are being followed up.

Göran Rosvall Stefan Christensen

Copy to EASA

Statens haverikommission (SHK) Swedish Accident Investigation Board

Postal address	Visiting address	Telephone	Fax	E-mail	Internet
P.O. Box 12538 SE-102 29 Stockholm	Teknologgatan 8 C Stockholm	+46(0)8-50886200	+46(0)8-50886290	info@havkom.se	www.havkom.se

Report RL 2010:12e

L-27/08
Report finalised 2 September 2010

Aircraft; registration and type	SE-DZB, EMB-145
Class, airworthiness	Normal, valid Certificate of Airworthiness with ARC (Airworthiness Review Certificate)
Registered owner/Operator	Corporate Aircraft Leasing Limited Grand Rue, St Martins GY4 6RU Guernsey Channel Islands/ City Airlines AB Box 2060 SE-438 12 LANDVETTER, Sweden
Time of occurrence	09.11.08, time 17:59 in darkness Note: All times are given in Swedish standard time (UTC + 1 hour)
Type of flight	Commercial air transport
Weather	According to METAR ESMS at 18:20: Wind 230°/12 knots, CAVOK, temperature/dew point +8/+6 ℃, QNH 1015 hPa
Persons on board:	
crew members	3
Passengers	18
Injuries to persons	None
Damage to the aircraft	None
Other damage	None
Commander:	
Age, certification	37 years, ATPL
Total flying time	7,866 hours, of which 6,107 hours on type
Flying hours previous 90 days	148 hours, all on type
Number of landings previous 90 days	78
First officer:	
Age, certification	32 years, CPL, ME+IR
Total flying time	1,739 hours, of which 1,277 hours on type
Flying hours previous 90 days	170 hours, all on type
Number of landings previous 90 days	45
Cabin crew members	One person

The Swedish Accident Investigation Board (SHK) was notified on 19 November 2008 that an aircraft with registration SE-DZB had an incident at 17:59 hours on 9 November 2008 in airspace at Malmö/Sturup airport, M län (Skåne county).

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

The investigation was followed by Britt-Marie Kärlin, Swedish Transport Agency.

The accredited representative from the Brazilian accident board, Centro de Investigação e Prevenção de Acidentes Aeronáuticos, was Fredrico Felipe.

General starting points and boundaries

SHK is a government agency that is responsible for investigating accidents and incidents of accidents in order to improve safety. SHK's accident investigations aim as far as possible to clarify both the cause of events and cause of the occurrence such as injuries and other effects. An investigation should provide a basis for decisions that aim to prevent a similar occurrence from happening again or to limit the impact of such an event. The investigation should also provide a basis for an assessment of the civil society's efforts made in connection with the occurrence and, if there is reason for it, for the improvement of the rescue service.

SHK´s accident investigations should answer three questions: What happened? Why did it happen? How should we avoid a similar occurrence?

SHK has no supervisory duties and is not tasked to apportion blame or liability or questions relating to damages. This means that responsibility and liability issues are not examined or described in connection with an investigation. Issues of guilt, liability and damages are handled in the judiciary or by e.g. insurance companies.

SHK's assignment is not, in addition to the investigation dealing with the rescue service, to study how people taken to hospital were treated there. Nor are the civil society´s activities in the form of social care or crisis management after the event investigated.

Summary

This aviation event involved two separate incidents, where the first was a loss of cabin pressure and the other reduced aircraft separation.

The aircraft, an Embraer 145 with call sign SDR051, had taken off from Gothenburg/Landvetter Airport for a scheduled flight to Prague. When the cruise altitude at FL 370 (approx. 11,300 metres) had been reached, the warning system indicated a fault in one of the systems that supplied air to, among other things, the pressure cabin. The pilots had started to take measures in accordance with the emergency checklist when the other system generated a warning and shut down.

The air conditioning system on this type of aircraft has a generally high failure rate. During fault tracing on the system the Pack Temp Sensor was changed, after which the system returned to normal operation. Whether the warning and system shutdown were caused by a fault in the unit that had been replaced has not been verified, but is entirely possible. The warning and shutdown could also, according to the manufacturer’s analysis, have been caused by incorrect connections in two electrical units.

It seems very likely that the remaining system became overloaded or overheated, and therefore shut down automatically as a result of the first fault.

The pilots observed that the cabin pressure reduced rapidly, and they began the actions in accordance with the checklist for falling cabin pressure. The pilots donned their oxygen masks and reported to air traffic control that they were commencing an “*Immediate descent*”. The pilots did not activate the transponder emergency code. The aircraft was initially cleared to FL290 but because an *“emergency descent”* had been reported to air traffic control, clearance was given to FL150. The crew also reported that they wished to land at Malmö/Sturup airport. The limitation of FL150 was due to other traffic, and an ATR72 with call sign CIM027, who was cruising on a possible collision course at FL130.

When the aircraft was handed over to the next air traffic controller who handled the lower airspace, information was received from the colleague that the aircraft had requested a descent to FL150, which was not the case. When the aircraft reported descent to FL100, on the new frequency there was not enough time for the air traffic controller to plan a traffic redirection that would comply with the separation rules. When interviewed, the pilots related that the procedure with the oxygen masks was awkward and that they perceived the quality of radio communications was poor during the entire sequence of events.

Despite the air traffic controller instructed CIM027 to descend immediately, minimum separation was lost and SDR051 passed 1.27 nm in front of CIM027 with an altitude difference of 800 feet. However the crew of CIM027 reported that they had visual contact with the descending aircraft all the time.

The first incident was caused by deficiencies in the air conditioning system in respect of automatic shutdown.

The second incident was caused by a lack of co-ordination between the air traffic controllers. A contributory factor was the poor quality of radio communications between the aircraft and air traffic control.

Recommendations

It is recommended that EASA:

- Takes the necessary measures to minimise the risk of unjustified shutdown on the CPU, and to ensure that the two air conditioning systems operate independently of each other, *(RL 2010:12 R1)*.
- Investigates the conditions for that transponders in the future will be equipped with a quick selection feature for the emergency code 7700, *(RL 2010:12 R2)*.

It is recommended that the Swedish Transport Agency should:

- Ensure that training and continuation training of air traffic controllers is changed in respect of the altered traffic procedures necessary in the case of a - reported or suspected - emergency descent, so that the aircraft is always assumed to be descending to FL100 or lower, *(RL 2010:12 R3)*.
- Ensure that training and continuation training of air traffic controllers is changed in respect of the altered traffic procedures necessary in the case of a - reported or suspected - emergency descent, so that it will be assumed that communication could be interrupted, *(RL 2010:12 R4)*.
- Investigate the conditions for the introduction of a system in the Eurocat air traffic management system, equivalent to the “pointer symbol” that was in the previous ATCAS (Air Traffic Control Automatic System) system, *(RL 2010:12 R5)*.
- Ensure that the checklists for emergency descent always include providing information to air traffic control, (*RL 2010:12 R6*).
- Ensure that aircraft checklists for emergency descent always include setting the transponder to emergency code 7700, (*RL 2010:12 R7*).

1 FACTUAL INFORMATION

1.1 General

The aviation events that are the subject of this investigation consist of two separate and independent incidents, where the second event was a consequence of the first. The events have therefore, in certain parts of this report, been called *the first incident* and *the second incident*. The factual description in the report describes both incidents as part of all the events that occurred during the flight.

1.1.1 Conditions

The flight was a scheduled passenger flight, call sign SDR051, from Gothenburg/Landvetter to Prague, performed by an Embraer 145 type aircraft registered SE-DZB. This would be the third flight for the crew that day. Planning for the flight proceeded in accordance with normal procedures, without any expectation of difficulties in respect of weather or of a traffic/operational character.

No technical problems or other remarks concerning the aircraft had been noted. It was planned that the commander would be the PF (Pilot Flying) for the first sector, and the first officer would be the PNF (Pilot Not Flying). It was planned for them to change over for the return flight from Prague. At departure there were three crew and 18 passengers on board.

1.1.2 The first incident

The take-off and climb out took place without problems, in accordance with normal operational procedures. The aircraft reached its cruising altitude at FL370[1] on a southerly course over Skåne, southern Sweden. After a few minutes at cruise – about 30 minutes after take-off – the pilots' warning panel, EICAS[2], showed a warning concerning pack 1[3], which meant that this particular system shut down automatically. The first officer began to read the QRH[4] in order to carry out the necessary actions to deal with the situation.

