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**Pressurization emergency, Final Report by the Aircraft Accident Investigation Bureau concerning the incident to the McDonnell Douglas DC-9-82 aircraft, LN-RML operated by SAS Scandinavian Airlines System under flight number SK 682 on 13 July 2003**

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**Micro-summary:** Following cabin depressurization, this MD-82 made an emergency descent and diversion.

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**Event Date:** 2003-07-13 at 1246 UTC

**Investigative Body:** Aircraft Accident Investigation Bureau (AAIB), Switzerland

**Investigative Body's Web Site:** <http://www.bfu.admin.ch>

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# Final Report by the Aircraft Accident Investigation Bureau

concerning the incident

to the McDonnell Douglas DC-9-82 aircraft, LN-RML

operated by SAS Scandinavian Airlines System

under flight number SK 682

on 13 July 2003

over Swiss territory

This report has been prepared solely for the purpose of accident/incident prevention. The legal assessment of accident/incident causes and circumstances is no concern of the incident investigation (art. 24 of the Air Navigation Law). For data protection reasons the masculine form is used exclusively in this report for the naming of both sexes.

## Ursache

- Während dem Reiseflug begann auf Grund einer Abschaltung der linken und rechten Druckbelüftungsanlage die Kabinenhöhe mit einer Steiggeschwindigkeit von 1000 ft/Min. zu steigen.
- Das Abschalten der Druckbelüftungsanlage wurde durch ein fehlerhaftes *ground discrete signal*, welches zur automatischen Abschaltfunktion gelangte, ausgelöst.
- Der Kondensator C20 im Stromversorgungsteil fiel infolge von Spannungsspitzen aus. Als Folge davon wurde der Stromkreis A4U28 beschädigt. Dies wiederum führte dazu, dass ein *ground discrete* Ausgangssignal erzeugt wurde.
- Der falsche *ground mode* wurde durch einen Kurzschluss in der ACARS MU DLM-900 verursacht.

## Final Report

**Aircraft** McDonnell Douglas Corporation MD-82 LN-RML  
**Operator** SAS Scandinavian Airlines System  
**Owner** CL Airfinance Ltd., sold to SAS per 15.03.2001

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**Pilots: Commander** Norwegian citizen, born 1963

**Licence** ATPL

<b>Flight experience</b>	<b>Total in SAS</b>	5196	<b>in the previous 90 days</b>	65
	<b>on incident type</b>	2710	<b>in the previous 90 days</b>	65

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**Pilots: Copilot** Norwegian citizen, born 1964

**Licence** CPL

<b>Flight experience</b>	<b>Total in SAS</b>	2950	<b>in the previous 90 days</b>	150
	<b>on incident type</b>	2950	<b>in the previous 90 days</b>	150

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**Place** Airwayposition ABESI on Airway UN 851

**Coordinates** 46 09.35 N / 009 02.3 E **Altitude** FL 320

**Date and time** 13 July 2003, 12:46 UTC

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**Type of operation** Commercial scheduled flight / SAS SK 682

**Flight phase** Cruise

**Accident type** Cabin decompression

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### Injury to persons

	<b>Crew</b>	<b>Passengers</b>	<b>Others</b>
<b>Fatal</b>	---	---	---
<b>Serious</b>	---	---	---
<b>Minor or none</b>	5	139	

**Damage to the aircraft** None

**Other damage** None

## Synopsis

On July 13th 2003 a McDonnell Douglas MD-82, registration LN-RML, operated by Scandinavian Airlines System (SAS) as flight SK 682, enroute from Rome to Copenhagen, made an emergency descent followed by a diversion to Zurich.

The emergency descent was executed due to cabin supply pressure drop during cruise causing a cabin climb with an uncontrollable rate of approximately 1000 feet/min.

The flight crew proceeded with the emergency checklist and declared an emergency situation. At 17 000 ft AMSL the Passenger Oxygen Masks deployed automatically.

An uneventful approach and landing was made in Zurich. No injuries to passengers or flight crew occurred, one passenger suffered pain in his ears.

