REPORT C 1993:57

Air Traffic Accident on 27 December 1991 at Gottröra, AB county

Case L-124/91

SHK Statens haverikommission ■ Board of Accident Investigation

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Translated by *Tim Crosfield M.A.* from the original Swedish
at the request of the Board of Accident Investigation

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

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1993-10-20

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L-124/91

Swedish Civil Aviation Administration

601 79 NORRKÖPING

Report C 1993:57

The Board of Accident Investigation (SHK) has investigated an aircraft accident which occurred on 27 December 1991 at Gottröra, AB county, involving an aircraft with registration OY-KHO.

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

Olof Forssberg | S-E Sigfridsson

Nils Benker | Henrik Elinder

Rune Lundin | Jan Mansfeld

Identical letters to:

The Swedish National Rescue Services Board
The National Police Board

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Abbreviations

AC	Alternate Current
AOL	All Operators Letters
AOM	Aircraft Operations Manual MD-80
APU	Auxiliary Power Unit
ARCC	Aeronautical Rescue Coordination Center
ARTS	Automatic Reserve Thrust System
ATR	Automatic Thrust Restoration
ATS	Auto Throttle System
CLAMP	Fixed throttles
CVR	Cockpit Voice Recorder
DFDR	Digital Flight Data Recorder
DFGC	Digital Flight Guidance Computer
DFGS	Digital Flight Guidance System
EFIS	Electronic Flight Instrument System
EGT	Exhaust Gas Temperature
EPR	Engine Pressure Ratio
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulations
FF	Fuel Flow
FMA	Flight Mode Annunciator
FOD	Foreign Object Damage
FOM	Flight Operations Manual
GA, G/A	Go around
GCU	Generator Control Unit
KIAS	Knots Indicated Air Speed
LMH	Line Maintenance Handbook
METAR	Aviation Routine Meteorological Report
N_1	Fan and low pressure rotor speed
N_2	High pressure rotor speed
NTSB	National Transportation Safety Board
PLA	Power Lever Angle
QAR	Quick Access Recorder
RM	Route Manual
SB	Service Bulletin
UTC	Universal Time Coordinated

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Report C 1993:57

Case L-124/91
Report finalized 1993-10-20

Aircraft; registration and type	**OY-KHO**, Douglas DC-9-81 (MD-81)
Time of incident	27-12-1991, 0851 hrs *Note:* All times in the report are given in Swedish normal time (SNT) = UTC + 1 hour
Place	Gottröra, AB County (pos 5946N 1808E)
Type of flight	Scheduled traffic
Weather	METAR Stockholm/Arlanda 0850 hrs: Wind 360°/11kts, visibility >10km, light intermittent snowfall, cloud 2/8 stratus base 600 ft, 6/8 stratus base 800 ft, temp/dew-point -0°C/-1°C, QNH 1013 hPa Sunrise 0848 hrs
Runway conditions	Taxiways 0830 hrs: Wet or pools, ice and packed snow, coverage 50%, mean depth 1 mm. Runway 08, 0830 hrs: Wet or pools, coverage 25%, mean depth 1 mm, braking action good.
Numbers on board	*Crew:* 6 *Passengers:* 123[1]
Personal injury	8 seriously injured, 84 slightly injured, the rest uninjured
Damage to aircraft	Totally destroyed
Captain's age, certificate	44 yrs, (Danish D)
Captain's flying hours	8,020 hrs, of which 590 on the type
First Officer's age, certificate	34 yrs, (Swedish B) with instrument rating
First Officer's flying hours	3,015 hrs, of which 76 on the type

The Board of Accident Investigation (SHK) was notified at 0911 hrs on 27 December 1991 that an aircraft with registration markings OY-KHO had crashed at 0851 hrs on that day shortly after takeoff from Stockholm/Arlanda airport, AB county.

The incident has been investigated by SHK represented by Olof Forssberg - chairman, S-E Sigfridsson - survival aspects, Nils Benker - flight operational matters, Henrik Elinder - flight technical matters, Rune Lundin - accident site investigation and Jan Mansfeld - rescue services matters.

[1] One passenger was a child under 2 years who according to international practice was registered in the passenger list together with its guardian as an "infant".

SHK was assisted by the following experts:

Engine and systems
Johan Claesson, Stig Laurell, Timo Pettersson, Bengt Rehn and Nils Sundin

Aircraft structure
Sten Öberg

Flight operations
Jorma Eloranta

Cabin safety
Agnetha Dahlqvist

Medicine
Lars Laurell and Henry Lorin

Training etc.
Sture Boström and Kristina Pollack

Police activities
Bertil Enemo

The investigation was followed by:

- *Swedish Civil Aviation Administration*
- *National Transportation Safety Board (NTSB)*, USA, by Thomas E. Haueter
- *Aircraft Accident Investigation Board (AAIB)*, Denmark by C.E. Hjort Pedersen

SHK has sent the draft final report to NTSB and AAIB for comments. NTSB's comments are included in the final report as Appendix 6.

Summary

The aircraft which was operated by Scandinavian Airlines System (SAS) took off on 27 December 1991 at 0847 hrs from Stockholm/Arlanda airport. It had landed at Stockholm/Arlanda at approx 2210 hrs the previous day and had been parked outdoors overnight. Prior to takeoff the aircraft was de-iced.

The captain made a rolling takeoff which was normal up to the rotation. In connection with liftoff the captain heard an abnormal noise which he could not identify. The noise was recorded by the aircraft's Cockpit Voice Recorder (CVR) as a low humming noise.

After approx. 25 seconds flight the right engine started to surge. The captain throttled back on that engine somewhat, but without the surging ceasing. The surges continued until the engine stopped delivering thrust 51 seconds after the surges had started.

When the flight had lasted approx. 65 seconds the left engine also started to surge, which the pilots did not notice before this engine also lost thrust. This happened two seconds after the right engine had failed.

When the engines had failed the crew prepared for an emergency landing. When the aircraft was entirely out of the cloud at a height of 300 to 250 metres the captain elected to try and land in a field in roughly the direction of flight, north-east of Stockholm/Arlanda. During the approach to the selected field the aircraft collided with trees. In the collision, the major part of the right wing was torn off. The tail of the aircraft struck the ground first. After impact the aircraft slid along the ground for approx. 110 metres before stopping. The fuselage was broken into three pieces on impact and during the subsequent braking on the ground. No fire broke out. One passenger incurred a disabling back injury. Apart from four persons, all on board made their own way out of the aircraft.

The Board of Accident Investigation finds that the accident was caused by SAS' instructions and routines being inadequate to ensure that clear ice was removed from the wings of the aircraft prior to takeoff. Through this, the aircraft took off with clear ice on the wings. In connection with liftoff clear ice came loose and was ingested by the engines. The ice caused damage to the fan stages of the engines which led to engine surging. The surges destroyed the engines.

Contributory causes were:

- The pilots were not trained to identify and correct engine surges.
- ATR – which was unknown within SAS – was activated and increased engine throttles without the pilots' knowledge.

As a result of its investigation the Board of Accident Investigation is submitting 15 recommendations.

1 Factual Information

1.1 History of the flight

An aircraft of type DC-9-81 operated by Scandinavian Airlines System (SAS) and registered in Denmark with the markings OY-KHO landed at Stockholm/Arlanda Airport on 26 December, 1991, at 2209 hrs. It came from Zürich and had been flown at cruising altitudes at which the external air temperature varied between -53 and -62°C. The flight at these altitudes had lasted approx. 1 hour and 40 minutes. On landing there remained approx. 2,550 kg fuel in each wing tank.

After landing the aircraft was parked at gate 2 at the international terminal. During the night a flight technician inspected the aircraft. He was compelled to clean slush from the landing gear to be able to inspect it. When he left the aircraft on 27 December at approx. 0200 hrs he noted that ice had formed on the upper surface of the wings. The air temperature had up to that point been +1°C.

On the morning of 27 December the aircraft was to be flown to Copenhagen on SAS flight SK 751 with scheduled departure at 0830 hrs.

The mechanic responsible for handing over the aircraft on the morning of 27 December noted at about 0730 hrs frost coverage on the underside of the wings. He therefore checked whether there was ice on the upper side of the left wing by climbing a ladder, putting one knee on the wing and feeling the forward part of the wing with his hand. He found no ice, but did find slush. Using a ladder he checked the air inlet of the left engine and found nothing abnormal. At 0650 the external air temperature had sunk to +0°C. At 0820 hrs an external air temperature of -0°C was recorded.

The aircraft was fuelled with 1,400 kg of fuel and was ready for de-icing at 0830 hrs. The mechanic had after consultation with the captain ordered de-icing of the underside of the wings also, because of the frost they had seen there. There had been no discussion of clear ice.

During de-icing of the upper side of the wings the mechanic after a first spraying with de-icing fluid ordered further de-icing to make sure that the wings would be free of slush. For the de-icing a total of 850 l de-icing fluid type I was used. The temperature of the fluid was approx. 85°C. After de-icing the mechanic did not check whether there was any clear ice on the upper side of the wings, since he had previously found none.

The person who operated the spray nozzle of the de-icing truck has stated that he saw that one of the four indication tufts fixed to the upper side of each wing moved during the spraying. A passenger who had been sitting in a window seat reported that the tufts on the wing he could see through the window did not move during the spraying.

The mechanic reported to the captain "Yes, de-icing finished". During the engine startup procedure the captain asked "And they've got it good and clean under the wings?" The answer was "Yes, there was a lot of ice and snow, now it's fine, it's perfect now". This part of the conversation between the captain and the mechanic ended with the captain saying: "That sounds fine, then, thanks".

While the aircraft was being de-iced the pilots carried out a routine run-through of, among other things, the departure procedure from Stockholm/Arlanda. During this the captain mentioned, regarding the procedure for engine failure "Engine failure follow... 2000... that's very general".

After engine startup the captain taxied the aircraft to runway 08. The engine de-icing systems were 'on' for both engines and there was no indication of malfunction in the systems. While taxiing out the captain initially steered the aircraft somewhat to the side of a strip of slush, which was finally crossed at low speed. The average speed during the taxiing, which took approx. two and a half minutes, was 15 kts (28 kph). The captain made a rolling take-off which up until the rotation went normally. The Auto Throttle System (ATS)[1] was engaged.

The captain started to rotate the aircraft at 0847.07 hrs. Three passengers have said that they saw ice coming off the upper side of the wings as the aircraft took off. At the same time the captain heard an abnormal noise which he could not identify. The sound was recorded by the Cockpit Voice Recorder (CVR) as a low hum.

After about 25 seconds' flight bangs, vibrations and jerks were perceived in the aircraft. The jerks were experienced as repeated heavy braking.

The pilots realised that engine malfunctions had developed and, using the engine instruments, traced the malfunctions to the right engine. The first officer said "... think it's a compressor stall". The captain has stated that - because of the vibrations and the rapid changes in the digital presentation - he had difficulty in reading the engine instruments. He reduced right throttle somewhat, but without the malfunction ceasing. The throttling-down was recorded as a reduction from 1.904 EPR[2] to 1.870 EPR. Altitude was then approx. 2,000 ft (600 m)[3] and 43 seconds had passed since commencement of rotation.

It can be seen from the aircraft's flight recorder that engine surges had occurred. In the right engine the first surge was recorded 25 seconds after rotation. The aircraft was then at 1,124 ft (343 m) and in cloud. The autopilot was not switched on. According to the flight recorders, throttle control simultaneously changed to an automatic mode which increased throttle setting with altitude. This was indicated discreetly on the instrument panel but not noticed by the pilots.

In the left engine the first surge was recorded 64 seconds after rotation. The pilots never realised that the left engine was surging.

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[1] The system is described under 1.6.4.4.

[2] Engine Pressure Ratio (EPR) gives the relation between the engine's total outlet pressure and inlet pressure, and is a reference value for engine thrust.

[3] Unless otherwise stated, altitudes given are the aircraft's height above mean sea level (MSL). Stockholm/Arlanda is 123 ft. (40 metres) and the site of the crash 82-115 ft (25-35 metres) above MSL.

An attempt to switch on the autopilot at an altitude of 2,616 ft (797 m) failed and activated the voice warning "Autopilot". The warning continued for the rest of the flight.

The right engine failed 51 seconds after the first engine surge had been recorded. The left engine failed two seconds later, 78 seconds after rotation. The aircraft's indicated speed was then 196 kts (363 kph) and indicated altitude 3,206 ft (977 m). Shortly after this the aircraft reached its greatest indicated altitude 3,318 ft (1,011 m).

Slightly later the two EFIS display screens in front of the captain went dead. He made no attempt to recover the EFIS presentation so during the rest of the flight had to rely on a smaller backup instrument for his flight attitude information.

The first officer has stated that it was only when the engines stopped that he noted the warning indications from the engine instruments and saw that the outlet temperatures were over 800°C. Thirteen seconds after all thrust had ceased, fire warning was given for the left engine. The first officer then activated the fire extinguishing system for that engine. Grey smoke was noticed in the forward part of the aircraft. Fire warning ceased after 26 seconds.

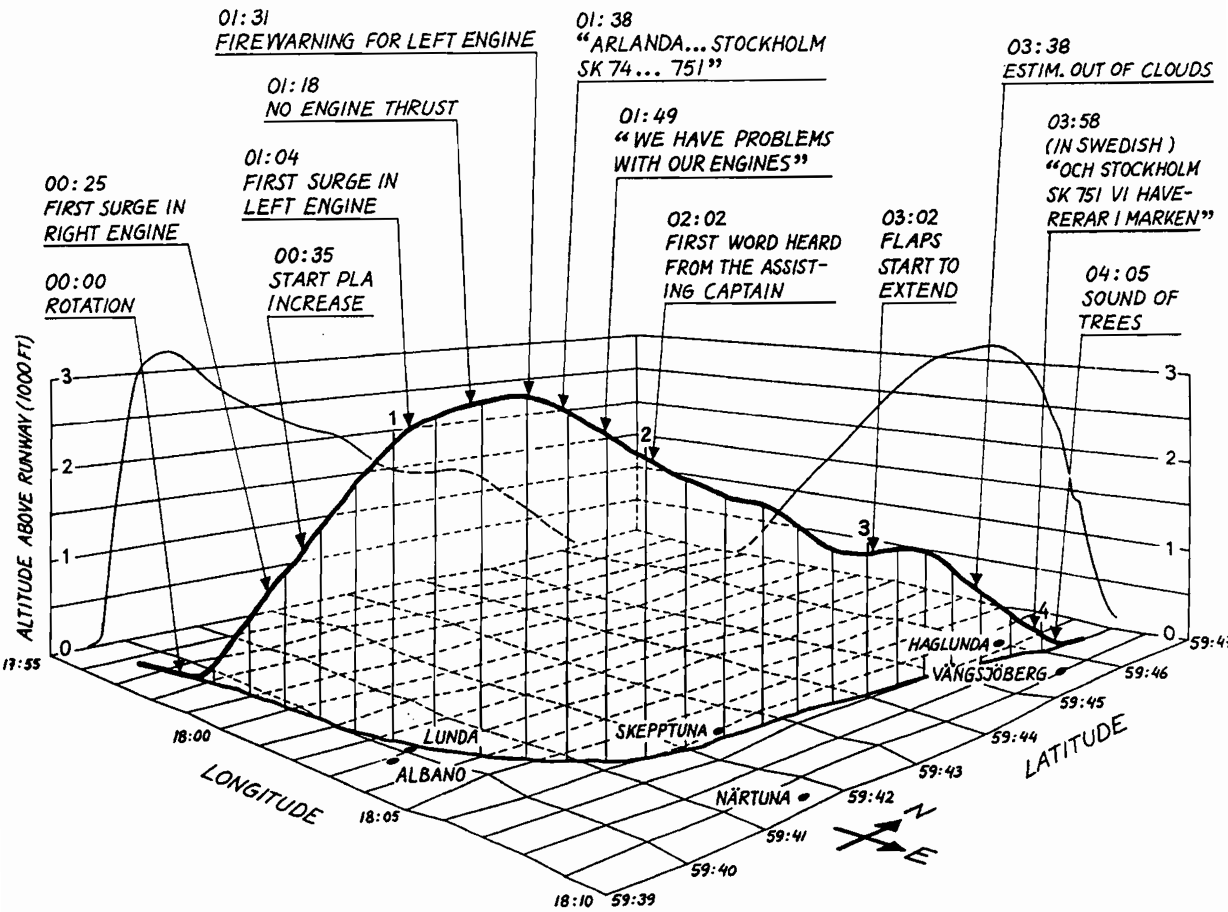
The air hostess sitting in the cabin rear jump seat was informed by a flight captain travelling privately that the right engine was surging. She tried unsuccessfully to contact the aircraft's captain on the intercom to notify him. She then got the message to the purser who passed it on to the captain.

A uniformed SAS captain in seat 2C realised that the crew were having problems. He hurried to the cockpit and asked if he could be of any help. The first officer gave him the emergency/malfunction checklist and the captain instructed him to start the auxiliary power unit (APU). The assisting captain's voice was first recorded two minutes and two seconds after rotation when he said "Look straight ahead". He then urged the captain several times to "look straight ahead".

Once the engines had lost all thrust the crew prepared for emergency landing. The captain began to glide the aircraft in a gentle left turn which was interrupted on an approximately northerly heading. At the same time the first officer notified Stockholm control that there were engine problems and asked to return to Stockholm/Arlanda. The air traffic controller ordered a right turn to bring the aircraft back for landing at Stockholm/Arlanda (runway 01). The captain continued, however, the northerly glide. The captain called several times "Prepare for On Ground Emergency". The order was passed aft once by the assisting captain. The purser made a complete announcement over the PA system in accordance with the notification.

When the aircraft was approx. 420 m above the ground and still in cloud the assisting captain started gradually extending the flaps. According to the flight recorders, speed was then approx. 165 kts. The flaps were fully extended approx. 30 seconds later at a height of approx. 300 m above the ground. At a height of approx 340 m (1,100 ft) above the ground the captain said: "Flaps eh ... eh", whereupon the assisting captain answered: "Yes, we have flaps, we have flaps, look straight ahead, look straight ahead!"

Flight path



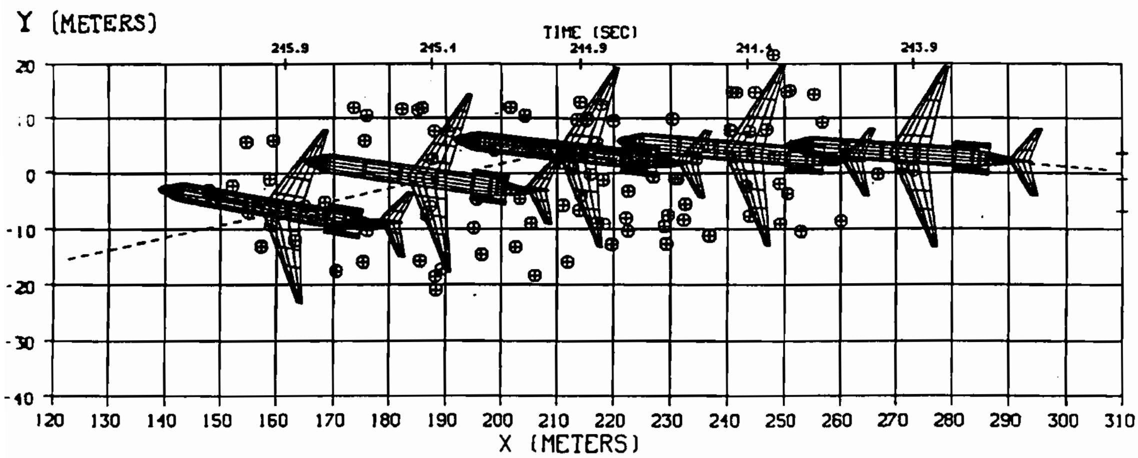
When the aircraft was entirely free of the cloud at 300 to 250 m (980 to 820 ft), the captain judged that a large field far to the right could not be reached. Instead he chose to attempt an emergency landing in a field more or less in his direction of flight, north-east of Stockholm/Arlanda. During the approach to the field the captain corrected his heading about 25° to the right to avoid houses further on in the intended direction of landing.

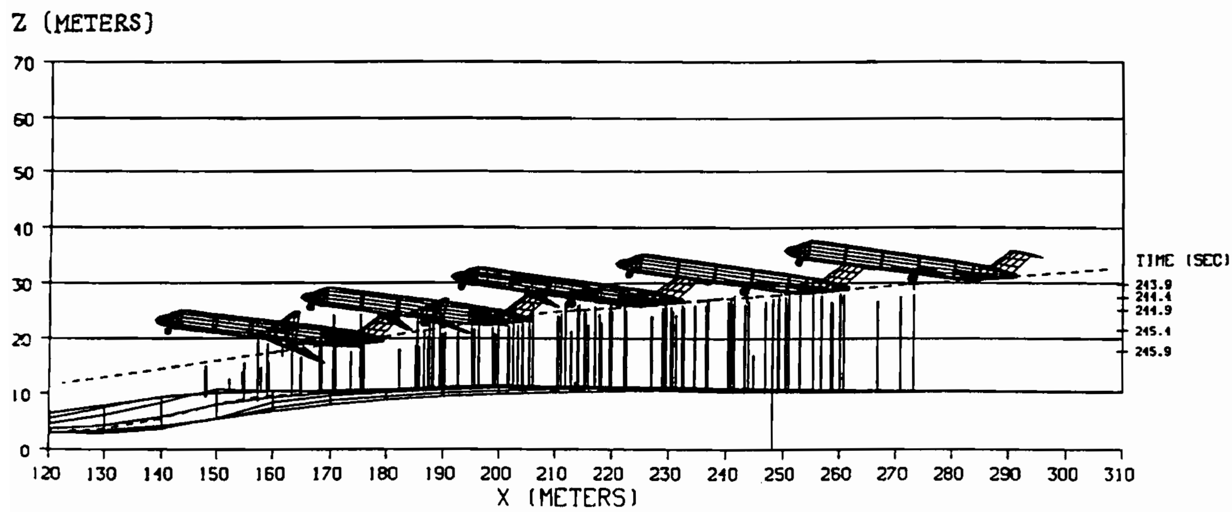
Seventeen seconds before the aircraft struck the ground the first officer asked "Shall we get the wheels down?" This was answered by the assisting captain with the call: "Yes, gear down, gear down." Eight seconds later, when height was 56 m, the first officer reported to Stockholm control: "and Stockholm SK 751 we are crashing to the ground now." A further seven seconds later the sound of contact with trees was recorded on the CVR.

According to the flight recorders the landing gear was extended and locked at about the same time as the aircraft hit the first trees. The speed had then decreased to 121 kts. The major part of the right wing was torn off and the aircraft began to bank right. The last flight recording one second before impact was 107 kts, with a 19.7° right bank.

Four minutes and seven seconds after rotation the aircraft hit sloping ground, first with the tail. On impact, a right bank of 40.1° was recorded. After impact the aircraft slid along the ground about 110 m before stopping. The fuselage was broken into three on impact and during the subsequent braking along the ground. There was no fire. All 129 on board survived. Except for four persons, all made their way out of the aircraft themselves.

The final phase of the flight





1.2 Personal injuries

	Crew	*Passengers*	*Others*	*Total*
Fatal	–	–	–	–
Seriously injured	1	7	–	8
Slightly injured	3	81	–	84
No injuries	2	35	–	37
Total	**6**	**123**[4]	–	**129**

1.3 Damage to the aircraft

The aircraft was totally destroyed on impact.

[4] One of the passengers was an infant under two years who according to international practice was recorded in the passenger list together with the guardian as "infant".

1.4 Other damage

Shortly before striking the ground the aircraft collided with a number of large coniferous trees. Over an area of about 125 m in length and in breadth corresponding to the aircraft's wingspan, trees were broken.

At the time the ground had a frozen crust and was covered with some centimetres of snow. When the aircraft struck the ground, limited ground damage was caused to a grass infield.

Following collision with the trees some 3,600 l of aviation fuel was spread from the right wing tank over two areas of about 900m² each. From the left wing tank about 250 l of remaining fuel was dealt with during decontamination. The remainder, about 3,300 l, was spread over an area of about 900m² on impact.

Approx. 100 l of hydraulic fluid drained into the area of impact.

During the fuel decontamination a number of draining ditches were dug for collecting aviation fuel and hydraulic fluid.

1.5 The crew

1.5.1 The captain

Sex Male
Age 44 yrs
Certificate Airline Transport Pilot's Licence (Danish D)

Flying hours

previous ...	*24 hours*	*90 days*	*Total*
All types	3	154	8,020
This type	3	154	590

Number of landings this type previous 90 days: 101
Flight training on type concluded 25-07-1990.
Latest periodic flight training (PFT) carried out 29-09-1991 in DC-9-80 simulator.
Latest supervision flight 26-09-1991.

The captain received his flight training in the Danish Air Force, where he flew F 104 Starfighters, subsequently transferring to DC-3's. He was appointed as a pilot with SAS in 1979, where he flew DC-9's until 1984. Thereafter he flew Fokker F-27's until 1990. On 24 August 1990 he was approved as a captain on MD-80's.

1.5.2 The first officer

Sex _ Male
Age 34 yrs
Certificate Commercial Pilot's Licence (Swedish B) with instrument rating

Flying hours

previous...	*24 hours*	*90 days*	*Total*
All types	0	74	3,015
This type	0	74	76

Number of landings this type previous 90 days: 47
Flight training on type concluded 13-11-1991.
Completed base release 13-12-1991.

The first officer received his flight training in the Swedish Air Force, where he flew mainly AJ 37 Viggen. He was appointed as a pilot with SAS in 1987. He served the first four years as system operator on DC-10's. For three of those years he was an instructor.

1.5.3 Cabin crew

	Sex/age	*Flying hours*	*Latest emergency training*	*Flying hours last 24 hrs before flight in question*
1	Female, 45 yrs (Purser)	8,058, of which on DC9 6,472	04-12-1991	0
2	Female, 26 yrs	1,967, all on DC9	10-09-1991	4 hr 31 min
3	Male, 26 yrs	1,248, all on DC9	12-10-1991	2 hr 12 min
4	Female, 33 yrs	1,280, all on DC9	29-08-1991	0

1.6 The aircraft

1.6.1 Basic data

Owner:	Kastrup Aircraft Limited, 2-2-1 Ohtemachi, Chiyoda-ku, Tokyo 100, Japan
Operator:	Scandinavian Airlines System Frösundaviks Allé 1, S-161 87 Stockholm, Sweden
Type:	McDonnell Douglas DC-9-81 (MD81)
Serial number:	53 003
Year of manufacture:	1991
Gross weight:	Max permissible 64,410 kg (142,000 lbs), current 55,017 kg (121,290 lbs)
Centre of gravity:	Within permitted limits (17% MAC/LIZFW 24 on takeoff)
Engine manufacture:	Pratt & Whitney
Engine model:	JT8D-217C (JT8D-219 derated)
Number of engines:	2
Fuel loaded before event:	Jet A1
Aircraft	
Total flying time:	1,608 hrs
Number of cycles:	1,272
Operating time since latest periodic check:	
Daily inspection	0 hrs
Weekly inspection	19 hrs
A3- inspection	159 hrs
Left engine	S/N P725828D
Total operating time:	1,608 hrs
Number of cycles:	1,272
Right engine	S/N P725833D
Total operating time:	1,608 hrs
Number of cycles:	1,272

For aircraft OY-KHO, Danish Certificate of Airworthiness No. 2564 valid until 30 June 1992 was issued.

1.6.2 Aircraft type MD-81

1.6.2.1 Certification

The official designation of the aircraft type is DC-9-81. This may be supplemented with the abbreviation MD-81 but only together with the official designation.

The type is the basic version of the MD-80 series (earlier Super 80) manufactured by McDonnell Douglas in California, USA. The MD-80 series is a development of aircraft type DC-9. The fuselage is 45.1 m long and the wings have a span of 32.9 m. The fuselage cross-section is the same as that of the DC-9.

The MD-81 was certified by the Federal Aviation Administration, FAA, on 26 August 1980. The certification was based on the type certification of aircraft DC-9 of 23 November 1965.

The certification inspection was governed by the Federal Aviation Regulations (FAR). On certification it was stated – for reasons of cabin safety – that the aircraft should meet the requirements of chap. 25 FAR with amendments 25-1 through 25-40. Amendment 25-40 came into force on 2 May 1977. Later amendments did not need to be applied.

1.6.2.2 Design of fuel tanks

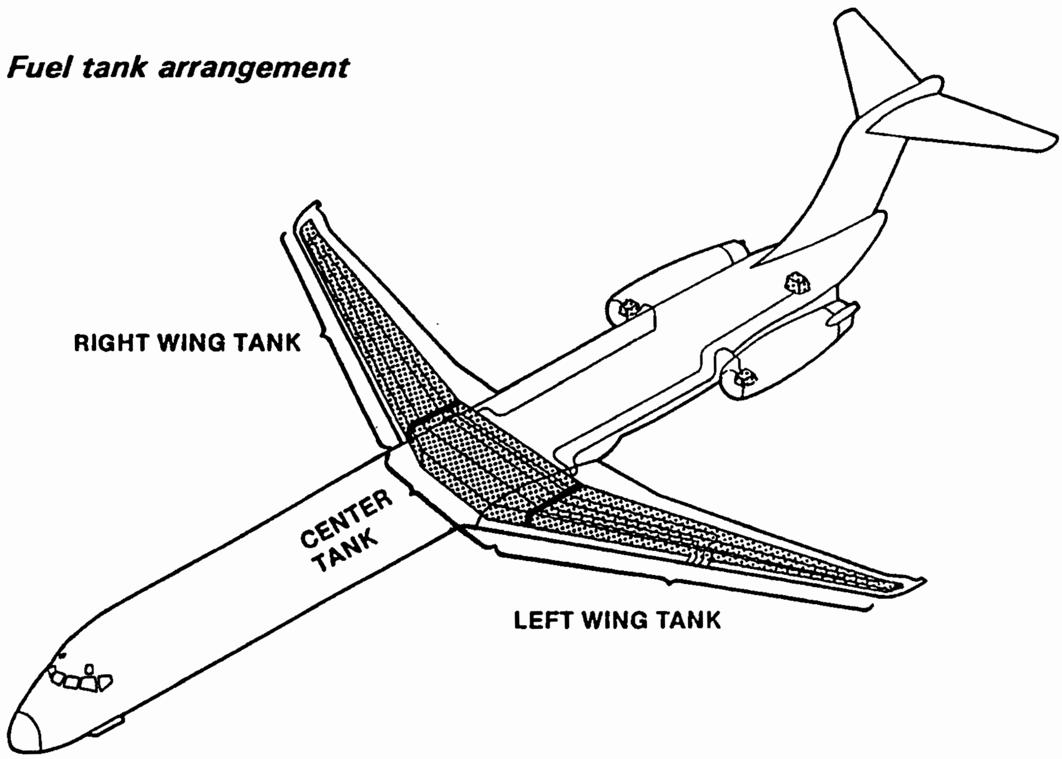
The MD-81 has three separate fuel tanks:

	Capacity
Centre tank	9,340 kg
Left main tank (wing tank)	4,200 kg
Right main tank (wing tank)	4,200 kg
Total capacity at density 0.803 kg/litre:	**17,740 kg (22,092 l)**

The centre tank, which is the only fuselage tank in the MD-81, extends partly out in the wings and separated from the wing tanks by a bulkhead at approx. 1.6 m from the fuselage. Here also are the lowest point and greatest depth of the wing tanks. The tanks are of the "integral" type, which means that their outer skin is formed by the actual wing and fuselage structure which has been rendered fluid-proof. The centre tank supplies both engines with fuel. Each wing tank normally supplies the engine on the same side of the fuselage as itself. The centre tank is normally emptied first, then the wing tanks.

Pressure fuelling is carried out from a central fuelling panel in one wing. The wing tank filling pipes empty into the outer end (near the wing tips) which are near the highest points of the tanks.

Fuel tank arrangement



1.6.3 Engines

1.6.3.1 General

The engines of the MD-81 are a further development of the engines which power the DC-9. Among other things the two fan stages have been replaced by one fan stage and the air intake area increased by approx. 30%.

Each engine is mounted on a pylon on the rear part of the fuselage. The engine centre line is approx. 1.0 m outside the fuselage and approx. 0.8 m above the upper surface of the wings. The engine air intake diameter is approx. 1.2 m.

The engine is of turbofan type. It has two rotors, a low-pressure rotor and a high-pressure rotor, each consisting of a compressor and a turbine and intermediate rotor shaft. Forward of the front compressor, on the same rotor shaft, a fan accelerates air through an outer by-pass duct surrounding the core engine and also feeds the core engine compressors with air.

1.6.3.2 Thrust

Engine version 217C is certified to develop a maximum thrust of 20,850 lbs (9,457 kp) for at most five minutes (ten minutes during single-engine flight). The maximum permissible exhaust gas temperature (EGT) is 625°C for five minutes and 630°C for two minutes. To reduce engine wear and noise, maximum thrust is not normally used on take-off.

The required thrust is normally calculated by the Thrust Rating Computer in the DFGS (see 1.6.4.1) and is checked by the pilots using tables.

The following defined thrust levels according to SAS AOM MD-80 Vol 2 are of interest:

MAX TAKEOFF (MTO)
Certified maximum permitted takeoff thrust. The thrust is attained in the EPR interval 1.99–1.83.

NORMAL TAKEOFF (NTO)
Fixed reduced MTO thrust. The thrust is attained in the EPR interval 1.93–1.77.

GO-AROUND (G/A)

Thrust for go-around after aborted landing. The thrust is attained in the EPR interval 1.96–1.82.

CLIMB (CL)
Thrust for normal climb after takeoff. Thrust is attained in the EPR interval 2.08–1.64. In the present case CLIMB EPR should have been 1.86 at 1,500 ft altitude.

1.6.3.3 Engine surging

Aerodynamic disturbances in a compressor in operation can lead to engine surging. This occurs at high power setting when the compressor is no longer able to compress the incoming air to the pressure obtaining in the engine's combustion section. The air flow then suddenly reverses, is shot violently in the opposite direction and a surge occurs. In favourable conditions the engine normally recovers directly the pressure in the compressor and combustion section sinks. But if the original aerodynamic disturbances persist, a new surge can rapidly develop. Normally, repeated surges cease if the power setting is reduced sufficiently.

Engine surging entails very great thermal and mechanical strains, which can cause damage to the engine. Special inspection is normally required when an engine has surged.

The surge margin is a way of expressing the engine's resistance to aerodynamic disturbances. Greater margins give better conditions for the engine to absorb external and internal aerodynamic disturbances without developing surging. The surge margin varies between engine types and individual engines. Damage or wear to fan blades, compressor blades or guide vanes and much clearance between blades and external seals are factors that can cause aerodynamic disturbances in a compressor. The disturbances can alter the relationship between the rotors' rotation speeds, which can reduce the surge margin.

A comparison between the engine type in the MD-81 and other available engine types of the same category including the DC-9 type, shows that new engines of these types have approximately the same surge margins.

1.6.3.4 Design regulations regarding ingestion of foreign objects into the engines

The design regulations for the aircraft type (FAR part 25 and part 33) include requirements regarding the engine's tolerance of the ingestion of foreign objects, and rules for the siting of the engines.

The relevant FAR chapters may be summarised as follows:

FAR 33.77 – Foreign object ingestion
The engines shall under normal operating conditions tolerate ingestion of foreign objects (max 2.14 kg) assumed to be birds, ice, hail or water. By ice is meant such ice as may form in the air intake during flight. The engine shall tolerate the ingestion of water in certain quantities and hail of specified size and intensity.

FAR 25.1091 - Air intake
The aircraft shall be designed so that water and slush on runways and taxiways cannot be sucked into the engine air intakes in injurious quantities. Air intakes shall be so placed as to minimise the risk of ingestion of foreign objects.