While reading out from the checklist, however, another warning appeared, for pack 2, after which this second system also shut down automatically. The pilots observed that there was a rapid reduction in cabin pressure (i.e. an increase in cabin altitude), and prepared the relevant measures according to practised procedures for emergency situations with falling cabin pressure. They donned their oxygen masks and the communication controls were adjusted to manage radio traffic while wearing the masks. At that time the aircraft was at a position just south-west of Malmö/Sturup airport.

The aircraft left its cruising level altitude at FL370 and at the same reported by radio: "*Immediate descent*". Clearance from air traffic control was initially given to descend to FL290. At the same time, the air traffic controller noted that the aircraft had begun to turn to the east. Soon thereafter the aircraft declared "*Emergency descent*" on that frequency. A new clearance from air traffic control was then given to descend to FL150. This clearance was not however read back from the aircraft, and instead the message "*Mayday, Mayday, Mayday, SDR051, emergency descent*", was transmitted.

---

[1] FL 370: 37,000 feet (approx. 11,300 metres).
[2] EICAS: Engine Indicating and Crew Alerting System
[3] Pack 1: Unit in the air conditioning system, see Section 1.6.2.
[4] QRH: Quick Reference Handbook, Checklists for abnormal conditions and emergency situations.

The descent continued at an average rate of descent of about 7,000-8,000 feet per minute, and at the same time the pilots advised that they wished to land at Malmö/Sturup airport. At this point the aircraft was instructed to change the radio frequency for radar guidance towards Sturup.

1.1.3 *The second incident*

When the pilots contacted air traffic control on the new frequency, the aircraft was descending through FL182. The pilots reported then that they were making an emergency descent and intended to descend to FL100. The air traffic controller then revised the previous clearance to FL150 to now apply to FL140. The aircraft was also informed that the cleared altitude for SDR051 was "*due to traffic*". The particular traffic that could come into conflict was a Danish aircraft on a domestic flight, a Cimber Air ATR 72 with call sign CIM627, en route from Copenhagen/Kastrup airport to Rönne on Bornholm at FL130. The route between these two destinations passes over Swedish territory and crosses the southern part of Skåne.

The collision warning system on board SDR051 was activated during the subsequent descent, providing an RA (Resolution Advisory). This message referred to traffic at a distance of 12 nm and meant a proposal for an avoidance manoeuvre. At this time the air traffic controller repeated the previously given altitude restriction of "*FL140*" to SDR051 twice more, but received no clear confirmation from the aircraft that this instruction would be complied with and/or that it had been correctly understood.

The air traffic controller then instructed the Danish aircraft to descend to FL70. In connection with this, CIM027 was also informed that there was an aircraft above it making an emergency descent. There was no time however to carry out the instructions. When SDR051 resumed radio communication, the aircraft was descending through FL126 and had passed in front of the Danish aircraft at a distance of 1.24 nm and an altitude difference of 800 feet. The crew of CIM027 reported in connection with this that they had visual contact with the descending aircraft. SDR051 was then given radar vectors to Sturup and landed without any further problems.

The incident occurred during darkness in airspace south of Malmö/Sturup airport.

1.1.4 *The air traffic control sequence of events – graphical overview*

The graphic below was taken from the internal investigation by the LFV ANS[5] of the events. Figures 1 to 4 show the relative positions of the two aircraft at various points in the event sequence. The information in the boxes refers to both aircraft, CIM627 Cimber Air and SDR051 City Airline, with the aircraft positions indicated by the black squares and the dotted lines their latest tracks.

---

[5] LFV: Luftfartsverket, ATM provider in Sweden.

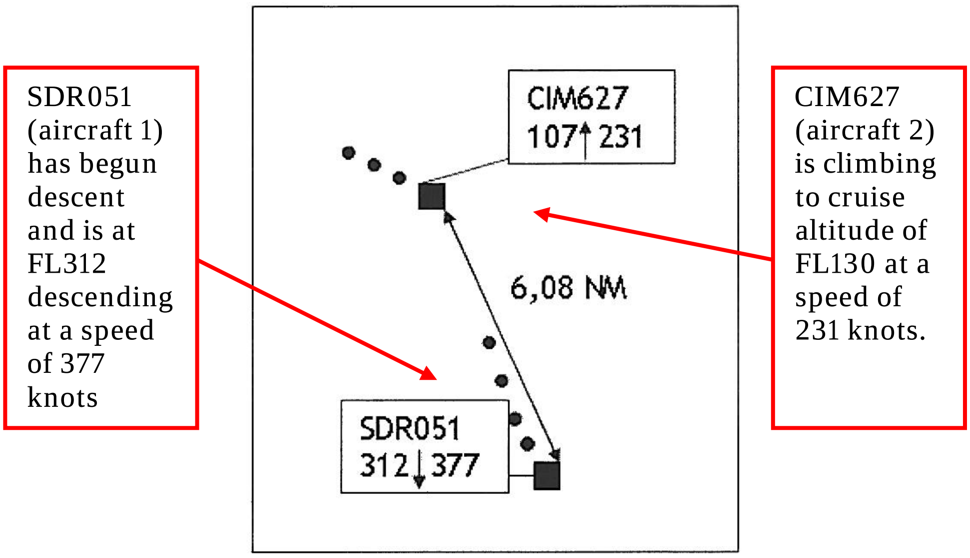

Fig. 1. Phase leading up to the sequence of events.

At this stage, aircraft 1 had commenced its descent. The air traffic controller experienced difficulty in communicating with the pilots. The aircraft requested radar vectors for a landing at Sturup. Clearance was given to FL150, but the air traffic controller was not sure whether this was sufficient and whether the aircraft would remain at that flight level.

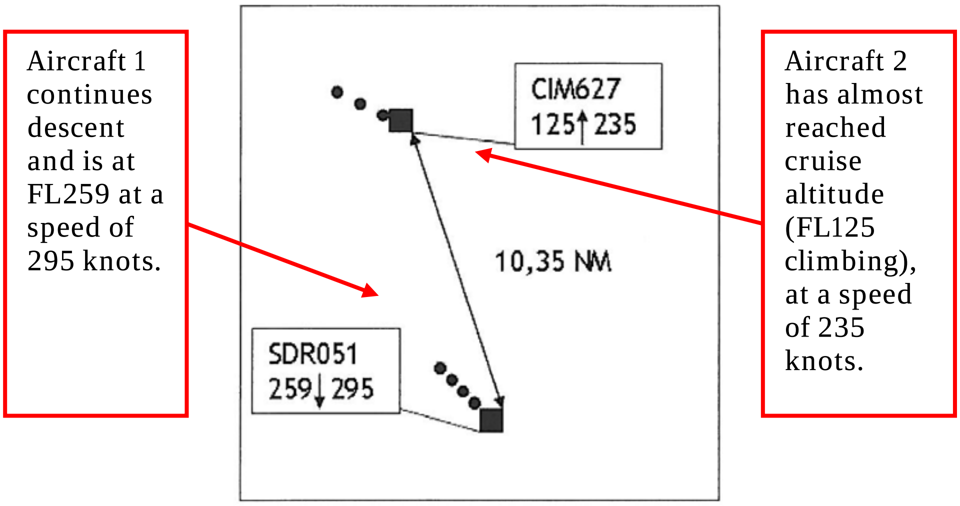

Fig. 2, Continued sequence of events.

Aircraft 1 was instructed to change frequency and contacted Malmö control for continued radar vectoring towards Sturup. At this stage 3.5 minutes had passed since the aircraft had declared an “emergency descent”.