The loss of cabin pressure was caused by a technical fault. An internal short-circuit in a computer (ACARS), not in direct relation with the air-condition system, caused an uncontrolled signal to shut down the air-condition system.

## 1. Factual information

### 1.1 History of the flight

The aircraft McDonnell Douglas MD-82, registration LN-RML, was on a scheduled commercial flight from Rome (FCO), departed 11:40 UTC, to Copenhagen (CPH). The commander was pilot flying (PF). The copilot was pilot not flying (PNF) and therefore responsible for the communication, the checklist- and paperwork and the monitoring of the flight progress. At 12:46 UTC, shortly after entering Swiss territory on airway UN 851 at position ABESI, the crew noticed a slight cabin pressure loss (increase of cabin altitude). The aircraft was in a steady cruise phase at FL 320. About one minute later the crew noticed the pressure change (unusual ear pressure), the caution light „PRESSURE FLOW“ on the Cabin Pressure Selector Panel illuminated. At the same time the ACARS light on the Selcal Control Panel and the Aircraft Communication And Reporting System (ACARS) HI-chime came on. No associated ACARS failure message on the Multifunction Control Display Unit (MCDU) or ACARS printer was displayed. This active ACARS advisory could not be reset when using the Selcal Control Panel Push to Reset button. The crew tried to reset the light/chime using the Attendants Call Reset Switch without success. After the observation of the Flow Light, the left and right Air-Condition Pressure Indicators indicated approximately 10 PSI and the Cabin Climb Indicator showed a rate of approximately 1000 ft/min. The Auto-Throttle reverted to CLMP mode, and NO MODE was announced on the Thrust Rating Panel (TRP).

The crew followed the emergency checklist „CABIN ALT/Rapid de-compression“. Simultaneously the commander asked for immediate descent to FL 100. The weather conditions were according to VMC rules. Clearance was given by Zurich ACC initially down to FL 250. During descent the crew tried to control the cabin pressure manually, without success. As the cabin altitude started to climb uncontrolled with 1500 ft/min or more (the instrument scale is calibrated for a maximum positive/negative cabin rate of 1500 ft/min, the rate indicating pointer was at the very end of the scale), the commander immediately declared emergency. Zurich ACC cleared SK 682 down to FL 100 under radar guidance. When descending through approximately 17 000 ft AMSL, the cabin altitude passed 14 000 ft climbing and the oxygen masks in the cabin were automatically deployed. Because the pressure loss was not very strong, only a few passengers put the oxygen mask on as demonstrated by the cabin crew before the flight. After firm ordering by the

cabin attendants via the Cabin Public Address System, more passengers protected themselves by pulling the masks. The crew informed Zurich ACC about their intention to divert to Zurich airport. They were radar vectored to runway 14. The approach and landing was uneventful. Touchdown on runway 14 was at 13:04 UTC, the hardstand position was reached at 13:11 UTC.

Zurich ACC (Skyguide) informed the airport authority about the reason of the unscheduled landing after the aircraft was on ground. Therefore the ground organisation was only ready 15 minutes after the aircraft came to a stop at the parking position. The passengers were kept on board, awaiting the Swiss Ground Manager to arrange the disembarkation. The crew made a first debriefing with the passengers in the aircraft, a second one was made in the transit lounge. None of the passengers were injured and nobody asked for medical assistance at that time. Only hours later one passenger contacted a doctor.

## **1.2 Injuries to persons**

The one passenger reported pain in his ears and asked for medical treatment because of possible damage to the eardrum. A doctor from the Airport Medical Centre examined the passenger. Minor blood accumulation was found at the tympanic membrane. The airport medical centre sent the passenger to the university hospital Zurich for further investigation. The result from the hospital was an effusion of blood in the right ear (haematotympanon after barotrauma) with no impairment of health to this passenger. The passenger returned to Rome the following day.

## **1.3 Damage to aircraft**

There was no damage to the aircraft.

## **1.4 Other damage**

There was no other damage.

## **1.5 Personnel information**

The SK 682 flight crew consisted of a commander and a first officer. The cabin crew consisted of 3 flight attendants.