1.6.4 Automatic systems

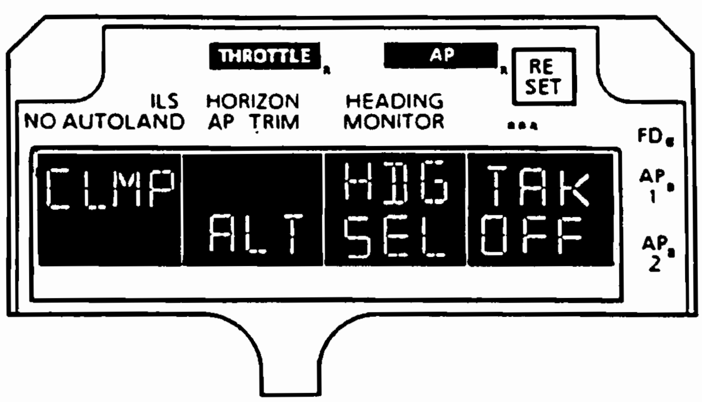
1.6.4.1 Digital Flight Guidance system (DFGS)

DFGS is a dual autopilot and navigation system for reducing the pilots' work load. The autopilot is certified for use from 200 ft. above the ground after takeoff. In the system's two main computers, Digital Flight Guidance Computers (DFGC) are integrated a number of functions such as Flight Director (FD), Thrust Rating Computer (TRC), Auto Throttle system (ATS), Automatic Reserve Thrust System (ARTS), Automatic Thrust Restoration (ATR) and others. During operation, both DFGS systems are active and supply each pilot with flight information and instructions.

1.6.4.2 Flight Mode Annunciator (FMA)

The FMA provides each pilot with information on the current status of the DFGS.

The information is presented in the indication dial on the panel of the instrument.
The instrument panel has two identical FMA's.

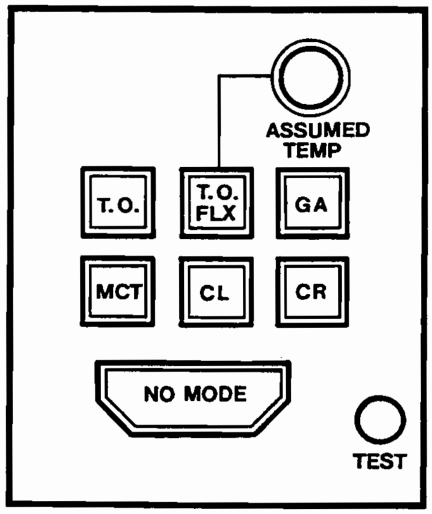


1.6.4.3 EPR Select Panel

On the EPR select panel, on the middle instrument panel, the pilots can select the desired thrust level (see 1.6.3.2), using buttons on the panel.

When a button is pressed, it lights up. The Thrust Rating Computer (TRC) then calculates the correct EPR for the thrust level specified on the EPR Select Panel.

The information affects, among other things, the Auto Throttle System (ATS).



1.6.4.4 Auto Throttle System (ATS)

The ATS is a DFGS function which automatically manoeuvres the engine throttles. This takes place simultaneously and equally. The engines are synchronised within a limited range to the same EPR. The pilot can always override the throttles manually, or immediately cut out the automatic system with a switch on either throttle lever.

During the takeoff roll the automatic throttle control function is automatically cut out at a speed of 60 KIAS. The throttle levers are then retained in their present positions by the "CLAMP" function. The CLAMP function ceases as soon as a different thrust level is selected.

1.6.4.5 Automatic Thrust Restoration (ATR)

Certain airlines, but not SAS, employ noise abatement thrust cutback procedures. When these procedures were approved, the FAA made certain views known. These led to the type being equipped with a system that in a case of engine failure automatically increased the thrust of the other engine. The system, which functions independently of ARTS, was certified in March 1983 and subsequently introduced as standard irrespective of whether the special takeoff procedure was used. Not until 1992 was the designation Automatic Thrust Restoration (ATR) introduced in the FAA Approved Airplane Flight Manual and in the MDC Flight Crew Operating Manual. The present report uses the term ATR even though this term had not been introduced at the time of the accident.

The ATR, like the ARTS, is a DFGS function and records if an engine stops. When the ATR is activated the CLAMP function ceases, ATS is reactivated and the thrust level automatically changes to G/A, which corresponds to an "active" and normally higher EPR (increases on increased speed and altitude). If ATS is switched on and EPR for G/A is higher than EPR for NTO, the engine throttle levers are automatically moved forwards until the thrust of one engine reaches EPR for G/A.

ATR is automatically *armed* if the following three conditions are met:

- The Flight Director pitch axis is set for Takeoff.
- The Aircraft's height above the ground is more than 350 ft.
- The current EPR of both engines is below EPR for G/A.

ATR is *activated* automatically when, among other times, engine EPR's differ by 0.25 or more at the same time as engine N_1 speeds differ by 7% or more in the same direction.

There is no special indicator lamp showing that the ATR has been activated but the pilots can read this out from the following:

- "CLMP" indication on FMA changed to "EPR G/A".
- "T.O." button extinguished and "GA" button lighted up on EPR Selector Panel.
- Throttle levers move forwards.

It emerged during the inquiry that there was within SAS no knowledge of the ATR at the time of the accident. A description of the system was, however, included in the FAA Approved Flight Manual under the heading "Manual Thrust Cutback Procedures for Noise Abatement" and in McDonnell Douglas' Flight Crew Operating Manual under the heading "Select Flight Director/Autopilot Takeoff Mode". The system was not, however, included in the aircraft manufacturer's internal technical material for delivery test flights, the Production Flight Procedure Manual (PFPM).

1.6.4.6 Automatic Reserve Thrust System (ARTS)

The ARTS, which is a DFGS function, is a condition for permitting the aircraft type to be operated with fixed reduced takeoff thrust (NTO). The purpose of ARTS is, in the case of single engine failure, to ensure maximum takeoff thrust (MTO) on the functioning engine.

For takeoff with NTO thrust, ARTS is *armed* before the aircraft leaves the ground, provided that the ARTS switch is in the "AUTO" position.

The ARTS records a loss of thrust by comparing the engine N_1 speeds and is *activated* if there is a difference in RPM of 30.2% for at least 0.05 seconds, provided that the N_1 RPM of both engines simultaneously exceeds 64%. The pilots are alerted that ARTS has been activated by the "ART" indicator lamp on the instrument panel lighting up. When ARTS is activated the fuel flow to both engines is increased in one step through the operation of a solenoid valve in the fuel control unit of each engine.

The system functions independently of ATS and does not affect the throttle levers. It is cut out by the ARTS switch being turned off.

1.6.4.7 Fuel Control Unit (FCU)

A fuel control unit on each engine governs the flow of fuel. It receives information on, among other things, throttle lever position, RPM, ambient air temperature and combustion section pressure. Using this information, the fuel flow to the engine's fuel manifold is calculated and regulated.

1.6.5 Other relevant aircraft systems

1.6.5.1 Electronic Flight Instrument System (EFIS)

The aircraft has two independent EFIS systems that each include two colour Display Units (DU) in front of each pilot. On the screen are presented synthetic images of some of the flight and navigation instruments. Connection of one side's EFIS images to the other side's EFIS display units is possible.

Start-up of the EFIS system takes 1–6 seconds.

1.6.5.2 Electrical systems

The MD-81 has a three-phase alternating current system of 115/200 V, 400 Hz, and a direct current system of 28 V. Power is generated by three AC generators each of 40 KVA mounted each on one engine and on the APU (see 1.6.5.3). The engine generators are driven via a hydromechanical Constant Speed Drive, CSD, which ensures that the generator speed remains constant in normal operation even if the engine speed varies. On the engines, the CSD is driven by the N_2 rotor via the engine's gearbox. On the APU the generator is direct-driven.

For an engine generator to be able to deliver current at the correct voltage and frequency, the engine N_2 speed must be at least 42–45%. Each generator has the capacity to supply all electrical systems required during flight. The generator of an engine is automatically disconnected if that engine's fire handle is pulled.

The alternating current system is divided into two separate systems, left and right, supplied by their own generator. The APU or an external source of electrical power can be connected manually or automatically to one system or both simultaneously.

Two series-connected 14 V batteries can supply the most vital direct-current systems for a limited time and - via an inverter - the alternating current systems. The most important flight instruments, including the left EFIS and communications and navigation radio no. 1, can be supplied with current in this way for up to 30 minutes if none of the generator systems is functioning. Switchover to the battery system is effected with a switch marked "Emergency Power" above the left pilot seat.

1.6.5.3 Auxiliary Power Unit (APU)

The MD-81 is equipped with an auxiliary power unit (APU) in the lower part of the fuselage behind the pressure bulkhead. The APU consists of a gas turbine engine with auxiliary systems that can supply electrical power and compressed air. The APU can be used independently of the functional status of the main engines. The unit, which is normally supplied with fuel from the right main tank, is started on the ground using electrical power from the aircraft's batteries. APU electrical start in flight requires AC power; however, in the absence of AC power, the APU is windmill started.

The APU is started with a spring-return switch on the APU CONTROL PANEL in the cockpit. When it starts, three air inlet doors open. In flight, it normally takes 30–50 seconds from the APU being started until it can deliver electrical power. An indicator lamp (APU power available light) on the electricity panel on the ceiling indicates when the APU is ready for use.

1.6.5.4 AC Crosstie System

Should either generator be unable to supply the ordinary system with power, the functioning generator automatically takes over the supply of current through the AC Crosstie System. Cross-connection takes place in the AC Crosstie Relay which is controlled by the AC Generator Control Unit (GCU) of each generator and the AC Bus Control Unit (BCU). Modifications SB 90-201 and SB 91-201, intended to eliminate the risks of delay in cross-connection in the AC Crosstie Relay, were not mandatory, and were not carried out on the left GCU. If the N_2 speed of one engine falls below 42–45% its generator is unable to deliver current at the correct voltage and frequency, which automatically results in cross-connection through the crosstie function.

1.6.5.5 Emergency oxygen system

The passenger oxygen system is arranged as a module system with an oxygen generator for each seating section, one for each toilet and one for each cabin crew seat. Each module supplies 1–4 oxygen masks. The connected masks can be supplied with oxygen for at least fifteen minutes.

Oxygen is produced by sodium chlorate being converted to free oxygen and a residual salt in a chemical reaction with the production of heat. Following activation, the chemicals container can reach a surface temperature of +260°C.

The oxygen generator is activated by the downward pull caused by a person putting on an oxygen mask. The tension caused when the mask falls of its own weight is normally insufficient to activate the generator. When one mask in a module has activated the generator, oxygen is distributed to all masks in the module. There is no valve for turning off the oxygen generator, for which reason oxygen flows out until all oxygen has been liberated.

1.6.6 Cabin safety

1.6.6.1 Flight deck

On the flight deck there are two pilot seats of IPECO manufacture. There is also an extra seat (jump seat/observer seat). The certification requirements prescribe that the seats must withstand a static load of 2.0 g upwards, 4.5 g downwards, 9.0 g forwards and 1.5 g sideways (FAR 25.561).

As emergency exits the flight deck has an openable window by each pilot seat. The window is opened by a handle being moved backwards, inwards, backwards. Above each window opening there is a rope that can be used for reaching the ground.

1.6.6.2 Passenger cabin

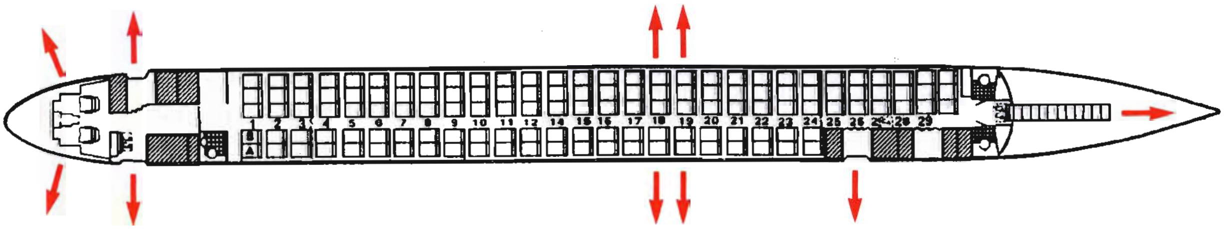
The passenger cabin has 133 passenger seats and five seats for cabin staff. The cabin is divided into two classes with a moveable cabin divider.

The passenger seats are manufactured by Flight Equipment & Engineering Ltd. They have two-point safety belts and are arranged in 29 rows, 1–12 and 14–30. In rows 1–12 and 14–24 there are five seats per row, two to the left of the centre aisle (A B) and three to the right (C D E). In rows 25–30 there are only the three right seats (C D E) since the left part is taken up by the rear galley.

The five seat positions for the cabin crew are jump seats fitted with four-point safety belts. A double seat (forward jump seat) is mounted facing aft on the rear wall of the cockpit. A forward-facing double seat is mounted on the rear door (aft jump seat). A forward-facing single seat (mid jump seat) is fixed to the galley wall at the level of seat row 27.

For all cabin seats, the same certification requirements apply as for the pilot seats.

Cabin layout with emergency exits



Above the passenger seats there are overhead bins manufactured by C & D Interiors. Certification requires that the bins be able to withstand the same load as the seats. Under the bins are Passenger Service Units (PSU) including air nozzles, loudspeakers, reading lamps and oxygen equipment. Each PSU is mounted on one side on the fuselage with a longitudinal hinge. The centre aisle side rests on a longitudinal strip.

The cabin contains ten galley units of Bucher manufacture, five at the front of the cabin and five at the rear. The front units are designated 1, 2, 2A (right side) and 3 and 3A (left side). They are located between the forward doors and the passenger area. The rear galley units (4, 5, 6, 7 and 7A) are located on the left side by the aft service door. In conjunction with the galley units there are storage spaces and wardrobes.

Serving as forward emergency exits from the passenger cabin are to the left the entrance door and to the right the forward service door. Serving as rear emergency exits are, to the left, the rear service door and the rear entrance door, the tail-cone exit. The two entrance doors are approx. 80 cm wide and 180 cm high. The service doors are approx. 70 cm wide and 120 and 150 cm high respectively. The forward entrance door and the service doors are opened by lifting and turning a handle, whereupon the door is pushed outwards and swung outwards, forwards to the locked position.

For the emergency exits there are slides. These are armed before takeoff and secured after landing. If the exits are opened when the slides are armed, the slides are automatically inflated. The slides can be detached from the fuselage if necessary and used as floats.

As centre emergency exits, there are two openable windows on each side as over-wing exits. The openings are approx 50 cm. wide and 90 cm high. The threshold height is approx 50 cm. On the outside the drop to the wing is approx 70 cm. These exits are opened by pulling a handle inwards and lifting the window into the cabin.

1.6.6.3 Other information

The emergency equipment on board the aircraft also includes checklists, first aid kits, oxygen for medical purposes, smoke alarms in the toilets, fire-extinguishing equipment, electric torches, emergency lighting, life jackets, emergency locator transmitters, emergency transceivers, megaphones and tools.

1.6.7 Technical status

1.6.7.1 Delivery status

The aircraft was delivered to SAS on 10 April 1991. Installation of floor proximity escape path lighting and cabin equipment including pantry was carried out by SAS in its own workshops after delivery. On delivery there was a remaining remark regarding a poor fit between the upper and lower parts of the rear pressure bulkhead (where the rear door is installed). The fault was rectified by fitting an insert.

1.6.7.2 Maintenance status

The aircraft was maintained according to the applicable maintenance programme. No technical remarks judged to have affected the course of events are documented in the aircraft's technical logs.

For the outdoor parking the night before the accident no air intake covers were used on the engines. The Company's Line Maintenance Handbook (LMH) prescribes that protective covers shall be used if there is a risk of snow or ice collecting in the air intakes.

1.6.7.3 Modification status

All issued and applicable airworthiness directives had been acted upon according to applicable requirements.

1.7 Meteorological information

About 45 minutes before the aircraft landed on 26 December there was snow and rain at Stockholm/Arlanda. This changed 25 minutes later to light drizzle alternating with rain. There was a thin layer of slush on the runway system on landing. The temperature at the time of landing was +1°C.

During the night the precipitation changed to light snow and rain, with moderate snowfall for a few hours. The temperature sank slowly from +1°C to +0°C around 0700 hrs. Wind was northerly, speed 5–10 knots. At the time of departure there was intermittent light snow. The temperature was -0°C.

METAR Stockholm/Arlanda 0850 hrs: Wind 360°/11 kts, visibility >10 km, light intermittent snowfall, cloud 2/8 stratus base 600 ft, 6/8 stratus base 800 ft temp/dew point -0°C/-1°C, QNH 1013 hPa.

Sunrise was at 0848 hrs.

During the rescue operation it was overcast but with no precipitation, with temperatures around 0°C. The ground was frozen crust with a thin layer of snow.

1.8 Navigational aids

Not applicable.

1.9 Radio communications

Communications were normal prior to the flight and during takeoff on Stockholm/Arlanda ground and tower frequencies. When the aircraft lifted, the crew changed frequency to departure control for Stockholm/Arlanda, which was retained during the short flight. No distress message was sent. Parts of the communication are reported in 1.11.

1.10 Airport data

The status of Stockholm/Arlanda airport at the time of the accident was according to AIP-SWEDEN.

Runway 08 used for the takeoff is 2,500 m long and 45 m wide, and is of concrete.

Runway conditions 0830 hrs:

- Taxiways: wet or pools, ice and packed snow, coverage 50%, average depth 1 mm.
- Runway 08: Wet or pools, coverage 25%, average depth 1 mm, braking action good.

The runway system had been cleared of snow and according to the crew was free from visible cover except for a narrow strip of snow some centimetres high left by the snow clearing equipment on the apron north of the area where the aircraft was parked.

1.11 Flight and sound recorders

1.11.1 Flight Data Recorders

The aircraft was equipped with two digital recording systems working in parallel:

- Digital Flight Data Recorder (DFDR) type Sundstrand P/N 980-4100-BXUS, S/N 4437.
- Quick Access Recorder (QAR) P/N 51431-1. S/N 1041-02-91.

The DFDR met official requirements as to crash survivability and contained data from the latest 25 flying hours. The QAR contained data for technical follow-up from approx. the latest 50 flying hours. Both systems were supplied from the Left Radio AC bus. The equipments each recorded 94 parameters at a recording frequency of 8 times a second for certain rapidly-varying parameters to once every fourth second for certain other parameters.

The whole course of events until two seconds after impact was recorded, with the exception of two brief interruptions due to a power cut in the Left Radio AC bus.

The information in the DFDR and in the QAR was copied, under the supervision of the Aircraft Accident Investigation Board, Denmark, onto computer diskettes by SAS' Flight Recorder Analysis section in Copenhagen. The QAR contained more useable recordings than the DFDR did, for which reason only information from the QAR has been used in the typescripts referred to.

Using information from the CVR (see 1.11.2) and recorded tapes from Air Traffic Control, information from the QAR tape has been synchronised with UTC time. Each recording has in this way been given UTC time ± 1 second.

Recordings relevant to the inquiry are given in Appendix 2.

1.11.2 Cockpit Voice Recorder – CVR

The aircraft was equipped with a CVR type Sundstrand Data Control Inc. AV557C, P/N 980-6005-076 and S/N 12083 supplied with current from the Right Radio AC bus.

The CVR met official requirements as to crash survivability and contained recorded sound from the latest 30 minutes during which it was switched on.

The information was re-recorded by the Air Accidents Investigation Branch (AAIB) in Britain and a typescript of the contents was made by Avicraft AB.

The sound recording covered the whole course of events until one second after ground impact, on four channels as follows:

Channel 1 - Service Interphone Channel (SI)
On this channel was recorded interphone conversation between the flight deck and the passenger cabin or within the passenger cabin; also the captain's communication with the ground technician and announcements to the passengers.

Channel 2 - Right Pilot Audio (RP)
On this channel was recorded all radio traffic via the right audio panel.

Channel 3 - Left Pilot Audio (LP)
On this channel was recorded all radio traffic via the left audio panel.

Channel 4 - Cockpit Area Microphone (AM)
This channel was used to record all sound on the flight deck using a microphone in the ceiling, between the pilots.

Recordings relevant to the inquiry are given in Appendix 3.

1.12 Site of accident and aircraft wreckage

1.12.1 Site of accident

Position 5946N, 1808E

The site of the accident lies 700 m NW of Vängsjöberg farm, Gottröra parish, Norrtälje municipality, AB County. The ground area where the aircraft collided with trees is a slight plateau of exposed rock covered with 14–16-m-tall coniferous trees and about 35 m above sea level. Along the path of the crash through the wood the ground first slopes downwards by 8 m over approx. 60 m and is then an infield of 700 m x 400 m at approx. 25 m above sea level. The infield is covered with soil to a depth of approx. 0.4 m over clay. The aircraft struck the ground on the slope and slid approx. 110 m before stopping. During the slide it crossed a 0.7-m-deep ditch. The nearest building is the inhabited cottage of Korsbro 400 m east of the point of impact. The distance to a public road is 450 m.

Engine parts were recovered from an area of approx 900 m x 300 m under the flight path east of Lunda church (pos 5940N, 1804E) approx 5 km from the runway at Stockholm/Arlanda.

1.12.2 Aircraft wreckage

1.12.2.1 The fuselage

On impact the fuselage broke into three pieces. The forward part extended from the nose to seat row 7 in the cabin, the middle part from seat row 8 to seat row 21 and the rear part from row 24 backwards.

The underside structures were much damaged in the forward part of the wreck. The indentations were largest in the left of the front part - approx 80 cm - and smallest in the right rear part - approx 18 cm. Damage to the underside structure in the middle and rear parts was limited. The cabin floor had limited damage. Apart from damage in the areas of the breaks, the floor structure was ruptured only at row 5 on the right side.

The major part of the right wing had separated from the fuselage. Wing parts lay spread out along the path of the crash. The underside of the left wing was severely damaged.

Both the main landing gear and the nose gear had separated from the fuselage.

On the flight deck there were deformations in the floor structure and ruptures in the pilot seat floor rails. The deformations were most evident on the right side of the flight deck. The pilot seat height adjustment devices had been damaged, allowing the seats free vertical movement. The seats were examined in cooperation with, among other organisations, the manufacturer, as reported under 1.16.3.

In the forward portion of the passenger cabin the overhead bins and their mountings had been damaged. The two modules on the left had parted completely from their mountings and fallen down onto the backs of passenger seats. On the right side the modules had parted from their ceiling mountings but not from the wall mountings. The modules from row 3 and rearwards were resting on seat backs. A number of bin lid locks had broken and the lids had come open. The cabin divider - which was between rows 3 and 4 - had fallen down together with the bins. In the middle portion of the wreck the damage was limited to the break areas. At the forward break the forward part of the left bin had fallen. At the rear break the bins on both sides had fallen. A number of bin lid locks had broken. According to available information, the bins were not excessively loaded with baggage.

In all three parts of the wreck most of the PSUs had loosened from the bin structures and were hanging either by their outer hinges or by wiring. Many of the oxygen masks had been released from the PSUs and some had also been activated. Some of the cabin crew oxygen masks had also been released.

In the forward part of the passenger cabin, seat 1B had parted from its inner anchor point. The floor rails of seats 7A and B had parted from their anchorages. The backs of seats 3B, 4D and 6D had been deformed.

In the middle part, damage was limited. On the left (seats A and B) there was no damage except that row 22 (A and B), at the rear break point, were separated from the aircraft. There was a certain amount of damage on the right side, chiefly in the rear portion, as a consequence of the lateral loading. Seat rows 14–18 (CDE) were damaged and had partly parted from their floor mountings. The seats of rows 19-21 (CDE) had parted from their legs. Row 21 (CDE) was found loose in the cabin. Rows 22 and 23 (CDE) were found outside the aircraft.

The seat of the middle cabin crew seat was deformed.

In the forward galley area the walls of galley 3 had been deformed in two places and one floor mounting had ruptured. The ceiling at galley 1 had been pressed downwards. The ceiling panel between galleys 2 and 3 had fallen in. The exit sign at galley 3 was missing. The door to the flight deck had broken off.

Approach to accident site

The aircraft wreckage

Openings in the fuselage

In the rear galley area the door of one of the two ovens in galley 5 had come open. The oven element was hanging half out. The contents of the oven (essentially steel baskets of bread), and hand baggage and newspapers, had been spread out in the galley in front of the rear service door. The newspaper trolley had been moved from its place in a storage area on the right side to the galley area on the left side. The ceiling between the toilets aft of the galleys was pressed downwards. In the toilets, fittings and the contents of cupboards lay about loose.

Both forward emergency exits were open. The entrance door slide had not inflated. The service door slide had inflated but was punctured. The slides had been detached and used as somewhere for people to lie down. Both rear emergency exits were shut. According to information from the crew it was impossible to

Cabine damage

open them immediately after the crash. The rear service door could be opened later. Three of the four emergency exit windows were open. According to information from witnesses, the rear right exit was blocked with loose seats, cabin luggage etc.

1.12.2.2 The engines

Both engines exhibited extensive external and internal damage. The external damage consisted chiefly of impact damage to the air intakes, engine cowlings and exhaust sections.

The engines were dismounted from the aircraft and have undergone an extensive technical examination. The result of this examination is reported in 1.16.1.

1.12.2.3 Other aircraft systems affected

Fuel system

Technical examination of the aircraft's fuel system has revealed nothing to indicate a fault in the system that can have influenced the functioning of the engines.

Engine fire protection system

A check of the fire extinguishing system showed that fire bottle no 2 was activated. The fire extinguishing valve for the left engine was open.

Air conditioning system

Components of the aircraft's air conditioning system that can have been of significance for the course of events have been checked without anything abnormal being discovered.

Mechanical steerage and control systems

Components of the aircraft's steerage and control systems that can have been of significance for the course of events have been checked without anything abnormal being discovered.

1.13 Medical information

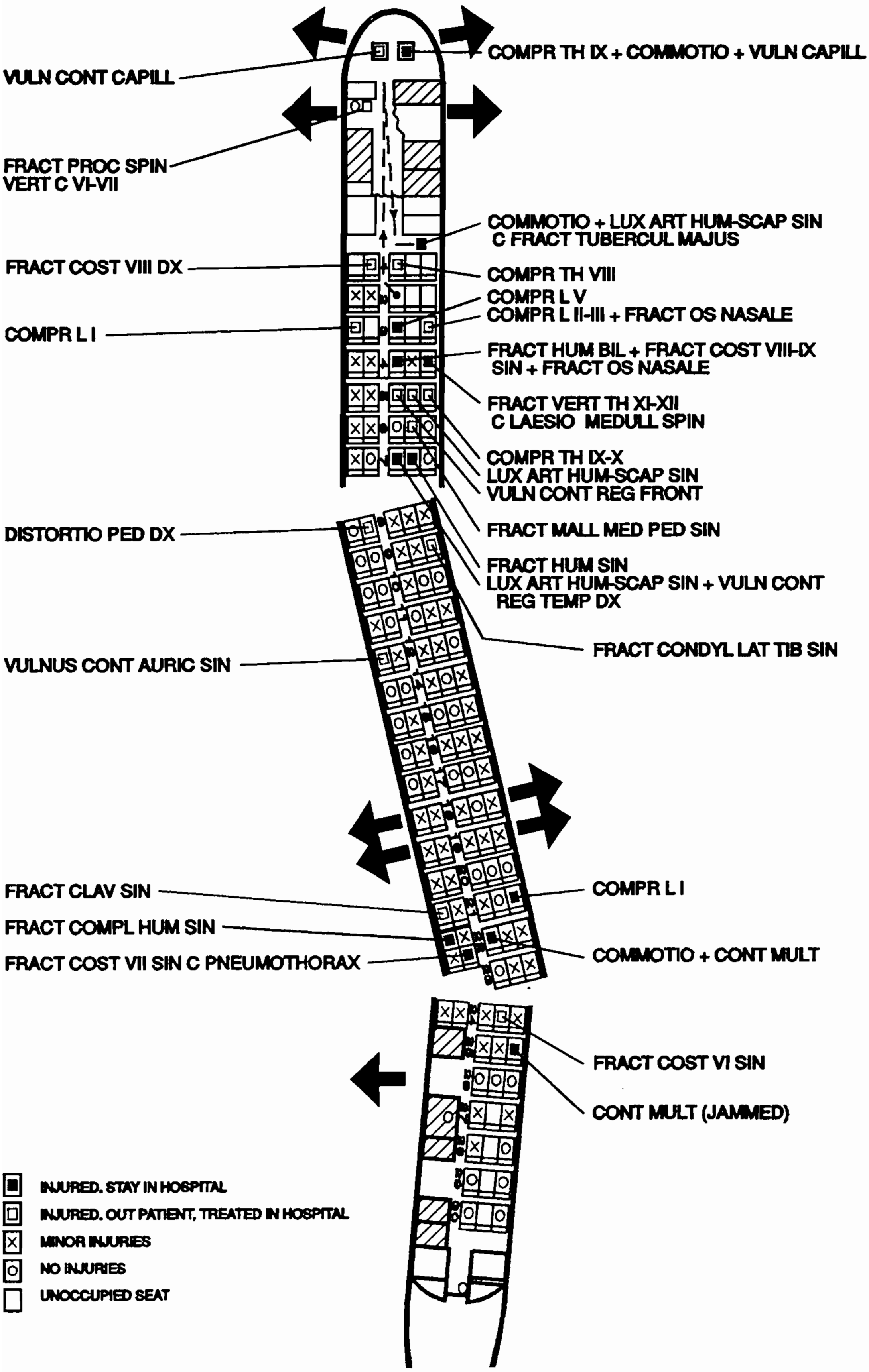
Nothing indicates otherwise than that the crew were in good physical and mental condition. The injury profile is as follows:

	Crew	*Passengers*
Hospital care	1	11
Outpatients' care	2	13
Slight injuries	-	60
Uninjured	3	39
Total	**6**	**123**

Four of the eleven passengers admitted to hospital were discharged after 24 hours. After a week all but one had been discharged. One of these was subsequently readmitted for further care. The most seriously injured person had sustained vertebral fractures with neurological complications. The injury is judged to be disabling.

Most of those injured, and those with the most serious injuries, were sitting in the forward part of the aircraft, with a concentration to the right side. Here there were eight of totally nine cases of back injury and five of totally seven shoulder and arm injuries. Another concentration of injuries was among those sitting near the rear fuselage break. Those sitting in the middle and rear parts of the aircraft sustained slighter injuries or were uninjured.

Injury profile



1.14 Fire

During the flight, fire occurred in the engines (see 1.16.1.1). No fire broke out on impact.

1.15 Survival aspects

1.15.1 Evacuation

Under the guidance of the cabin crew, the aircraft was evacuated quickly and without panic breaking out. One passenger was caught fast and could not be helped out by those on board. He was later helped by rescue personnel (see 1.15.2.3). About half of the passengers who could leave the aircraft unaided did so through the openings caused by the breaking up of the fuselage. The others used the available emergency exits.

1.15.2 Rescue operations

1.15.2.1 External conditions

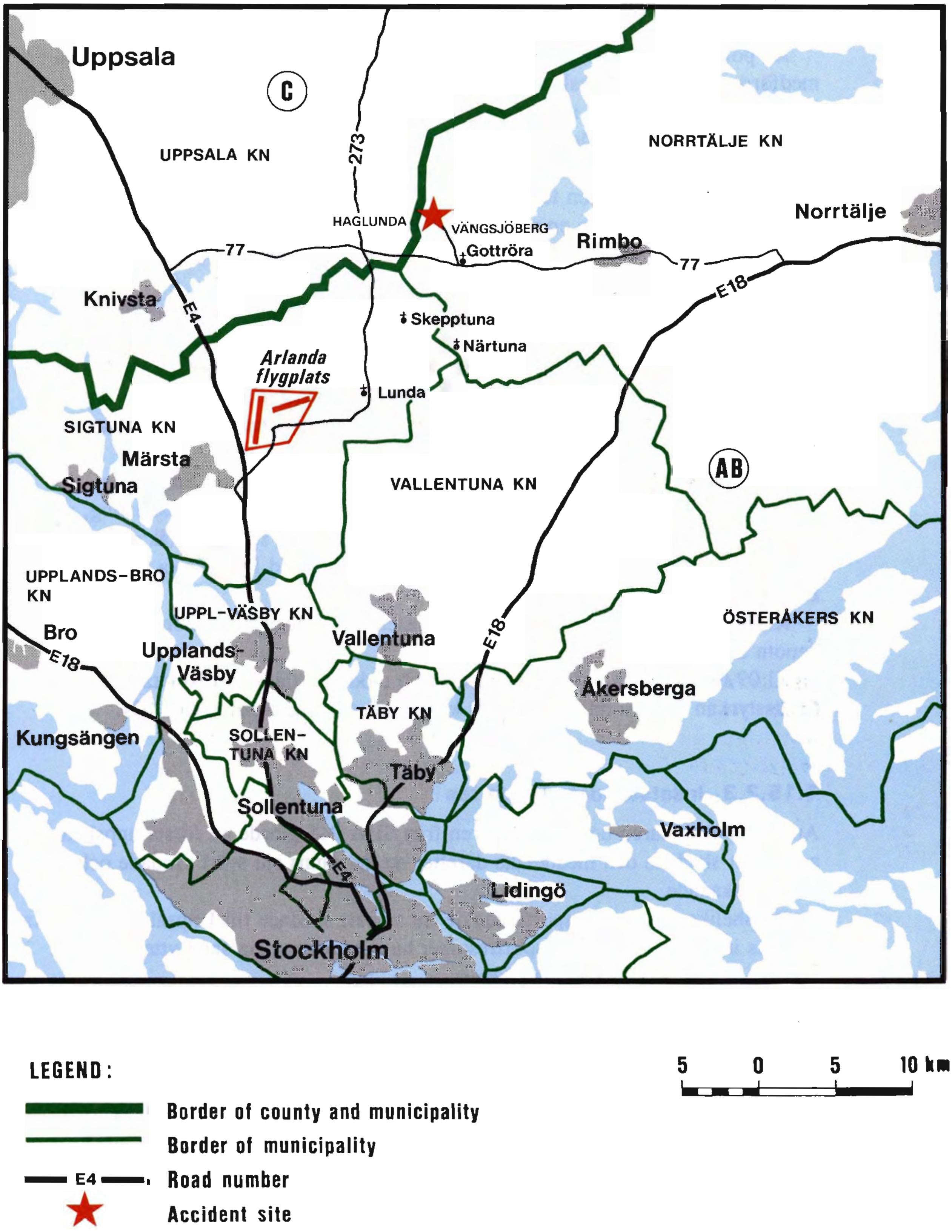
The site of the accident is in Norrtälje municipality, AB county. The border with Uppsala municipality, C county, runs approx. 1.5 km from the site. The border with Sigtuna municipality, AB county, runs approx. 4 km from the site. The road connecting the site with public highway 77 is gravel surfaced and varies in width from 4.2 to 5.2 m. From the crossroads at highway 77, the distance to Stockholm/Arlanda is 24 km, to Norrtälje 31 km and to Uppsala 39 km. The roads in the area were slippery at the time.

The site of the accident entailed difficulties in radiocommunications.

1.15.2.2 The alarm phase

The alarm "Risk of accident" was given at 0850 hrs by air traffic control. The alarm went to the ARCC and the SOS emergency centre in Stockholm (SOS-A). A few minutes later the alarm "Accident or presumed accident at unknown location" was given. At the first alarm the ARCC had been informed that radar contact had been lost and that the aircraft was then on bearing 034° at a distance of 10 nautical miles from Stockholm/Arlanda. At 0858 hrs a request from the ARCC for search assistance was received by the police ambulance helicopter (SHA 945) on standby at Barkarby. At 0905 hrs the location of the accident became known when a passenger telephoned the 90 000 emergency number from the nearby cottage.