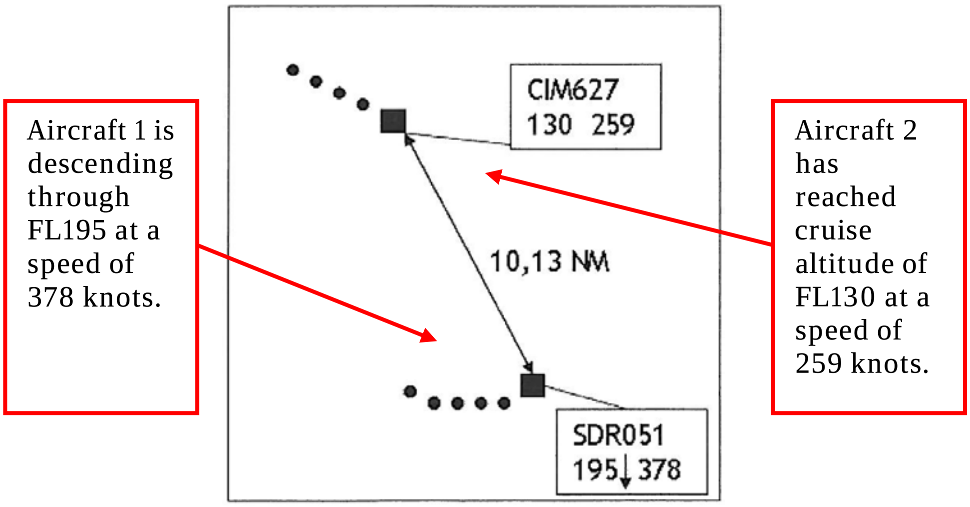

Fig. 3. Continued sequence of events.

Aircraft 1 was making a left turn towards the cleared heading of 340°. When the aircraft called up on the new frequency, it reported that it was making an emergency descent and intended to descend to FL100. The air traffic controller then instructed aircraft 1 to stop descending and stay at FL140 because of conflicting traffic. Aircraft 1 replied to this by asking the air traffic controller to confirm FL140. The air traffic controller confirmed the new altitude clearance but at the same time asked aircraft 2 to descend immediately to FL70.

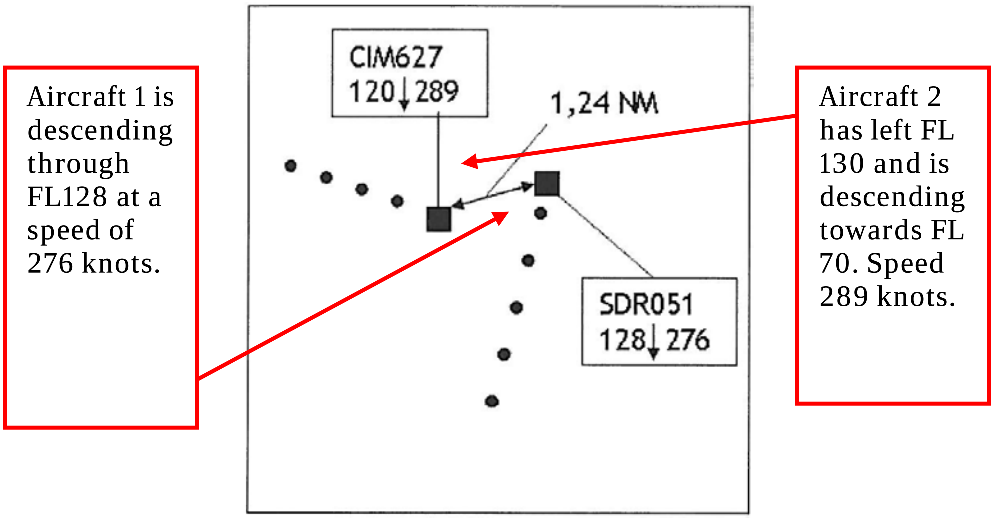

Fig.4, Concluding phase of the sequence of events – the incident.

Aircraft 1 passed in front of aircraft 2 at a minimum distance of 1.24 nm and a minimum altitude difference of 800 feet. At FL126 aircraft 1 requested a new vector to Sturup and was then cleared to descend to 3,000 feet. Aircraft 2 was instructed to stop descending and was at the same time given further information about aircraft 1. Aircraft 2 then replied: "*We got him in sight at all time so no big deal for us*".

1.1.5 *The air traffic control sequence of events – general*

SDR051 was planned to pass through Malmö ATCC[6] en route to Prague. The flight took place in the upper airspace called sector 8. This area is normally supervised by two air traffic controllers, of whom one is a planner and the

[6] Air Traffic Control Centre.

other the executive controller. The lower part of this airspace – FL285 and below – is called sector L and is also supervised by two air traffic controllers.

In 2005 Malmö ATCC went over from the earlier ATCAS system to using the newer Eurocat 2000e system.

When SDR051 requested "Immediate descent" initial clearance only to FL290 was granted, because the lowest level of sector 8 was FL285. After the aircraft declared an emergency situation, a further descent to FL150 was granted, while at the same time the air traffic controller for sector 8 (FL8) contacted his/her sector L (FLL) colleague for co-ordination. FL8 also stated the aircraft position so that FLL could quickly identify the radar label on the display.

According to the internal investigation carried out by the LFV ANS it was later discovered that co-ordination took place in the same way as when they worked using the older ATCAS system, where the air traffic controllers could see each other's pointer symbols on their respective radar displays. This function does not exist in the current Eurocat system. The interviews with the air traffic controllers revealed that this could have delayed the localisation of SDR051 by FLL. During the co-ordination, FLL also pointed out CIM625 as possibly conflicting traffic for SDR051's emergency descent. SDR051 had not yet at this time changed frequency from FL8 to FLL.

SDR051 was then asked whether they wished to go to Malmö/Sturup, which they confirmed. During the co-ordination between the air traffic controllers, it was also debated how far SDR051 should need to descend. During this discussion FL8 mentioned that SDR051 had itself requested FL150 (which was not recorded on the ATC tape), but that it was not clear whether the aircraft wished to remain at that level. At this stage it was apparent that it was also difficult to maintain radio contact with the aircraft.

FL8 gave SDRo51 instructions to turn left to a course of 340° towards Sturup and at the same time received confirmation from FLL that it was OK to send over the aircraft to the FLL frequency. At this stage 3.5 minutes had passed since SDR051 had declared an emergency descent. The dialogue between FLL and SDR051 is presented in Section 1.1.6 below.

1.1.6 Transcript of the ATC tape recording excerpt

The following transcript from the tape recording that was obtained from ATC presents the dialogue from the moment of transfer to FLL until SDR051 passed in front of CIM627.

Transmission from:	Message
SDR051	Radar, SDR051 in an emergency descent due to (unreadable) we are at FL182 descending to 100 heading 350 left turn.
FLL	SDR051 re-cleared to FL140 due to traffic, call you back shortly for further descent.
SDR051	For SDR051?
FLL	140, descent to FL140, SDR051.
SDR051	Eh.... FL140 confirm SDR051?
FLL	That is correct.
FLL	CIM627 descent immediately to FL70 due to an emergency descent.
CIM627	Say again for CIM627?
FLL	627 descent immediately FL70.
CIM627	Immediately 70.
FLL	There is an emergency descent above you.
CIM627	Roger we are descending
FLL	SDR051 level out 140, 140. Traffic below.
SDR051	We are already (unreadable) further --- to traffic advisory.

At the moment of the final transmission in the table above, SDR051 was descending through FL128 and had passed 1.24 nm in front of CIM627.

1.1.7 *Interviews with the crew*

In the interviews with the crew held by SHK the sequence of events was described by both the commander and the first officer. When the first warning appeared, the first officer began to read out the abnormal checklist of actions to be taken. The first officer had hardly begun on the list before the next warning, relating to pack 2, occurred. After this, both pilots could see by means of the cabin altitude instrument, how the cabin altitude rapidly increased, and they decided to don their oxygen masks.

In connection with this the commander also ordered the first officer to report to air traffic control that they had commenced an emergency descent. There was general agreement between the accounts given by both pilots. The only point where they differed was in their perceptions of the time between the first warning until the pilots had doned their oxygen masks.

The commander estimated that it was three minutes and the first officer thought that it was less than one minute. Both pilots believed the situation was under control, but there were certain factors that caused difficulties. The procedure for donning on the masks and establishing communication was time-consuming and awkward. The quality of the radio communications was poor enough to cause problems during the entire sequence of events. The crew considered that this was due to the fact that they were not used to the altered quality of transmissions from the microphones in the oxygen masks.

The transponder emergency code, 7700, was not set during the incident. According to both pilots, the reason for this could have been that this action was not contained in the emergency descent checklist. Nor was there a quick selector to activate 7700 on the transponder in this particular type of aircraft.

The pilots considered that the co-operation with air traffic control was in general good, but pointed out that the communication difficulties prevented the maintenance of normal radio traffic with the air traffic controllers during the course of events.