## **1.6 Aircraft information**

### **1.6.1 Aircraft Data**

Type/Model:	MD – 82
Fuselage number:	53002
Serial number:	1835
Registration date:	15 March 1991
Accumulated flight hours:	28 255
Accumulated flight cycles:	22 685

### 1.6.2 Engine Data

	Left	Right
Type:	JT8D-217C	JT8D-217C
Serial number:	725757	716722
Installed date:	14 October 2000	12 October 2000

### 1.6.3 Maintenance Records

Check Type	Base	Date
B – Check:	Stockholm	4 July 2003
P – Check:	Stockholm	29 September 2003
MSC:	Oslo	6 July 2003

### 1.7 Meteorological information

The weather in the region of the incident was influenced by high pressure. The air was stable and dry. The actual weather in the region of the incident was as follows:

Clouds:	1/8 – 3/8 cumuli, base at around 6500 ft AMSL
Weather:	no significant weather phenomena
Visibility:	20 km
Pressure:	QNH Lugano (LSZA) 1011 hPa, QNH Zürich (LSZH) 1017 hPa
Danger:	none

Wind at FL 320:	060° / 15 kts
Temperature at FL 320:	- 56° degrees celsius

### 1.8 Aids to Navigation

Not applicable.

### 1.9 Communications

Not applicable.

### 1.10 Aerodrome information

Not applicable.

## **1.11 Flight recorders**

### **1.11.1 Flight Data Recorder (FDR)**

Not analyzed.

All available Aircraft Condition Monitoring System (ACMS) parameters are stored in the Quick Access Recorder (QAR) cartridge.

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

The CVR recordings were of no use, as the circuit breaker was not pulled after the occurrence and the recording of the relevant communication was overwritten until the aircraft reached the parking position.

### **1.11.3 Quick Access Recorder (QAR)**

Data analyzed.

Per design only limited information is available for Cabin Supply Pressure, Cabin Altitude and Cabin Rate of Climb.

## **1.12 Wreckage and impact information**

Not applicable.

## **1.13 Medical and pathological information**

Not applicable.

## **1.14 Fire**

Not applicable.

## **1.15 Survival aspects**

Not applicable.

## **1.16 Tests and Research**

Maintenance performed different pressure tests with running engines in connection with pressurizing and depressurizing the cabin (simulated flight conditions). These tests were performed according to manufacturer's instructions. All parameters were within limits.

During operation of the air-condition system on ground, maintenance found the ground air check valve near the ground pneumatic connector leaking. After replacing the check valve, the aircraft was released to service by maintenance.

The same flight crew transferred the aircraft from Zurich as ferry flight to Stockholm (ARN) 14 July 2003.



ACARS circuit breaker was reset prior to the ferry flight, but the ACARS system was reported unserviceable during the whole flight. Left and right air-condition system operated without any remarks, and the problem seemed to have been corrected.

The ground air check valve underwent investigation by the SAS Company Investigation Team (CIT). The investigation revealed a partly worn flapper seal, but this seal leakage could not have caused both air-condition systems to shutdown.

During further troubleshooting following actions have been performed:

<b>Action:</b>	<b>Findings:</b>
• Single engine second segment climb switches tested	no remarks
• Cabin diff pressure switches tested	no remarks
• Left/right primary heat exchangers tested	no remarks
• Fuselage leakage check performed solenoid wiring checked	no remarks
• Left/right air-condition system pressure regulator valve solenoid wiring checked	no remarks
• Wiring between R2-147 / R2-148 terminal X2 to diff pressure switch 1 S1-485 checked	no remarks
• Left/right air-condition systems compressor discharge and turbine inlet terminal switches tested	no remarks
• Left/right air-condition system shutdown switches tested	no remarks
• Flow control valve sense lines and ram air scope checked for obstruction and/or leakage	no remarks
• ACARS MU replaced and tested	no remarks
• Replaced ACARS MU was investigated by the workshop	an internal short-circuit was found at power supply circuit board A4
• ACARS MU was sent to Rockwell Collins, Cedar Rapids for further investigation and repair	done
• Shop report requested from Rockwell Collins after investigation	done

Due to the assumption that an internal short-circuit in the ACARS MU caused both air-condition system to shutdown, it was decided by the Engineering Department to coil and stow the suspect aircraft wiring in accordance with MTO-231099. The MTO, applicable to all SK Airline MD-80, was started 18 July 2003.