Shortly after 0850 hrs the ARCC alerted the Defence Forces helicopter on standby at Visby airport. In addition, the helicopter crews not on standby at the


Uppsala
C
UPPSALA KN
273
NORRTÄLJE KN
HAGLUNDA
VÄNGSJÖBERG
Gottröra
Rimbo
Norrtälje
77
77
E18
Knivsta
E4
Skepptuna
Närtuna
Arlanda flygplats
Lunda
SIGTUNA KN
Märsta
Sigtuna
VALLENTUNA KN
AB
UPPLANDS-BRO KN
UPPL-VÄSBY KN
Bro
E18
Upplands-Väsby
Vallentuna
E18
ÖSTERÅKERS KN
Åkersberga
TÄBY KN
Kungsängen
SOLLEN-TUNA KN
Täby
Sollentuna
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LEGEND:
Border of county and municipality
Border of municipality
E4
Road number
Accident site
5 0 5 10 km

military bases at Berga, Säve, Uppsala and Söderhamn were contacted. In view of the information regarding preparation time for the mission and estimated flight time to the accident site, the ARCC later cancelled the order for the Säve helicopter.

Of the two police helicopters at Barkarby, SHA 945 was airborne at 0902 hrs. It carried a male anaesthesiology nurse and an ambulance medical orderly. It immediately established radio contact with SOS-A and the Stockholm/Arlanda tower. At an altitude of 700 ft over Rotebro the helicopter received signals from the aircraft's emergency location transmitter (ELT). Using this indication the helicopter was able to localise the site of the accident at 0915 hrs and give the ARCC a first orientation. The helicopter landed at the site at 0922 hrs. Another police helicopter (SHA 950) took off from Barkaby at 0906 hrs and arrived, with a mechanic, at the accident at 0926 hrs.

At 0852 hrs, SOS-A began to alert ambulances to a predetermined break point. By 0910 hrs, eleven ambulances had been alerted.

At 0853 hrs the duty fire engineer at Räddsam Norr[5] was alerted. At the same time SOS-A ordered all rescue service units to switch to "channel 2", i.e. national channel H 02. Ambulances and police helicopters were ordered to use channel 68.

At 0854 hrs the liaison centre at the police headquarters in Stockholm was alerted.

At 0856 hrs the duty official at the Stockholm County Council offices was alerted. On her directive a doctor was later alerted to serve as staff medical officer. Between 0856 and 0859 hrs, further medical care teams at Karolinska Hospital and Danderyd Hospital were alerted.

Between 0900 hrs and 0903 hrs the rescue service and the police authority in Uppsala were alerted by the Uppsala SOS centre (SOS-C).

At 0906 hrs the police authority and rescue service in Norrtälje were alerted. The task force from Norrtälje (Rimbo) knew nothing about the expression "channel 02".

1.15.2.3 The first phase of the operation

The anaesthesiology nurse and the nurse from SHA 945 made a first estimate of the numbers of injured, subsequently stating that there were seven seriously injured and seven slightly injured.

The police helicopters transported the three most seriously injured to Uppsala Akademiska Hospital (UAS) before other hospital transport resources had had time to become operational, and also a slightly injured person to Danderyd Hospital.

The first rescue vehicles, which came from the Rimbo fire station, arrived at approx. 0925 hrs with a station officer as director of rescue. He was quickly informed that a man was trapped in the aircraft. Shortly thereafter the duty fire engineer from Räddsam Norr arrived and took over the rescue command. He jud-

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[5] Räddsam Norr is a cooperative organisation run jointly by the municipal rescue services in Sollentuna/Upplands Väsby, Järfälla/Upplands Bro, Sigtuna and The Södra Roslagen Fire Service Association

ged that the job could be carried out in a relatively short time. He therefore decided not to establish a full management staff or to bring up and erect the heated tents that were available at the new break point he had decided upon at the Gottröra petrol station. He requisitioned buses from Greater Stockholm Local Transport (SL) for removal of the uninjured.

The first commander of the rescue operation took the foollowing general decisions:

1. Assist the injured that had come out of the aircraft.
2. Take precautions against fire by laying out a hose from the tank vehicle and covering the released fuel with foam.
3. Free the man who was trapped.

The decision was carried out between 0945 hrs and 0950 hrs. The man who was trapped proved to be not seriously injured. Another passenger was therefore judged to be the one most needing transport. This was effected by police helicopter, which took off at 0952 hrs.

At 0934 hrs the Räddsam Norr command bus, which is based at Järfälla fire station, had arrived at the break point. It could not make radio contact with the director of rescue.

The person in command at the break point shall, according to the rescue plan, be a leading fireman. At the time, this function was fulfilled by an acting leading fireman. He could not make radio contact with the first commander of the rescue operation.

The first police patrol vehicle, with an inspector and a sergeant from Norrtälje, arrived at the site at 0935 hrs. The inspector requested reinforcements from Norrtälje and learned that police personnel in squad vans and police cars were on their way from Stockholm, Uppsala and Märsta. The first squad group from Stockholm arrived at 0950 hrs. The Norrtälje inspector ordered this group to carry out outer cordoning-off and to start identifying and registering the passengers. A police force from Uppsala were ordered to erect an inner cordon. Between 0955 hrs and 1000 hrs a deputy police superintendent arrived from Stockholm and stated that he had been appointed senior police officer by the acting county police commissioner. The other squad groups arrived thereafter.

The injured were attended to by the medical teams present and were driven away in ambulances or buses.

The Karolinska Hospital and Danderyd Hospital medical teams alerted by SOS-A arrived at the site of the accident at around 1000 hrs. Shortly after this a medical care team from Huddinge Hospital arrived in the helicopter from the Naval Forces helicopter squadron at Berga, which had been alerted by the ARCC. The reason for this team's presence was a standing agreement between the hospital and the squadron that squadron helicopters will always fetch medical staff from the hospital if there is an alert. This agreement was unknown to SOS-A, nor was SOS-A informed of it. Lastly, a team from Akademiska Hospital in Uppsala arrived on its own initiative. A doctor from Karolinska Hospital undertook at 1015 hrs to act as senior medical officer.

Around 1015 hrs most of the initial medical care was completed. Two injured persons were still lying on stretchers but were being looked after.

Removal of the seriously injured was completed at approx. 1020 hrs.

At 1000 hrs sanding of the road from the break-point to the accident site was ordered. At about 1025 hrs a command bus from Stockholm police headquarters arrived at the break-point. After about an hour the officer in charge of the bus decided to move it up to the accident since the break point was not satisfactory as regards communications.

1.15.2.4 The subsequent operation

The first commander of the rescue operation, his first decision largely implemented, made new dispositions as follows:

1. To place the injured in vehicles.
2. To gather the uninjured in the cottage building.

A passenger list was available at the accident site at 1045 hrs. Acting on information that passengers were missing, a search party was organised at 1045 hrs. The search gave no result and was abandoned at 1200 hrs.

Police identification and registration was started at approx. 0950 hrs. Two policemen were detailed to the injured who were still in the field awaiting transport. Two policemen were responsible for escorting the others up to the cottage and identifying and registering these and the people who had already made their way there.

Identification and registration at the cottage originally followed a plan by which all would be identified and registered before being allowed to enter the cottage. The plan was later altered partly because some passengers had already gone into the cottage and partly because the work was taking an appreciable time. The group at the cottage was later reinforced so that it could start working as two units. The intention was that those who were registered could also be ticked off the lists in connection with transport.

Owing to inconsistencies in the passenger list and registration, a search from a police helicopter was undertaken between 1305 hrs and 1335 hrs. At this point it was called off since the passengers presumed missing had been accounted for.
A check of the passenger list showed it to be incomplete. The Norrtälje police had not obtained a complete passenger list until 1400 hrs.

A final check of the passengers listed in the police registration against the airline's passenger lists was concluded at 1517 hrs. It then emerged that three people had left the site earlier without the police being able to register them.
A representative of the airline had, however, been informed of this.

1.15.2.5 Conclusion of the operation

Only a fairly small portion of the helicopter resources were needed for medical transport. The uninjured passengers were therefore offered helicopter transport. Only 26 passengers accepted this offer; the others would be transported by bus.

Buses arrived at the break point at 1037 hrs but owing to the state of the road up to the accident site could not drive there without prior sanding. Sanding was delayed partly because the police personnel at Gottröra church in the vicinity of the break point did not feel able to let the sand vehicles through along the Vängsjöberg road until the ambulances had left the site of the accident. Sanding had to be done twice but was finally completed at approx. 1125 hrs. At 1230 hrs the last bus left the site.

1.15.2.6 Action by the hospitals

At Norrtälje Hospital the accident became known when the rescue service was alerted. Readiness at the hospital was raised with the establishment of a disaster room. Only three passengers were brought to the hospital, of whom two with minor injuries, who were treated at the outpatients' department.

An alert to Danderyd Hospital at 0855 hrs had been understood as a readiness alarm and a medical care team had been despatched. No further message was received via the emergency telephone. By listening to the radio, emergency department staff became aware that an aircraft had crashed. At the request of the surgeon on second call the emergency ward sister tried unsuccessfully to contact SOS-A on the emergency telephone. Somewhat later another nurse got through, but was told that they had no time to give information. There was no contact between the medical team that had been despatched and the hospital. The emergency department had been cleared in readiness to receive possible injuries from the air crash. Planned operations were not postponed, however. No disaster room was set up since no disaster alert had gone to the hospital from SOS-A. At about 1100 hrs the head of the surgical department in contact with SOS-A received information that, probably, no injured persons would be brought to Danderyd. Despite this eight patients were brought, starting at 1150 hrs. None needed to be admitted for treatment. At about 1400 hrs the hospital was informed by emergency telephone that normal work could be resumed.

At Karolinska Hospital the operations programme for the day, apart from operations already commenced, was stopped, for which reason there were seven manned operation theatres ready at 1000 hrs. According to the disaster plan the emergency department and the admissions section were cleared. No contact with SOS-A via emergency telephone could be made when the hospital attempted at 0930 hrs to report that a disaster room had been established. At about 0940 hrs contact was made with the duty official at the County Council offices. The disaster room had direct contact with the senior medical officer at the injury site, frequently via the first commander's telephone. Even after the senior medical officer's first report there was a fairly clear picture of how great a medical care load could be expected. The hospital received 39 injured, of whom six were admitted for care.

Löwenströmska Hospital was alerted by SOS-A at 0945 hrs. Two operation theatres were prepared and a disaster room was organised, and SOS-A was informed of this at 1015 hrs. Five injured persons were brought to the hospital, of whom three were admitted for care.

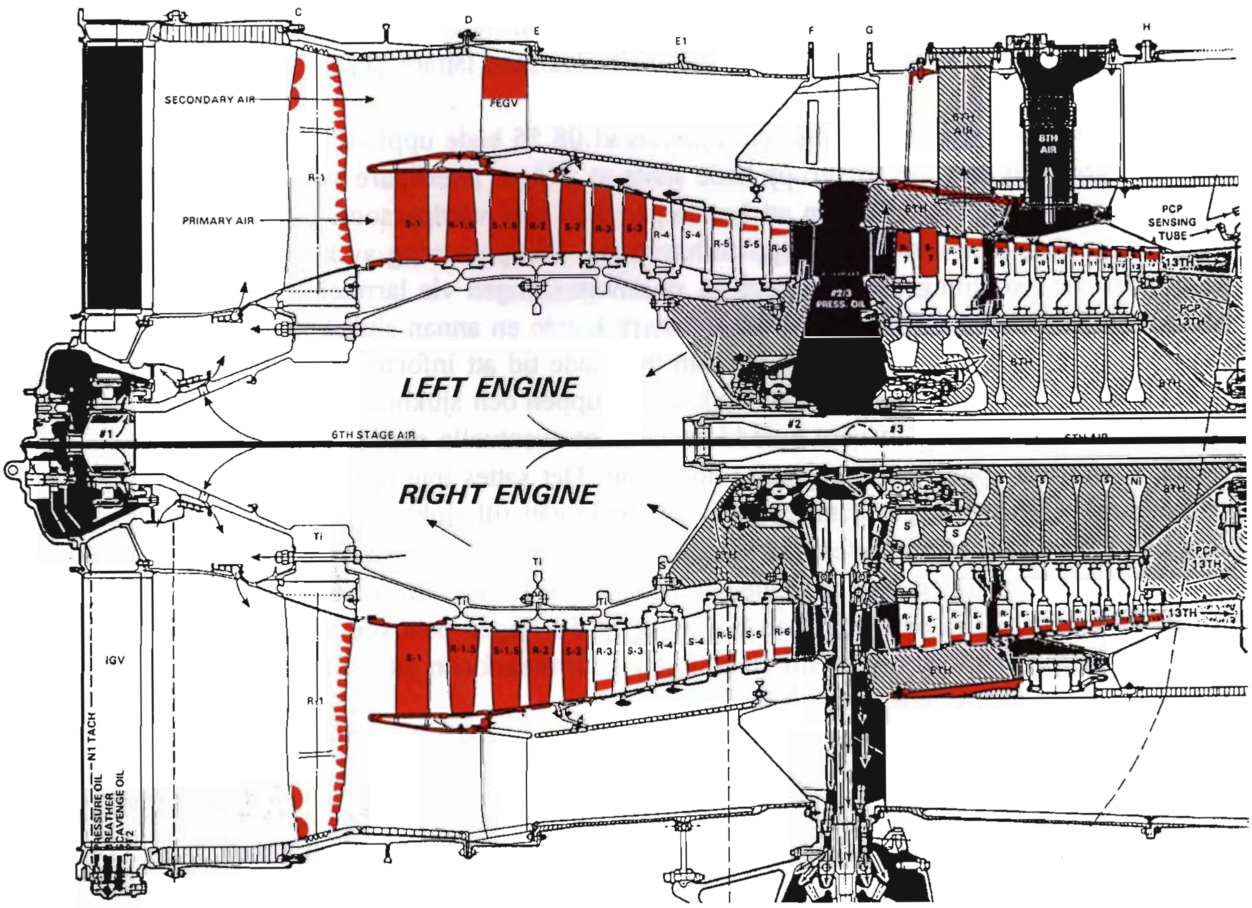
1.16 Special tests and investigations

1.16.1 Engines

Both engines have undergone technical examination by Scandinavian Aero Engine Services AB. The intention of the investigation was primarily to

- map the damage to the engines
- analyse the exact course of the engine failures
- examine whether there were technical faults in the engines prior to the accident.

Fan- and compressor-damages



The following account of engine damage includes only the overall damage to engine modules and components considered to be of significance to the accident enquiry.

1.16.1.1 Engine fire

Fire in the rear compressor

Melt damage and spraying of among other things molten titanium alloy were found in the rear compressors of both engines at stg 7 and stg 8 and aft. Compressor blades stgs 7, 8 and 9 and the rear inner fan case in the intermediate cases of the engines are made of titanium alloy.

Fire inside left engine cowling

In the left engine there were soot deposits and fire damage between the engine and the engine cowlings, mainly on the right side in the area of the main fuel duct.

1.16.1.2 Damage to the left engine

Fan stage

Of the fan's 34 blades eight, relatively evenly distributed, had up to 15 mm-deep and 50 mm-long soft indentations in the concave sides of the leading edges. The damage was in an area from the blade tips and 175 mm in towards the centre. Its appearance is typical for impact damage from "soft objects" (birds, ice and similar).

All fan blades had extensive impact damage along the whole trailing edge, with broken-off blade pieces up to approx. 20 x 20 mm in size. The trailing edges were bent towards the convex side up to approx. 20 mm into the blade chord. The appearance of the damage is typical for impact damage from "hard objects" (metal objects, stones and similar).

Fan blade damage in the left engine

The outer fan blade rubstrip was very worn around its whole circumference. The breadth of the wear groove averaged 86.3 mm: nominal groove width is 72.1 mm. The rubstrip was worn 1.85 mm over nominal dimension at the leading edge and 2.84 mm at the trailing edge. Blade tip clearance was 5.3–6.6 mm.

Bits had been torn off from the sound absorbing liners in the fan case.

Front compressor

In the front compressor the stator outer shroud stg 1 had parted from the core engine owing to the stg 2 compressor case rupturing round its entire circumference. In the case there remained 25 of a total of 56 vanes. These were greatly bent in the direction of rotation. The stator inner shroud stg 1 had been broken and had separated. Pieces of the shroud were recovered from the by-pass duct.

There was extensive damage to compressor blades, vanes and seals in all compressor stages. In the front compressor stages the compressor blades and guide vanes were entirely or partly broken off. The rubber sealing had been torn loose from the stator outer shrouds. The remaining compressor blades and rotor vanes were broken off or greatly deformed. Damage to and fracture surfaces on the compressor blades indicate that they have been subjected to abnormal axial and radial loads.

Segments of the outer fan exit guide vanes (fan exhaust) were missing between the 4-o'clock and the 11-o'clock positions. Other segments were in their original positions but partially damaged and bent in the direction of the engine's rotation.

Compressor intermediate group

The front compressor fan duct was cracked right through in two places, to lengths of approx 120 mm and 750 mm, and had extensive damage in the by-pass duct sound absorbing liner.

The rear compressor fan duct was sooty on the outside and had cracked round its whole circumference. Several holes had been made in the duct, one of which was approx 230 x 120 mm in size and located at approximately the 3.30 o'clock position. Through one of the holes, parts of a ruptured stg 7 stator projected.

The rear compressor case had several large holes round its entire circumference and had broken into two parts. The material had melted or burned away in the holes. The holes were localised to the area outside rear compressor stgs 7 and 8. Parts of the ruptured stg 7 stator projected through the compressor case.

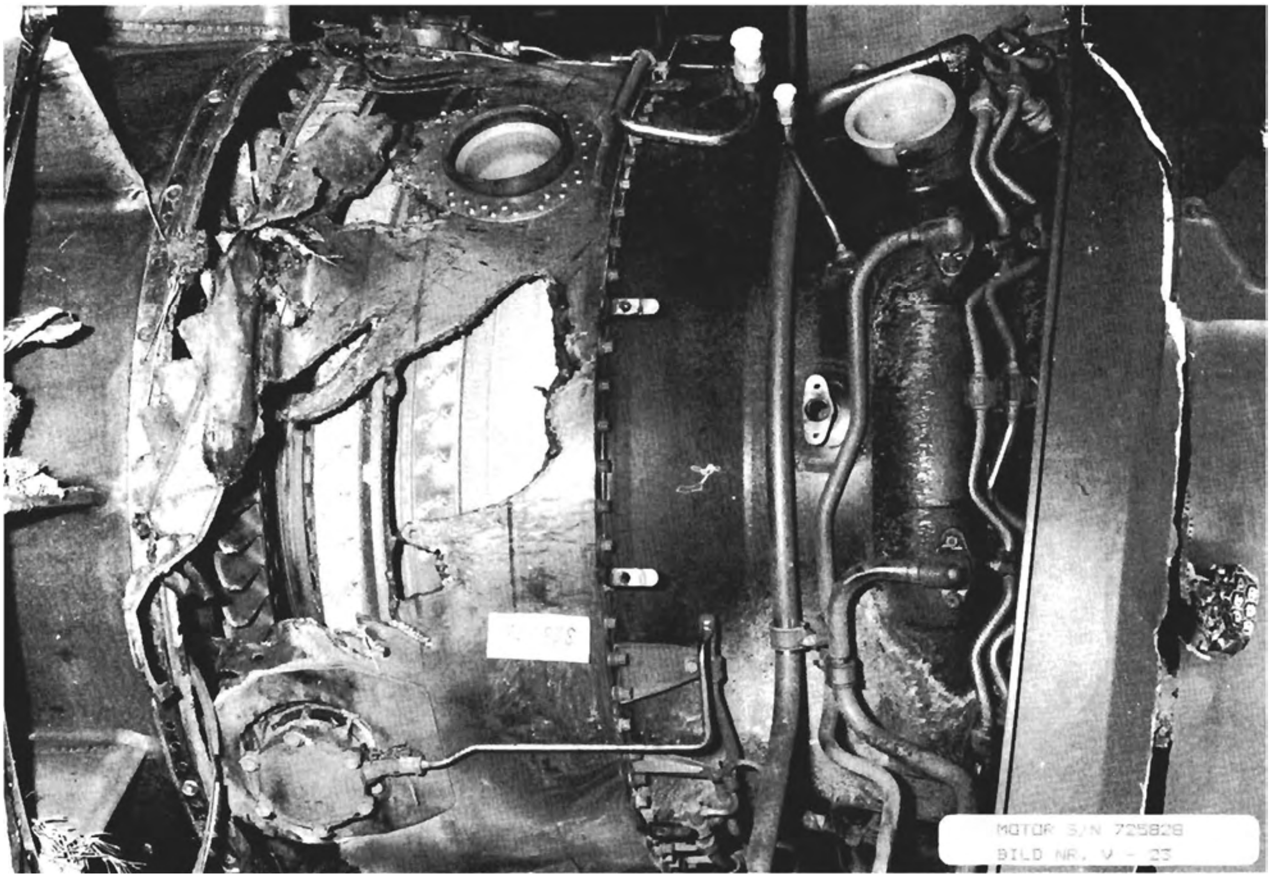
The intermediate case had extensive damage to its guide vanes, seals and sound absorbing liners.

Rear compressor

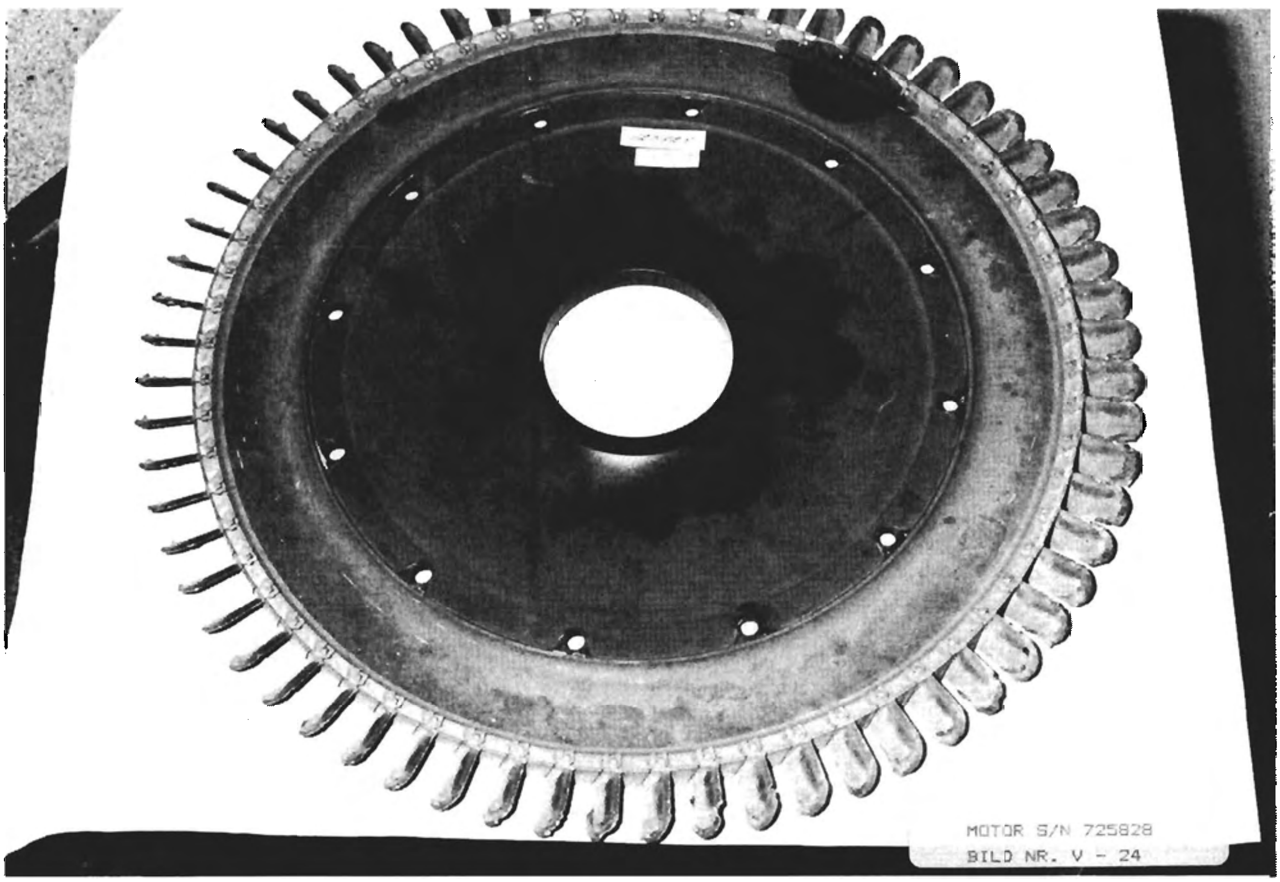
The blades of the rear compressor exhibited much damage to their leading edges, trailing edges and tips. The greatest damage had arisen in stgs 7, 8 and 9. The blades there had been shorn and burned off by approx. 16 mm. They had lost their rectangular shape and gained a rounded profile. Some were deformed.

The stg 7 stator had ruptured and left its original position between rotor stgs 7 and 8. Parts of its outer shroud with suspended vanes stuck out through the rear compressor case between the 9-o'clock and 1-o'clock positions. The inner shroud

Compressor cage damage



Damaged blades in rear compressor



with its seal had ruptured and projected from a hole in the rear compressor fan duct between the 4-o'clock and 7-o'clock positions. Of a total of 52 guide vanes in stg 7, 12 had left the engine.

The front part of the stg 8 stator outer shroud, which supports the stg 7 stator, had ruptured around its whole circumference.

The other compressor stators had varying degrees of impact damage and burn damage.

Miscellaneous

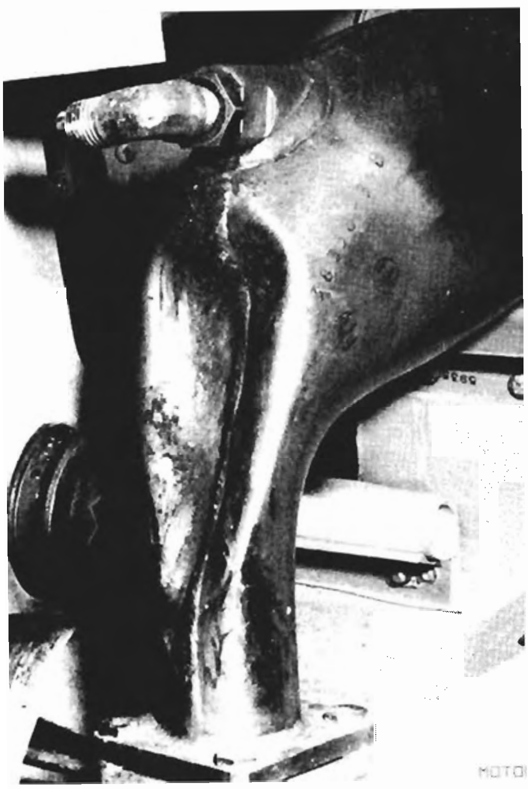
The burn-through barrier outside the rear compressor fan duct was sooty. Its anti-abrasion cover exhibited burn damage and had partly melted. The bleed air manifolds for de-icing had holes which had been caused by ejected metal parts.

Damage had occurred in connection with ground impact.

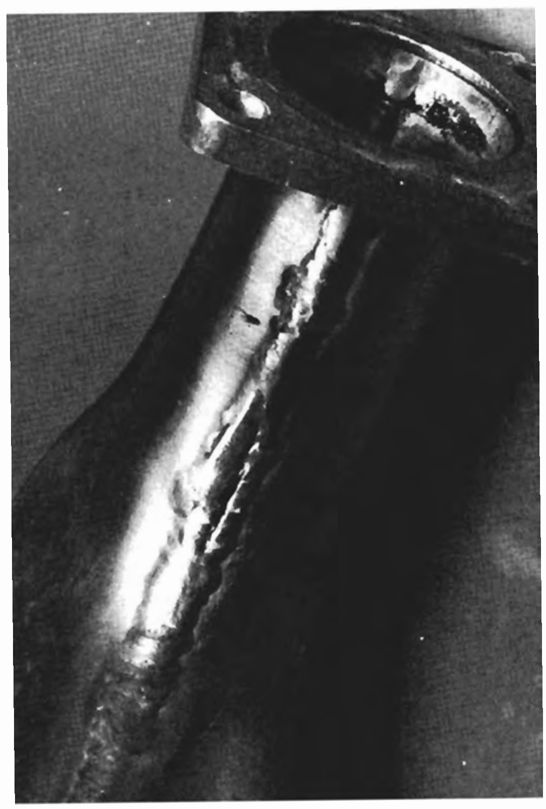
Fuel duct

Fuel duct P/N 9938338-6 between the fire bulkhead towards the fuselage and the engine fuel regulator at compressor stg 7 had impact damage on the side facing the engine. On the opposite side of the fuel pipe approx 42 mm from its upper flange there was an approx. 22-mm-long fissure in a welded seam, with a maximum gap width of approx. 1.2 mm. In tests, the measured flow through the fissure was approx. 5 litres per min at a fuel pressure of 1 psig and approx 13 litres per minute at 15 psig.

Damaged fuel duct



Fissure in welded seam



Metallurgical examination of the pipe revealed that there were manufacturing defects in the weld seam in the area where the fissure had occurred. The weld fissure is judged to have arisen in connection with the opposite side of the fuel pipe being subjected to the impact that caused the damage on that side. The impact created tensions in the defective weld joint which caused it to crack.

Other engine modules

Apart from the damage judged to have occurred in connection with the ground impact, other internal damage to the engine was chiefly confined to metal coatings and limited impact and wear damage.

1.16.1.3 Damage to the right engine

Fan stage

In seven fan blades, in two sectors of 50° each and separated by 70°, there were soft indentations of up to 15 mm in depth and 80 mm in length in the concave side of the leading edges. The damage was in an area from the blade tips and 110 mm towards the centre. Its appearance is typical for damage from "soft objects".

All fan blades exhibited great impact damage along the whole trailing edge with broken-off blade pieces of up to approx 30 x 20 mm in size. The trailing edges were bent towards the convex side, up to approx. 20 mm into the blade chord. The appearance of the damage is typical for impact damage from "hard objects".

The outer fan blade rubstrip was very worn around its whole circumference. The breadth of the wear groove averaged 86.5 mm. Nominal groove width is 72.1 mm. The rubstrip was worn 2.00 mm above nominal dimension around the leading edge and 2.44 mm around the trailing edge. Blade tip clearance was 5.4–6.0 mm.

Bits had been torn off from the sound absorbing liners in the fan case.

Front compressor

In the front compressor the stator outer shroud stg 1 had parted from the core engine owing to the stg 2 compressor case rupturing round its entire circumference. In the case there remained 37 of a total of 56 vanes. These were greatly bent in the direction of rotation and were pressing against the outer shroud. The stator inner shroud stg 1 had ruptured and separated. Pieces of the shroud were recovered from the by-pass duct.

There was extensive damage to compressor blades, vanes and seals in all compressor stages. In the front compressor stages the compressor blades and guide vanes were entirely or partly broken off. The rubber sealing had been torn loose from the stator outer shrouds. The remaining compressor blades and rotor vanes were broken off or greatly deformed. Damage to and fracture surfaces on the compressor blades indicate that they have been subjected to abnormal axial and radial loads.

Some of the outer fan exit guide vanes (fan exhaust) were twisted in their seatings. The fan exit duct behind the guide vanes had been broken off.

Compressor intermediate group

The front and rear compressor fan ducts had damage to their sound absorbing liners.

The rear compressor case had a number of large holes corresponding to approx. 80% of its circumference. The material had melted or burned away in the holes. The holes were localised to the area outside rear compressor stgs 7 and 8. Molten material had solidified in the compressor bleed valves and at the bottom of the rear compressor case.

The intermediate case had damage to its seals and guide vanes.

Rear compressor

The blades of the rear compressor exhibited much damage to their leading edges, trailing edges and tips. The greatest damage had arisen in stgs 8 and 9. The blades there had been shorn and burned off by approx. 18 mm. They had lost their rectangular shape and gained a rounded profile. Some were deformed.

The guide vanes of the stg 7 stator showed impact damage to their leading edges measuring up to 5 x 5 mm. Their trailing edges were damaged by abnormally high temperature. Approx. 25 mm of the normal 35 mm vane chord remained in the most heavily damaged area.

The front part of the stg 8 stator outer shroud had ruptured around its whole circumference. An approx 10 mm-broad ring forming a support for the stg 7 stator had come loose. In the outer shroud a burn hole of approx. 30 x 7 mm had been made.

The other compressor stators had varying degrees of impact damage and burn damage.

Miscellaneous

The bleed air manifolds for de-icing had holes which had been caused by ejected metal parts. Mechanical damage had occurred in connection with ground impact.

Other engine modules

Apart from the damage judged to have occurred in connection with the ground impact, other internal damage to the engine was chiefly confined to metal coatings and to limited impact and wear damage.

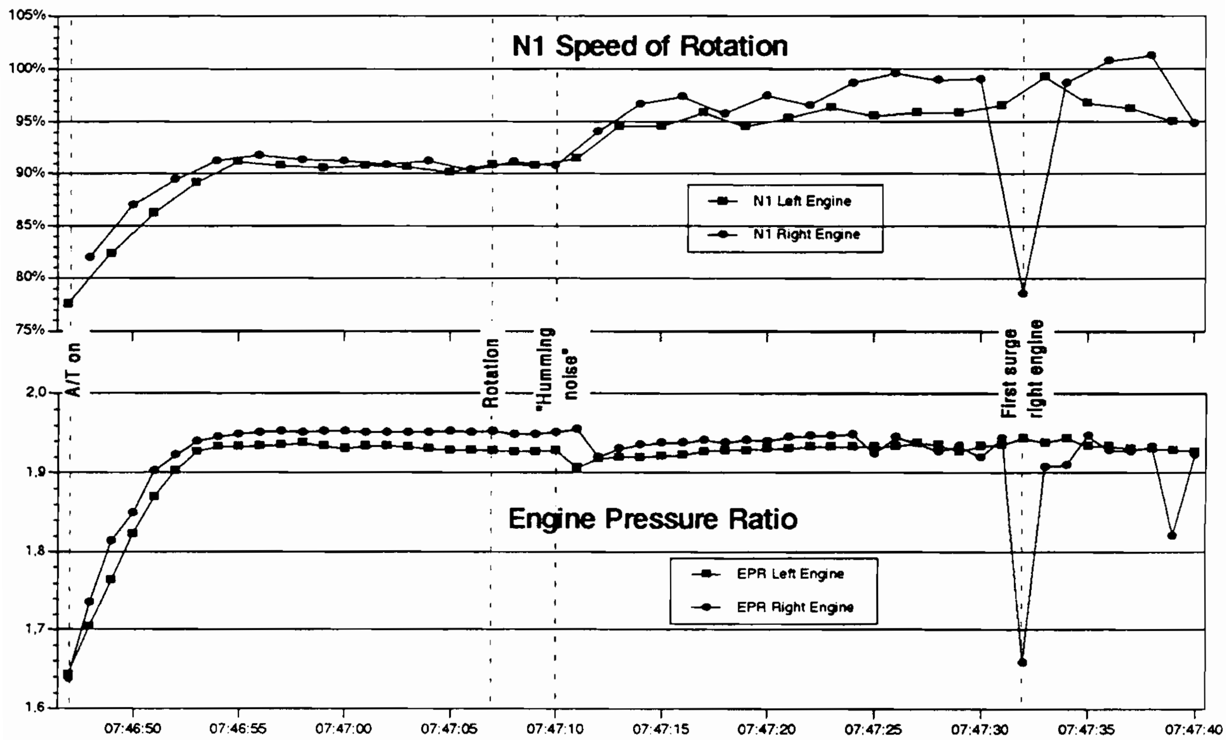
1.16.1.4 Collected engine parts

Some 500 engine parts were recovered from the ground in an area overflown by the aircraft approx 60–75 seconds after rotation. The pieces represent about 30% of the total material missing from the engines at the technical investigation. Parts from both engines have been identified. The collected parts come from the front parts of the engines and consist chiefly of exhaust fan guide vanes, compressor blades, parts of stators and from compressor cases.