When the oxygen masks in the passenger cabin deployed, the mask over the cabin attendant's seat did not come down, which meant that the cabin attendant had to sit in an ordinary passenger seat. This also meant that the normal communication with the cockpit via the intercom could not be accomplished during the first part of the events.

1.2 Injuries to persons

	Crew members	Passengers	Others	Total
Fatal	–	–	–	–
Serious	–	–	–	–
Minor	–	–	–	–
None	3	18	–	21
Total	3	18	–	21

1.3 Damage to the aircraft

None.

1.4 Other damage

None.

1.5 The crew

1.5.1 The commander

The commander was 37 years old at the time and had a valid Airline Transport Pilot Licence.

Flying hours previous	24 hours	90 days	Total
All types	3.6	148	7,866
This type	3.6	148	6,107

Number of landings this type previous 90 days: 78.
Flight training on type carried out in 1998.
Latest PC (Proficiency Check) carried out on 6 March 2008 on an EMB 145.

1.5.2 Co-pilot

The co-pilot was 32 years old at the time and had a valid CPL/ME+IR Licence.

Flying hours previous	24 hours	90 days	Total
All types	3.6	170	1,739
This type	3.6	45	1,277

Number of landings this type in the previous 90 days: 45.
Flight training on type carried out on 9 October 2006.
The most recent PC was carried out on 25 September 2008 in an EMB 145.

1.5.3 Cabin crew members

One person.

1.5.4 *The crew members' duty schedule*

Both pilots were on the same duty roster and were on day three of a 5 day duty cycle. The pilots had been on duty for 6.5 hours when the incidents occurred and had a planned duty time on that day of 9.8 hours.

1.6 The aircraft

1.6.1 *General*

The aircraft		
Manufacturer	Embraer	
Type	EMB-145	
Serial number	145113	
Year of manufacture	1999	
Gross mass	Max. authorised take-off/landing mass 20,990 kg, actual 17,391 kg	
Centre of mass	Index 27.6, within the permitted limits	
Total flying time	21,952.1 hours	
Number of cycles	14,009	
Flying time since latest inspection	111.6 hours/75 cycles	
Fuel loaded before event	JET A1	
Engine		
Manufacture	Rolls Royce/Allison	
Engine model	AE 3007A	
Number of engines	2	
Engine	No. 1	No. 2
S/N	310133	310151
Total operating time, hrs	19,918.3	10,818.8
Operating time since overhaul	3,841.3	5,488.0
Cycles since overhaul	2,467	3,518

The aircraft had a valid Certificate of Airworthiness with valid approval certificate (ARC – Airworthiness Review Certificate).

The type of aircraft is a transport aircraft for carrying about 50 passengers. It is equipped with two turbojet engines and a pressure cabin.

Fig. 5 EMB-145, SE-DZB. Photograph: Maarten Wagemans

1.6.2 Air conditioning system

This type of aircraft is equipped with two separate air conditioning systems which supply the cabin with air for ventilation and pressurization. The system also ensures that the cabin air has the desired temperature and humidity. Each individual system is capable of pressurizing the cabin for flight up to flight level 250.

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 main components of the air conditioning systems are mostly located under the cabin floor at the front of the aircraft. The system is operated by the pilots via two control panels which are located in the ceiling above the windscreen.

1.6.3 Cooling system

Each air conditioning system includes a cooling system, called the Cooling Pack System (CPS), which contains a cooling module called the Air Control Module (ACM). The ACM is driven by bleed air from the respective engine. The CPS and its associated components are controlled via a computerised control unit called the Digital Temperature Control (DTC), which receives control signals from, among other sources, a number of temperature sensors in the system. One of these is called the Pack Temp Sensor and is located in the inlet duct from the CPS to the cabin (Pack Duct).

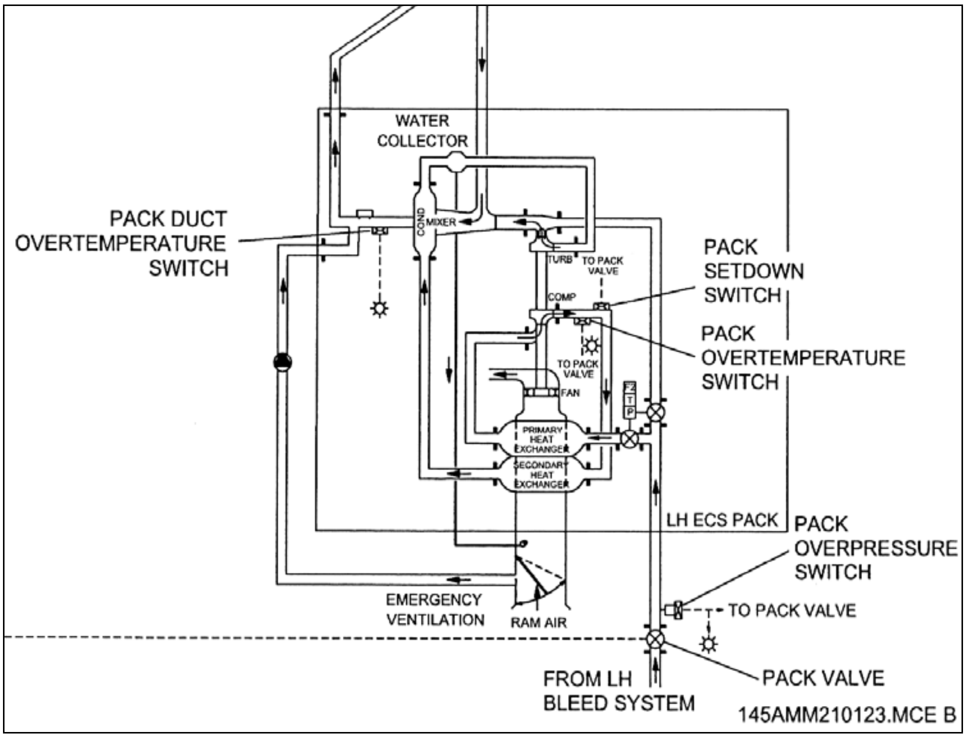

Fig. 6. CPS.

In the CPS is a warning system which is activated if the temperature or the pressure in the system becomes too high. This system is controlled by a temperature sensor, the Pack Overtemp Switch (243°C), and a pressure sensor, the Pack Overpressure Switch (55 PSI) which are located in the part of the CPS where bleed air is taken in from the engine, and a temperature sensor, the Pack Overtemp Switch (93°C) which is located in the Pack Duct.

On activation of the Pack Duct Overtemp Switch (243°C) or the Pack Overpressure Switch (55 PSI), the CPS is automatically switched off. At the same time a warning is shown, “PACK X OVLD” on the Engine Instrument and Crew Alerting System (EICAS) on the pilots’ instrument panel. In the case of an automatic shutdown of the CPS, restarting must take place manually.

Activation of the Pack Duct Overtemperature Switch (93°C) only activates the warning: “PACK X OVHT” in the EICAS.

The CPS can operate in a HIGH or LOW STAGE MODE depending on the loading, i.e. the cabin pressure requirement. Switching between the HIGH and LOW STAGE MODE takes place automatically via the DTC. When operating in the HIGH STAGE MODE the CPS works at higher temperatures and pressures which, among other things, results in higher temperatures in the PACK DUCT.

1.6.4 SB No. 145-21-0014

On 12 March 1999 the aircraft manufacturer published Service Bulletin (SB) No. 145-21-0014 with the intention of improving the temperature stability of the air conditioning system. SB 21-00-14 prescribed, among other things, the relocation of the connector pins in two electrical connectors (P0082 and P0083), and the installation of diodes in two of the relays (K0319 and K0320) which are contained in each CPS.

SB No. 145-21-0014 was implemented in SE-DZB on 30 June 1999 after the aircraft had flown 500 hours. The operator found however that even after taking this action the temperature in the air conditioning system was sometimes unstable.

1.6.5 SB No. 145-21-0015

On 14 May 1999 the aircraft manufacturer published SB No. 145-21-0015 with the intention of reducing the number of cases of incorrect PACK X OVLD warnings. Part of the modification was also to switch the logic controlling the automatic shutdown of the ACM in the case of suspected overheating. Changing the logic meant that automatic shutdown would also take place on activation of the Pack Duct Overtemperature Switch (93°C).