MTO completed 26 July 2003.

MD80 Aircraft Condition Monitoring System (ACMS) application:

The SK Airline MD80 fleet has aircraft wiring installation prepared for an ACMS application system. This system is designed to sample aircraft and engine parameters and process reports. The reports are processed in the ACARS Management Unit before being down linked. An input parameter is obtained from a

discrete input pin, an ARINC 429 broadcast input word, the FDAU 573 databus or a derived source (e.g. Flight Mode process, Pressure Altitude calculation). Left and right air-condition systems operation is detected by a discrete input to the ACARS Management Unit. Discrete input from left and right air-condition system is used to set the primary condition for stable cruise processing.

The system had been tested but was still not active due to the non-availability of the ACARS MU Mini ACMS application software.

### **1.17 Organizational and management information**

The ACARS system installation and associated aircraft wire installation was certified by the Federal Aviation Administration (FAA).

The installation had a Supplementary Type Certificate number STO1766AT-D issued by the FAA. The certificate was issued 01<sup>st</sup> December 1998.

The aircraft involved in the incident also had provision for a MD80 Mini ACMS application.

The system had wiring interface with left and right air-condition systems (discrete inputs to the ACARS Management Unit). The FAA certified the MD80 Mini ACMS Application wiring installation and discrete inputs. The installation was certified under the same Supplementary Type Certificate number STO1766AT-D issued by FAA and was issued 01 December 1998.

The local Authorities OPS-utvalget STK had also approved the MD80 ACMS Application System and associated wiring.

### **1.18 Additional information**

The airport authority Zurich informed the Swiss Federal Aircraft Accident Investigation Bureau about the incident.

An investigation according to ICAO Annex 13 was opened on the same day. The flight crew was interviewed in the office of the airport authority Zurich and the technical investigation was done by SR-Technics.

### **1.19 Useful or effective investigation techniques**

Not applicable.

## 2. Analysis

### 2.1 Technical aspects

During cruise at FL 320 the pilots noticed an increase in cabin altitude first by some discomfort in their ears. At the same time a HI-chime sounded but the pilots did not receive any ACARS messages on the MCDU or ACARS printer. This active ACARS advisory could not be reset using the Selcal Control Panel Reset Button and the pilots tried to reset the Attendants Call. The Attendant Call reset switch is located on the Overhead Annunciator Panel close to the Cabin Pressure Selector Panel. The Flow Light was observed during the attempt to reset the HI-chime. HI-chime continued after Attendant Call was reset. The Auto Throttle reverted to Clamp Mode and No Mode was illuminated at the Thrust Rating Panel. Left and right Cabin Supply Pressures were initially indicating approximately 10 PSI, but there was no flow in the air-condition systems. Due to no air supply from the air-condition system, the cabin started a climb at a rate of 1000 ft/min.

Left and right air-condition system shutdown was caused by a ground signal to both Air-condition Systems Auto Shutdown Relays R2-147 and R2-148. The aircraft wiring schematic shows a connection from ACARS MU DLM-900 pins TP11K and TP12A to the air-condition auto shutdown relays R2-147 and R2-148 (Appendix 2). Pins TP11K and TP12A are unique in the DLM-900 in that the pins are capable of functioning as both, inputs and outputs. These connections created an incorrect ground discrete signal to both, the left and right air-condition auto shutdown relays R2-147 and R2-148. The relays activated the left and right air-condition system pressure regulator valve solenoids and the left and right flow control valve solenoids. Both, the pressure regulator and the flow control valves and the left and right air-condition systems moved to the closed position, completing the air-condition auto shutdown.

A pressure of approximately 10 PSI was initially indicated after the air-condition system shutdown. This was due to an internal leakage in the left / right pressure regulator valves. Pressure built up in the air-condition pneumatic duct between the pressure regulator and the flow control valve. After a short period of time the pressure dropped and the pressure supply indicators indicated 0 PSI.