1.16.1.5 Shift in N_1 and EPR at liftoff

At liftoff an increase in engine N_1 rotation speed by 4% in the left engine and 6% in the right engine was recorded in the QAR. At the same time EPR sank by 0.03 and 0.02 units respectively. These recordings have been compared with corresponding values from earlier takeoffs with OY-KHO and with other MD-81's. The comparison shows that the values at the relevant takeoff were not normal.

Shift in N_1 and EPR at liftoff



1.16.1.6 Follow-up of operational performance

The performance trend of the engines has been examined for the period 11 April 1991 until the accident. Both engines show about the same changes during the period. The changes are expected and normal. There is nothing to indicate that prior to the relevant flight the engines had been exposed to anything abnormal that can have affected their performance.

1.16.1.7 Effect of ARTS

The engine fuel control units were checked in a test rig under the same operational conditions as those obtaining shortly before the engines failed. When the ARTS was activated the fuel flow to each engine increased in one step by approx. 1,300 lbs/h (734 l/h), which is normal.

1.16.2 Other systems involved

1.16.2.1 APU

The aircraft's APU was of Garrett GTCP-98DHF type, S/N P-1106. The APU and auxiliary system have been checked in the workshop. In a test run the APU was started and fully loaded at the first attempt.

Technical examination of the air intake doors shows that these were open on impact. Earth and grass had been sucked in a way that indicates that the APU was running at operational speed on impact. After the accident, electrical system components were in positions that correspond to there being an electrical power supply from the APU.

1.16.2.2 Electrical components

A number of electrical systems and components in the Electronics Compartment under the cockpit were much demolished on impact. Consequently it has been impossible to test their function.

The electrical components of the crosstie system and of significance for the course of events have been checked wherever possible. No faults or deviations that could have essentially affected the functioning of the system prior to the accident have been found.

In addition a number of components of the aircraft's steering and indication systems have been checked without remark.

1.16.2.3 EFIS system

The components of the left-side EFIS system have been checked as far as possible. No faults or deviations that could have essentially affected the functioning of the system prior to the accident have been found.

1.16.3 Cabin safety

1.16.3.1 Crash simulation

Together with the Air Accidents Investigation Branch (AAIB), Great Britain, SHK has performed a simulation of the course of the crash. The study was carried out by Cranfield Impact Centre Limited (CIC) and the Motor Industry Research Association (MIRA), both in Britain. Using known details of the aircraft's speed, attitude, roll angle, mass and distribution of mass during the course of the accident, CIC has calculated speed and load in different directions for a number of positions in the aircraft. In view of the fact that personal injuries, both in number and severity, were concentrated to the front of the aircraft, the calculations concentrated chiefly on this part. The result of these calculations may be summarised as follows.

For passengers in the front part of the aircraft, acceleration was probably

- longitudinally (x-direction) between −13.5 and −20 g,
- laterally (y-direction) between ±3.7 and ±5 g and
- vertically (z-direction) between +29 and +30 g.

Using the CIC calculations MIRA has experimentally studied the difference in the load on various parts of the body depending on whether the passenger adopted a brace position. The studies show that the load increases appreciably if the passenger adopts a normal sitting position, for example the maximal load on the head increases by 55%. The compression force acting on the spine increases from 2.24 kN to 13.5 kN.

1.16.3.2 Pilot seats

The pilot seats have been examined in cooperation with the manufacturer and AAIB. The result may be summarised as follows.

Regarding the *first officer's* seat it was first noted that a clip of the bulldog type had been mounted on one side of the seat frame with self-threading screws. The penetrating screw had scored grooves that nearly penetrated an internal part of the frame.

When the seat was dismantled it was noted that both pins of the height adjustment mechanism had been shorn off at their holes. The holes were remarkably undamaged. Examination revealed that the pins had probably been placed in the third hole from the top, which corresponds to a height of approx. 25 mm above the lowest position of the seat.

In the lower part, minor compression damage was observed in both front legs at the level of the rear part of the floor mountings. Minor compression damage could also be seen in the right lower sectional strip of the height adjustment mechanism.

The seat back exhibited compression damage, mainly at the height of the armrest. This damage was probably caused by forces transmitted from the shoulder belts, which are anchored in the lower part of the back plate and deflected forwards at neck height.

The seat itself had compression damage that showed that the load had been directed forwards at least as much as downwards. The seat underlay showed almost no other damage than what had been caused by the seat hitting the bottom after the height adjustment pins had shorn.

The damage to the *captain's* seat was of the same kind as the damage to the first officer's seat. There were, however, some differences.

The seat showed screw holes and damage from a clip of the same type as that mentioned above, which had been fitted later. The clip had, however, been removed.

The height adjustment mechanism showed the same damage as that found on the first officer's seat. Here, too, it was difficult to determine which hole the pins had been in, but the indications were that it was the second from the top, i.e. a somewhat lower position than the first officer's seat.

The back was practically undamaged, with only little compression damage in the lower part. The back tilt control was somewhat bent.

Damage to the frame was minor and resembled that to the first officer's seat. The only difference was that the only compression damage of any extent was to the right front leg.

1.16.3.3 Passenger seats

Some of the passenger seats from the aircraft were examined in collaboration with the manufacturer and AAIB. The test result shows that the design met the certification requirements for loading in all directions. The seats also withstood a forwards-downwards load increase of 10% without visible deformation. When lateral load was increased from the 3.0-g certification requirement to 3.87-g, the seat collapsed.

1.16.3.4 Overhead bins

The design of the overhead bins was examined in cooperation with the manufacturer and NTSB. The results show that the design well meets the certification requirements.

1.16.4 De-icing equipment

The relevant equipment was used for several de-icings on the morning of 27 December 1991. After the accident the equipment was withdrawn from service and underwent a technical investigation by SAS on 28 December. The result of the examination including liquid samples analysed, was placed at the Board's disposal.

At the Board's request Hägglunds/Moelv A/S, Norway, undertook a technical examination of the complete equipment at Stockholm/Arlanda on 3–4 January 1993. The purpose of the investigation was to determine whether the de-icing equipment had functioned according to the stated specifications when used for the de-icing of OY-KHO. Besides the technical examination, samples of the consignment from which the de-icing fluid used for de-icing OY-KHO came, were analysed.

In the technical examination of the equipment, nothing emerged that would indicate any fault or significant departure from the relevant specification that could have affected its capacity to remove any ice and snow from the aircraft.

Samples of concentrated de-icing fluid were taken on 28 December 1991 from the de-icing vehicle used and on 3 January 1992 from the refilling depot. The glycol concentration is of marginal significance for de-icing but is significant in preventing re-freezing after de-icing. Analysis of both samples shows that the glycol concentration in them was higher than 92.6%, which meets the relevant specification.

1.17 Other information

1.17.1 The assisting captain

The assisting captain is 47 years old. He was accepted at the age of 17 as a trainee pilot in the Air Force. When posted he flew the J 35 Draken aircraft. He was appointed as a pilot by SAS in 1968.

He served on aircraft types DC-8 and Boeing 747 until 1987, when he was appointed captain with service on DC-9's. He then converted to MD-80's and at the time of the accident had approx. 920 hours flying hours on this aircraft type.

1.17.2 Technical and operational documents

1.17.2.1 Technical documentation

Maintenance Manual MD-80 (MM)

The MM is the manufacturer's technical material, prepared for SAS, for inspection and maintenance of the aircraft type.

Line Maintenance Handbook (LMH)

The LMH is published by the company and contains standards and regulations for maintenance carried out on the aircraft in operation at bases and external stations.

1.17.2.2 Flight operational documentation

FAA Approved Airplane Flight Manual Model DC-9-81 (FAA-AFM)

The FAA-AFM is published by the manufacturer of the aircraft and approved by the Federal Aviation Authority FAA. It contains operating limits in connection with certification. FAA-AFM forms part of the certificate of airworthiness for each individual aircraft.

Flight Crew Operating Manual MD-80 (FCOM MD-80)

The FCOM is a flight manual published by the manufacturer of the aircraft.

Flight Operations Manual (FOM)

The FOM is published by the company and contains standards and regulations for flight operations. It contains both official regulations and company regulations.

Aircraft Operations Manual MD-80 (AOM MD-80)

The AOM MD-80 is the pilots' handbook used by SAS pilots. It is a company-adapted edition of FCOM and contains, among other things, the checklists described below.

Route Manual (RM)

The route manual is published by the company and must be carried by each pilot when flying. It contains information required for IFR flying and is revised once a week. A daily update is included in the briefing for every flight.

In the RM section 6 in OPERATIONAL INFORMATION, de-icing on the ground is described.

Checklists

Checklists are excerpts from the AOM and are divided into two categories, normal checklist and emergency/malfunction checklist.

The normal checklist is used on every flight and for the MD-80 contains about 140 points to check, each containing one or more actions. How the actions are to be performed is described in detail in what is termed the Expanded checklist. The actions must be well known.

The emergency/malfunction checklist is used when malfunctions occur. It consists of a binder with twelve sections. It is arranged so that certain malfunctions are considered so serious that they are marked in a special way. If one of these malfunctions occurs the pilots shall be able to take certain action without needing to consult the checklist: "by heart" items. In the POWER PLANT section such measures are given only for "Two-engine flameout".

Regarding engine surging the checklist contains on page 13 in the same section the following.

ENGINE SURGING AND POPPING IN FORWARD THRUST

INDICATIONS

- ▸ Fluctuating or high EGT.
- ▸ N_1 and/or N_2 fluctuating.
- ▸ Popping or surging sound may be heard.

ACTIONS

1. AT switch .... OFF.
2. Throttle, affected engine .... REDUCE THRUST (IDLE IF REQUIRED).
3. Condition .... CHECK
   - If Surging or popping continues, perform ENGINE SHUTDOWN Check List, 12-5.

   If surging or popping stops.
4. ENG IGN switch .... GRD START & CONTIN.
5. ENG anti-ice switches .... ON.
6. PNEU X-FEED VALVE lever, affected side ..... OPEN
7. AIR-FOIL anti-ice switches .... ON
   – Correct EPR for ENG ANTI-ICE on.
8. Throttle .... SLOWLY ADVANCE.
9. Condition .... DETERMINE
   – No surging or popping – end of procedure.

If surging or popping reoccurs

10. ENG ANTI-ICE switch, affected engine .... OFF
11. Operate engine below level that causes surging or popping and avoid icing conditions or shutdown engine, see ENGINE SHUTDOWN Check List, 12-4.
12. End of Procedure.

The emergency/malfunction checklist contains in an appendix a checklist for emergency landing and ditching covering 24 items where item no 21 indicates:

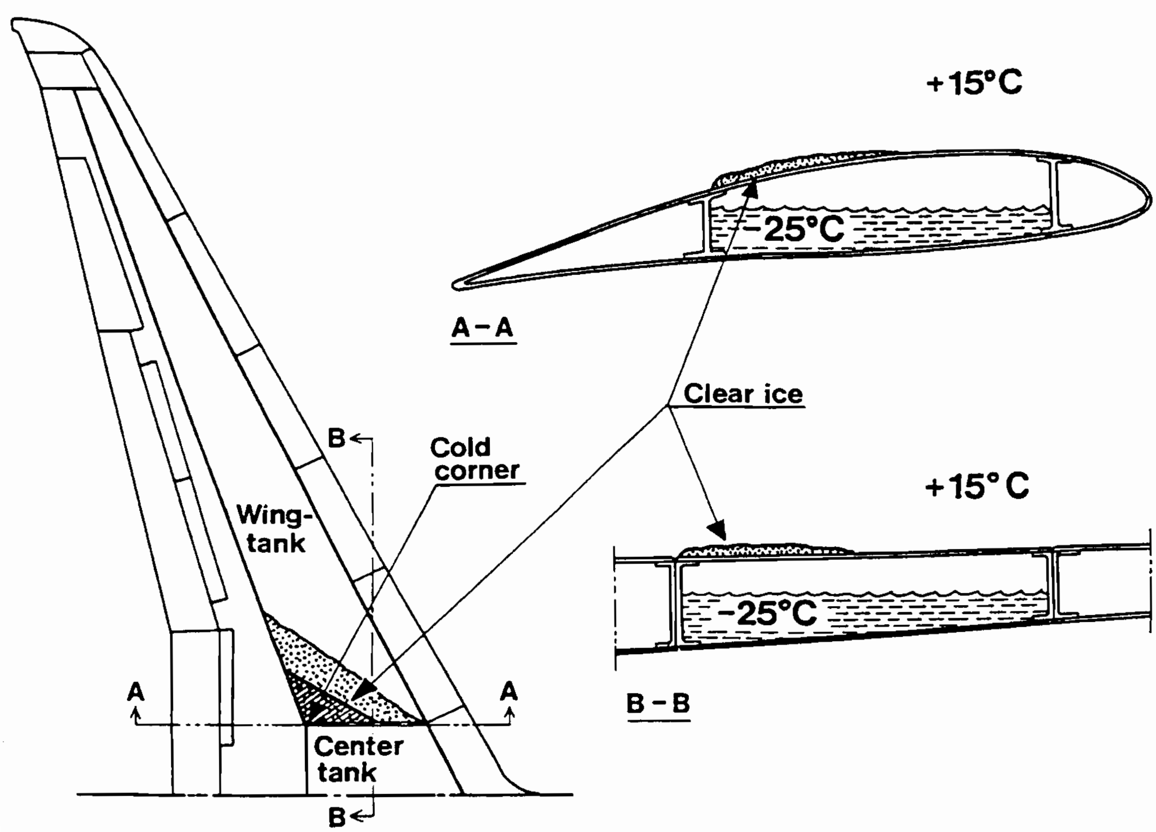
21. Landing gear – Landing only .... DOWN & CHECKED
    – Landing config: FLAPS 28
    ARM SPOILER
    (Except for main gear unsafe or up indication).

1.17.3 Clear Ice

1.17.3.1 History

The DC-9 aircraft in various versions has been in traffic since 1965 and up to December 1991 nearly 2,000 had been manufactured. On the DC-9-51 two extra tanks were installed in the fuselage to give the aircraft extra range. On the MD-80

Clear ice



series the volume of the centre tank was increased by partly extending it into the enlarged wings. The innermost part of the neighbouring wing tanks, which contain the unused, often greatly chilled, remaining fuel, then came almost exactly in front of the engine air intakes.

Up until 1981 several cases of "soft" FOD damage had been reported on all DC-9 versions. In the same year both engines, one seriously, of a Finnair DC-9-51 were damaged by clear ice which came off the wings at takeoff and was ingested by the engines. This event was reported to the authorities, manufacturer and operators.

After a number of cases where clear ice has been found remaining on the wings following de-icing, Finnair summarised its experience in a report in 1985, in which the problem of undiscovered, unremoved clear ice was headlined as "The most difficult systematic threat to flight safety today".

1.17.3.2 Actions prior to the accident

The authorities

For supervision, etc., of SAS the Danish, Norwegian and Swedish civil aviation authorities have formed a joint body - *OPS-utvalget.* OPS-utvalget has set up a special supervisory body, *Skandinaviska tillsynskontoret* (the Scandinavian Civil Aviation Supervisory Agency, STK) to exercise technical and operational flight supervision on its behalf.

At a meeting in May 1989 STK considered a flight occurrence report from SAS on engine surging as a result of ice being ingested by the engines of a DC-9-81 on a flight between Stockholm and Helsinki. The meeting resulted in a letter to SAS in which STK drew attention to the information material McDonnell Douglas had published on the clear ice problem and urged SAS to examine the need of corrective action.

At a meeting in August 1989 STK followed up the letter to SAS regarding the need of corrective action. SAS announced at a meeting on 11 October that work was in hand with, among others, the manufacturer on the clear ice issue and that a report was being produced. The report, which dealt with both short-term and long-term action, would be sent to STK as soon as it was finished. Bulletins on current de-icing procedures were circulated within the Flight Operations Department and were in production in the Technical Division.

In a letter to STK in November 1989 SAS reported on an "MD-80 ICE FOD CONFERENCE" in Zürich the previous month. It emerged from the report that some of the measures proposed at the conference required decisions by SAS management.

In the minutes of an STK meeting in February 1990 it was noted that SAS had reported active work on "DC-9 Ice Ingestion" and that SAS was participating in international cooperation in the area. As a result of this work SAS produced Swedish-language de-icing instructions for winter operations 1991/92. This was judged by STK to be good basic material for solving the clear ice problem. STK also made sure that the instructions were used in training.

STK also noted what the SAS Line Maintenance Handbook (LMH) of 15 September 1991 contained regarding the discovery and removal of clear ice. STK considered that it was clear from the LMH that there should be a follow-up check when clear ice had been found on the upper wing surface, and that the only way of doing this was to feel the wing with the hands. STK judged the LMH to be an entirely satisfactory basis for the production of detailed regulations. At this point STK changed its technical representative at Arlanda and this person underwent a period of training. STK therefore considered it was unable to go more deeply into the clear ice problem but assumed that it was being well taken care of through SAS' own checks.

The aircraft manufacturer

From 1985 McDonnell Douglas gave extensive information, including several "All Operators Letters" (AOL) that dealt with the clear ice problem. In an AOL of 14 October 1986 operators were informed of how Finnair had solved the problem of discovering clear ice. In 1986 the manufacturer recommended the installation of warning triangles with indication tufts on critical wing areas. In 1989 these became standard on newly-built aircraft. In 1988 and 1989 McDonnell Douglas arranged "Theme conferences" dealing with clear ice formation and measures for preventing engine damage. SAS took part in these conferences.

In 1991 McDonnell Douglas supplied the following modifications (Service Bulletin, SB) for the purpose of overcoming the clear ice problem:

►*Ice FOD Alert system - SB 30-64 (dated 02 April 1991)*: on the upper side of each wing a sensor is installed that sends a warning signal to the pilots if there is ice.

►*Inboard Refuelling System - SB 28-59 (dated 02 April 1991)*: this modification implies alteration to the fuel system so that new, warmer fuel is mixed with stationary, cold fuel in the deep part of the inner part of the wing tanks.

►*Alternate Fuel Burn System, AFBS - SB 28-58 (dated 08 April 1991)*: this system, the purpose of which is to create an insulating layer of air between the wing tank fuel and the upper side of the wing, automatically arranges consumption from the centre tank and the wing tanks alternately. First, fuel is used down to a level corresponding to approx. 5,000 kg in the centre tank. Then the wing tanks are connected so that their fuel is used down to a level corresponding to about 1,800 kg in each wing tank. Then the centre tank is re-connected and emptied.

The above modifications were not mandatory. They were introduced by the manufacturer as standard on aircraft delivered from the beginning of October 1991. With the exception of one trial aircraft they have not been introduced on SAS MD-81's delivered before that time.

The airline company

The problem of clear ice on this aircraft type had been known within SAS since 1985. Warning triangles with indication tufts were installed following a technical order in October 1987. In various bulletins over the years the clear ice problem was described in detail and in December 1988 an AOM bulletin to pilots mentioned that the problem was considered the greatest current threat to flight safety.

On 26 October 1991 SAS distributed a FLIGHT DECK BULLETIN/WINTERIZATION to all pilots. In the Basic Regulations section it said "It is the P-i-C's responsibility to check the aircraft for any ice or snow that may affect performance". A special section on "CLEAR ICE" treated the problem of clear ice and pointed out "Although the awareness within Line Maintenance is mostly good, the responsibility again leans on P-i-C that the aircraft is physically checked by means of a hands-on check on the upper side of the wing. A visual check from a ladder or when standing on the ground is *not* enough".

On 6 December 1991 SAS issued an AOM Bulletin MD-80 which among other things dealt with the risk of engine damage caused by clear ice. The Bulletin also mentioned that for certain destinations (Linate, Fiumincino and Nice) there were obvious clear ice problems since the attention of the ground personnel there could not always be expected to be the best. In addition it was stated that "rime on the underside of the wing is a good reason to believe that there is ice on the upper surface during precipitation".

In the MD-80 STUDY GUIDE that pilots use when training on the MD-80, clear ice was not mentioned. The computerised self-studies referred to current regulations in FOM and AOM. These contained no information on the clear ice problem. After the accident the first officer stated that he had never realised the extent of the clear ice problem during his training on the MD-80.

In the AOM section that deals with what is termed walk-around inspection there was no special instruction regarding an ice check before flying. However, an illustration showed a suitable inspection route running under the wing leading edge where rime frost normally forms under the wing tanks. The normal checklist included no special item on ice and snow except for a point regarding de-icing with the engines running. In the associated expanded checklist it was stated for this control item only that the time required for the fluid to work - the holdover time - should be verified against a table.

In the DE/ANTIICING chapter in the RM, nothing was stated about the problem of clear ice.

The technical division is responsible for de-icing being carried out correctly. In the division the clear ice problem was well known and had been dealt with in training, instructions and technical bulletins. Prior to the winter season, personnel affected at Arlanda were given training in de-icing.

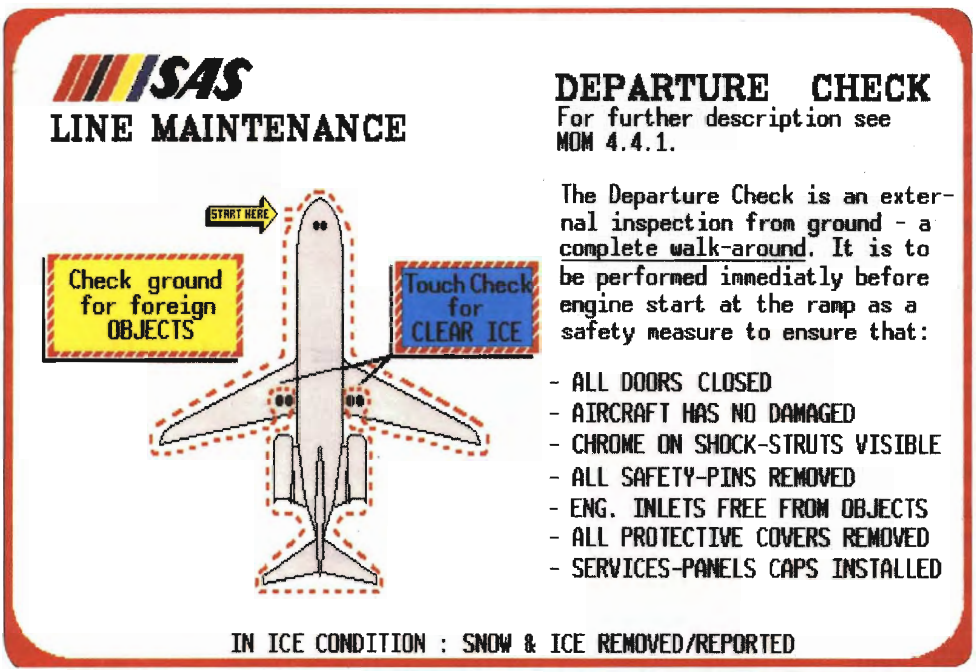
The LMH, section 6.12.3 "DEPARTURE CHECK" contained the following instruction: "Check that the aircraft is free from ice, snow and frost with special attention to clear ice forming (touch check). Also that arrangements for remote de-icing are coordinated with P-i-C. NOTE: If clear ice is formed, the aircraft shall be inspected after de-icing to ensure that all clear ice has been removed."

In the LMH section 7.9.3 "SNOW AND ICE ELIMINATION ON GROUND" the clear ice problem was mentioned under the heading "CHECKS FOR THE NEED TO DE-ICE" as follows: "If frost or ice has formed on the lower wing surface tank area and the aircraft, during its ground time, has been subjected to precipitation conditions (rain, drizzle, fog) or when there is a doubt as to whether clear ice has

formed on the wing upper surface, the wing upper surface must be checked using suitable means of access in order to detect the possible clear ice.
Heavy freezing has been reported during drizzle/rain even at temperatures up to +15°C. It must always be remembered that below a snow/slush layer there can be clear ice which is very difficult to detect."

Swedish-language "Line Maintenance De-icing Instructions, Winter 91/92" (see appendix 5) was issued in November 1991. Here, current instructions and general guidance concerning ice formation and de-icing had been compiled for personnel affected in Sweden. The de-icing instructions, which did not have the status of registered technical documentation, were used in training and were distributed to technicians and mechanics. For daily use each technician and mechanic had been supplied with an excerpt from the LMH in the form of a plastic-covered checklist for the departure check as illustrated below.

Checklist for departure check



The mechanic responsible for handing-over the aircraft was appointed by the company in June 1990 and trained in de-icing that autumn. He went on a one-day refresher course in autumn 1991, during which the de-icing instructions mentioned above were gone through.

Regarding clear ice, the de-icing vehicle personnel had received the same training as technicians and mechanics. The instructions used were the "Line Maintenance De-icing Instructions, Winter 91/92" mentioned earlier. There was no special written instruction regarding the removal of clear ice found on the wings.

The employee who handled the de-icing vehicle spray nozzle was appointed in November 1991. He had undergone a three-day course in de-icing with one day of theoretical instruction and two days of practical training. This was followed by three weeks of practical exercises on aircraft, which included the removal of clear ice. He had also seen a video film about the problem. During his two months' employment he had removed clear ice several times.

1.17.3.3 Actions after the accident

FAA

FAA arranged a meeting on 17 June 1992 with MD-80 operators as a consequence of the FAA Notice of Proposed Rule Making (NPRM) on the mandatory introduction of SB 28-59 Piping for Inboard Refuelling system and SB 30-64 Ice FOD Alert System. The airline companies questioned the effectiveness of the modifications. The FAA then agreed to postpone the requirement pending trials which four airline companies, including SAS, were to carry out during the 1992/93 winter season.

On 3 January 1992 the FAA decided in AD 92-03-02 that SB 30-59 (installation of four warning triangles with indication tufts on the upper surface of the wings) should be obligatory.

The aircraft manufacturer

The aircraft manufacturer has circulated to the airline companies affected a number of AOL dealing with the following subjects among others:

- Inspection and action to prevent clear ice on the upper wing surface
- Action in connection with frost coverage in the tank area on the underside of the wing
- Removal of snow and ice
- Takeoff when there is risk of ice formation
- MD-80 engine surging.

In addition the manufacturer has arranged many conferences on the problem of ingestion of ice into MD-80 engines.

The airline company

The day after the accident SAS telexed all stations where the company operates DC-9/MD-80, requiring that the upper side of the wings should be physically inspected as part of the normal departure check all the year round. Inspection for the presence of clear ice should be repeated after de-icing. All indication tufts should be felt by hand.

Subsequently, and with revision dates starting on 30 December 1991 a number of revisions and supplements have been made to the LMH, including:

- Methods and equipment for checking for the presence of clear ice before and after de-icing
- Reporting of clear ice check carried out
- Transfer of fuel from wing tanks (main tanks) to centre tank
- Mounting of engine protective cover
- Inspection of engine air intakes

1.17.4 Other actions after the accident

FAA

The FAA prescribed on 23 April 1992, in airworthiness directive AD 92-10-13, that the flight manual for the aircraft type, Airplane Flight Manual, should be supplemented with information on, among other things, the risk of ATR being activated by engine surging, together with instructions on how pilots should act in the event of engine surging during takeoff. As the first item in these instructions it is prescribed that ATS shall be disengaged.

The aircraft manufacturer

The FAA-AFM has been revised regarding measures in the event of engine surging. The manufacturer has published an AOL (FO-AOL-9-021 MD-80 Engine Surges) for airline companies concerned. This deals with, among other matters, the following:

- FAA AD 92-10-13.
- The Automatic Reserve Thrust System (ARTS)
- The Automatic Thrust Restoration system (ATR)

The airline company

The AOM has been supplemented with information on the ATR.

The normal checklist has been supplemented regarding report-back after completed clear ice check.

The emergency/malfunction checklist has been supplemented regarding action in the event of engine surging.

1.17.5 SK 483, 27 December 1991

An SAS MD-81 flight SK 483 took off from Stockholm/Arlanda 18 minutes after OY-HKO for a flight to Oslo. The aircraft had been parked outdoors overnight and prior to the flight had been de-iced by the same personnel as had de-iced OY-KHO but supervised by a different mechanic. After landing in Oslo a passenger informed the captain that he had heard abnormal noises on takeoff and observed clear ice on the wings. When the wings were inspected it was found that about 20% of the left wing and 30% of the right wing were covered with clear ice, starting approx. 1.5 metres from the fuselage. After the engine air intakes had been inspected and the aircraft de-iced, it was flown back to Stockholm/Arlanda. There the engine fan stages were checked, whereupon it was found that five fan blades of the left engine had soft indentations on the concave side of the leading edge and had to be replaced.

1.17.6 The company's technical and operational organisation

Technical division

The technical division is responsible for all flight-technical maintenance. The head of the division is responsible to the civil aviation authorities. The work is done at the bases in Copenhagen/Kastrup, Oslo/Fornebu and Stockholm/Arlanda and at a number of out-stations within the SAS network. Certain areas of responsibility are shared among the different bases. Administrative responsibility for line maintenance lies with the Copenhagen base. Each base bears responsibility for control.

Operational division

In the operational division the Vice President, Flight Operations, not the head of the division, is responsible operationally to the civil aviation authorities. Under the VPO is the flight standards department, with the task of issuing operational regulations, developing operational standards, setting objectives for pilot training and following up flight operations.

Within the department, operational responsibility lies with a Fleet Chief Pilot, of whom there is one for each aircraft type. To assist him he has a Fleet Technical Pilot, a Fleet Engineer and a Chief Flight Instructor. At each base there is a Chief Pilot for each aircraft type, part of whose job is to follow up on operational standards through continual contact with the line pilots.

The DC-9 Fleet Technical Pilot had an additional task as "project pilot, de-icing". There was no job description. His main task was to disseminate knowledge of de-icing procedures and to write the annual FLIGHT DECK BULLETIN/WINTERIZATION. After every winter season a working group under his leadership met and evaluated de-icing operations during the preceding season. The working group also met every autumn to lay down guidelines for de-icing during the coming season.

Quality assurance

Over and above the quality assurance integrated within the line organisation, there is a special Quality Assurance function. Its job is to check that work is performed according to the requirements in force. In the technical division it reports directly to the head of the division while in the operational division it reports directly to the Vice President, Flight Operations.

This organisational structure implies that quality assurance is a part of the line organisation.

In a staff function reporting directly to the Head of SAS, there is a quality management group. The task of this group is to scrutinise operations in a more general manner from the viewpoint of total quality. The group is represented in a working group set up by the airline company, the Flight Safety Quality Board.

2. Analysis

2.1 The flight

2.1.1 The pilots' action prior to the engine failures

The humming noise recorded by the CVR after the rotation was heard by the captain but he could not identify it. When the aircraft had reached an altitude of 1,124 ft, the CVR recorded the noise of an engine surge. At that point 25 seconds had elapsed since the rotation. Seven seconds later at 1,482 ft, the next engine surge was recorded. This was followed three seconds later by a further surge, whereupon the first officer, according to the CVR said "Think it's ... compressor stall".

Since the aircraft was vibrating heavily and the engine parameters were fluctuating rapidly, the engine instruments were difficult to read, particularly for the captain who also had to concentrate on flying the aircraft. In these conditions the pilots found the digital presentation, in particular, hard to read.

In a stressed and critical situation the size and design of instruments are of great significance. In connection with the Kegworth accident in England,[1] the AAIB made an enquiry among 120 pilots regarding their experience of electronic engine instruments of the same model as those on OY-KHO. Briefly, the study found that approx. half of those asked considered that the shorter electronic hands on the modern instruments were harder to read in the case of rapid changes than the old electromechanical instruments were.

Despite the difficulty of reading the instruments the pilots traced the malfunction to the right engine and the first officer suspected surging. At this point the captain moved the right engine throttle lever backwards without the surging stopping. This was recorded by the QAR as a throttle lever change by about 10%.[2] Since ATR had been activated previously (see 2.2.1), however, the throttle lever had moved forwards about 7% from the CLAMP position. Therefore the captain's action moved the throttle lever backwards to a position that was only 3% lower than the CLAMP position. If the corresponding reduction had been made from the CLAMP position, the power would have been reduced by another 7%. Whether this would have been enough to eliminate the engine surging cannot be established. Since ATR was in operation, which the pilots were unaware of, the throttle increase continued as soon as the captain had released the throttle lever.

The captain did not call for the emergency/malfunction checklist. Approx.

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[1] AAIB Report 4/90 on the accident to Boeing 737-400 G-OBME near Kegworth, Leicestershire on 8 January 1989

[2] Full throttle from idling to maximum thrust represents 100% and corresponds to a change of 60° in throttle lever angle.

22 seconds after the first engine surge, the first officer made an utterance which must be interpreted as a question to the captain about the emergency/malfunction checklist. The first officer then took it out but it was never consulted.

There was no simulator or other training on the engine surging problem. The lack of such training and the circumstance that actions in the event of engine surging were not "by heart" items in the emergency/malfunction checklist explain why the pilots did not take adequate action. A practical simulator trial showed that simply getting to the first action in the checklist takes about the time that elapsed from the start of the surging until both engines had broken up.

Because of the speed at which things happened, the information from a captain in the rear of the cabin that "the right engine is stalling", which the air hostess attempted to convey to the pilots, was of no help either. The hostess' unanswered call to the captain via the interphone was made only about ten seconds before the engines failed.

One question asked during the investigation was why the captain did not choose to level off at 2,000 ft, which is the current flyout altitude in the event of engine failure on takeoff, and reduce thrust on both engines. The explanation can be that the malfunction in question in the emergency/malfunction checklist is not referred to "ENGINE FAILURE". The Board considers that the captain's decision to continue climbing through the altitude mentioned was in agreement with established and trained routines.

The circumstance that the crew had no time to use the emergency/malfunction checklist explains why the captain did not continue the initial throttle-back on the right engine even though the jerks and vibrations in the aircraft persisted. The risk of incorrect action had been pointed out to pilots partly in the context of the Kegworth accident, in which the cause of the crash was that the wrong engine was turned off in connection with engine malfunction. The pilots were therefore instructed not to do anything in haste. Thrust loss in one engine should not normally affect the other engine. They therefore had no reason to suspect that it was anything except an isolated - albeit undefined - malfunction in the right engine which at worst could lead to the failure of that engine.

Engine surges are not unusual in modern jet engines. They can lead rapidly to the engine's destruction. It is therefore of the greatest importance that the pilots without delay take the action to stop the surges prescribed in the emergency/-malfunction checklist. The Board of Accident Investigation find it remarkable that engine surging during takeoff was not treated in the FAA Approved Flight Manual. Nor did the checklists produced by the manufacturer and SAS contain any by-heart item regarding action in the event of engine surging. The Board further considers that action in the event of engine surging should have been dealt with during the aircraft type training and practised regularly in the simulator.

2.1.2 The pilots' action after the engine failures

After the engines had failed the first officer called up Stockholm control. Eleven seconds later he reported that there were problems with the engines and that they needed to return to Stockholm/Arlanda. That the first officer in this situation did not use the "MAYDAY, MAYDAY, MAYDAY" emergency call probably did not affect the course of events. It is important that emergency calls are in fact used when the situation requires this.

Since the cockpit door was open, the uniformed captain in row 2 was able to follow what was happening. Seeing the situation as critical and unable to notice that any action was being taken regarding the surging he himself had identified, he hurried in to the cockpit to offer assistance. The captain accepted the offer and requested him to start the APU. That the first officer handed the newly-arrived captain the emergency/malfunction checklist must be interpreted as indicating that the first officer also saw him as a reinforcement to the crew. The assisting captain's action, which may be questioned on grounds purely of principle, turned out to have several positive effects.

With both the aircraft's engines out the pilots were in an extremely difficult position. An emergency landing under such circumstances places great demands upon the pilots, since it is important that the one who is flying the aircraft can devote his undivided attention to flying. In the Board's opinion there is nothing to show otherwise than that the three pilots separately and jointly contributed to the successful emergency landing.