According to the manufacturer 102 of 117 affected aircraft in the fleet had been modified in accordance with that SB. Subsequently delivered aircraft had the modification implemented during production, which meant that a total of about 856 of this type of aircraft had been modified in accordance with this SB.

In this operator’s fleet of five EMB-145s only SE-DZB had been modified in accordance with this SB, which was implemented on 10 January 2004 at a total flying time of 11,353 hours.

1.6.6 Checklists - air conditioning

The warnings that are shown in the cockpit in association with faults in the air conditioning system are announced as “cautions” in yellow text on the EICAS display in the cockpit. Warnings of emergency status are “warnings” shown with red text. The attention of the crew is also drawn by a master warning or master caution being lit on the panel, followed by either three or one “chimes” respectively (audible signals).

The various messages that are announced on the EICAS can also be found in the checklist for emergency/abnormal procedures, where red “warnings” are in the section concerning emergencies and yellow “cautions” in the abnormal section. For each of the warnings announced by EICAS there is an associated section containing procedures/actions in the checklist, appropriate to the fault that has been detected.

The faults arising in the air conditioning system generated cautions, with the associated measures being in the abnormal checklist. There are a large number of faults described in the air conditioning part of the checklist. Common to most of these procedures is that the alternative: “Both packs affected?” is in the list. In those cases where the answer to this question is affirmative there is a short checklist as follows:

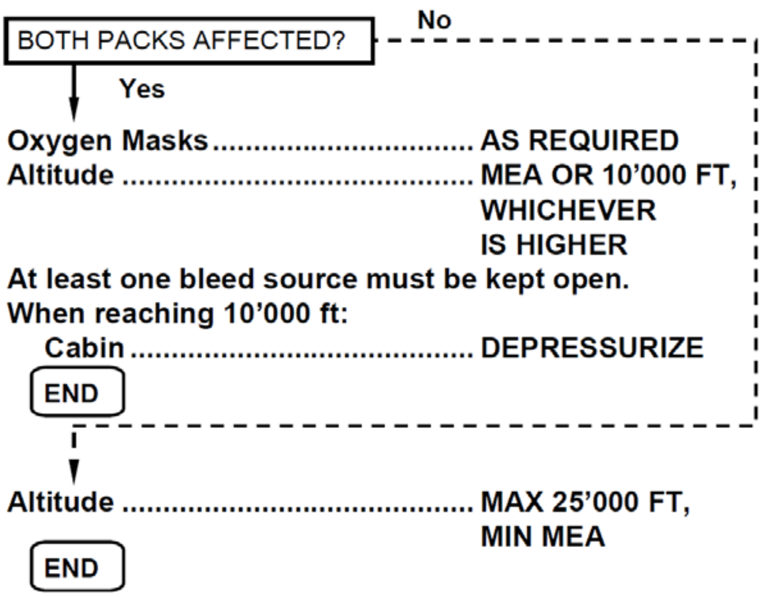

Fig 7. Extract from the abnormal section of the emergency checklist.

The above measures show that in the case of a fault that causes the cabin to lose pressure – causing the cabin altitude to increase – the crew should if necessary don their oxygen masks and begin a descent to 10,000 feet. In only one of the procedures relating to various faults in the air conditioning system (Pressurization automatic system failure/cabin depressurization), is there a reference to “rapid cabin depressurization” in the emergency checklist.

1.6.7 Checklists - rapid cabin depressurization

When the cabin altitude exceeds 10,000 feet both a warning and a voice message are activated. The actions to be taken are in the emergency checklist as follows:

RAPID CABIN DEPRESSURIZATION

Aural Warning: Voice Message **CABIN**.
EICAS Indication: CAB ALT value in red.
Condition: Cabin altitude has exceeded 10'000 ft.

Crew Oxygen Masks .... DON
Crew Communication .... ESTABLISH

Passenger Oxygen............................ AS REQUIRED
Altitude .... MEA OR 10'000 FT, WHICHEVER IS HIGHER

EMERGENCY DESCENT
Procedure (NAP-6) .... AS REQUIRED

END

Fig 8. Extract from the emergency checklist.

The two first items on the emergency checklist mean that the crew must don their oxygen masks and establish communication. The frame around these items indicates that these are "by heart items", i.e. the crew must have memorised them.

The practical implementation in the cockpit is that the pilots remove their headsets in order to don their oxygen masks. After this the headsets can be put back on to utilise the listening function. The microphones in the oxygen masks must then be activated manually in order that transmissions can take place.

When this has been done the checklist refers (as required) to the next checklist for emergency descent to state the actions associated with a descent to 10,000 feet.

1.6.8 *Checklists – emergency descent*

The following checklist must be used on commencing an emergency descent:

EMERGENCY DESCENT

FSTN Belts .... ON
Cabin Crew .... NOTIFY
Thrust Levers .... IDLE
Speed Brakes .... OPEN
Airspeed .... MAX 250 KIAS
Landing Gear .... DOWN
Descent .... INITIATE
Altitude .... MEA OR 10'000 FT, WHICHEVER IS HIGHER

IF STRUCTURAL DAMAGE IS SUSPECTED, USE THE FLIGHT CONTROLS WITH CAUTION AVOIDING HIGH MANEUVERING LOADS AND REDUCING AIRSPEED AS APPROPRIATE.

END

Fig 9. Extract from the emergency checklist.

The checklist contains information concerning actions to be taken in certain cases, and is intended to facilitate the descent as quickly as possible to 10,000 feet. There is no item in the checklist regarding information to air traffic control when an emergency descent is initiated. Nor is there any instruction to set the aircraft transponder to 7700, the emergency code.

1.6.9 On-board oxygen

In situations where it is necessary to use oxygen on board, the pilots have permanently installed oxygen bottles which are connected to their oxygen masks at each pilot seat. The masks are also equipped with microphones for radio transmissions and internal communication. These microphones are normally not activated, but must be switched in by a switch on the panel.

In the case of the cabin crew there are portable oxygen containers (which can also be used for medical purposes) and masks above the cabin crew seats of the same type as those provided for passengers.

In the passenger cabin are “drop down” masks for the passengers which drop down through hatches in the ceiling which open automatically if the cabin pressure falls. These masks chemically generate oxygen from oxygen generators and provide a supply for about 15 minutes of normal oxygen consumption.

In the case of a fall in pressure, the crew must try in a suitably short time to descend to FL100 or lower. At this altitude the natural oxygen pressure is sufficiently high to ensure the necessary oxygen supply for normal human needs.

1.7 Meteorological information

According to METAR ESMS at 18:20: Wind 230°/12 knots, CAVOK, temperature/dew point +8/+6°C, QNH 1015 hPa.

1.8 Aids to navigation

Not applicable.

1.9 Radio communications

The tape recording that was obtained from the ATC recordings is presented at Section 1.1.6 in edited form.

1.10 Aerodrome information

Not applicable.

1.11 Flight recorders and voice recorders

None of the data from the aircraft flight data recorder was used in this investigation.