The incorrect ground discrete signal from the ACARS MU caused the left and right Thrust Rating Isolate Relays R2-254 and R-255.

The Maintenance Control Centre (MCC) had searched for irregularities with respect to the aircraft pressurization system. The malfunctioning of the cabin pressurization system or an associated component could not be duplicated on ground. The Maintenance Control Centre did not find a conclusive cause to the failure of either the pressurization, the pneumatic nor the air-condition system. The ground air-check valve in the pneumatic system was changed. Before changing the valve, a leak test was performed with a leak rate well within limits. Therefore the leaking ground air check valve could be excluded with high probability as source of the decompression. The ground air check valve was not relevant to the failure of the system and most probably not responsible for the cabin decompression.

The short-circuit in the ACARS management unit, which shut down the air-condition system without control, is the most logical cause.

This failure occurred due to an insufficient risk analysis being performed prior to the MD-80 ACARS MU Mini ACMS wiring installation.

## 2.2 Human and operational aspects

The decision of the flight crew to perform an emergency descent was appropriate. The diversion was necessary, as the final destination Copenhagen could not be reached with the actual amount of fuel due to the required low-level on an unpressurized flight.

If the Air Traffic Control Centre Zurich (Skyguide) would have informed the airport authority as soon as it became clear that an aircraft with problems diverts to Zurich, the ground organisation would have had more time to react and be ready for passenger care upon arrival of the aircraft at the final position.

### 3. Conclusions

#### 3.1 Findings

- All crew members held the necessary licences.
- The aircraft had no technical entries in the aircraft log in connection with cabin pressurization, pneumatics, or air-condition systems.
- Both left and right air-condition systems air supply stopped during cruise due to the left and right air-condition system auto shut down function being activated by an incorrect ground discrete signal from the ACARS MU DLM-900 (P/N 822-0666-003 S/N 538).
- The left and right air-condition system pressure regulator valves and flow control valves closed.
- Cabin altitude started to climb with a rate of approximately 1000 ft/min.
- The flightcrew tried to control the cabin pressure manually. The outflow valve was completely closed.
- The emergency descent was performed in accordance with the Emergency Descent Checklist and the Cabin Altitude Rapid Decompression Checklist.
- At FL 170 the cabin altitude passed 14 000 ft. The passenger oxygen masks deployed automatically as per design.
- The flightcrew declared an emergency situation and initiated a diversion to Zurich airport. The approach and landing to runway 14 were uneventful.
- Elapsed time from the occurrence until landing was 18 minutes.
- The exchange of relevant informations between Air Traffic Control (Skyguide) and the airport authority was not optimal. The consequence was a late reaction of the ground organisation. The passengers could be cared for only 15 minutes after the aircraft reached its parkposition.

### 3.2 Causes

- During cruise the cabin altitude started to climb with a rate of 1000 ft/min caused by left and right air-condition system shutdown.
- Air-condition systems shutdown caused by an incorrect ground discrete signal to the auto shut down function.
- Failure of the input power supply capacitor C20 was due to a combination of power transients that culminated in the failure of A4U28 circuit. The failure resulted in a ground discrete output signal being sensed.
- Incorrect sensed ground mode was caused by an internal short-circuit in the ACARS MU DLM-900.

Berne, 9 September 2005

Aircraft Accident Investigation Bureau

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## Appendix 1

### Abbreviation list

ACARS	Aircraft Condition and Reporting System
ACMS	Aircraft Condition Monitoring System
CB	Circuit Breaker
CIT	Company Investigation Team (SAS)
CL MP	Clamp (Autothrottle Mode)
DFGC	Digital Flight Guidance Computer
DLM-900*	Model number of an MU
FDAU	Flight Data Acquisition Unit
FL	Flight Level
MCDU	Multifunction Control Display Unit
MTO	Modification Technical Order
MU	Management Unit
TRP	Thrust Rating Panel

- \* DLM-900 circuit A2U28 is the device that drives pins TP11K and TP12A connected to the left/right air-condition system wiring.