The two left EFIS display monitors failed shortly after the engines had ceased to function. Because of this it was asked during the enquiry whether the captain should not have tried to recover the EFIS presentation by switching over the right EFIS images to the left display units, or to use emergency power. Another possibility would have been to hand over the flying of the aircraft to the first officer, since he had functioning EFIS displays. In the opinion of the Board there is no evidence that the outcome would have been in any respect more positive as a result of such action.

As stated under 1.1 the flaps were extended successively after the engines had stopped. SAS emergency/malfunction checklist for MD-80 does not include sufficient instructions regarding speed and flap positions for approach and landing with both engines out. Emergency/malfunction checklists for older versions of the DC-9 contain such instructions. The Board of Accident Investigation considers it a shortcoming of the MD-80 emergency/malfunction checklist that such instructions are lacking. The pilots' action must nevertheless be considered to have been successful in this case.

2.1.3 The cabin crew's action

The cabin crew's action in preparation for the flight followed the prescribed routines. Since departure was delayed, there was plenty of time for preparation.

As stated above one of the hostesses tried unsuccessfully via the interphone to contact the flight deck to pass on the information that "the right engine is stalling". She did not use the "emergency call", i.e. depress the ring button for at least ten seconds.

The instructions on reporting to the flight deck any irregularities during flight, e.g. engine malfunctions, do not specify that emergency call should be used. They say only that reports shall be made, but not how. In the situation under discussion it is uncertain whether the pilots would have answered even if the hostess had used emergency call, and in any case the information would have come too late to be of any help to the pilots. In a different situation it may be of crucial significance that the cabin crew make contact with the flight deck. It is therefore a shortcoming that the instructions to the cabin crew do not specify when emergency call is to be used.

According to the emergency instructions the captain shall one minute before an emergency landing order the adoption of brace positions by repeatedly turning the "fasten seat belts" signs on and off – the brace-for-impact signal. This was not done. As opposed to this the captain called a number of times "Prepare for an on ground emergency" which on one occasion was repeated in a loud voice by the assisting captain. Since the door to the flight deck was open the call was heard by the cabin crew and a number of the passengers.

The purser passed on the captain's announcement via the loudspeaker system, followed 20 seconds later by the instruction "Keep your seat belts fastened, keep calm". Approx. 20 seconds before the crash the purser called over the loudspeaker system "Bend down, hold your knees". The instruction was also called out in English and in Swedish by the cabin crew in the rear section of the cabin.

Most of the passengers followed the cabin crew's instruction to adopt a brace position, which on the basis of the studies reported under 1.16.3.1 must be judged to have contributed to the personal injuries being slight.

The cabin crew emergency checklist includes regulations on action for prepared emergency landings. On the other hand there are no provisions for cabin crew action in emergencies of the kind that occurred here.

According to the cabin crew instructions information concerning flight safety must be announced in English on international flights. On SAS aircraft where the majority of passengers can be expected to be Scandinavian citizens the Board of Accident Investigation considers that such information should also be given a Scandinavian language.

From the communication point of view it was of value that the flight deck door was open. The captain's intentions reached the purser. The open door also led to both the cabin crew and the assisting captain becoming aware of the emergency. That the flight deck door was open fits less well with what is termed the sterile flight deck concept which, among other things, implies that pilots may not be disturbed during takeoff and landing phases.

The open door is held in position by a magnet, which is too weak to keep the door secure in the event of a heavy landing or heavy turbulence. If the door comes loose it can injure those of the cabin crew that have their seats in the front part of the cabin. From the point of view of crash safety the aircraft is certified with the door shut.

Against the background of the foregoing the Board of Accident Investigation questions whether flying with the flight deck door open should be permitted.

2.2 Effect of ATR and ARTS

2.2.1 ATR

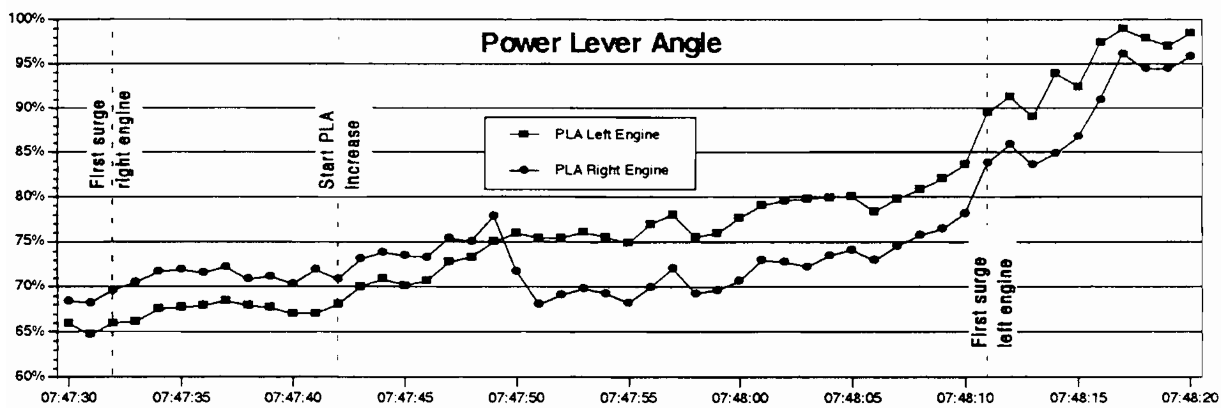
In the event of loss of thrust from one engine during the takeoff phase, ATR must ensure that the ATS immediately regulates thrust on the functioning engine to EPR G/A. The ATS always manoeuvres the engine throttle levers simultaneously and equally. This means that an engine thrust increase initiated through ATR will also affect the engine that caused the system to be activated.

When the climbing aircraft passed 350 ft. above ground, the criteria necessary for automatic arming of ATR were fulfilled.

Under 2.3.3 an account is given of the occurrence and effect of the surges that started in the right engine. When the first surge occurred the engines' EPR's were recorded as 1.943 and 1.657 respectively and N_1 rotation speeds as 97.9% and 78.5% respectively. The EPR difference then became 0.286 and the N_1 difference 19.4% which means that the conditions for automatic activation of ATR were met. That activation actually took place is shown by the fact that, according to the QAR recordings, the ATS changed over from CLAMP to G/A one second after the first surge.

As the ATS went over to G/A it started to increase the throttle to enable engine thrust to attain the new higher EPR that applied for G/A. Since this EPR rose with increasing flight altitude, the throttle increase for both engines increased successively during the climb.

Automatic PLA increase



As will be shown under 2.3.2 the damage to the engines' fan stages caused aerodynamic disturbance which led to the engines' EPR decreasing somewhat in relation to the other performance parameters. This meant that more throttle than normal was required for the engines to attain G/A EPR.

Engine surging is normally stopped by throttle cutback. As opposed to this, an increase in throttle results in the surges continuing with increased intensity. What is exceptional in this case was that both engines were subjected in principle to the same treatment with the result that both failed in the same way.

When approving ATR the FAA did not foresee that this system could be activated by an engine surge and cause increased throttle to the surging engine. The risk was first noticed in connection with this accident, which caused the FAA to issue Airworthiness Directive AD 92-10-13. This prescribes that the FAA-AFM shall be amended with information on, among other things, the risk of ATR being activated by engine surging, together with instructions on how pilots are to act in the event of engine surging during takeoff. The first item in these instructions prescribes that ATS shall be disconnected.

The Board of Accident Investigation considers that - for operators who do not use Noise Abatement Thrust Cutback Procedures - it should also be possible to deactivate ATR.

2.2.2 ARTS

On takeoff the ARTS was armed automatically. One second before thrust on the right engine was lost the N_1 rotation speed of this engine started to decrease rapidly at the same time as the engine surging persisted in the left engine. The engines' N_1 rotation speeds were then 95.8% and 55.4% respectively. The N_1 rotation speed difference between the engines was thus greater than 30.2% at the same time as the N_1 RPM of both engines was greater than 64%, which means that the ARTS was probably activated on that occasion. The momentary increase in fuel flow to the left engine recorded a second later may indicate that this was the case. Two seconds later the left engine also stopped delivering thrust.

2.2.3 Knowledge of ATR within SAS

At the time of the accident there was no knowledge of ATR within SAS. The pilots were therefore not trained on ATR and information about it was not included in their operational documentation.

However, all the necessary information was given in the aircraft manufacturer's manuals available within the company. While the system was not included in the manufacturer's internal documentation for production trial flights, Production Flight Procedure Manual (PFPM), it was described in the FAA Approved Flight Manual under the heading "Manual Thrust Cutback Procedures for Noise Abatement" and in McDonnell Douglas' Flight Crew Operating Manual under the heading "Select Flight Director/Autopilot Takeoff Mode".

Hence ATR was described in manuals which every operator is obliged to know. Even though the system was originally developed for use in special procedures not applied by SAS, a sufficiently careful study of the manuals should have led to SAS noting the system and training its pilots in its function.

If the pilots had been informed concerning ATR they would have had more chance of noticing the changeover from CLAMP to G/A. They would then have been better prepared to take adequate action.

It was a serious deficiency in flight safety that the pilots lacked knowledge of ATR and its function. ATR is activated without special indication and in such a way that it can escape the pilots' notice. Increased throttle on both engines now took place without the pilots' knowing.

2.3 The engine failures

2.3.1 General

Nothing has emerged to indicate that the aircraft's engines before the rotation had any technical fault that affected the development of engine surging. However, a manufacturing fault in a weld seam in the aircraft's main fuel duct to the left engine contributed to a fuel leak occurring in connection with the engine failure.

The course of the failure was very similar in both engines. The following analysis of the sequence of events therefore applies to both engines unless otherwise stated.

2.3.2 Aerodynamic disturbances in the fan stages

Modern turbofan engines are sensitive to damage to fan blades and outer fan blade seals. Fan blade damage located on the blades outer tips is particularly critical. Such damage can at high engine power cause local fan tip stall. The N_1 rotation speed increases and EPR then decreases somewhat in relation to other engine parameters. The fan tip stalls can increase and form "rotating cells" in the fan stage with what are called continually rotating fan tip stalls.

On liftoff the QAR recorded an increase in N_1 rotation speed by 4% in the left engine and 6% in the right engine, and a decrease in the EPR values by 0.02 and 0.03 units respectively. This change in performance is abnormal. The performance change and the humming noise recorded on the CVR approx. three seconds after the rotation indicate that a continually, rotating fan tip stall had developed, at least in the right engine.

The damage found to the leading edges of the fan blades is located at the tips of the blades and is of the nature of "soft" indentations without gashes or scratches. This type of damage arises when ice, birds or similar are ingested by the engines. The outer fan blade seal was damaged at the same time by the blades being bent and twisted so that the tips came into contact with the sealing surface and ground away a certain portion of the sealing material.

2.3.3 Engine surging

The origin and effect of engine surging is described under 1.6.3.3. The increase in N_1 rotation speed changed the relationship between the front and the rear compressor rotation speeds, which reduced the engine surge margin. At the then high power output, there therefore existed the conditions for the aerodynamic disturbances in the fan stage to propagate themselves to the compressors and cause engine surging.

The first of a number of surges in the right engine was recorded on the QAR and the CVR 25 seconds after liftoff. In the QAR printout the surges were recorded as strong fluctuations in several parameters. Throttle advance (PLA) was then 69.56% and the engine's EPR prior to the surge was 1.943. It is shown in 2.2.1 how the ATS through the effect of ATR was activated and caused an increase in throttle approx. ten seconds after the first surge. This increase contributed to the fact that the surging continued and intensified until the engine finally broke up 51 seconds after the first surge.

Surging in the left engine started 64 seconds after liftoff. PLA was then 89.45%. EPR two seconds before the first surge was 1.963. The surging continued until the engine broke up 14 seconds later.

The risk of engine surging as a consequence of damage in the fan stages depends on the extent and character of the damage. The right engine fan blades had the most extensive damage at their tips while those in the left engine had the greatest damage nearer the centre. This is the main reason why the surging in the left engine started later and at a higher power output. Once the left engine had started surging, this took place with greater force since the engine was then working at higher power.

2.3.4 Compressor failures

The surges subjected the engines to aerodynamic and mechanical stresses that became greater with the increasing engine power. The engine damage indicates that the stg 1 stators were finally broken up by these stresses. The impact damage found on the fan blade trailing edges was caused largely by broken-off stator pieces. The pieces then accompanied the air flow into the front compressors, causing extensive damage to their front stages. Blades and guide vanes in the rear parts of the compressors were damaged by pieces struck loose further forward in the engines.

Experience from earlier cases of compressor damage in connection with engine surging shows that the stg 1 stator has often been the first engine element to fail. Even before the OY-KHO accident the engine manufacturer had started to introduce a reinforced mounting for the vanes in the stator inner ring to increase the resistance of the engine to surging. This modification had not, however, been introduced on the engines under examination.

Greater forces were liberated when the compressors broke up, which for each engine is judged to have taken about one second. Broken-off engine pieces were also thrown forwards in the front compressors and further dispersed out through the fan ducts. Engine pieces from both engines were collected from an area crossed by the aircraft at the moment when, according to the QAR recording, the engines broke up.

The right engine surged for 51 seconds before failing. The surging in the left engine occurred at higher output and hence loaded the engine with greater forces. This engine therefore broke up after surging for only 14 seconds. The course of the failure in this engine may have been further accelerated by an increased fuel flow caused by the ARTS being activated shortly before the engine broke up (see 2.2.2).

There is nothing to show that the engines had any other damage when surging started than the limited damage that arose in the fan stages when the aircraft lifted. This damage was probably not so extensive as to prevent the surging in the right engine from stopping if power had been reduced sufficiently. The right engine could subsequently have been used with reduced thrust. In the left engine, surging would probably not have occurred at all if the original thrust had been maintained during the climb. With sufficiently reduced thrust in the right engine and maintained thrust in the left, the engines would probably not have failed. The aircraft would then have been able to return for landing.

2.3.5 Fire in the rear compressors

Titanium alloys can be ignited and burn at temperatures over 1,600°C if sufficiently large quantities of oxygen are available. The compressor blades in stgs 7–9 in the rear compressor, and the rear compressor case, are made of titanium alloy. Both engines have damage that shows that titanium burning occurred in these areas.

When the engine compressors failed there was high air pressure and thereby a copious supply of oxygen. Local high temperatures were generated through friction between rotating, static and broken-off metal pieces. Titanium alloy pieces were thus ignited. Through a combination of high temperatures and mechanical load, holes were made in the engines' rear compressor cases which serve as pressure vessels for the rear compressors. The pressure and temperature thereby decreased rapidly, causing the titanium fire to stop spontaneously after the brief break-up phase.

2.3.6 Fire inside the left engine cowlings

When the left engine failed a hole was pierced in the fan duct level with stgs 7 and 8. Pieces of the stg-7 stator were ejected through the hole and struck the main fuel pipe. This was deformed on the side facing the engine, causing a fissure in a weld seam on the opposite side of the pipe because the strength of the joint was reduced through a manufacturing error. Through this fissure aviation fuel was sprayed at high pressure into the engine space, where it ignited.

The fire activated the fire alarm system 13 seconds after the left engine had failed. When the first officer shortly after this activated the left engine fire extinguishing system the fuel supply was closed off and the fire extinguished.

2.4 Clear ice

2.4.1 *The formation of clear ice*

It is well known that clear ice can form on the upper surfaces of wings under conditions of high atmospheric humidity or rain in combination with greatly chilled wings. It is also well known that such ice is broken off through movements of the wings on liftoff.

During the flight from Zürich the fuel had become greatly chilled. On landing there were 2 550 kg of fuel in each wing tank, which represents approx 60% of the tank volume. This volume of fuel was enough to chill the upper surfaces of the wings. The meteorological conditions for the formation of clear ice where almost optimal. The flight technician who inspected the plane during the night noted that clear ice had already formed on the wings. In addition, passengers saw during the de-icing that the indication tufts were not moving and on liftoff that ice was coming off the wings. It is clear from 2.3.2 that the engine damage was initiated by "soft" objects being sucked into the engines.

Against this background the Board of Accident Investigation finds it beyond all doubt that clear ice loosened from the wings in connection with the aircraft's liftoff, and that the ice was then ingested by the engines.

2.4.2 *De-icing*

It is ultimately the captain's responsibility to ensure that de-icing is done with sufficient care. It is, however, the technical division that must answer for de-icing being performed and checked. Besides the bulletins issued within the technical division during the course of the year, training was organised before the start of the winter season for all personnel concerned. Each mechanic was provided with a checklist which specified that he should check whether there was any clear ice by feeling the wing upper surfaces with his hand.

There were no detailed instructions in defined nomenclature that described how to check for the presence of clear ice, how the ice should be removed or how the follow-up check and the report to the captain should be effected.

In the present case it should have been clear to the mechanic that he should check whether there was any clear ice, since rime had been noted on the underside of the wings in the tank area. He did perform this examination by climbing up on a ladder and, with one knee up on the leading edge of the left wing near the fuselage feel the upper side of the wing with one hand. He could not discover any clear ice there and concluded wrongly that there was no clear ice further aft either. There was ice there, however, on an area which he, with this particular means of checking, could not reach.

To be able to carry out an effective examination it would have been necessary for the mechanic to have gone out onto the wing, which was slippery because of the precipitation.

Since he could not find any clear ice before the de-icing, the mechanic had no reason, given the instructions in force, to check this again after de-icing had been carried out.

The technical equipment used for the de-icing was checked by the Board of Accident Investigation. The examination shows that it met the relevant specifications.

2.4.3 SAS' handling of the clear ice problem

The risk of ingestion of clear ice by the engines of the aircraft type has been known for many years. As early as 1985 a DC-9-51 suffered serious engine damage for this reason. On the MD-80 series, the risk is greater due to the configuration of the wing tanks and the larger engine air intake area. The manufacturer has therefore over the years taken a number of steps to inform operators of the problem and has distributed numerous service bulletins intended to reduce the risks.

The problem has thus long been known within SAS. In 1987 the aircraft were equipped with warning triangles with indication tufts to facilitate the discovery of clear ice. The matter has also been covered in internal information over the years. In, among other places, the Winterization Bulletin to all SAS pilots, issued in October 1991, the problem was elucidated once again. It was stated that it is the captain's responsibility to check the presence of snow and ice which might affect the aircraft's performance.

In the training of MD-80 pilots the clear ice problem has not been specially dealt with; nor were there any special written instructions for the pilots' action if there was a risk of clear ice. If the pilots had had more knowledge and unambiguous instructions, they would probably have been more alert to the risk of clear ice formation.

For technical personnel, LMH contains the following as regards checking for clear ice. "... when there is a doubt as to whether clear ice has formed on the wing upper surface, the wing upper surface has to be checked using suitable means of access in order to detect the possible clear ice." The (Swedish-language) "Line Maintenance De-icing Instructions, Winter 1991/92" for the Arlanda base contains the following statement about clear-ice control. "Physical hand contact with the wing upper side and tapping with the back of a screwdriver are the only reliable methods of discovering clear ice ... if external conditions give reason to suspect clear ice, the upper sides of both wings must be inspected even if the wing inspected first is free of clear ice."

Technical personnel were thus familiar with the clear-ice problem through training and information. In the Board's view, however, the clear-ice problem as dealt with in LMH, which is the formal governing document for direct work, had an obscure position and lacked detailed instructions on how the check for clear ice was to be carried out; nor was there any follow-up on how the check was performed in daily practice.

The Board further finds it surprising that there was no routine for reporting on observations regarding clear ice. It has been established that the technician who inspected the aircraft during the night noted the presence of clear ice. There were, however, no instructions obliging him to report this to the mechanic who was to carry out the departure check next morning.

Furthermore, the technical personnel had no access to suitable aids for checking effectively. To reach the critical area on the upper side of the wing without risking an accident, either special tools or specially-built ladders would have been required.

It must be considered remarkable that the numerous different warning signals on the risks associated with clear ice that have reached SAS over the years have not led to effective action being taken to ensure that aircraft did not take off with clear ice on their wings.

It is obvious that SAS self-monitoring has been deficient regarding the handling of the clear-ice problem. It also emerges that the Scandinavian Civil Aviation Supervisory Agency was not aware of the deficient quality assurance. The Board points out that the idea of self-monitoring presupposes that the supervisory authority ensures that the company possesses a well functioning system of quality assurance.

2.5 Electrical disturbances

2.5.1 Electrical power failure

According to the QAR typescript, there were two brief failures of electrical power in the aircraft's left electrical system during the flight.

The first electrical failure occurred 16 seconds after the left engine had ceased to deliver thrust, and lasted approx. two seconds.

Prior to the electrical failure the aircraft's left electrical system was supplied from the generator of the left engine and the right from the generator of the right engine. Three seconds before the failure, the left engine fire extinguishing system was activated. At that point the generator of that engine was disconnected, whereupon the right generator assumed the supply of all electrical power through the AC crosstie system. The wind speed drove the N_2 rotor of the right engine at about 50% revolutions, which was sufficient for its generator to supply both electrical systems.

The two-second power cut associated with the cross-over connection may have been due to a delay in the left GCU which in turn governs the AC crosstie relay. Modifications SB 90.201 and SB 91.201, the purpose of which is to eliminate the risk of cross-over delays, had not been made to this GCU. The delay may also have been caused by a fault in one of the units it has not been possible to check, or by incorrect voltage in the system.

The second electrical failure occurred 29 seconds later and lasted about 8 seconds.

At this point the N_2 rotation speed of the right engine had decreased to approx. 41%. At this low r.p.m. the right generator was now unable to deliver current at the right voltage and frequency. Hereby there arose a total power failure in both electrical systems.

After the engines had stopped the assisting captain attempted to start the aircraft's APU. He himself thought that the attempt had been unsuccessful. It can be assumed that the attempt was made about half a minute after the thrust of both engines had been lost.

Technical examination of the APU shows that the attempt to start it was successful, and that it was running at full rotation speed on impact with the ground. The normal time from initiation of APU start-up in the air until it can deliver electrical power to the system is 30 to 50 seconds. The point at which the APU could start to deliver power to both systems coincides well with the point at which, according to the QAR, the power failure ceased 53 seconds after the engines had stopped delivering thrust. Both electrical systems were subsequently supplied from the APU until the crash.

2.5.2 EFIS

According to the captain the two left pilot position EFIS display monitors went dead after the engine failures. The left EFIS system is included in the left electrical system and was therefore without power during the two electrical failures mentioned above.

Starting the EFIS normally takes 1–6 seconds. It has not been possible to establish why the left EFIS did not restart after the power failures. Many of its components were damaged in the crash and could not be examined. Faults can have occurred in one of these components in connection with the two power failures so close in time.

The right EFIS was also without voltage during the second power failure. The pilots observed no problem with this system, for which reason as far as may be judged there was a normal restart when voltage was restored.

2.6 Survival aspects

2.6.1 General

A series of fortunate circumstances led to the chances of surviving the accident being good. A possible site for the emergency landing was within reach. The aircraft was slowed down in a very favourable way and touched down the right way up. The breakup of the fuselage into three parts created good opportunities for evacuation even though only five of the eight emergency exits could be used. No fire broke out despite the large quantities of fuel spread out over the location of the accident.

2.6.2 Cabin safety

The Board's investigation first shows that the aircraft's structure and fittings of met the certification requirements. An entirely different question - discussed in part below under 2.7.1 - is whether the requirements for certification are at a suitable level.

Regarding one point the answer must be an unequivocal no. This concerns the requirements for the overhead bins. Despite the fact that the design proved to meet the relevant certification requirements with a good margin and that the bins were not overloaded, many of them fell down off their mountings. In addition, a large number of bin doors opened, which allowed hand baggage to fall out. It must be considered unsatisfactory that the demands are so low that the bins and their contents can cause injury to passengers in a crash which otherwise was no more serious than that all on board survived - most with slight injuries only. The Board, accordingly, together with the National Transportation Safety Board, in March 1992 urged the FAA to consider a change in the requirements to the effect that they be defined on the basis of the dynamic forces in different directions that arise in a crash in which those on board have the prospect of managing without serious injuries.

The toll of injuries depends not only on speed and loads but also on the length of the pulses. The investigations of speeds, loads and pulse-lengths made for those who were in the front portion of the aircraft show - as confirmed by the medical investigation - that the stresses were near the limit beyond which serious injury is inevitable.

Three of the aircraft's eight emergency exits could not be used. In one case - the rear emergency exit over the right wing - this is partly connected with the fact that overhead bins had been emptied of their contents and that this, together with other material, was blocking access to the door. In another case - the rear entrance door - the investigation shows that this was because of structural damage in connection with impact. In the third case, however, the cause was that the contents of certain stowage spaces and - chiefly - of one of the ovens in the rear galley area were blocking the evacuation route so that while the opening mechanism was accessible it could not be used. In the Board's opinion a tightening of the requirements for such stowage areas should be considered with the aim of reducing the risk of emergency exits being blocked in the manner of the present case.

The Board of Accident Investigation would also here draw attention to the placing of the mid jump seat. It is understood that this was chosen to improve the view of the part of the cabin forward of the galley area. However, the seat, unless vacant, inevitably blocks the evacuation route forwards for those who are sitting further aft if the aft door should be unusable; a situation which is far from unreasonable. It can therefore be asked whether this design solution is suitable.

The cabin crew's action during the course of the crash and directly afterwards contributed to the personal injuries being limited and the evacuation being accomplished quickly and efficiently. The Board has however noted that the cabin crew were unable to reach their emergency checklists from the positions they are to adopt in emergency situations. This appears unsatisfactory.

2.6.3 *Rescue operations*

2.6.3.1 Alarm and search

In the opinion of the Board of Accident Investigation the alarm and search were accomplished efficiently. In certain cases the turnout times were shorter than would have been expected.

2.6.3.2 The rescue operation

During the investigation criticism - chiefly from the passengers - was directed at the work at the location of the accident. The criticism was largely that it took much too long and that the passengers were obliged to wait outdoors for a long time.

When the duty fire engineer from Räddsam Norr - who was first commander for most of the duration of the operation - arrived at the accident he found that only a few people were injured. He knew that a number of helicopters were on their way to the location, that ambulances were also on their way, and that buses had been requisitioned for removal of the uninjured and slightly injured. On this basis he judged that the operation would be brief. Consequently he did not order up to the accident site the heated tents that were available at the break point. Further, he did not set up a management staff.

Three circumstances hampered the initial phase of the operation. The first was that the first commander was not initially aware of the radio communication difficulties at the site. The second was that he underestimated the problem of registration and transport of slightly injured and uninjured passengers. The third was that the traffic control directives to police personnel at Gottröra church were sketchy. Because of the communication problems they could not get supplementary instructions by radio either. They were therefore compelled to judge unaided what vehicles should be allowed to pass. The problems of communication were well known to the Norrtälje police personnel but hardly at all to the other forces on the spot. However, they were soon discovered, although no action was taken to solve them until the personnel in the police command bus, with better technical equipment, on their own initiative moved the bus from the break point to the accident location.

During the investigation it emerged that the rescue service was unaware that there were oxygen generators containing sodium chlorate on board the aircraft. The Board considers this circumstance should be dealt with in rescue service training.

2.6.3.3 Registration

Registration of those on board is a necessity in order to ascertain that nobody is missing. It is a particularly delicate task for the police. Since a serious air accident quickly becomes known, great pressure develops to obtain information on the situation as regards the passengers. The information that is released must be correct. Clearly, it must not happen that the police inform a relative that a passenger enquired about has been found and is unhurt if this information has not been checked as being entirely reliable. Unconfirmed information of this nature given too early can, if it later proves incorrect, entail a greater tragedy for relatives than if they had had to wait longer for correct information.

In view of this it was, in the Board's opinion, fully justified of the registering policemen to take great pains to really ensure that all were registered and checked against the passenger list. The painstaking registration procedure should also be seen in relation to the fact that both at the location of the accident and in the media there had been reports that some persons were missing or had possibly made their way to a summer cottage in the vicinity. Uncertainty as to the number of passengers caused the deployment of extensive resources to search for persons presumed missing.

The process of registration is time-consuming and is eased if a reliable passenger list is available. Not until 1400 hrs was a complete list available. This caused delays. The Board finds that cooperation between SAS and the police did not function satisfactorily in this respect.

The Board of Accident Investigation further considers that the registration could have been carried out in a better manner. In the Board's opinion more staff should have been detailed for registration - specially in the case of the uninjured and slightly injured passengers who were at the cottage. It must also be noted that there were deficiencies in the method of registering and in the management thereof. Lastly, it appears inexplicable that the first, incomplete passenger list to reach the police communications centre in Stockholm was not at the location of the accident until 37 minutes later.

2.6.3.4 Management and coordination

In major or protracted rescue operations the first commander should as soon as possible assemble a staff to support him in the work. In the rescue instructions for Stockholm/Arlanda airport it is assumed that a staff is set up. However, getting such a staff organised and working takes a certain amount of time.

The first commander chose an damage area controller and divided the damage area into sectors. However, no emergency service operator or staff commander was chosen. If the first commander had detailed persons for these functions he would have freed himself from direct involvement in communication problems and the details of the operation. In this way he would have been able to devote himself to the overall function of leading and coordinating the operation and following up given directives.

The first commander's difficulties in judging the effects of the communication problems and the time and resources required for registration are, in the Board's opinion, explained by the fact that these matters had not received sufficient attention in the training exercises carried out during the planning of the Stockholm/Arlanda rescue services.

It may further be asked whether the rescue service official in charge at the break point ought not to have the qualifications of a first commander for major emergencies at municipality level. He needs to possess wide experience of different types of rescue operation. He must first and foremost ensure that communication is established with the first commander so that the latter's intentions are implemented at the break point. It has not been possible to establish whether other means than radio were tried for establishing contact with the rescue management. In the Board's view, such means should have been attempted from the break point.

A number of medical care teams were at the location of the accident about an hour after the crash, and this must be considered an entirely reasonable time. The first inventory of the injured was completed by then and the most seriously injured were being removed or prepared for transport.

The staff doctor whom the county-council official on duty called to SOS-A found difficulty in gaining a coherent picture of the operation at the injury site. This was in part because the alarm service operators were so occupied that nobody could help the doctor to use external connections to obtain information or give directives. For example, it was not until 14.00 hrs that he was informed that there was a medical care team from Huddinge Hospital, since this team had not been called out through SOS-A.

The staff doctor was not kept informed on the operation at the injury site. This was not only because of the overloaded radio and telecommunications. The senior medical officer considered it natural to contact the disaster room at the Karolinska Hospital, his ordinary place of work. In the event, therefore, practically all medical transport was run without control from the staff doctor, who had the combined picture of the mobilised medical care resources. Such resources therefore remained unused. Above all, the medical organisation at the accident location could have been wound up earlier.

The Board of Accident Investigation considers that the medical attention given to injured persons at the location of the accident functioned well. However, coordination between the different medical care groups and the allocation of the medical resources through SOS-A could have been better.

The rescue work came to affect the rescue services of several municipalities and, in the initial phase - also the national rescue service. A rescue operation of this character entails a definite need of coordination among various organs of the community.

If extensive rescue help is required within the municipal rescue service, according to section 34 of the Ordinance on the Rescue Services (1986:1107), the County Council shall assume responsibility for the service in the municipalities affected by the operation. According to section 35 the County Council shall after consultation with the county municipalities and authorities involved produce the plans the Council needs to be able to carry out its responsibility.

An accident involving a large passenger aircraft probably requires such major rescue action that the County Council should assume the responsibility for the rescue service and establish a rescue plan. The current rescue instructions for Stockholm/Arlanda, which theoretically apply only to accidents within the airport area and its immediate vicinity - were developed by Sigtuna municipality, the ARCC, the airport's air traffic control, the Stockholm police authority and certain private interests. In the opinion of the Board of Accident Investigation, the County Council should have directed the work of producing such a plan. Since similar issues are of concern at Sweden's other major airports, the Swedish National Rescue Services Board as the central supervisory authority should initiate and participate in the planning. Since there are few major airports in the country it should be possible to ensure that there is realistic training within the municipalities that could be affected. It would be a great advantage if the planning could result in well-trained management teams able to function in whichever of a country's municipalities the accident occurs. Such management should also include a senior medical officer and senior police officer.

The Board of Accident Investigation earlier noted certain shortcomings in the rescue work. These can be related almost exclusively to the fact that the participating groups had not trained together sufficiently. According to the Norrtälje rescue plan the municipality shall take part in the joint exercises organised regularly by the municipal rescue services around Stockholm/Arlanda. It has, however proved to be the case that the municipality has not participated in such exercises for several years.

2.7 Miscellaneous

2.7.1 Issues regarding certification

The certification of the DC-9-81 (MD-81) in 1980 is based on the original type certification of the DC-9 from 1965. The reason for this is the system of "derivatives" which has long been general within the aircraft industry. Under the system an aircraft that can be said to be a new version of an earlier type is not type certified from the beginning. Instead, the old type certificate is extended to apply also to the new version. This in turn means that FAR regulations that have been introduced after the original type certification are not immediately applied to the more recent versions.

It is obvious that changes in the regulations cannot always be applied directly to newly-built, production-line aircraft if this requires basic redesigning. It ought, however, to be entirely possible to adapt production to the new requirements more quickly than at present.

Furthermore, in the current FAR regulations, the risk of FOD damage caused by ice - e.g. clear ice or blue ice - forming on the aircraft, to rear-mounted engines is not taken into account in the current FAR regulations.

The Board is aware that these issues are being discussed, for example in the context of work on common European airworthiness regulations (JAR). In the Board's opinion, however, there is reason to stress the necessity that the safety authorities reconsider the extent to which new versions of older aircraft types may be approved without new type certification. The Board further questions whether the circumstance that an aircraft type was once type certified on the basis of the requirement level then applying is sufficient reason for exempting later individuals of the type from the application of regulations coming into force after type certification.

2.7.2 The location of the accident

Following extensive decontamination over several months it is judged that no protracted damage has occurred to the immediate vicinity, ground water or surrounding areas of water.

The land around the location of the accident has been restored as far as possible.

3 Conclusions

3.1 Findings

1 The pilots and the cabin crew were qualified to perform the flight.

2 The aircraft was airworthy.

3 Clear ice formed on the upper surfaces of the wings overnight.

4 The clear ice was not discovered during the check made before the aircraft was de-iced.

5 The de-icing carried out before the flight did not remove the clear ice from the wings.

6 The company's instructions, routines and equipment were insufficient for ensuring the discovery and removal of clear ice.

7 On liftoff, clear ice was broken off the wings and ingested by the engines, damaging the engine fan stages.

8 The damage led to engine surging in the right engine.

9 The pilots had insufficient knowledge and training to enable them to identify the malfunction and take the necessary action. The pilots did not use the emergency/malfunction checklist.

10 Without the pilots noticing it, engine power was increased automatically through the effect of ATR, which involved an increase in the intensity of the surging.

11 There was no knowledge of ATR within SAS.

12 The surges loaded the engine so that its stage 1 stator broke up and the engine failed.

13 The increase in engine power also caused the left engine to start surging until - two seconds after the right engine - it failed in the same manner.

14 In connection with the engine failures, titanium fires broke out in both engines, and a fuel fire in the left engine. The titanium fires went out spontaneously. The fuel fire was extinguished by the first officer with the engine fire extinguishing system.

15 After the engine failures the captain lost his EFIS presentation in consequence of electrical power failure.

16 When both engines had lost all thrust the aircraft was glided to an emergency landing.

17 The emergency/malfunction checklist for MD-80 did not include sufficient instructions regarding speed and flap position for approach and landing with MD-80 with both engines unserviceable.

18 The pilots sent no distress signals.

19 Shortly before impact with the ground the aircraft collided with some trees, whereupon the major part of the right wing was torn off.

20 On impact with the ground the fuselage was broken into three parts.

21 Extensive damage was caused to the cabin fittings. Overhead bins fell down. A large number of bin doors opened.

22 Three of the eight emergency exits could not be used for evacuation.

23 On impact with the ground loads arose that - at least in the forward part of the cabin - exceeded the certification requirements for the aircraft.