1.12 Location of occurrence and aircraft wreckage

1.12.1 Incident site

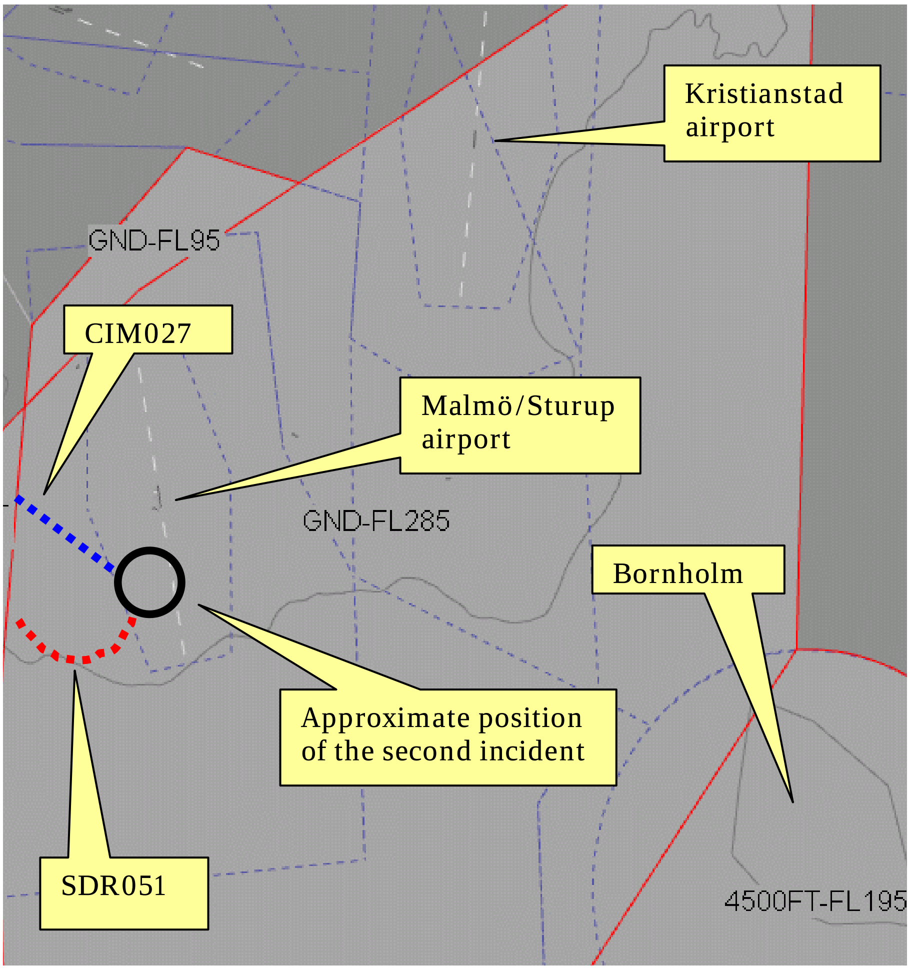

Fig. 10. Sector L.

The above map shows a part of Sector L, indicating the tracks of both aircraft during the events and the approximate position where the reduced aircraft separation occurred.

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

Not applicable

1.15 Survival aspects

1.15.1 Emergency descent - general

An emergency descent that is commenced by an aircraft that is at a high altitude may have been preceded by a number of different events or faults. Apart from a drop in cabin pressure – either rapid or slow – a forced immediate descent can be caused by a technical fault, damage to the aircraft, fire on board, a bird strike, illness, criminal acts. etc.Common to all events leading to an emergency descent is that a severe emergency situation of some kind has arisen on board.

The commander's priorities in such a situation are normally to come out of the severe situation and if possible take action to rectify the problem that has caused it.

1.15.2 The medical effects of a lack of oxygen

The air we breathe consist of about 21% by volume of oxygen and about 78% by volume of nitrogen, along with small amounts of other gases. This mixture is more or less constant in the atmosphere, regardless of altitude. As altitude increases, the air pressure reduces, and thereby also the oxygen pressure, i.e. the partial pressure of oxygen in the actual volume of air. At an altitude of 19,000 feet the air pressure is half that at sea level, meaning that the oxygen pressure is reduced to about 10%. Thus the number of oxygen molecules per given air volume reduces by an equivalent amount. In practical terms this means that each breath at 19,000 feet altitude only aspirates half the amount of oxygen compared to the same volume of air at sea level.

One way for the body to compensate for the low oxygen pressure is to increase the rate of breathing. The symptoms of an oxygen deficiency are, apart from an altered state of consciousness, headache, dizziness, nausea, cramp and temporarily impaired vision. The other immediate physical signs that can be observed are an increased heart and breathing rate, along with cyanosis, a blue tinge round the nail beds and lips.

The effect on the human body in the presence of reduced oxygen pressure is highly dependent on individual conditions. In general it can be said that certain functions are negatively affected even with a minor reduction in oxygen pressure. Night vision is for example already affected at an altitude of 8,000 feet. At 10,000 feet the cognitive functions start to be weakened, i.e. our ability to collect, process and use information.

In the case of a rapid reduction of oxygen pressure while breathing normal air, the body is less able to adapt to the new conditions. When for example climbing or hiking, the body gradually adapts to greater altitude with its lower oxygen pressure. The expression that is used to measure consciousness is called TUC (Time of Useful Consciousness), and can be defined as the time interval – depending on the degree of activity – during which one can be considered to be able to function more or less normally. The following table indicates the approximate time intervals during which an otherwise normally performing individual is able to maintain useful consciousness in situations with a lack of oxygen.

It should be mentioned that the values in the table were obtained from a study where the individuals were breathing oxygen from a mask, and that the lack of oxygen was caused by removing the mask. The TUC in situations where the individual is breathing normal air is shorter for each given altitude than when at an equivalent altitude an oxygen supply is removed. This is due to the higher saturation level of oxygen in the blood when breathing pure oxygen instead of normal air.

Altitude	Immediate removal of mask; moderate activity	Immediate removal of mask; no activity
28,000 feet	1 minute	1 minute and 30 seconds
30,000 feet	45 seconds	1 minute and 15 seconds
35,000 feet	30 seconds	45 seconds
40,000 feet	18 seconds	30 seconds

Fig. 11. TUC table – Time of Useful Consciousness (Carlyle, 1963).

In this particular incident there was a rapid but gradual reduction of oxygen pressure via breathing in normal air, so that the TUC would probably be shorter than the time intervals given in the table.

1.16 Tests and research

1.16.1 Technical examination of the air conditioning system

When fault tracing the air conditioning system after the incident, it was suspected that the Pack Temp Sensor in the left side CPS was faulty, and it was replaced. After taking this action the system operated normally and the aircraft was put back into service. There was no subsequent fault tracing of the sensor.

Five days later, while flying at FL370, OVHT was again activated for the left side system.

In connection with fault tracing on this second failure, it was noted that two pins in two electrical connectors, P0082 and P0083, part of the left side air conditioning system, were incorrectly located. All indications were that the incorrect mounting was done in connection with the implementation of SB No. 145-21-0014. According to the operator, it was easy to misinterpret the modification instructions.

After the electrical connectors had been corrected, both air conditioning systems were checked while flying up to an altitude of FL370, and were found to operate normally.

Incorrect location of the connector pins could, according to the manufacturer, have led to the temperature signals to the DTC being incorrect, and that a warning concerning overheating in the system was generated falsely.

Fig.12. Electrical connector P0082.

1.16.2 *Temperature in the Pack Duct*

The air temperature in the Pack Duct is measured, among other things, by the Pack Duct Overtemperature Switch (93°C). This sensor is physically located immediately after a unit in the CPS called the Condenser Mixer, in which, among other things, hot air is mixed with cold air.

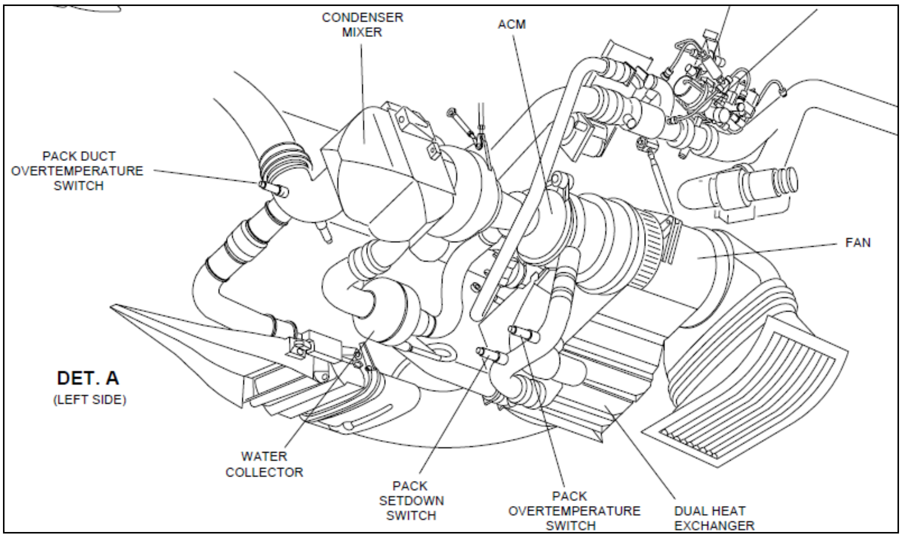

Fig. 13. The right hand CPS.

Practical tests carried out by the operator showed that the air temperature at the sensor's position was not homogeneous and stable. Small changes in the sensor body position inside the outlet duct resulted in large changes in the temperature being sensed. The temperature profile in the duct was also affected by how heavily the CPS was being loaded.