24 All those on board survived, most without physical injury. One passenger suffered a disabling back injury.

25 The site of the accident was located from a helicopter after about 20 minutes and land rescue forces were at the location ten minutes later.

26 Transport of those on board was completed after about 3 hours and 30 minutes.

27 A complete passenger list was available to rescue personnel after about 5 hours.

3.2 Causes of the accident

The accident was caused by SAS' instructions and routines being inadequate to ensure that clear ice was removed from the wings of the aircraft prior to takeoff. Hence the aircraft took off with clear ice on the wings. In connection with liftoff, the clear ice loosened and was ingested by the engines. The ice caused damage to the engine fan stages, which led to engine surges. The surges destroyed the engines.

Contributory causes were:

- The pilots were not trained to identify and eliminate engine surging.
- ATR - which was unknown within SAS - was activated and increased the engine power without the pilots' knowledge.

4 Recommendations

The Board of Accident Investigation recommends the Swedish Civil Aviation Administration regarding aircraft of the DC-9-80 series to

1. arrange that airline companies have instructions and procedures to ensure that the aircraft for which they are technically responsible do not take off with clear ice on their wings,
2. seek the introduction of a means of deactivating ATR,
3. seek the inclusion, in the emergency/malfunction checklist, of initial actions in case of engine surging as by-heart items, to be regularly practised in the simulator,
4. seek the addition to the emergency/malfunction checklist of instructions for emergency landing in the case of loss of thrust from both engines,
5. seek to make it possible for cabin crew members to reach their emergency checklists from their emergency positions,
6. consider increasing the stringency of the requirements for the fixing of loose galley equipment,
7. consider the need of a prohibition on the cockpit door being open during takeoff and landing.

The Board of Accident Investigation further recommends the Swedish Civil Aviation Administration to

8. ensure that SAS possesses a well-functioning system of quality assurance,
9. seek, in international cooperation between civil aviation authorities,
   the supplementation of current design regulations with regard to the risk of FOD damage to rear-mounted engines and caused by ice forming on the aircraft,
10. seek, in international cooperation between civil aviation authorities, a limitation of the possibilities of certifying new versions of older aircraft models without new type certification,
11. seek, in international cooperation between civil aviation authorities, for new safety requirements to be applied earlier in the production run,

12 seek to ensure that safety information in aircraft operated in international traffic by Scandinavian airline companies is also given in one of the Scandinavian languages

13 seek the development of better routines for making passenger lists available in the event of accidents.

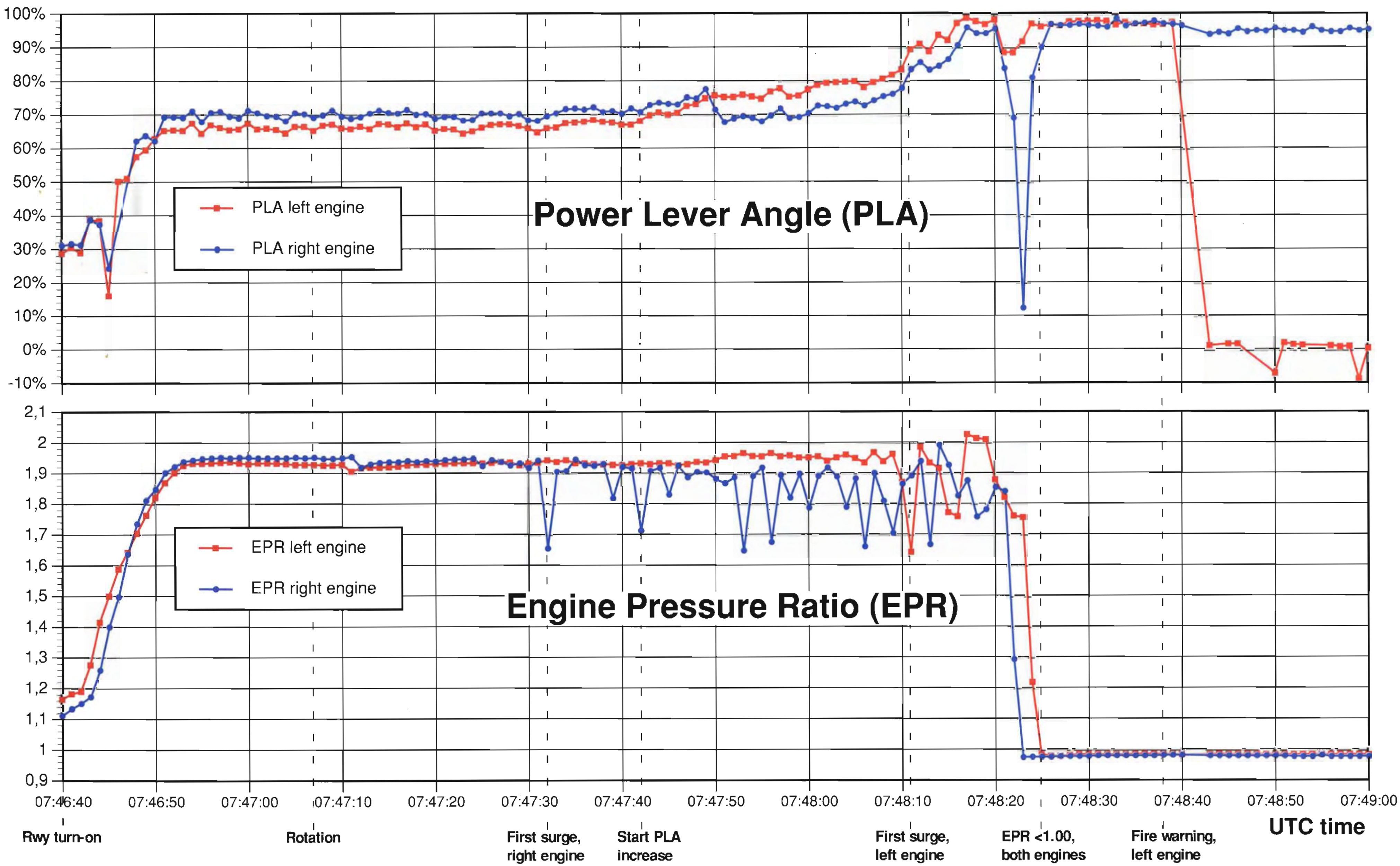
The Board of Accident Investigation recommends the Swedish National Rescue Services Board to

14 ensure that the planning for rescue operations following air accidents in the vicinity of major airports be improved and encourage regular practical training for such operations.

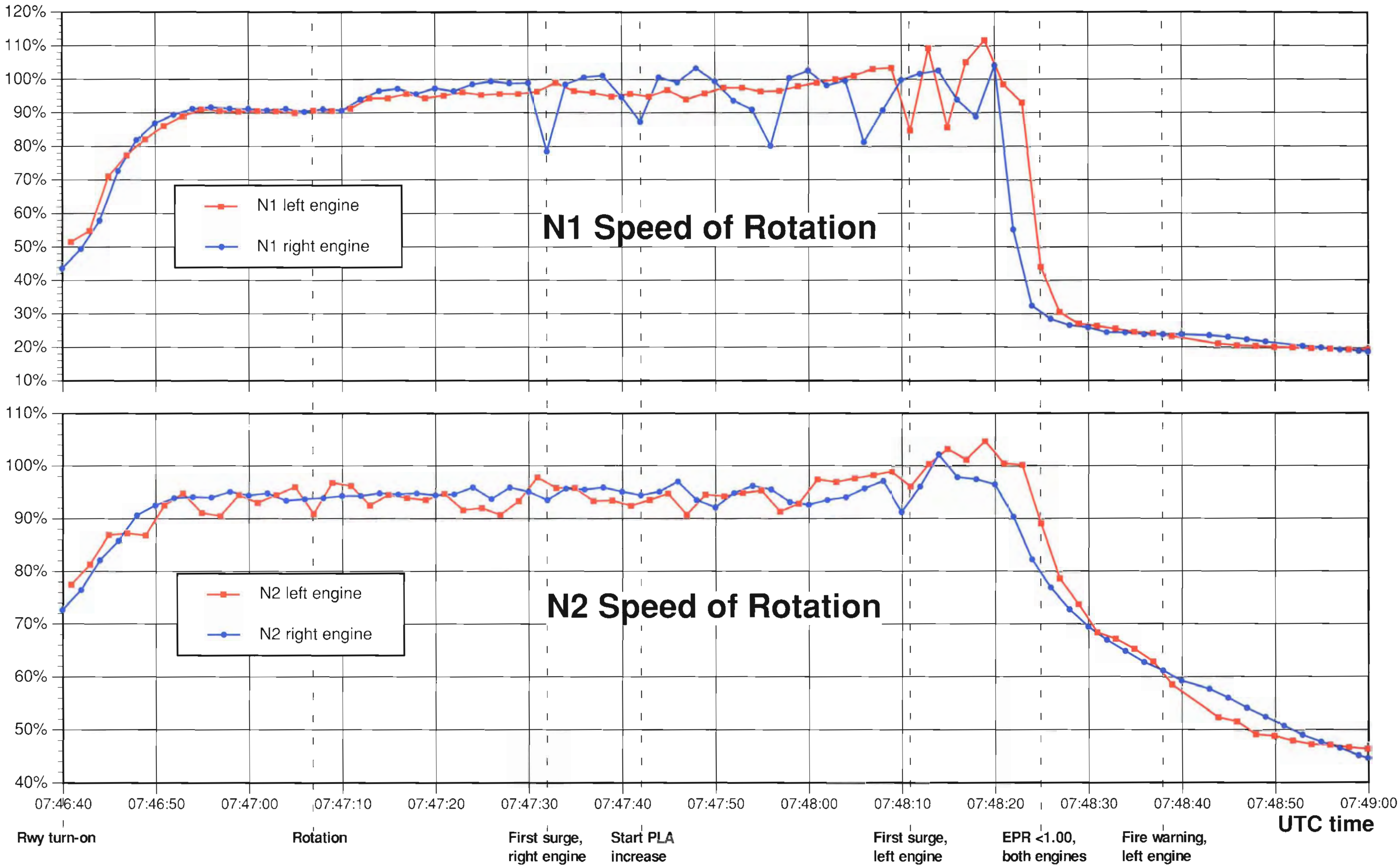
The Board of Accident Investigation recommends the National Police Board to

15 improve methods and training concerning the registration of persons in the event of major accidents.

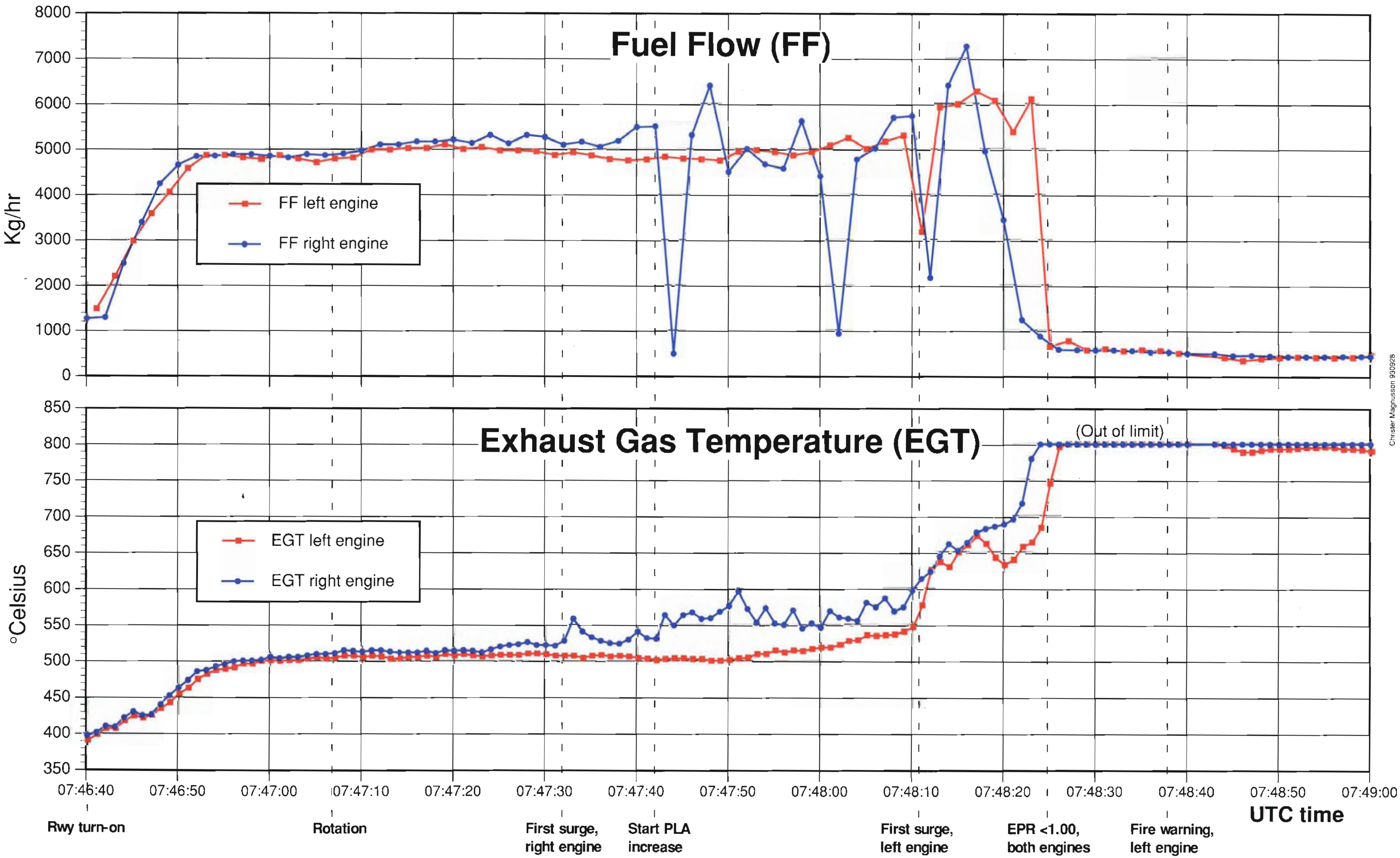
QAR Parameter Plot



QAR Parameter Plot



QAR Parameter Plot



QAR "Engine" parameters

101		1	77	78	15	16	68	69	70	71	66	67	72	73	79	98	41	95	96	44	113	
GMT a/c hh:mm	Time UTC correct	Press Alt comb	Power LevLH %	Power LevRH %	EPR Eng 1	EPR Eng 2	N1% Eng 1	N1% Eng 2	N2% Eng 1	N2% Eng 2	EGT Eng 1 degr	EGT Eng 2 degr	FF#1 -217 kgs/h	FF#2 -217 kgs/hr	Brake Pr LH Press	Pneu Man Press	Fire Warn Eng 1	Ing 20J	Ign 4J	Radio keying VHF1	Sync error flag	Comments
	07:46:20	99	12.67	17.38	1.063	1.041		27.7		54.5	388	379		532	39	20.8						
7:45	07:46:21	100	22.61	21.92	1.068	1.041	32.9		60.5		392	381	901		34			off	on			
	07:46:22	101	21.92	21.39	1.079	1.042		28.2		55.8	401	383		660	34	21.3						
	07:46:23	100	21.74	20.34	1.089	1.044	37.5		68.5		419	389	951		39				on			
	07:46:24	101	22.09	20.17	1.094	1.048		29.7		58.6	423	394		681	34	21.7						
7:45	07:46:25	102	21.92	21.04	1.098	1.050	40.4		66.5		417	400	908		34			off	on			
	07:46:26	102	21.92	20.87	1.100	1.054		31.5		59.9	410	403		688	39	22.0						
	07:46:27	103	22.44	20.17	1.100	1.055	41.2		68.2		403	403	894		34				on			
	07:46:28	103	22.96	20.00	1.102	1.057		32.8		61.6	398	400		660	34	22.5						
7:46	07:46:29	103	22.61	21.39	1.102	1.059	41.7		70.1		395	397	929		34			off	on			
	07:46:30	103	22.44	20.34	1.102	1.059		33.4		61.9	393	395		667	34	22.9						
	07:46:31	103	22.09	20.69	1.104	1.059	41.9		70.8		392	393	908		34				on			
	07:46:32	103	22.09	20.87	1.104	1.061		33.6		61.7	391	390		646	34	23.2						
7:46	07:46:33	103	26.28	26.10	1.116	1.061	42.0		71.7		391	388	1192		34			off	on			
	07:46:34	104	25.58	26.63	1.131	1.074		35.7		65.9	398	393		1007	34	23.6						
	07:46:35	105	25.76	25.93	1.137	1.089	47.2		74.5		409	413	1192		39				on			
	07:46:36	105	26.80	25.06	1.142	1.100		41.1		70.6	406	419		1007	34	23.8						
7:46	07:46:37	105	23.84	26.80	1.144	1.105	48.6		75.3		400	415	1185		39			off	on			
	07:46:38	105	22.96	26.28	1.144	1.109		42.9		71.1	396	409		986	34	23.9						
	07:46:39	106	25.23	26.10	1.144	1.111	48.8		74.4		394	402	1206		34				on			Runway turn-on
	07:46:40	106	28.72	31.17	1.165	1.113		43.7		72.7	391	398		1277	34	23.9						
7:46	07:46:41	107	30.47	31.69	1.183	1.135	51.7		77.6		399	402	1483		39			off	on			
	07:46:42	109	28.90	31.34	1.191	1.152		49.4		76.5	407	411		1305	39	23.8						
	07:46:43	108	38.84	38.84	1.276	1.174	55.0		81.4		407	410	2199		39				on			
	07:46:44	109	38.50	37.45	1.415	1.259		57.9		82.1	418	423		2490	34	23.8						
7:46	07:46:45	112	15.98	24.36	1.500	1.400	71.2		87.0		425	431	2980		24			off	on			
	07:46:46	115	50.19	-82.78	1.587	1.498		72.7		85.8	422	426		3398	34	24.4						
	07:46:47	115	51.06	-1.62	1.642	1.637	77.5		87.3		426	427	3583		34				on			Autothrottle on
	07:46:48	117	57.52	62.23	1.704	1.735		81.9		90.6	435	441		4249	29	25.4						
7:46	07:46:49	118	59.44	63.80	1.763	1.813	82.3		86.9		443	453	4058		24			off	on			
	07:46:50	118	62.75	62.23	1.822	1.848		86.9		92.5	455	464		4661	34	26.3						
	07:46:51	117	65.20	69.39	1.869	1.902	86.2		92.6		463	474	4583		39				on			
	07:46:52	117	65.37	69.39	1.902	1.922		89.4		93.9	475	486		4852	39	27.4						
7:46	07:46:53	118	65.20	69.21	1.926	1.939	89.1		94.9		482	488	4867		39			off	on			Autothrottle clamp
	07:46:54	118	67.47	71.13	1.932	1.944		91.2		94.1	488	493		4860	39	28.5						
	07:46:55	118	64.32	67.99	1.932	1.948	91.1		91.2		489	496	4867		29				on			
	07:46:56	115	66.94	70.61	1.933	1.950		91.7		94.0	491	500		4895	39	29.5						
7:46	07:46:57	115	66.07	70.96	1.935	1.952	90.7		90.6		496	501	4817		34			off	on			
	07:46:58	115	65.37	69.56	1.937	1.950		91.3		95.1	496	501		4895	44	30.5						
	07:46:59	115	65.72	69.04	1.933	1.952	90.5		94.6		500	502	4781		20				on			
	07:47:00	112	67.47	71.30	1.930	1.952		91.2		94.4	501	506		4860	39	31.6						
7:46	07:47:01	111	65.72	70.61	1.933	1.950	90.7		93.1		500	504	4867		39			off	on			
	07:47:02	115	65.89	69.73	1.933	1.950		90.8		94.8	501	506		4824	29	32.9						
	07:47:03	114	65.55	69.56	1.932	1.950	90.6		94.6		501	506	4789		49				on			
	07:47:04	108	64.50	68.16	1.930	1.950		91.2		93.4	503	508		4895	34	34.3						

Christer Magnusson 930709

QAR "Engine" parameters

101		1	77	78	15	16	68	69	70	71	66	67	72	73	79	98	41	95	96	44	113	
GMT a/c hh:mm	Time UTC correct	Press Alt comb	Power LevLH %	Power LevRH %	EPR Eng 1	EPR Eng 2	N1% Eng 1	N1% Eng 2	N2% Eng 1	N2% Eng 2	EGT Eng 1 degr	EGT Eng 2 degr	FF#1 -217 kgs/h	FF#2 -217 kgs/hr	Brake Pr LH Press	Pneu Man Press	Fire Warn Eng 1	Ing 20J	Ign 4J	Radio keying VHF1	Sync error flag	Comments
7:46	07:47:05	104	66.42	70.61	1.928	1.952	90.1		96.1		505	510	4711		24			off	on			
	07:47:06	105	66.42	70.26	1.928	1.950		90.3		93.7	503	510		4874	34	35.5						
	07:47:07	101	65.20	69.21	1.928	1.952	90.8		91.0		504	511	4789		29				on			ROTATION BY DEFINITION
	07:47:08	100	66.77	69.91	1.926	1.948		91.1		93.9	507	515		4909	24	37.1						
7:46	07:47:09	95	67.12	71.30	1.926	1.948	90.7		96.9		507	514	4817		29			off	on			
	07:47:10	83	65.89	69.56	1.928	1.950		90.7		94.3	505	513		4973	29	38.6						"Humming" noise
	07:47:11	67	65.72	68.86	1.906	1.954	91.4		96.3		507	515	4987		24				on			
	07:47:12	81	66.42	69.39	1.917	1.919		94.0		94.3	506	515		5108	34	39.1						Gear up selected
7:46	07:47:13	107	65.72	70.43	1.919	1.930	94.5		92.6		503	513	4987		225			off	on			
	07:47:14	136	67.29	71.30	1.919	1.935		96.6		94.8	503	512		5108	328	39.6						
	07:47:15	167	67.12	70.61	1.920	1.937	94.5		94.6		505	512	5023		337				on			
	07:47:16	195	66.24	70.43	1.922	1.937		97.3		94.6	505	512		5172	337	39.8						
7:46	07:47:17	240	67.47	71.48	1.926	1.941	95.8		94.0		507	514	5023		333			off	on			
	07:47:18	291	66.24	70.08	1.928	1.937		95.7		94.8	505	511		5172	342	40.1						
	07:47:19	345	67.12	70.26	1.928	1.941	94.5		93.6		509	515	5101		34				on			
	07:47:20	402	65.20	68.86	1.930	1.939		97.4		94.4	507	514		5214	39	40.2						
7:46	07:47:21	455	65.72	69.39	1.930	1.944	95.3		94.8		509	515	5001		34			off	on			
	07:47:22	516	65.55	69.39	1.932	1.946		96.5		94.6	507	514		5143	34	40.4						
	07:47:23	579	64.32	68.34	1.932	1.946	96.3		91.7		506	512	5044		44				on			
	07:47:24	634	65.02	68.51	1.932	1.948		98.6		95.9	507	516		5314	39	40.4						
7:46	07:47:25	696	66.07	70.43	1.932	1.924	95.5		92.1		508	520	4973		34			off	on			
	07:47:26	756	66.94	70.43	1.933	1.944		99.5		93.7	508	522		5136	29	40.5						
	07:47:27	814	67.12	70.43	1.937	1.937	95.8		90.8		508	523	4973		34				on			
	07:47:28	881	67.12	69.56	1.935	1.926		98.9		95.9	510	526		5314	34	40.4						
7:47	07:47:29	938	66.59	70.26	1.926	1.933	95.8		93.4		510	522	4952		44			on	on			
	07:47:30	1000	65.89	68.34	1.933	1.919		99.0		95.1	509	522		5271	39	40.2						
	07:47:31	1061	64.67	68.16	1.935	1.943	96.5		97.9		507	521	4874		49				on			
	07:47:32	1124	65.89	69.56	1.943	1.657		78.5		93.5	507	528		5108	34	40.0						First surge right engine
7:47	07:47:33	1185	66.07	70.43	1.937	1.907	99.2		95.9		507	558	4930		39			off	on			Autothrottle EPR G/A-mode
	07:47:34	1246	67.47	71.65	1.943	1.909	(97,9)	98.6		95.7	504	541		5172	29	39.7						
	07:47:35	1302	67.64	71.83	1.933	1.946	96.7		95.9		507	533	4867		29				on			
	07:47:36	1354	67.81	71.48	1.933	1.928		100.7		95.5	508	528		5058	29	39.4						
7:47	07:47:37	1402	68.34	72.18	1.930	1.926	96.2		93.4		506	525	4774		24			off	on			
	07:47:38	1448	67.81	70.78	1.930	1.932		101.2		95.9	507	524		5186	34	39.1						
	07:47:39	1482	67.64	71.13	1.928	1.819	95.0		93.5		506	530	4746		24				on			Second surge right engine
	07:47:40	1527	66.94	70.26	1.926	1.922		94.8		95.1	504	541		5491	39	9.7						
7:47	07:47:41	1566	66.94	71.83	1.930	1.917	95.8		92.5		503	532	4767		34			off	on			
	07:47:42	1609	67.99	70.78	1.933	1.715		87.4		94.4	501	531		5505	34	7.1						Start pwr lever angle increase
	07:47:43	1651	69.91	73.05	1.930	1.909	95.0		93.6		502	563	4824		34				on			
	07:47:44	1697	70.78	73.75	1.933	1.919		100.7		95.1	503	549		489	34	9.1						
7:47	07:47:45	1738	70.08	73.40	1.933	1.831	97.0		94.8		503	563	4789		49			off	on			
	07:47:46	1790	70.61	73.22	1.926	1.926		99.2		97.0	502	567		5314	39	8.6						
	07:47:47	1838	72.70	75.32	1.930	1.887	94.1		90.8		502	558	4774		44				on			
	07:47:48	1890	73.22	74.97	1.937	1.906		103.4		93.5	500	559		6399	44	8.8						
7:47	07:47:49	1941	74.97	77.76	1.935	1.904	95.9		94.6		500	568	4746		34			off	on			

( ) = calculated value

Christer Magnusson 930709

QAR "Engine" parameters

101 GMT a/c hh:mm	Time UTC correct	1 Press Alt comb	77 Power LevLH %	78 Power LevRH %	15 EPR Eng 1	16 EPR Eng 2	68 N1% Eng 1	69 N1% Eng 2	70 N2% Eng 1	71 N2% Eng 2	66 EGT Eng 1 degr	67 EGT Eng 2 degr	72 FF#1 -217 kgs/h	73 FF#2 -217 kgs/hr	79 Brake Pr LH Press	98 Pneu Man Press	41 Fire Warn Eng 1	95 Ing 20J	96 Ign 4J	44 Radio keying VHF1	113 Sync error flag	Comments
	07:47:50	1995	75.84	71.65	1.943	1.882		99.5		92.1	501	576		4505	34	8.7						Right throttle partial retard
	07:47:51	2046	75.32	67.99	1.956	1.870	97.7		94.3		503	596	4938		29				on			
	07:47:52	2103	75.32	69.04	1.957	1.889		93.7		94.8	504	572		5008	24	8.7						
7:47	07:47:53	2156	76.02	69.73	1.967	1.650	97.7		94.9		509	553	4973		34			off	on			
	07:47:54	2208	75.49	69.21	1.957	1.893		91.0		96.2	509	573		4668	34	8.7						
	07:47:55	2259	74.80	68.16	1.956	1.920	96.5		95.4		514	552	4930		44				on			
	07:47:56	2312	76.89	69.91	1.967	1.678		80.2		95.5	511	550		4576	34	8.7						
7:47	07:47:57	2362	77.94	72.00	1.956	1.896	96.7		91.4		514	570	4860		24			off	on			
	07:47:58	2410	75.49	69.21	1.959	1.822		100.5		93.1	513	545		5619	34	8.7						
	07:47:59	2455	75.84	69.56	1.952	1.900	98.1		92.9		516	552	4930		44				on			
	07:48:00	2502	77.59	70.61	1.952	1.789		102.7		92.6	518	546		4405	44	8.8						
7:47	07:48:01	2538	78.98	72.88	1.956	1.893	99.2		97.5		518	569	5079		34			off	on			
	07:48:02	2578	79.51	72.70	1.941	1.920		98.3		93.5	522	560		922	29	8.7						
	07:48:03	2616	79.68	72.18	1.952	1.891	100.2		97.0		527	558	5243		44				on			
	07:48:04	2652	79.86	73.40	1.961	1.791		99.7		94.0	528	555		4781	39	8.7						
7:47	07:48:05	2682	80.03	74.10	1.950	1.885	101.3		97.7		535	580	5001		44			off	on			
	07:48:06	2723	78.29	72.88	1.935	1.663		81.4		95.7	534	574		5023	39	8.7						
	07:48:07	2767	79.68	74.45	1.969	1.902	103.3		98.3		535	586	5165		24				on			Start flaps retraction
	07:48:08	2810	80.73	75.67	1.939	1.811		90.8		97.1	536	568		5697	24	8.7						
7:47	07:48:09	2854	81.95	76.37	1.963	1.707	103.6		99.0		540	574	5292		49			off	on			
	07:48:10	2894	83.52	78.11	1.872	1.867		99.9		91.3	546	597		5732	34	8.8						
	07:48:11	2943	89.45	83.70	1.644	1.894	84.9		96.2		576	613	3164		29				on			First surge left engine
	07:48:12	2980	91.20	85.79	1.987	1.941		101.8		96.1	625	623		2157	29	8.7						
7:47	07:48:13	3016	88.93	83.52	1.935	1.670	109.5		100.5		636	644	5917		29			off	on			EGT above max both engines
	07:48:14	3047	93.82	84.74	1.917	1.994		102.7		102.2	629	661		6406	29	8.8						
	07:48:15	3075	92.25	86.66	1.772	1.928	85.9		103.3		649	652	5980		44				on			
	07:48:16	3087	97.31	90.85	1.759	1.828		94.0		97.9	659	663		7257	29	8.8						
7:47	07:48:17	3105	98.88	96.09	2.028	1.878	105.3		101.3		672	677	6264		34			off	on			
	07:48:18	3115	97.83	94.34	2.015	1.759		88.8		97.5	661	682		4945	24	8.7						
	07:48:19	3129	96.96	94.34	2.011	1.783	111.8		104.8		642	685	6058		44				on			
	07:48:20	3140	98.36	95.74	1.880	1.856		104.2		96.5	632	688		3441	20	8.8						
7:47	07:48:21	3153	88.58	84.04	1.822	1.843	98.6		100.6		639	695	5370		39			off	on			N1 drop right engine
	07:48:22	3163	88.58	69.39	1.761	1.296	(95,8)	55.4		90.4	657	717		1227	39	8.7						Prob ARTS activation
	07:48:23	3181	91.90	12.67	1.756	0.978	93.1		100.3		663	779	6094		34				on			EPR < 1.00 right engine
	07:48:24	3194	97.13	81.43	1.220	0.979		32.5		82.3	683	799		865	39	8.7						
7:47	07:48:25	3206	96.26	90.33	0.985	0.979	44.3		89.2		744	799	631		34			off	on			EPR < 1.00 left engine
	07:48:26	3212	96.96	97.13	0.981	0.979		28.6		77.0	795	799		568	39	8.4						
	07:48:27	3227	96.61	96.78	0.981	0.981	30.7		78.8		799	799	752		34				on			
	07:48:28	3236	97.66	96.78	0.983	0.981		26.7		72.8	799	799		560	29	8.0						
7:48	07:48:29	3244	97.83	97.13	0.985	0.981	27.3		73.9		799	799	546		39			off	on			Autothrottle off
	07:48:30	3253	97.83	96.78	0.985	0.981		26.1		69.5	799	799		553	39	8.0						
	07:48:31	3268	98.01	96.61	0.985	0.983	26.6		68.5		799	799	575		34				on			
	07:48:32	3282	97.83	96.26	0.985	0.983		24.6		67.0	799	799		553	34	7.7						
7:48	07:48:33	3291	96.78	98.70	0.985	0.983	25.8		67.3		799	799	525		34			off	on			
	07:48:34	3299	97.48	96.61	0.985	0.983		24.5		64.9	799	799		539	34	7.6						

( ) = calculated value

Christer Magnusson 930709

QAR "Engine" parameters

101 GMT a/c hh:mm	Time UTC correct	1 Press Alt comb	77 Power LevLH %	78 Power LevRH %	15 EPR Eng 1	16 EPR Eng 2	68 N1% Eng 1	69 N1% Eng 2	70 N2% Eng 1	71 N2% Eng 2	66 EGT Eng 1 degr	67 EGT Eng 2 degr	72 FF#1 -217 kgs/h	73 FF#2 -217 kgs/hr	79 Brake Pr LH Press	98 Pneu Man Press	41 Fire Warn Eng 1	95 Ing 20J	96 Ign 4J	44 Radio keying VHF1	113 Sync error flag	Comments
	07:48:35	3306	97.13	97.31	0.987	0.983	24.8		65.4		799	799	553		34				on			
	07:48:36	3313	97.13	97.48	0.987	0.983		24.0		62.8	799	799		511	34	7.5						
7:48	07:48:37	3315	96.78	98.01	0.987	0.983	24.4		63.0		799	799	532		34			off	on			
	07:48:38	3317	96.96	97.31	0.987	0.985		24.0		61.2	799	799		511	34	7.3	FIRE1					"Fire left engine" -warning
	07:48:39	3318	97.48	97.13	0.987	0.985	23.6		58.7		799	799	482		34		FIRE1		on			
	07:48:40	3308	-21.00	96.78	0.985	0.985		24.0		59.3	799	799		482	29	7.1	FIRE1					
	07:48:41																					Data missing due pwr fail
	07:48:42																					First Officer pulls fire handle
	07:48:43	3281	1.32	94.17	0.985	0.983		23.7		57.8	799	799		468	34	7.1	FIRE1					
	07:48:44	3271	??????	94.86	0.987	0.983	21.3		52.5		797	799	376		39		FIRE1		on			
	07:48:45	3258	1.85	94.34	0.985	0.983		23.2		56.1	792	799		426	34	7.0	FIRE1					
7:48	07:48:46	3237	1.85	95.91	0.985	0.983	20.8		51.7		788	799	312		34		FIRE1	off	on	VHF1		
	07:48:47	3217	-30.06	95.04	0.985	0.983		22.5		54.2	788	799		433	34	6.9	FIRE1					
	07:48:48	3205	-19.37	95.39	0.985	0.983	20.6		49.3		790	799	348		39		FIRE1		on	VHF1		
	07:48:49	3190	-47.82	95.21	0.985	0.983		21.8		52.5	792	799		419	34	6.9	FIRE1			VHF1		
7:48	07:48:50	3168	-6.87	96.09	0.985	0.983	20.3		49.0		792	799	376		34		FIRE1	off	on	VHF1		
	07:48:51	3142	2.19	95.39	0.985	0.983		7801.9		50.8	792	799		404	34	6.8	FIRE1					
	07:48:52	3118	1.67	95.39	0.985	0.981	20.1		48.1		793	799	390		34		FIRE1		on			
	07:48:53	3101	1.50	94.86	0.985	0.981		20.5		49.1	794	799		404	34	6.8	FIRE1					
7:48	07:48:54	3085	-89.48	96.44	0.985	0.981	19.9		47.4		794	799	383		34		FIRE1	off	on			
	07:48:55	3064	-33.69	95.39	0.985	0.985		20.0		47.8	795	799		404	29	6.8	FIRE1					
	07:48:56	3038	1.32	95.04	0.985	0.981	19.7		47.3		794	799	376		29		FIRE1		on			
	07:48:57	3014	0.97	95.04	0.985	0.981		19.4		46.6	792	799		411	29	6.8				VHF1		
7:48	07:48:58	2993	1.15	96.09	0.985	0.981	19.5		46.8		792	799	383		29			off	on	VHF1		
	07:48:59	2974	-8.50	95.39	0.985	0.981		19.0		45.2	791	799		411	34	6.8				VHF1		
	07:49:00	2946	0.62	95.74	0.985	0.981	19.5		46.5		789	799	426		34				on	VHF1		
	07:49:01	2918	0.28	95.04	0.985	0.981		18.6		44.1	788	799		404	34	6.8						
7:48	07:49:02	2892	2.54	96.78	0.985	0.981	19.6		47.0		788	799	397		34			off	on			
	07:49:03	2870	-9.05	95.21	0.985	0.981		18.4		43.2	787	799		411	29	6.8				VHF1		
	07:49:04	2845	-25.17	95.91	0.985	0.981	19.6		46.1		786	799	411		34				on	VHF1		
	07:49:05	2818	-12.67	95.56	0.985	0.981		18.0		42.8	785	799		404	34	6.8				VHF1		
7:48	07:49:06	2785	-8.87	96.44	0.985	0.981	19.4		45.1		784	799	419		29			off	on			
	07:49:07	2759	-4.88	95.21	0.985	0.981		17.8		42.2	783	799		447	34	6.8						
	07:49:08	2740	-1.44	95.74	0.985	0.981	19.1		47.0		783	799	411		34				on			
	07:49:09	2719	-3.25	95.39	0.985	0.981		17.6		41.3	782	799		426	34	6.8						
	07:49:10																					Data missing due pwr fail
	07:49:11																					- " -
	07:49:12																					- " -
	07:49:13																					- " -
	07:49:14																					- " -
	07:49:15																					- " -
	07:49:16																					- " -
	07:49:17																					- " -
	07:49:18	-1	-0.71	95.21	0.981	0.983		17.4		41.4	761	799		461	34	7.0						
	07:49:19	-1676	0.45	95.39	0.981	0.983	18.8		44.1		755	799	341		34				on			

QAR "Engine" parameters

101 GMT a/c hh:mm	Time UTC correct	1 Press Alt comb	77 Power LevLH %	78 Power LevRH %	15 EPR Eng 1	16 EPR Eng 2	68 N1% Eng 1	69 N1% Eng 2	70 N2% Eng 1	71 N2% Eng 2	66 EGT Eng 1 degr	67 EGT Eng 2 degr	72 FF#1 -217 kgs/h	73 FF#2 -217 kgs/hr	79 Brake Pr LH Press	98 Pneu Man Press	41 Fire Warn Eng 1	95 Ing 20J	96 Ign 4J	44 Radio keying VHF1	113 Sync error flag	Comments
	07:49:20	-1692	0.28	94.86	0.981	0.983		17.4		41.4	745	799		390	34	7.1						
7:48	07:49:21	2373	0.28	95.91	0.979	0.983	18.2		42.5		734	799	234		34			off	on			
	07:49:22	2346	0.80	95.21	0.979	0.983		17.5		41.4	720	799		433	34	7.1						
	07:49:23	2317	0.45	95.04	0.978	0.983	17.2		40.0		702	799	192		34				on			
	07:49:24	2293	0.45	95.04	0.978	0.983		17.4		41.3	688	799		419	34	7.1						
7:48	07:49:25	2269	0.45	96.26	0.976	0.983	16.1		37.5		673	799	64		34			off	on			
	07:49:26	2268	-21.91	31.34	0.976	0.983		17.5		41.5	657	799		419	34	7.3						
	07:49:27	2220	16.68	12.67	0.976	0.983	14.9		34.9		642	799	35		34				on			
	07:49:28	2193	17.20	11.97	0.976	0.983		17.5		41.2	629	799		390	34	7.3						
7:49	07:49:29	2191	17.55	12.84	0.976	0.983	13.6		31.9		615	799	0		34			off	on			
	07:49:30	2191	17.55	11.62	0.974	0.981		17.4		41.3	604	799		404	34	7.3						
	07:49:31	2191	17.55	11.62	0.974	0.983	12.5		29.4		593	799	85		34				on			
	07:49:32	2191	17.55	11.27	0.974	0.979		17.4		41.1	585	799		440	34	7.4						
7:49	07:49:33	2191	17.20	12.49	0.974	0.983	11.6		27.0		578	799	50		34			off	on			
	07:49:34	2191	17.55	11.62	0.976	0.979		17.4		41.1	573	799		248	34	7.4						
	07:49:35	2191	17.55	11.97	0.974	0.983	10.8		24.9		567	799	21		34				on			
	07:49:36	2191	17.73	11.79	0.976	0.981		17.4		41.2	561	799		489	34	7.4						
7:49	07:49:37	2191	17.55	12.49	0.974	0.981	19.9		22.9		555	799	0		34			off	on			
	07:49:38	2037	17.38	11.62	0.974	0.981		17.3		41.2	551	799		376	34	7.5				VHF1		
	07:49:39	2023	17.38	11.79	0.976	0.981	9.7		21.1		547	799	7		34				on			
	07:49:40	2009	17.73	11.79	0.974	0.981		17.3		41.3	544	799		397	34	7.5				VHF1		
7:49	07:49:41	1995	17.55	13.36	0.974	0.981	18.3		19.7		540	799	57		34			off	on	VHF1		
	07:49:42	1982	51.76	14.59	0.974	0.981		17.3		40.9	536	799		404	34	7.5				VHF1		
	07:49:43	1964	81.95	14.59	0.974	0.981	??????		18.1		532	799	0		34				on	VHF1		
	07:49:44	1946	77.24	68.34	0.976	0.981		17.2		40.8	528	799		411	34	7.5				VHF1		
7:49	07:49:45	1928	80.21	71.83	0.976	0.981	1494.0		16.8		526	799	28		34			off	on			
	07:49:46	1911	80.21	72.00	0.976	0.981		17.2		40.7	522	799		404	34	7.6						
	07:49:47	1890	71.30	-0.53	0.976	0.981	1433.0		15.6		520	799	0		34				on			
	07:49:48	1869	65.72	47.40	0.976	0.981		??????		40.2	517	799		411	34	7.6						
7:49	07:49:49	1850	66.24	12.67	0.976	0.983	15.4		29.0		514	799	21		34			on	off			
	07:49:50	1822	66.24	58.91	0.974	0.983		17.2		40.7	513	799		411	34	7.6						
	07:49:51	1796	66.07	57.34	0.974	0.981	4130.4		1800.4		510	799	64		34				off	VHF1		
	07:49:52	1768	66.24	57.34	0.974	0.981		17.1		40.9	508	799		411	34	7.6				VHF1		
7:49	07:49:53	1733	66.77	40.24	0.974	0.981	1671.8		25.5		506	799	64		34			on	off	VHF1		
	07:49:54	1709	82.65	79.68	0.972	0.981		34.4		40.9	503	799		411	34	7.5				VHF1		
	07:49:55	1680	79.68	79.33	0.974	0.981	1755.4		4681.1		502	799	28		34				off	VHF1		
	07:49:56	1656	79.68	78.81	0.974	0.981		34.6		41.0	499	799		433	34	7.6						
7:49	07:49:57	1632	79.33	79.86	0.972	0.981	??????		11.3		496	799	0		34			off	on			
	07:49:58	1611	79.33	78.98	0.974	0.981		17.4		41.4	492	799		419	34	7.6						
	07:49:59	1599	79.51	79.33	0.974	0.981	14.2		8777.1		490	799	14		34				off			
	07:50:00	1586	85.62	85.09	0.974	0.981		17.4		41.2	490	799		419	34	7.6						
7:49	07:50:01	1574	85.62	85.96	0.974	0.983	771.6		20.2		488	799	35		34			on	off			
	07:50:02	1560	85.44	84.92	0.976	0.981		17.4		41.2	486	799		411	34	7.5						
	07:50:03	1549	85.27	85.09	0.976	0.983	1847.8		19.6		485	799	7		34				off			
	07:50:04	1543	85.44	84.92	0.976	0.983		17.4		41.2	483	799		419	34	7.6						

QAR "Engine" parameters

101 GMT a/c hh:mm	Time UTC correct	1 Press Alt comb	77 Power LevLH %	78 Power LevRH %	15 EPR Eng 1	16 EPR Eng 2	68 N1% Eng 1	69 N1% Eng 2	70 N2% Eng 1	71 N2% Eng 2	66 EGT Eng 1 degr	67 EGT Eng 2 degr	72 FF#1 -217 kgs/h	73 FF#2 -217 kgs/hr	79 Brake Pr LH Press	98 Pneu Man Press	41 Fire Warn Eng 1	95 Ing 20J	96 Ign 4J	44 Radio keying VHF1	113 Sync error flag	Comments
7:49	07:50:05	1536	85.62	86.14	0.978	0.983	1526.5		1897.8		480	799	28		34			on	off			
	07:50:06	1524	85.62	85.09	0.976	0.983		34.6		41.0	478	799		411	34	7.6						
	07:50:07	1511	85.44	84.92	0.976	0.983	1494.0		8777.1		476	799	64		34				off			
	07:50:08	1506	85.27	84.74	0.978	0.983		17.3		81.8	474	799		383	34	7.7						
7:49	07:50:09	1502	85.44	85.96	0.978	0.983	1231.9		7801.9		473	799	7		29			on	off			Start of flaps extension
	07:50:10	1492	85.79	85.09	0.978	0.983		17.3		40.9	470	799		404	34	7.7						
	07:50:11	1482	85.27	84.92	0.978	0.983	3510.9		2065.2		469	799	50		34				off			
	07:50:12	1480	85.44	84.92	0.978	0.983		17.3		41.0	466	799		404	29	7.6						
7:49	07:50:13	1476	85.62	85.79	0.979	0.985	12.7		??????		464	799	14		34			on	off			
	07:50:14	1478	85.44	84.92	0.979	0.985		17.2		40.8	463	799		404	34	26.9						
	07:50:15	1484	85.62	85.09	0.981	0.985	826.1		1404.3		461	799	50		34				off			
	07:50:16	1493	85.27	84.74	0.981	0.985		17.2		40.7	459	799		411	34	18.7						
7:49	07:50:17	1495	85.62	85.79	0.983	0.985	12.7		923.9		459	799	57		34			on	off			
	07:50:18	1503	85.62	85.09	0.983	0.985		34.0		40.6	457	799		419	20	19.7						
	07:50:19	1504	85.27	84.74	0.983	0.987	763.2		1114.6		455	799	28		15				off			
	07:50:20	1501	85.44	84.57	0.985	0.987		17.0		40.1	453	799		411	34	15.3						
7:49	07:50:21	1496	85.62	85.96	0.985	0.987	462.0		1494.0		452	799	57		34			on	off			
	07:50:22	1488	85.62	85.09	0.985	0.987		33.7		39.9	451	799		411	34	16.7						
	07:50:23	1480	85.44	85.09	0.985	0.987	668.7		1897.8		450	799	28		29				off			
	07:50:24	1469	85.62	84.92	0.987	0.987		33.5		39.9	448	799		411	29	16.1						
7:49	07:50:25	1455	85.62	85.96	0.985	0.987	2700.7		2808.7		447	799	14		34			on	off			
	07:50:26	1437	85.62	84.92	0.985	0.987		8777.1		39.7	446	799		404	34	16.6						
	07:50:27	1422	85.44	84.92	0.985	0.987	3343.7		1755.4		444	799	14		34				off			"Landing gear" -warning
	07:50:28	1403	85.27	84.57	0.987	0.987		16.7		39.4	443	799		411	34	16.7						
7:50	07:50:29	1388	85.44	85.79	0.987	0.987	1800.4		8777.1		442	799	35		34			on	off			
	07:50:30	1369	85.62	84.92	0.987	0.987		33.4		39.6	441	799		390	34	16.8						
	07:50:31	1348	85.27	84.74	0.987	0.989	923.9		1755.4		439	799	28		34				off			
	07:50:32	1325	85.62	84.92	0.987	0.989		??????		39.1	439	799		411	34	17.3						
7:50	07:50:33	1304	85.44	85.62	0.987	0.989	2340.6		610.6		437	799	0		34			on	off			
	07:50:34	1274	85.44	84.92	0.987	0.989		16.4		39.2	435	799		411	34	16.9						
	07:50:35	1237	85.27	84.74	0.987	0.987	4388.6		595.1		435	799	50		29				off			
	07:50:36	1205	85.62	84.92	0.987	0.989		16.4		39.0	434	799		404	34	17.0						
7:50	07:50:37	1165	85.27	85.79	0.987	0.989	856.3		644.2		432	799	7		34			on	off			
	07:50:38	1127	85.44	84.74	0.987	0.989		16.4		38.9	432	799		397	29	17.2						
	07:50:39	1093	85.62	84.92	0.987	0.987	1462.9		948.9		430	799	0		34				off			Flaps fully extended
	07:50:40	1057	85.44	84.92	0.985	0.987		16.3		39.1	429	799		426	34	17.2						
7:50	07:50:41	1021	85.27	85.79	0.985	0.987	877.7		605.3		429	799	14		34			on	off			
	07:50:42	986	85.44	84.74	0.987	0.987		16.3		38.8	427	799		411	34	17.5						
	07:50:43	957	85.44	84.92	0.987	0.987	2925.7		595.1		425	799	7		34				off			
	07:50:44	929	85.62	84.92	0.987	0.987		16.3		38.8	425	799		390	34	17.4						
7:50	07:50:45	902	85.62	85.96	0.987	0.987	731.4		80.4		425	799	35		34			on	off			
	07:50:46	875	85.44	84.92	0.987	0.989		16.3		38.6	424	799		419	34	17.3						
	07:50:47	847	85.27	84.92	0.987	0.987	2808.7		548.6		422	799	14		34				off			
	07:50:48	817	85.27	84.57	0.987	0.989		16.3		38.9	422	799		426	34	18.1						
7:50	07:50:49	795	85.44	85.62	0.989	0.989	8777.1		936.2		422	799	21		34			on	off			

QAR "Engine" parameters

101		1	77	78	15	16	68	69	70	71	66	67	72	73	79	98	41	95	96	44	113	
GMT a/c hh:mm	Time UTC correct	Press Alt comb	Power LevLH %	Power LevRH %	EPR Eng 1	EPR Eng 2	N1% Eng 1	N1% Eng 2	N2% Eng 1	N2% Eng 2	EGT Eng 1 degr	EGT Eng 2 degr	FF#1 -217 kgs/h	FF#2 -217 kgs/hr	Brake Pr LH Press	Pneu Man Press	Fire Warn Eng 1	Ing 20J	Ign 4J	Radio keying VHF1	Sync error flag	Comments
	07:50:50	775	85.44	84.74	0.989	0.989		16.2		38.7	421	799		411	34	17.8						
	07:50:51	749	85.44	84.92	0.989	0.989	2925.7		3510.9		421	799	50		34				off			
	07:50:52	731	85.62	84.74	0.989	0.989		32.4		38.6	420	799		426	34	17.9						
7:50	07:50:53	707	85.62	85.79	0.989	0.989	662.4		1800.4		420	799	14		34			on	off			
	07:50:54	677	85.62	84.92	0.989	0.989		16.2		38.7	419	799		419	34	18.0						
	07:50:55	648	85.62	85.09	0.989	0.989	2421.3		1276.7		418	799	0		34				off			"Too low gear" -warning
	07:50:56	621	85.62	84.92	0.989	0.989		16.2		38.6	417	799		426	34	17.9						
7:50	07:50:57	577	85.62	85.96	0.989	0.989	2507.8		2700.7		415	799	0		34			on	off			
	07:50:58	542	85.62	84.92	0.989	0.989		32.5		38.4	415	799		404	34	17.9						
	07:50:59	511	85.62	85.09	0.989	0.989	1897.8		1003.1		414	799	0		5				off			
	07:51:00	478	85.62	84.92	0.987	0.989		??????		38.1	413	799		383	10	18.3						
7:50	07:51:01	441	85.62	85.79	0.987	0.989	4681.1		3191.7		412	799	7		24			on	off			
	07:51:02	409	85.44	84.74	0.989	0.989		16.1		38.1	410	799		433	29	17.8						"Whoop-whoop pull up" -warning
	07:51:03	370	85.44	85.09	0.989	0.989	8777.1		3343.7		409	799	0		29				off			
	07:51:04	356	85.44	84.57	0.989	0.989		32.4		38.0	408	799		404	24	17.7						
7:50	07:51:05	319	85.62	85.79	0.989	0.989	??????		1671.8		407	799	35		29			on	off	VHF1		
	07:51:06	294	85.62	84.92	0.989	0.991		31.9		37.4	405	799		383	29	17.9				VHF1		
	07:51:07	274	85.27	84.92	0.991	0.991	1595.8		5401.3		405	799	43		29				off	VHF1		
	07:51:08	250	85.27	84.57	0.991	0.991		15.8		37.4	403	799		419	29	17.6						
7:50	07:51:09	225	85.27	85.79	0.991	0.991	3343.7		1433.0		401	799	14		29			on	off			
	07:51:10	208	85.44	84.92	0.992	0.996		15.7		37.2	401	799		468	34	17.9						"Sink rate" -warning
	07:51:11	202	85.27	84.92	0.991	0.994	877.7		1755.4		400	799	43		29				off			
	07:51:12	176	86.49	85.09	0.994	0.994		31.1		36.7	399	799		227	122	26.3						First impact with trees
:50	07:51:13	129	84.04	85.96	0.961	0.989	856.3		7801.9		398	799	0		83			on	off			
	07:51:14	100	84.22	86.14	2.461	1.002		25.4		40.0	397	799		745	73	47.5					sync	
	07:51:15	0	??????	??????	1.650	1.650	0.0		0.0		9	9	0		0		FIRE1		off	VHF1	sync	
	07:51:16	0	??????	??????	1.650	1.650		0.0		0.0	9	9		0	0	0.0	FIRE1			VHF1	sync	QAR stops

QAR "Flight" parameters

101 GMT a/c hh:mm	Time UTC correct	1 Press Alt comb	30 Ralt Coars feet	3 IAS DADC kts	4 Hdg degr	13 Ailer Left +=TEU	7 Bank Att#1 degr	5 Pitch Att#1 degr	12 ElevPo Left +=TEU	10 Pitch Trim Pos	26 Vert Acc G	9 Lat Acc G	36 Long Acc G	14 Rud pos	19 Flap pos Left	20 Slat Pos Left	48 Land Gear Right	32 Auto Pilot Eng	60 DFGS code	59 DFGS mode	58 Squat sw	29 Mid Mark Beac	89 Wing Anti ice	47 GPWS Mode 1-4,6	113 Sync error flag	Comments
	07:46:20	99	-0	0	43	14.2	-0.0	-0.0	2.3		1.03	0.018	-0.002	2.8		mid		off	26	armed	ground					
7:45	07:46:21	100	-0	0	43	14.2	-0.0	-0.0	2.4	5.1	1.03	0.018	-0.002	-1.0	11	mid	down	off	0	throt						
	07:46:22	101	-1	0	44	14.1	-0.0	-0.0	2.5		1.03	-0.004	0.008	-3.6		mid		off	14	roll	ground					
	07:46:23	100	-1	0	44	14.1	-0.0	-0.0	2.7	5.1	1.05	0.022	0.006	-2.6	11	mid	down	off	14	pitch						
	07:46:24	101	-1	0	44	14.1	-0.0	-0.0	2.7		1.05	-0.008	0.012	-1.3		mid		off	26	armed	ground					
7:45	07:46:25	102	-1	0	45	14.1	-0.0	-0.0	2.7	5.1	1.03	-0.004	0.010	-4.5	11	mid	down	off	0	throt						
	07:46:26	102	0	0	44	14.1	-0.0	-0.0	2.7		1.04	-0.012	0.016	-4.8		mid		off	14	roll	ground					
	07:46:27	103	-0	0	44	14.1	0.0	-0.0	2.7	5.1	1.03	-0.016	0.014	-5.0	11	mid	down	off	14	pitch						
	07:46:28	103	1	0	43	14.2	0.0	-0.0	2.9		1.04	-0.028	0.014	-5.3		mid		off	26	armed	ground					
7:46	07:46:29	103	-1	0	43	14.2	0.0	-0.0	3.0	5.1	1.04	-0.020	0.014	-3.1	10	mid	down	off	0	throt						
	07:46:30	103	-1	0	42	14.2	0.4	-0.0	3.0		1.04	-0.024	0.012	-8.3		mid		off	14	roll	ground					
	07:46:31	103	-0	0	41	14.2	0.4	-0.0	3.0	5.1	1.03	-0.030	0.014	-8.9	11	mid	down	off	14	pitch						
	07:46:32	103	1	0	40	14.3	0.4	-0.0	3.0		1.06	-0.037	0.018	-8.6		mid		off	26	armed	ground					
7:46	07:46:33	103	1	0	39	14.0	0.4	-0.0	2.9	5.1	1.04	-0.039	0.020	-5.1	11	mid	down	off	0	throt						
	07:46:34	104	-0	0	37	14.0	0.4	-0.0	2.6		1.05	-0.028	0.029	-0.0		mid		off	14	roll	ground					
	07:46:35	105	-0	0	36	13.9	0.4	-0.0	2.1	5.1	1.05	-0.028	0.033	4.1	11	mid	down	off	14	pitch						
	07:46:36	105	-0	0	36	13.7	0.4	0.0	1.7		1.08	-0.014	0.035	8.4		mid		off	26	armed	ground					
7:46	07:46:37	105	-1	0	37	13.7	0.0	-0.0	1.4	5.1	1.04	0.041	0.031	10.2	11	mid	down	off	0	throt						
	07:46:38	105	1	0	39	13.8	0.0	-0.0	1.3		1.06	0.049	0.033	11.1		mid		off	14	roll	ground					
	07:46:39	106	-1	0	43	13.7	0.0	-0.0	1.4	5.1	1.06	0.075	0.031	10.4	11	mid	down	off	14	pitch						Runway turn-on
	07:46:40	106	-1	0	48	13.7	0.4	-0.0	1.2		1.05	0.082	0.041	8.3		mid		off	26	armed	ground					
7:46	07:46:41	107	-1	0	52	13.6	0.0	-0.1	1.2	5.1	1.06	0.100	0.045	7.4	11	mid	down	off	0	throt						
	07:46:42	109	-0	0	57	13.1	0.0	-0.4	0.4		1.04	0.086	0.053	5.8		mid		off	14	roll	ground					
	07:46:43	108	-1	0	62	13.6	-0.0	-0.4	0.0	5.1	1.05	0.114	0.086	-5.0	11	mid	down	off	14	pitch						
	07:46:44	109	1	0	67	13.4	-0.4	-0.4	0.0		1.05	0.116	0.138	-9.3		mid		off	26	armed	ground					
7:46	07:46:45	112	-1	32	71	13.2	-0.4	-0.3	0.1	5.1	1.08	0.102	0.165	-4.3	11	mid	down	off	0	throt						
	07:46:46	115	-1	33	74	12.2	-0.4	-0.1	0.0		1.07	0.065	0.200	-3.0		mid		off	14	roll	ground					
	07:46:47	115	-1	35	75	10.5	-0.4	-0.4	0.0	5.1	1.09	0.025	0.214	5.3	11	mid	down	off	14	pitch						Autothrottle on
	07:46:48	117	1	38	75	8.8	-0.4	-0.4	-1.1		1.05	0.022	0.234	5.6		mid		off	26	armed	ground					
7:46	07:46:49	118	-1	43	75	6.8	-0.4	-0.4	-2.1	5.1	1.05	0.020	0.242	6.4	11	mid	down	off	4	throt						
	07:46:50	118	-0	46	75	5.1	-0.4	-0.4	-2.3		1.07	0.027	0.254	-1.3		mid		off	14	roll	ground					
	07:46:51	117	1	52	75	3.5	-0.4	-0.4	-2.0	5.1	1.05	0.029	0.263	-1.5	11	mid	down	off	14	pitch						
	07:46:52	117	-1	57	75	2.5	-0.4	-0.4	-2.4		1.04	0.022	0.267	1.8		mid		off	26	armed	ground					
7:46	07:46:53	118	-0	63	75	1.7	-0.0	-0.3	-2.8	5.1	1.05	-0.022	0.269	1.8	11	mid	down	off	2	throt						Autothrottle clamp
	07:46:54	118	-1	70	74	1.3	-0.0	-0.2	-2.7		1.12	-0.028	0.265	6.4		mid		off	14	roll	ground					
	07:46:55	118	0	77	74	1.1	-0.0	-0.4	-2.9	5.1	1.07	-0.018	0.261	4.6	11	mid	down	off	14	pitch						
	07:46:56	115	-1	78	74	1.0	-0.0	-0.4	-2.8		1.11	-0.020	0.263	6.1		mid		off	26	armed	ground					
7:46	07:46:57	115	-1	83	74	0.8	-0.4	-0.4	-3.0	5.1	1.10	-0.006	0.261	5.1	10	mid	down	off	2	throt						
	07:46:58	115	-0	89	74	0.8	-0.0	-0.5	-2.5		1.06	0.033	0.257	4.3		mid		off	14	roll	ground					
	07:46:59	115	-0	94	74	0.8	-0.0	-0.3	-3.0	5.1	1.05	0.016	0.250	6.3	10	mid	down	off	14	pitch						
	07:47:00	112	0	99	74	0.7	-0.0	-0.0	-3.4		1.06	0.039	0.250	-0.0		mid		off	26	armed	ground					
7:46	07:47:01	111	-1	104	75	0.7	-0.0	-0.1	-2.9	5.1	1.06	0.031	0.250	-0.3	10	mid	down	off	2	throt						
	07:47:02	115	-1	106	75	0.7	-0.0	-0.2	-2.7		1.05	-0.010	0.242	-0.2		mid		off	14	roll	ground					
	07:47:03	114	-0	111	74	0.4	-0.0	-0.4	-3.2	5.1	1.14	-0.041	0.248	5.5	10	mid	down	off	14	pitch						
	07:47:04	108	-0	115	74	0.4	-0.0	-0.5	-3.9		1.09	-0.024	0.242	3.1		mid		off	26	armed	ground					

Bilaga 3b sid 1–7

Christer Magnusson 930709

QAR "Flight" parameters

101 GMT a/c hh:mm	Time UTC correct	1 Press Alt comb	30 Ralt Coars feet	3 IAS DADC kts	4 Hdg degr	13 Ailer Left +=TEU	7 Bank Att#1 degr	5 Pitch Att#1 degr	12 ElevPo Left +=TEU	10 Pitch Trim Pos	26 Vert Acc G	9 Lat Acc G	36 Long Acc G	14 Rud pos	19 Flap pos Left	20 Slat Pos Left	48 Land Gear Right	32 Auto Pilot Eng	60 DFGS code	59 DFGS mode	58 Squat sw	29 Mid Mark Beac	89 Wing Anti ice	47 GPWS Mode 1-4,6	113 Sync error flag	Comments
7:46	07:47:05	104	-0	119	74	0.4	-0.0	-0.3	-3.4	5.1	1.06	-0.024	0.236	4.5	10	mid	down	off	2	throt						
	07:47:06	105	-1	125	74	0.6	-0.0	-0.2	-3.1		1.14	0.033	0.240	-0.5		mid		off	14	roll	ground					
	07:47:07	101	0	132	74	0.5	-0.0	-0.1	-0.7	5.1	1.20	0.012	0.236	1.8	10	mid	down	off	14	pitch						**ROTATION BY DEFINITION**
	07:47:08	100	1	136	74	0.4	-0.0	0.0	5.1		1.24	-0.032	0.250	-0.0		mid		off	26	armed	ground					
7:46	07:47:09	95	3	139	74	3.0	0.4	2.4	5.1	5.1	1.10	-0.037	0.309	-1.0	10	mid	down	off	2	throt						
	07:47:10	83	4	142	74	3.9	0.4	6.2	6.4		1.13	-0.008	0.375	-1.8		mid		off	14	roll	air					**"Humming" noise**
	07:47:11	67	10	143	74	7.3	0.7	9.9	7.3	5.1	1.24	0.041	0.387	-4.3	10	mid	down	off	14	pitch						
	07:47:12	81	22	154	73	7.4	1.4	12.1	5.5		1.18	-0.008	0.379	-3.1		mid		off	26	armed	air					**Gear up selected**
7:46	07:47:13	107	39	152	72	0.6	-0.4	13.5	4.2	5.1	1.25	-0.020	0.370	-0.0	10	mid	down	off	2	throt						
	07:47:14	136	65	157	71	-2.7	-1.8	14.8	3.0		1.24	-0.024	0.366	-0.7		mid		off	14	roll	air					
	07:47:15	167	97	163	70	-3.1	-1.8	16.4	1.4	5.1	1.25	-0.020	0.360	-0.8	10	mid	trans	off	14	pitch						
	07:47:16	195	137	163	70	0.3	1.8	17.7	-1.0		1.18	-0.037	0.356	1.3		mid		off	26	armed	air					
7:46	07:47:17	240	183	161	70	-0.8	1.1	18.2	0.0	5.1	1.19	-0.028	0.354	-1.5	10	mid	trans	off	2	throt						
	07:47:18	291	234	163	70	2.9	2.8	18.2	-1.2		1.21	0.035	0.332	-0.3		mid		off	14	roll	air					
	07:47:19	345	288	168	70	3.1	3.2	18.5	-1.4	5.1	1.05	-0.010	0.328	1.3	10	mid	trans	off	14	pitch						
	07:47:20	402	343	166	70	3.3	3.2	19.1	-2.3		1.04	-0.012	0.326	1.0		mid		off	26	armed	air					
7:46	07:47:21	455	401	164	70	-0.6	1.4	19.3	-2.1	5.1	1.07	-0.018	0.332	-0.3	10	mid	up	off	2	throt						
	07:47:22	516	458	160	69	-2.1	0.0	19.0	-1.6		0.97	-0.030	0.313	-1.2		mid		off	14	roll	air					
	07:47:23	579	511	162	69	0.0	1.1	18.5	-2.5	5.1	1.00	-0.024	0.318	-1.3	11	mid	up	off	14	pitch						
	07:47:24	634	574	162	69	1.5	2.1	18.7	-2.2		1.03	0.010	0.322	-1.2		mid		off	26	armed	air					
7:46	07:47:25	696	632	163	70	2.0	2.1	18.8	-2.0	5.1	1.01	-0.008	0.311	-1.0	11	mid	up	off	2	throt						
	07:47:26	756	693	162	69	2.1	1.8	18.9	-1.8		1.02	-0.014	0.324	-1.2		mid		off	14	roll	air					
	07:47:27	814	769	161	69	2.1	1.4	19.2	-2.0	5.1	1.04	-0.018	0.328	-0.8	10	mid	up	off	14	pitch						
	07:47:28	881	835	162	69	0.5	0.0	19.2	-2.4		1.02	-0.014	0.320	-1.2		mid		off	26	armed	air					
7:47	07:47:29	938	893	153	69	0.0	-0.0	19.3	-2.4	5.1	1.03	-0.002	0.316	-0.8	10	mid	up	off	2	throt						
	07:47:30	1000	989	165	69	0.4	0.7	19.4	-2.1		0.98	-0.037	0.313	-0.2		mid		off	14	roll	air					
	07:47:31	1061	1074	163	68	0.4	0.0	19.5	-3.0	5.1	1.01	-0.028	0.316	-1.7	10	mid	up	off	14	pitch						
	07:47:32	1124	1135	160	69	2.2	-0.0	19.1	-4.8		1.01	-0.010	0.289	-2.0		mid		off	26	armed	air					**First surge right engine**
7:47	07:47:33	1185	1189	164	70	2.9	0.7	17.8	-5.2	5.1	0.88	-0.002	0.281	-0.7	10	mid	up	off	14	throt						**Autothrottle EPR G/A-mode**
	07:47:34	1246	1243	162	70	4.4	0.7	16.6	-4.8		0.85	-0.016	0.275	-0.2		mid		off	14	roll	air					
	07:47:35	1302	1291	161	69	3.8	-0.0	15.2	-4.9	5.1	0.85	-0.018	0.273	-1.2	10	mid	up	off	14	pitch						
	07:47:36	1354	1344	161	69	2.4	-2.5	14.2	-4.7		0.90	-0.012	0.285	-1.7		mid		off	26	armed	air	mm				
7:47	07:47:37	1402	1383	163	69	-1.8	-2.8	13.3	-1.8	5.1	0.87	0.035	0.281	-1.5	10	mid	up	off	14	throt		mm				
	07:47:38	1448	1474	162	69	0.3	-0.4	13.5	-1.1		1.01	-0.032	0.291	0.3		mid		off	14	roll	air	mm				
	07:47:39	1482	1514	164	68	0.4	1.1	14.6	-1.6	5.1	1.08	-0.026	0.311	-0.0	10	mid	up	off	14	pitch		mm				**Second surge right engine**
	07:47:40	1527	1537	166	68	1.2	1.1	15.3	-2.0		1.10	-0.034	0.313	-0.2		mid		off	26	armed	air	mm				
7:47	07:47:41	1566	1606	166	68	1.3	0.4	15.5	-2.2	5.1	1.07	-0.012	0.316	-1.3	10	mid	up	off	14	throt		mm				
	07:47:42	1609	1650	166	68	1.9	-0.0	15.6	-2.2		1.01	0.014	0.295	-1.7		mid		off	14	roll	air	mm	on			**Start pwr lever angle increase**
	07:47:43	1651	1705	167	68	1.2	-0.0	15.3	-2.4	5.1	1.05	-0.004	0.293	-1.2	10	mid	up	off	14	pitch		mm				
	07:47:44	1697	1761	170	69	1.2	0.0	15.7	-1.7		1.06	0.039	0.297	-1.0		mid		off	26	armed	air	mm				
7:47	07:47:45	1738	1833	165	69	2.3	2.1	16.3	-2.1	5.1	1.07	0.025	0.305	-0.0	10	mid	up	off	14	throt		mm				
	07:47:46	1790	1874	168	69	2.2	2.5	16.5	-2.7		1.07	-0.024	0.305	-0.3		mid		off	14	roll	air	mm	on			
	07:47:47	1838	1864	168	69	2.5	2.8	16.4	-2.7	5.1	1.06	-0.014	0.301	-0.8	10	mid	up	off	14	pitch		mm				
	07:47:48	1890	1919	171	69	2.4	2.5	16.2	-2.9		1.02	-0.032	0.291	-0.5		mid		off	26	armed	air					
7:47	07:47:49	1941	1997	169	70	2.7	2.5	16.0	-2.8	5.1	1.00	-0.018	0.291	-0.8	10	mid	up	off	14	throt						