1.17 Organisational and management information

The company was formed in 2001 and has its headquarters in Gothenburg. Its operations consist primarily of scheduled passenger traffic from Gothenburg to domestic and international destinations. The company is privately owned and at the time of the incidents operated a fleet consisting of Embraer 135 and 145 aircraft.

1.18 Other

1.18.1 CPS failure cases

During the most recent 12 months the aircraft manufacturer has become aware of a total of 22 unwarranted CPS shutdowns among a worldwide fleet of about 880 manufactured ERJ 135/140/145 aircraft. All these cases have affected aircraft where SB No. 145-21-0015 had been implemented.

According to the operator there were more cases of automatic shutdown of the ACM during flight concerning SE-DZB than for other aircraft of this type.

1.18.2 Emergency descent training – the crew

Both pilots stated that they had practised the procedures for emergency descent in simulator during the previous year. The training was not mandatory, in the sense that emergency descent must be practised on every PC/OPC occasion, but was included in the group of fault scenarios from which the instructor selected a certain number of exercises that would be practised on a particular occasion.

Paragraph (a) (2) (i) of Appendix 1 to EU-OPS 1.965, states an operator should establish a training programme such that all fault functions of the aircraft´s vital system should be covered during a three-year period.

1.18.3 Emergency descent training – the air traffic controllers

All four air traffic controllers stated that they had practised the procedures and routines in connection with emergency descent during the previous year's training sessions.

1.18.4 Regulations – emergency descent

According to ICAO Doc 8168, Aircraft Operations, Vol 1 (Flight Procedures), states that pilots in an emergency should set transponder code to 7700. According to ICAO Annex 2, "Rules of the Air", Section 3.6.2.1, states that pilots - in cases where an emergency situation forces the aircraft to deviate from a route – should inform the relevant ATS unit.

In Appendix 1 to EU-OPS 1.1045, which provides guidelines on the content of the operations manual, it is required that emergency procedures - as well as the associated check lists - include handling of fault functions of aircraft systems .

However, it is up to each country's regulatory authority to ensure that the instructions for example, transponder code and ATC-communication is provided in the current checklists

1.18.5 Environmental aspects

The incident did not have any negative environmental effects.

1.18.6 Equal opportunities aspects

This event has also been examined from the point of view of equal opportunities, i.e. against the background that there are circumstances to indicate that the actual event or its effects were caused by or influenced by the women and men concerned not having the same possibilities, rights or obligations in various respects. No such circumstances were however found.

2 ANALYSIS

2.1 The pressure drop in the cabin (the first incident)

2.1.1 The technical fault

It can be considered that the fault – with the resulting effects that arose – was not of a type that the crew could manage. When both the systems for pressurizing the cabin shut down, the cabin pressure falls - and the cabin altitude increases – in a relatively short time. As far as SHK can tell, the crew acted quickly and in accordance with the procedures and regulations that had been established.

The section in the Abnormal checklist that could be associated with the fault that had been announced by EICAS was begun by the first officer. During this procedure, however, there was a similar warning for the other system, so that there was no time to begin the actions in the list. The procedure of donning the oxygen masks was, as far as SHK could ascertain, applied by the crew in accordance with the memorised items in the checklist for Rapid decompression that were contained in the emergency checklist, as the first items.

There is no checklist that is directly intended for what now happened in the form of a “slow” depressurization, just that the crew are directed to the checklists that deal with faults in the air conditioning system and where both pressurized air systems have failed. Only one of these checklists - Pressurization automatic system failure/cabin depressurization – contains references out to the emergency descent checklist. This must be considered a deficiency, as all cases where both systems shut down lead to cabin depressurization, i.e. that the pressure falls and the cabin altitude increases.

2.1.2 The emergency descent

The checklist that shall guide the crew in the case of an emergency descent has as first items the instruction that the safety belt signs must be illuminated and the cabin staff informed. There is no item in the checklist to inform air traffic control when an emergency descent is initiated. Nor does the checklist have an item to set the emergency code of 7700 on the aircraft transponder.

Since in a stressful emergency situation it is easy to forget important actions, it is extremely important that the checklist contains all the necessary memory support. This includes both ordinary items as well as those which should have been learned by heart. SHK therefore considers that the checklist for emergency descent could be supplemented by both an item to provide information to air traffic control, and also an instruction to set the emergency code on the transponder. The crew also stated that the aircraft did not have a quick selection facility on the transponder to set 7700, and thought that this could have contributed to the failure to activate the emergency code.

It also emerged that the procedure of donning the oxygen masks and establishing communication had not proceeded completely satisfactorily in this particular incident. The training carried out in a simulator cannot, for obvious reasons, reflect the rapidly changing environment that arises in the cases of various kinds of pressure drop. However, simulator training for emergency descent is anyway to be seen as the best method of practising for this type of situation.

Emergency descent training is important in every respect. Apart from the purely technical flight procedures, it can be said that the memory items which are at the start of the Rapid decompression checklist, namely “Oxygen masks” and “Communication”, are vital for securing that the continued handling of the event will be carried out in a way that provides a reasonable level of flight safety. Even though the complete practice procedure for emergency descent is not obligatory at each PC/OPC check, SHK believes that “drill practice” in respect of oxygen masks and communications switching should form a mandatory part of every training session.

Considering that the crew probably have a heightened stress level in any incident where the pressure in the cabin rapidly or gradually falls, it is most likely that the time available to make conscious decisions and perform actions (TUC) at 37,000 feet is limited to 20-25 seconds. Regular practice of these procedures will – apart from the pure training value – also have the result that the awareness of the crews will increase, in respect of the degree of seriousness of such incidents.

2.1.3 The communication

Both pilots stated that there had been communications difficulties during the event. In this particular case, these became apparent by both the initial difficulty in establishing transmissions via the mask microphones, and also trouble in reporting to air traffic control as the situation continued.

Apart from the need for practice mentioned in Section 2.1.2. it can be said that the crew experienced the altered quality of the transmissions as troublesome. Poor radio communications can, in critical situations, according to SHK probably affect the motivation of the crew to maintain an otherwise desirable level of radio traffic.

When analysing the actions of the crew in respect of communication it should also be taken into account the fact that this was not considered to be a priority. In the commander’s assessment of the measures necessary in an emergency situation, flying and managing the aircraft – and thereby ensuring the safety of those on board – always comes first. As can be seen in earlier sections of this report, an emergency descent may be caused by a number of different reasons. Some of these can result in that meaningful radio communications is becoming impossible.

Regardless of the reasons for an emergency descent, it is justified to assume that radio traffic with the descending aircraft will be somewhere between poor quality and non-existent.

2.1.4 The failure of the left side CPS

The air conditioning system on this type of aircraft has a generally high failure rate. The problems often consist of temperature fluctuations, false warnings and uncommanded shutdowns. At times the faults are intermittent and therefore difficult to trace and repair.

The aircraft manufacturer has taken various measures to deal with these problems, including the issue of SB Nos. 145-21-0014 and 145-21-0015. Despite this, the operator has not experienced any real improvement in respect of the reliability of the system.

This particular incident began with PACK 1 OVHT or PACK 1 OVLD warnings shown on the EICAS during the flight. Soon thereafter the left side CPS shut down automatically.

During fault tracing on the system later the Pack Temp Sensor was changed, after which the system returned to normal operation.

Whether the warning and system shutdown was caused by a fault in the unit that had been replaced has not been verified, but is entirely possible. The warning and shutdown could also, according to the manufacturer's analysis, have been caused by incorrect connections in two electrical units, P0082 and P0083.

2.1.5 The failure of the right side CPS

No trouble shooting was carried out on the right hand CPU, which was then shut down, and after the incident its system operated normally again.

The fact that the right hand CPU shut itself down soon after the left hand CPU shut down indicates that these problems were associated.

At the time, the aircraft was flying at FL 370. which is over the highest altitude at which sufficient cabin pressure can be maintained with only one air conditioning system in operation. After the left side CPU shut down, the right side CPU was therefore required to work harder than usual.

It is quite likely that the right hand CPU thus became overloaded or overheated and hence automatically shut down.

The rapidity of the sequence, which took place in less than one minute, can indicate that the shutdown of the right side CPU was caused by an incorrect activation of the Pack Duct Overtemperature Switch (93°C).

The Pack Overtemp Switch (93°C) is located in the ducting immediately after the Condenser Mixer, where hot air is mixed with cold air. Practical tests carried out by the operator showed that the air temperature at the sensor's position was not homogeneous, and that dynamic hot and cold air streams can locally occur within this area.

SHK understands that there is a risk of this causing unwarranted activation of the Pack Overtemp Switch (93°C). If, in addition, the shutdown logic has been modified in accordance with SB No. 145-21-0015, this activation will mean an automatic shutdown of the CPU.

This theory is reinforced by information from the manufacturer that a total of 22 involuntary CPS shutdowns had occurred in the previous year, which must be regarded a large number when it is probable that the manufacturer does not learn of all shutdowns of this type that take place. Also, all the shutdowns had occurred on individual aircraft which had been modified in accordance with SB No. 145-21-0015.

In the experience of the operator it is also the case that undesired CPU shutdowns occurred more frequently on this particular aircraft, which was the only one to have been modified in accordance with SB No. 145-21-0015, than on other aircraft in the fleet which had not been modified.

2.1.6 SB No. 145-21-0015

Since the loss of one of the air conditioning systems as above, in certain situations probably increases the risk of false activation of the Pack Overtemp Switch (93°C) in the other air conditioning system, changing the connections for the shutdown logic in accordance with SB No. 145-21-0015, in the opinion of SHK leads to an increased risk of losing both systems during flight.

The loss of both air conditioning systems while flying at altitude, with the possible need for immediate and rapid reduction in altitude, can pose flight safety risks, on which light is shed in this investigation.

There are therefore reasons for the regulatory authorities and the aircraft manufacturer to take the necessary measures to minimise the risk of unjustified shutdown of the CPU, and to ensure that the two air conditioning systems operate independently of each other.

2.2 Reduced aircraft separation (the second incident)

2.2.1 Management of the incident – co-operation

When SDR051 requested “immediate descent” initial clearance to FL290 was granted, because sector 8 only controlled the airspace above FL285. When SDR051 had declared an emergency, further clearance was given to descend to FL150, which however never was acknowledged by the aircraft. The reason for this is not known, but there are strong indications that the decreased quality of radio communications contributed to certain radio messages not being understood – or understood incorrectly.

The co-ordination between the air traffic controllers for the upper flight level, FL8, and those for the lower airspace, FLL, was initially characterised by a degree of uncertainty. Contributory to this could have been that the co-ordination was handled in the same way as when they worked with the earlier ATCAS system, where it was possible to use a “pointer symbol” to transfer information.

SHK can confirm that this capability is not present in the current system, Eurocat. Even if this did not have any direct influence on the incident, it is possible that the co-ordination would have been facilitated if this chance of direct transfer had existed, instead, as matters are today, the controllers being forced to transfer a “mental picture” of the situation.

2.2.2 Management of the incident – handover

When SDR051 finally was transferred from FL8 to FLL, this took place with the assertion that the pilots had requested to descend to FL150. Such a request is not recorded and shown on the tape transcripts, so it is likely that the FL8 air traffic controller misunderstood the pilots’ intentions – or heard incorrectly due to the poor sound quality – and therefore believed that SDR051 only wished to descend to FL150.

When FLL took over the descending aircraft it was therefore with the understanding that the aircraft would descend to FL150 on the reported track of 340°. This track would present a conflict with CIM027 at FL130, but since the FLL believed that SDR051 would remain at FL150, there would be an alitude separation of 2,000 feet. On making initial radio contact it probably came as a surprise that the aircraft reported it would continue the emergency descent down to FL100.

The action taken by the air traffic controller to try to stop the descent of SDR051 by giving clearance to FL140 was in this situation fully understandable, since a possible conflict with CIM027 was at this stage obvious. However, with a crew which was completely focused on descending to FL100 – at a descent rate of 7-8,000 feet per minute - there was just not enough time left to “recover” the situation. Despite the final attempt by FLL to avoid the conflict by giving CIM027 altered instructions, the loss of separation became a fact.

2.2.3 *Emergency descent - general*

As mentioned earlier, an emergency descent is always regarded as a severe emergency situation. The possibility for a pilot to report his – and the aircraft's – situation to air traffic control always depends on what has happened and the consequences that it has brought. Some types of event, such as a broken cockpit windscreen, can effectively block all attempts to conduct meaningful radio communication, due to the roar of the wind.

Air traffic control cannot therefore always count on discovering the causes of an – announced or suspected - emergency descent. For the same reasons, nor can air traffic control expect to be able to maintain radio contact with an aircraft in an emergency descent by using normal procedures. This applies even if normal two-way radio contact has been possible initially.

The most usual cause of an emergency descent is some kind of problem with cabin pressurisation. In these cases the purpose of the descent is always to get down to a safe altitude with respect to the necessary oxygen level in the breathing air, i.e. to FL100 or lower.

SHK considers that the education and training of air traffic controllers could be reinforced and clarified concerning management and assessment of aircraft commencing an emergency descent. The procedures that are applied when such a descent has become identified – or suspected – should include clear operating procedures in respect of the expected altitude needs and loss of communication.

3 CONCLUSIONS

3.1 Findings

a) The pilots were qualified to perform the flight.
b) The aircraft had a Certificate of Airworthiness with valid ARC (Airworthiness Review Certificate).
c) The pilots experienced difficulty in communications while wearing their oxygen masks.
d) Only one of the checklists, containing “Both packs affected” had a reference to the Emergency descent checklist.
e) The Emergency descent checklist did not contain an item for informing ATC that an emergency descent was in progress.
f) The Emergency descent checklist did not have an item to set the emergency code of 7700 on the aircraft transponder.
g) The transponder did not have a quick selection facility to set the emergency code 7700.
h) Training for an emergency descent is not a mandatory item in PC and ATPL/Type ratings.
i) The air conditioning system had a high frequency of failures.
j) Two connector pins, included in the left side air conditioning system, were misplaced.
k) The reason for the CPU losses has not been fully determined.
l) There is a risk of incorrect activation of the Pack Overtemp Switch (93°C).
m) Changing the shutdown logic, in accordance with SB No. 145-21-0015, can increase the risk of losing both air conditioning systems during flight.
n) The new Eurocat system of air traffic control does not provide the possibility of information transfer via the “pointer symbol” that was present in the earlier ATCAS system.
o) On the handover between the air traffic controllers, incorrect information was provided that the descending aircraft had requested a descent to FL150.
p) The TCAS (Traffic Collision Avoidance System) collision warning system on the descending aircraft was activated (RA).
q The aircraft which was on a track liable to be crossed by the descending aircraft was in visual contact with it.

3.2 Causes of the incidents

3.2.1 The first incident

The incident was caused by deficiencies in the air conditioning system in respect of automatic shutdown.

3.2.2 The second incident

The incident was caused by a lack of co-ordination between the air traffic controllers. A contributory factor was the poor quality of radio communications between the aircraft and air traffic control.

4 RECOMMENDATIONS

It is recommended that EASA:

- Takes the necessary measures to minimise the risk of unjustified shutdown on the CPU, and to ensure that the two air conditioning systems operate independently of each other, *(RL 2010:12 R1)*.
- Investigates the conditions for that transponders in the future will be equipped with a quick selection feature for the emergency code 7700, *(RL 2010:12 R2)*.

It is recommended that the Swedish Transport Agency should:

- Ensure that training and continuation training of air traffic controllers is changed in respect of the altered traffic procedures necessary in the case of a - reported or suspected - emergency descent, so that the aircraft is always assumed to be descending to FL100 or lower, *(RL 2010:12 R3)*.
- Ensure that training and continuation training of air traffic controllers is changed in respect of the altered traffic procedures necessary in the case of a - reported or suspected - emergency descent, so that it will be assumed that communication could be interrupted, *(RL 2010:12 R4)*.
- Investigate the conditions for the introduction of a system in the Eurocat air traffic management system, equivalent to the “pointer symbol” that was in the previous ATCAS (Air Traffic Control Automatic System) system, *(RL 2010: R5)*.
- Ensure that aircraft checklists for emergency descent always include providing information to air traffic control, (*RL 2010:12 R6*).
- Ensure that aircraft checklists for emergency descent always include setting the transponder to emergency code 7700, (*RL 2010:12 R7*).