Christer Magnusson 930709

QAR "Flight" parameters

101		1	30	3	4	13	7	5	12	10	26	9	36	14	19	20	48	32	60	59	58	29	89	47	113	
GMT a/c hh:mm	Time UTC correct	Press Alt comb	Ralt Coars feet	IAS DADC kts	Hdg degr	Ailer Left +=TEU	Bank Att#1 degr	Pitch Att#1 degr	ElevPo Left +=TEU	Pitch Trim Pos	Vert Acc G	Lat Acc G	Long Acc G	Rud pos	Flap pos Left	Slat Pos Left	Land Gear Right	Auto Pilot Eng	DFGS code	DFGS mode	Squat sw	Mid Mark Beac	Wing Anti ice	GPWS Mode 1-4,6	Sync error flag	Comments
	07:47:50	1995	1978	170	70	3.2	2.5	16.0	-2.7		1.00	-0.032	0.281	-1.2		mid		off	14	roll	air		on			Right throttle partial retard
	07:47:51	2046	2039	168	70	3.0	2.8	15.9	-2.8	5.1	1.01	-0.006	0.287	-1.0	10	mid	up	off	14	pitch						
	07:47:52	2103	2115	170	71	4.3	2.5	16.1	-4.4		1.04	-0.032	0.277	-1.0		mid		off	26	armed	air					
7:47	07:47:53	2156	2173	170	71	3.0	1.4	15.5	-3.6	5.1	0.97	-0.026	0.273	-1.7	10	mid	up	off	14	throt						
	07:47:54	2208	2294	171	72	1.5	-0.0	14.7	-3.5		0.94	0.014	0.273	-1.7		mid		off	14	roll	air		on			
	07:47:55	2259	2342	171	72	1.6	-0.0	14.5	-3.9	4.9	0.97	-0.016	0.259	-1.0	10	mid	up	off	14	pitch						
	07:47:56	2312	2405	172	72	2.6	0.0	14.2	-3.5		0.95	0.020	0.269	-1.2		mid		off	26	armed	air					
7:47	07:47:57	2362	2463	172	72	2.3	-0.0	13.6	-4.6	4.7	0.96	-0.022	0.271	-0.7	10	mid	up	off	14	throt						
	07:47:58	2410	2499	173	72	2.1	-0.4	12.8	-4.5		0.91	0.035	0.257	-1.2		mid		off	14	roll	air		on			
	07:47:59	2455	2532	173	72	3.1	-0.7	11.5	-3.7	4.4	0.88	-0.018	0.246	-0.8	10	mid	up	off	14	pitch						
	07:48:00	2502	2559	174	72	3.1	-2.1	11.0	-3.0		0.93	-0.004	0.254	-1.8		mid		off	26	armed	air					
7:47	07:48:01	2538	2588	175	72	2.8	-3.2	11.0	-1.9	4.4	0.99	-0.002	0.265	-1.7	10	mid	up	off	14	throt						
	07:48:02	2578	2616	176	72	2.7	-4.2	11.4	-1.8		1.03	-0.014	0.267	-1.5		mid		off	14	roll	air		on			
	07:48:03	2616	2667	177	72	2.5	-5.3	11.7	-2.1	4.4	1.05	-0.032	0.273	-1.3	10	mid	up	engage	14	pitch						
	07:48:04	2652	2678	178	72	1.8	-5.3	12.1	-1.3		1.06	-0.026	0.275	-0.8		mid		engage	26	armed	air					
7:47	07:48:05	2682	2681	178	71	1.4	-4.6	12.7	-3.6	4.2	1.08	-0.010	0.275	-0.3	10	mid	up	engage	14	throt						
	07:48:06	2723	2707	179	71	1.5	-3.5	12.5	-1.8		1.06	-0.018	0.261	-0.7		mid		off	14	roll	air		on			
	07:48:07	2767	2822	179	71	1.8	-2.8	12.6	-1.5	4.2	0.99	-0.016	0.265	-0.5	8	mid	up	off	14	pitch						Start flaps retraction
	07:48:08	2810	2861	179	70	3.1	-2.8	12.9	-1.7		1.01	-0.026	0.279	-1.2		mid		off	26	armed	air					
7:47	07:48:09	2854	2948	180	70	3.5	-4.2	13.2	-1.8	4.2	0.98	-0.010	0.269	-1.8	6	mid	up	off	14	throt						
	07:48:10	2894	2943	180	69	3.5	-5.6	13.1	-3.5		0.97	-0.010	0.250	-1.7		mid		off	14	roll	air		on			
	07:48:11	2943	2989	180	69	1.1	-7.4	11.9	-2.7	4.3	0.86	-0.022	0.261	-1.0	3	mid	up	off	14	pitch						First surge left engine
	07:48:12	2980	2992	181	68	1.6	-8.1	10.6	-1.8		0.81	-0.049	0.232	-1.5		mid		off	26	armed	air					
7:47	07:48:13	3016	3001	181	67	1.3	-7.4	10.3	-2.3	4.3	0.90	-0.049	0.269	-1.7	0	mid	up	off	14	throt						EGT above max both engines
	07:48:14	3047	3023	183	66	0.6	-7.7	9.1	-2.3		0.89	-0.049	0.281	-1.0		mid		off	14	roll	air		on			
	07:48:15	3075	3026	186	65	0.5	-8.4	8.2	-1.2	4.3	0.87	-0.028	0.240	-1.5	0	mid	up	off	14	pitch						
	07:48:16	3087	3051	187	64	0.4	-9.5	8.0	0.0		0.98	-0.059	0.293	-1.7		mid		off	26	armed	air					
7:47	07:48:17	3105	3066	188	63	0.5	-10.9	8.6	3.0	4.4	1.19	0.071	0.322	-2.5	0	mid	up	off	14	throt						
	07:48:18	3115	3063	191	62	0.9	-11.3	9.8	-0.5		1.18	-0.006	0.324	-2.3		mid		off	14	roll	air		on			
	07:48:19	3129	3068	193	61	0.6	-11.3	9.8	-0.8	4.5	1.13	0.037	0.301	-1.7	0	mid	up	off	14	pitch						
	07:48:20	3140	3111	194	61	1.0	-10.2	9.1	-2.4		1.04	0.053	0.277	-1.2		mid		off	26	armed	air					
7:47	07:48:21	3153	3141	196	60	0.8	-9.5	8.6	-1.5	4.5	1.02	-0.006	0.179	-1.5	0	mid	up	off	14	throt						N1 drop right engine
	07:48:22	3163	3149	197	59	2.1	-8.4	8.4	-2.9		1.02	0.067	0.138	-2.5		mid		off	14	roll	air		on			Prob ARTS activation
	07:48:23	3181	3154	198	59	1.9	-6.3	7.7	-1.3	4.5	0.93	0.045	0.118	-2.3	0	mid	up	off	14	pitch						EPR < 1.00 right engine
	07:48:24	3194	3164	198	59	1.1	-4.9	7.4	-0.4		0.95	0.033	0.045	-0.7		mid		off	26	armed	air					
7:47	07:48:25	3206	3167	196	58	1.5	-3.9	7.6	0.0	4.5	1.05	-0.008	0.063	-0.8	0	mid	up	off	14	throt						EPR < 1.00 left engine
	07:48:26	3212	3185	194	57	1.4	-4.9	8.1	0.0		1.06	-0.016	0.067	-1.5		mid		off	14	roll	air		on			
	07:48:27	3227	3214	192	56	0.5	-7.0	8.4	-0.5	4.5	1.06	-0.020	0.067	-2.1	0	mid	up	off	14	pitch						
	07:48:28	3236	3250	191	55	-0.6	-8.8	8.6	1.9		1.06	-0.014	0.079	-2.3		mid		off	26	armed	air					
7:48	07:48:29	3244	3266	189	53	-0.7	-9.1	9.7	0.6	4.5	1.14	-0.014	0.094	-2.1	0	mid	up	off	0	throt						Autothrottle off
	07:48:30	3253	3264	187	52	-0.6	-9.5	10.5	-0.5		1.14	-0.014	0.100	-2.0		mid		off	14	roll	air		on			
	07:48:31	3268	3234	185	51	-0.9	-9.5	10.1	0.1	4.5	1.07	-0.016	0.082	-2.1	0	mid	up	off	14	pitch						
	07:48:32	3282	3331	183	50	-2.4	-9.5	9.1	0.2		0.94	-0.014	0.061	-2.1		mid		off	26	armed	air					
7:48	07:48:33	3291	3328	181	49	-1.3	-8.1	8.3	1.0	4.5	0.93	-0.018	0.065	-2.1	0	mid	up	off	0	throt						
	07:48:34	3299	3328	179	48	-2.4	-8.1	8.2	0.4		0.98	-0.020	0.071	-2.1		mid		off	14	roll	air		on			

QAR "Flight" parameters

101		1	30	3	4	13	7	5	12	10	26	9	36	14	19	20	48	32	60	59	58	29	89	47	113	
GMT a/c hh:mm	Time UTC correct	Press Alt comb	Ralt Coars feet	IAS DADC kts	Hdg degr	Ailer Left +=TEU	Bank Att#1 degr	Pitch Att#1 degr	ElevPo Left +=TEU	Pitch Trim Pos	Vert Acc G	Lat Acc G	Long Acc G	Rud pos	Flap pos Left	Slat Pos Left	Land Gear Right	Auto Pilot Eng	DFGS code	DFGS mode	Squat sw	Mid Mark Beac	Wing Anti ice	GPWS Mode 1-4,6	Sync error flag	Comments
	07:48:35	3306	3328	177	48	-0.4	-7.0	8.2	0.9	4.5	0.98	-0.020	0.077	-2.5	0	mid	up	off	14	pitch						
	07:48:36	3313	3331	177	46	-1.9	-7.7	8.3	2.4		1.02	-0.018	0.092	-2.8		mid		off	26	armed	air					
7:48	07:48:37	3315	3331	176	46	-2.7	-7.7	8.6	-1.5	4.5	1.05	-0.014	0.090	-2.8	0	mid	up	off	0	throt						
	07:48:38	3317	3328	174	45	-1.9	-7.0	7.1	-2.1		0.94	-0.018	0.071	-2.1		mid		off	14	roll	air		on			"Fire left engine" -warning
	07:48:39	3318	3331	173	44	-0.7	-6.7	4.8	2.7	4.5	0.83	-0.018	0.057	-2.3	0	mid	up	off	14	pitch						
	07:48:40	3308	3328	172	43	-0.5	-7.0	5.1	4.5		1.01	-0.020	0.098	-2.6		mid		off	26	armed	air					
	07:48:41																									Data missing due pwr fail
	07:48:42																									First Officer pulls fire handle
	07:48:43	3281	3331	172	40	-0.4	-7.7	7.8	-1.6		1.09	-0.008	0.112	-2.0		mid		off	14	roll	air		on			
	07:48:44	3271	3331	171	40	0.2	-7.7	5.4	0.7	4.4	0.92	-0.008	0.067	-1.7	0	mid	up	off	14	pitch						
	07:48:45	3258	3328	170	39	0.3	-8.1	3.3	6.9		0.87	-0.008	0.071	-2.3		mid		off	26	armed	air					
7:48	07:48:46	3237	3331	169	39	1.4	-8.8	4.7	5.5	4.4	1.15	-0.006	0.134	-2.3	0	mid	up	off	0	throt						
	07:48:47	3217	3331	169	37	1.0	-9.9	6.9	3.2		1.17	-0.008	0.143	-2.1		mid		off	14	roll	air		on			
	07:48:48	3205	3331	170	36	0.8	-10.9	6.9	2.1	4.4	1.14	-0.002	0.124	-2.1	0	mid	up	off	14	pitch						
	07:48:49	3190	3331	169	35	0.2	-10.9	5.5	1.7		1.00	0.004	0.092	-1.7		mid		off	26	armed	air					
7:48	07:48:50	3168	3331	169	34	0.2	-10.2	4.1	3.2	4.4	0.90	0.004	0.075	-1.3	0	mid	up	off	0	throt						
	07:48:51	3142	3331	169	33	0.3	-9.9	4.0	5.5		1.05	-0.004	0.114	-1.5		mid		off	14	roll	air		on			
	07:48:52	3118	3331	169	31	0.4	-9.5	5.6	4.3	4.6	1.15	-0.006	0.138	-1.5	0	mid	up	off	14	pitch						
	07:48:53	3101	3331	169	30	0.5	-9.5	6.7	2.4		1.16	-0.006	0.141	-1.8		mid		off	26	armed	air					
7:48	07:48:54	3085	3331	170	29	0.5	-10.2	6.3	2.4	4.5	1.09	-0.004	0.114	-2.0	0	mid	up	off	0	throt						
	07:48:55	3064	3331	170	27	0.5	-10.9	5.0	2.4		0.99	-0.004	0.090	-2.0		mid		off	14	roll	air		on			
	07:48:56	3038	3333	169	26	0.1	-11.3	4.4	3.5	4.5	0.99	-0.008	0.094	-2.1	0	mid	up	off	14	pitch						
	07:48:57	3014	3331	169	25	-0.2	-11.3	4.7	1.6		1.04	-0.006	0.100	-2.0		mid		off	26	armed	air					
7:48	07:48:58	2993	3331	170	24	-0.4	-11.3	4.5	1.2	4.5	1.02	-0.006	0.100	-2.0	0	mid	up	off	0	throt						
	07:48:59	2974	3328	170	22	-0.2	-10.9	3.6	2.3		0.96	-0.010	0.086	-1.3		mid		off	14	roll	air		on			
	07:49:00	2946	3331	171	21	-1.5	-10.6	3.3	3.9	4.5	1.00	-0.006	0.096	-1.7	0	mid	up	off	14	pitch						
	07:49:01	2918	3331	171	20	-2.1	-9.9	4.0	4.3		1.11	-0.006	0.120	-1.7		mid		off	26	armed	air					
7:48	07:49:02	2892	3328	172	19	-0.7	-8.1	5.2	2.0	4.5	1.14	-0.014	0.122	-1.0	0	mid	up	off	0	throt						
	07:49:03	2870	2716	172	17	0.1	-7.0	4.7	0.1		1.09	-0.018	0.108	-1.0		mid		off	14	roll	air		on			
	07:49:04	2845	2711	173	17	-1.2	-7.7	3.3	2.4	4.3	0.93	-0.010	0.075	-1.8	0	mid	up	off	14	pitch						
	07:49:05	2818	2700	173	17	-1.1	-7.7	3.0	6.1		1.03	0.012	0.100	-2.0		mid		off	26	armed	air					
7:48	07:49:06	2785	2665	174	15	0.2	-5.6	4.5	4.4	4.4	1.18	-0.006	0.130	-0.7	0	mid	up	off	0	throt						
	07:49:07	2759	2659	175	14	0.3	-4.9	6.2	2.3		1.20	-0.012	0.134	-0.3		mid		off	14	roll	air		on			
	07:49:08	2740	2639	175	13	0.3	-5.3	6.2	1.2	4.4	1.14	-0.012	0.118	-1.0	0	mid	up	off	14	pitch						
	07:49:09	2719	2648	175	13	0.3	-5.3	5.1	2.2		1.01	-0.002	0.088	-1.3		mid		off	26	armed	air					
	07:49:10																									Data missing due pwr fail
	07:49:11																									- " -
	07:49:12																									- " -
	07:49:13																									- " -
	07:49:14																									- " -
	07:49:15																									- " -
	07:49:16																									- " -
	07:49:17																									- " -
	07:49:18	-1	2353	1024	12	2.8	0.0	5.4	1.3		1.22	0.004	0.134	-0.5		mid		off	14	roll	air		on			
	07:49:19	-1676	2330	178	12	2.9	-0.0	5.3	0.1	4.8	1.15	0.004	0.108	-0.8	0	mid	up	off	14	pitch						

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QAR "Flight" parameters

101		1	30	3	4	13	7	5	12	10	26	9	36	14	19	20	48	32	60	59	58	29	89	47	113	
GMT a/c hh:mm	Time UTC correct	Press Alt comb	Ralt Coars feet	IAS DADC kts	Hdg degr	Ailer Left +=TEU	Bank Att#1 degr	Pitch Att#1 degr	ElevPo Left +=TEU	Pitch Trim Pos	Vert Acc G	Lat Acc G	Long Acc G	Rud pos	Flap pos Left	Slat Pos Left	Land Gear Right	Auto Pilot Eng	DFGS code	DFGS mode	Squat sw	Mid Mark Beac	Wing Anti ice	GPWS Mode 1-4,6	Sync error flag	Comments
	07:49:20	-1692	2283	178	12	2.5	-0.4	4.4	0.0		1.01	-0.004	0.077	-1.2		mid		off	26	armed	air					
7:48	07:49:21	2373	2257	178	11	0.8	-1.4	3.4	0.7	4.7	0.93	-0.006	0.063	-1.7	0	mid	up	off	0	throt						
	07:49:22	2346	2234	178	10	-1.4	-2.1	2.9	1.5		0.99	-0.002	0.077	-1.7		mid		off	14	roll	air		on			
	07:49:23	2317	2189	178	10	-0.8	-1.1	3.5	0.6	4.8	1.04	-0.020	0.082	-1.2	0	mid	up	off	14	pitch						
	07:49:24	2293	2185	179	9	0.4	0.0	3.8	2.2		1.06	-0.020	0.090	-0.8		mid		off	26	armed	air					
7:48	07:49:25	2269	2162	180	8	0.9	-0.0	4.4	2.1	4.8	1.12	-0.016	0.100	-1.3	0	mid	up	off	0	throt						
	07:49:26	2268	2136	180	8	0.9	-1.4	5.3	1.1		1.12	-0.008	0.102	-1.7		mid		off	14	roll	air		on			
	07:49:27	2220	2106	181	8	1.8	-1.8	5.3	0.8	4.8	1.11	-0.002	0.096	-1.5	0	mid	up	off	14	pitch						
	07:49:28	2193	2091	180	8	-0.9	-2.8	4.9	0.0		1.04	-0.006	0.084	-1.2		mid		off	26	armed	air					
7:49	07:49:29	2191	2067	179	8	-0.1	-2.1	0.0	3.8	4.8	1.06	-0.004	0.092	-1.0	0	mid	up	off	0	throt						
	07:49:30	2191	2054	180	8	0.4	-0.4	6.1	2.2		1.15	-0.016	0.112	-0.7		mid		off	14	roll	air		on			
	07:49:31	2191	2039	180	180	1.6	-0.0	7.0	0.3	5.0	1.14	-0.010	0.112	-0.8	0	mid	up	off	14	pitch						
	07:49:32	2191	1989	180	7	0.9	-0.7	6.9	0.0		1.10	-0.012	0.102	-1.2		mid		off	26	armed	air					
7:49	07:49:33	2191	1981	180	7	0.7	-1.4	6.2	0.2	5.0	0.99	-0.018	0.075	-1.3	0	mid	up	off	0	throt						
	07:49:34	2191	1994	180	7	0.0	-2.5	5.9	1.9		1.02	-0.004	0.088	-1.8		mid		off	14	roll	air		on			
	07:49:35	2191	1972	180	7	1.0	-1.8	6.6	0.5	5.0	1.06	-0.010	0.092	-1.5	0	mid	up	off	14	pitch						
	07:49:36	2191	1964	180	6	3.0	-0.7	6.7	0.3		1.03	-0.008	0.090	-1.0		mid		off	26	armed	air					
7:49	07:49:37	2191	1944	180	6	1.6	-1.8	6.5	0.5	5.0	1.00	-0.006	0.084	-1.0	0	mid	up	off	0	throt						
	07:49:38	2037	1933	175	6	1.3	-2.5	6.2	0.4		1.00	-0.004	0.082	-0.7		mid		off	14	roll	air		on			
	07:49:39	2023	1904	175	6	2.3	-2.5	6.2	1.6	5.0	1.01	-0.002	0.084	-0.8	0	mid	up	off	14	pitch						
	07:49:40	2009	1883	174	6	2.7	-2.1	6.3	1.6		1.04	-0.002	0.096	-0.7		mid		off	26	armed	air					
7:49	07:49:41	1995	1870	174	5	3.3	-1.1	6.5	0.0	5.0	1.04	-0.004	0.092	-0.5	0	mid	up	off	0	throt						
	07:49:42	1982	1861	173	5	2.6	-1.8	6.1	0.0		1.02	-0.002	0.090	-1.2		mid		off	14	roll	air		on			
	07:49:43	1964	1827	173	4	0.7	-3.2	5.1	2.2	5.0	0.95	-0.006	0.084	-1.3	0	mid	up	off	14	pitch						
	07:49:44	1946	1814	172	4	1.0	-3.5	5.3	0.4		1.01	-0.004	0.090	-1.2		mid		off	0	armed	air					
7:49	07:49:45	1928	1779	171	4	1.6	-2.5	5.4	1.6	5.0	1.02	-0.012	0.094	-1.0	0	mid	up	off	0	throt						
	07:49:46	1911	1769	171	3	-0.6	-2.5	5.5	0.3		1.03	-0.016	0.094	-0.8		mid		off	14	roll	air		on			
	07:49:47	1890	1744	172	2	0.2	-2.5	5.0	0.0	5.0	1.00	-0.012	0.086	-0.8	0	mid	up	off	14	pitch						
	07:49:48	1869	1727	172	2	0.3	-2.5	4.3	0.0		0.95	-0.006	0.073	-1.2		mid		off	0	armed	air					
7:49	07:49:49	1850	1706	171	2	-2.4	-2.1	3.6	0.5	5.0	0.95	-0.004	0.077	-0.8	0	mid	up	off	0	throt						
	07:49:50	1822	1684	170	2	0.0	-0.0	3.1	0.0		0.94	-0.016	0.073	-0.0		mid		off	14	roll	air		on			
	07:49:51	1796	1657	172	2	0.1	1.1	2.5	0.8	5.0	0.95	-0.010	0.075	-0.2	0	mid	up	off	14	pitch						
	07:49:52	1768	1633	172	2	0.3	1.8	2.5	3.2		1.05	-0.018	0.100	-0.8		mid		off	0	armed	air					
7:49	07:49:53	1733	1589	172	2	2.0	1.8	3.7	3.1	5.4	1.14	-0.016	0.120	-1.8	0	mid	up	off	0	throt						
	07:49:54	1709	1574	174	2	1.3	0.4	5.1	1.9		1.17	-0.002	0.130	-1.7		mid		off	14	roll	air		on			
	07:49:55	1680	1533	175	3	0.9	0.0	6.0	1.3	5.6	1.15	-0.010	0.130	-0.3	0	mid	up	off	14	pitch						
	07:49:56	1656	1518	173	3	1.5	0.7	6.3	2.2		1.12	0.004	0.116	-0.3		mid		off	0	armed	air					
7:49	07:49:57	1632	1499	177	3	1.2	1.1	7.1	0.0	5.9	1.14	-0.010	0.116	-0.3	0	mid	up	off	0	throt						
	07:49:58	1611	1506	175	3	1.1	1.1	7.8	0.1		1.13	-0.010	0.124	-0.5		mid		off	14	roll	air		on			
	07:49:59	1599	1482	174	3	1.6	1.8	7.9	-0.8	6.0	1.12	-0.010	0.112	-0.3	0	mid	up	off	14	pitch						
	07:50:00	1586	1473	172	3	2.3	2.8	7.4	-0.6		1.03	-0.008	0.094	-0.5		mid		off	0	armed	air					
7:49	07:50:01	1574	1468	173	3	2.7	2.5	6.9	1.1	5.9	0.94	-0.022	0.084	-1.3	0	mid	up	off	0	throt						
	07:50:02	1560	1456	170	3	1.1	1.1	7.3	1.1		1.01	-0.022	0.104	-1.3		mid		off	14	roll	air		on			
	07:50:03	1549	1440	168	4	1.0	0.0	8.3	0.0	5.9	1.13	-0.004	0.134	-1.8	0	mid	up	off	14	pitch						
	07:50:04	1543	1405	167	4	1.2	0.7	8.4	1.1		1.07	-0.004	0.120	-0.8		mid		off	0	armed	air					

QAR "Flight" parameters

101		1	30	3	4	13	7	5	12	10	26	9	36	14	19	20	48	32	60	59	58	29	89	47	113	
GMT a/c hh:mm	Time UTC correct	Press Alt comb	Ralt Coars feet	IAS DADC kts	Hdg degr	Ailer Left +=TEU	Bank Att#1 degr	Pitch Att#1 degr	ElevPo Left +=TEU	Pitch Trim Pos	Vert Acc G	Lat Acc G	Long Acc G	Rud pos	Flap pos Left	Slat Pos Left	Land Gear Right	Auto Pilot Eng	DFGS code	DFGS mode	Squat sw	Mid Mark Beac	Wing Anti ice	GPWS Mode 1-4,6	Sync error flag	Comments
7:49	07:50:05	1536	1409	168	4	0.9	0.7	7.9	2.4	5.8	1.03	-0.018	0.114	-0.7	0	mid	up	off	0	throt						
	07:50:06	1524	1397	166	4	0.9	0.7	8.4	0.2		1.10	-0.024	0.130	-0.8		mid		off	14	roll	air		on			
	07:50:07	1511	1400	168	4	0.9	0.0	8.5	1.3	5.8	1.04	-0.020	0.112	-1.7	0	mid	up	off	14	pitch						
	07:50:08	1506	1376	167	4	0.9	-0.0	8.8	2.4		1.05	-0.026	0.126	-1.5		mid		off	0	armed	air					
7:49	07:50:09	1502	1375	163	4	1.0	0.0	9.2	2.0	5.9	1.12	-0.010	0.118	-0.7	5	mid	up	off	0	throt						Start of flaps extension
	07:50:10	1492	1350	165	4	1.6	0.7	9.5	0.0		1.16	-0.014	0.104	-0.7		mid		off	14	roll	air		on			
	07:50:11	1482	1359	164	4	0.9	0.7	9.4	-0.6	5.9	1.17	-0.006	0.096	-0.5	10	mid	up	off	14	pitch						
	07:50:12	1480	1384	164	4	0.9	1.1	9.3	-0.2		1.08	-0.016	0.073	-0.3		mid		off	0	armed	air					
7:49	07:50:13	1476	1401	162	5	1.1	1.8	9.6	-1.6	5.9	1.08	-0.016	0.077	-0.8	11	mid	up	off	0	throt						
	07:50:14	1478	1442	158	5	3.0	2.8	9.3	-0.5		1.00	-0.008	0.065	-0.5		mid		off	14	roll	air		on			
	07:50:15	1484	1452	156	5	1.3	2.1	9.2	-0.1	5.9	1.00	-0.012	0.069	-0.8	11	mid	up	off	14	pitch						
	07:50:16	1493	1467	155	5	1.0	0.7	9.4	-0.3		0.99	0.012	0.071	-2.0		mid		off	0	armed	air					
7:49	07:50:17	1495	1461	152	6	0.3	0.7	9.3	-2.2	5.9	1.00	-0.002	0.073	-0.7	11	mid	up	off	0	throt						
	07:50:18	1503	1445	151	6	1.2	1.1	8.5	-1.1		0.94	-0.002	0.061	-0.2		mid		off	14	roll	air		on			
	07:50:19	1504	1440	149	6	0.8	1.1	7.3	0.0	5.8	0.91	-0.014	0.049	-0.2	13	extend	up	off	14	pitch						
	07:50:20	1501	1426	147	5	2.5	1.4	6.4	1.0		0.93	-0.020	0.045	-1.2		extend		off	0	armed	air					
7:49	07:50:21	1496	1409	144	6	2.1	0.7	6.2	0.9	5.8	0.99	-0.016	0.055	-1.8	19	extend	up	off	0	throt						
	07:50:22	1488	1400	143	6	1.1	0.0	6.2	0.1		1.06	-0.006	0.057	-1.5		extend		off	14	roll	air		on			
	07:50:23	1480	1387	142	6	1.6	0.4	5.5	-2.4	5.6	1.05	-0.002	0.045	-1.0	23	extend	up	off	14	pitch						
	07:50:24	1469	1368	142	6	2.4	1.1	3.8	-1.1		0.98	-0.008	0.027	-0.0		extend		off	0	armed	air					
7:49	07:50:25	1455	1335	141	6	0.0	0.4	2.2	-0.8	5.6	0.89	-0.018	-0.012	-0.8	27	extend	up	off	0	throt						
	07:50:26	1437	1344	141	6	0.5	0.7	1.6	0.6		0.97	0.004	-0.002	-1.5		extend		off	14	roll	air		on			
	07:50:27	1422	1304	140	7	0.6	2.5	2.0	1.7	5.6	1.05	-0.012	0.029	-0.0	27	extend	up	off	14	pitch						"Landing gear" -warning
	07:50:28	1403	1274	138	7	2.4	2.8	3.0	-1.0		1.06	-0.032	0.033	-0.7		extend		off	0	armed	air					
7:50	07:50:29	1388	1264	137	7	2.0	1.1	2.8	-2.4	5.6	1.03	-0.004	0.025	-1.8	28	extend	up	off	0	throt						
	07:50:30	1369	1241	137	8	1.5	0.7	1.7	-0.6		0.91	-0.008	0.004	-1.7		extend		off	14	roll	air		on			
	07:50:31	1348	1231	135	8	2.0	0.4	0.8	-0.5	5.6	0.98	-0.002	0.025	-1.0	28	extend	up	off	14	pitch						
	07:50:32	1325	1202	132	8	1.5	1.1	0.0	-0.3		1.01	0.022	0.022	-0.7		extend		off	0	armed	air					
7:50	07:50:33	1304	1171	133	8	1.2	2.1	-1.1	-0.2	5.6	0.97	-0.008	-0.004	1.0	32	extend	up	off	0	throt						
	07:50:34	1274	1141	133	8	2.4	2.8	-2.3	-0.6		0.98	-0.012	-0.022	1.0		extend		off	14	roll	air		on			
	07:50:35	1237	1106	132	8	0.8	1.8	-3.3	-0.2	5.6	1.00	-0.014	-0.030	-0.5	36	extend	up	off	14	pitch						
	07:50:36	1205	1081	134	8	0.5	1.4	-4.0	0.4		0.98	-0.020	-0.049	-1.5		extend		off	0	armed	air					
7:50	07:50:37	1165	1054	135	8	1.0	1.1	-3.9	-0.2	5.6	1.05	-0.012	-0.049	-2.1	39	extend	up	off	0	throt						
	07:50:38	1127	1017	135	8	1.7	1.1	-3.4	-1.0		1.09	-0.014	-0.047	-1.2		extend		off	14	roll	air		on			
	07:50:39	1093	973	137	9	1.9	0.4	-3.3	-0.7	5.6	1.06	0.012	-0.057	-1.3	40	extend	up	off	14	pitch						Flaps fully extended
	07:50:40	1057	938	139	9	0.9	-0.4	-3.3	0.1		1.05	-0.006	-0.065	-1.2		extend		off	0	armed	air					
7:50	07:50:41	1021	893	141	9	1.0	-0.0	-2.6	-0.3	5.6	1.07	-0.002	-0.063	-0.7	40	extend	up	off	0	throt						
	07:50:42	986	856	140	9	0.9	0.0	-1.6	-1.4		1.13	-0.020	-0.043	-0.5		extend		off	14	roll	air		on			
	07:50:43	957	818	138	8	3.1	1.8	-1.1	-2.5	5.6	1.11	-0.006	-0.047	-0.2	40	extend	up	off	14	pitch						
	07:50:44	929	781	138	8	2.0	1.8	-1.3	-0.8		1.04	-0.024	-0.047	-1.0		extend		off	0	armed	air					
7:50	07:50:45	902	762	135	8	1.0	1.1	-1.7	0.0	5.6	1.04	-0.014	-0.051	-1.5	40	extend	up	off	0	throt						
	07:50:46	875	740	136	9	1.2	1.1	-1.4	0.0		1.00	-0.010	-0.055	-1.3		extend		off	14	roll	air		on			
	07:50:47	847	713	137	9	0.9	1.4	-0.9	0.2	5.6	1.03	-0.012	-0.047	-1.3	40	extend	up	off	14	pitch						
	07:50:48	817	673	134	10	-4.3	2.1	-0.3	2.1		1.06	-0.028	-0.020	2.0		extend		off	0	armed	air					
7:50	07:50:49	795	653	132	10	-1.4	6.7	0.4	2.2	5.6	1.11	-0.020	-0.004	2.1	40	extend	up	off	0	throt						

Christer Magnusson 930709

QAR "Flight" parameters

101		1	30	3	4	13	7	5	12	10	26	9	36	14	19	20	48	32	60	59	58	29	89	47	113	
GMT a/c hh:mm	Time UTC correct	Press Alt comb	Ralt Coars feet	IAS DADC kts	Hdg degr	Ailer Left +=TEU	Bank Att#1 degr	Pitch Att#1 degr	ElevPo Left +=TEU	Pitch Trim Pos	Vert Acc G	Lat Acc G	Long Acc G	Rud pos	Flap pos Left	Slat Pos Left	Land Gear Right	Auto Pilot Eng	DFGS code	DFGS mode	Squat sw	Mid Mark Beac	Wing Anti ice	GPWS Mode 1-4,6	Sync error flag	Comments
	07:50:50	775	618	131	10	0.0	9.5	1.1	2.2		1.05	-0.028	-0.002	1.5		extend		off	14	roll	air		on			
	07:50:51	749	602	129	11	-3.9	10.9	1.4	-1.2	5.6	1.09	-0.043	0.020	1.0	40	extend	up	off	14	pitch						
	07:50:52	731	574	128	13	-1.9	13.7	0.4	1.0		1.01	-0.047	-0.010	-0.0		extend		off	0	armed	air					
7:50	07:50:53	707	562	126	15	3.4	19.0	-1.1	3.1	5.6	0.94	-0.034	-0.022	1.2	40	extend	up	off	0	throt						
	07:50:54	677	519	127	17	4.9	19.7	-1.8	4.0		0.92	-0.039	-0.026	-2.8		extend		off	14	roll	air		on			
	07:50:55	648	491	128	20	5.6	16.2	-1.8	4.7	5.6	1.09	-0.039	0.014	-5.9	40	extend	up	off	14	pitch				warn		"Too low gear" -warning
	07:50:56	621	465	131	24	8.7	14.8	-1.1	4.0		1.12	0.027	-0.006	-6.4		extend		off	0	armed	air			warn		
7:50	07:50:57	577	439	134	27	8.5	12.3	-0.3	2.6	5.6	1.19	-0.010	0.041	-3.0	40	extend	up	off	0	throt				warn		
	07:50:58	542	411	131	29	1.6	6.3	0.2	-1.5		1.20	-0.022	-0.002	-3.1		extend		off	14	roll	air		on	warn		
	07:50:59	511	380	130	30	0.9	2.1	-0.5	0.4	5.6	1.06	0.020	-0.026	-3.1	40	extend	trans	off	14	pitch				warn		
	07:51:00	478	349	133	31	4.3	3.5	-1.8	3.9		1.00	0.041	-0.049	-2.8		extend		off	0	armed	air			warn		
7:50	07:51:01	441	311	134	31	5.7	7.0	-1.7	0.8	5.7	1.01	-0.024	-0.041	-1.2	40	extend	trans	off	0	throt				warn		
	07:51:02	409	271	132	31	1.9	4.9	-0.4	0.7		1.12	-0.043	-0.037	-1.0		extend		off	14	roll	air		on	warn		"Whoop-whoop pull up" -warning
	07:51:03	370	249	132	30	-2.4	-0.0	0.5	0.8	5.8	1.12	-0.047	-0.010	-2.0	40	extend	trans	off	14	pitch				warn		
	07:51:04	356	230	131	31	-2.5	-2.1	1.1	4.2		1.05	-0.018	-0.006	-2.1		extend		off	0	armed	air			warn		
7:50	07:51:05	319	185	128	31	-0.8	-1.1	1.6	1.5	5.9	1.12	-0.024	0.022	-2.1	40	extend	trans	off	0	throt				warn		
	07:51:06	294	142	129	32	0.1	-0.0	2.1	8.5		1.08	-0.018	0.037	-2.5		extend		off	14	roll	air		on	warn		
	07:51:07	274	115	125	33	3.1	1.4	3.2	10.2	6.1	1.10	-0.008	0.055	-1.7	40	extend	trans	off	14	pitch				warn		
	07:51:08	250	118	122	33	2.3	1.1	4.9	6.9		1.12	-0.030	0.071	-2.3		extend		off	0	armed	air			warn		
7:50	07:51:09	225	79	123	34	4.6	0.7	6.8	6.1	6.6	1.13	-0.010	0.120	-3.1	40	extend	trans	off	0	throt				warn		
	07:51:10	208	71	118	34	4.3	2.1	8.2	3.5		1.12	-0.024	0.122	-1.3		extend		off	14	roll	air		on	warn		"Sink rate" -warning
	07:51:11	202	18	121	34	4.5	1.1	8.4	8.3	6.7	1.08	-0.189	-0.114	-5.0	40	extend	down	off	14	pitch						
	07:51:12	176	14	120	36	-0.8	6.3	7.9	8.0		0.98	-0.212	-0.348	-2.1		extend		off	0	armed	air					First impact with trees
:50	07:51:13	129	39	107	40	15.4	19.7	6.5	5.5	6.8	0.81	-0.269	-0.403	-2.1	39	extend	down	off	0	throt						
	07:51:14	100	739	0	49	-84.3	40.1	0.8	6.7		2.09	-1.044	-1.017	-72.4		extend		engage	14	roll	air		on		sync	
	07:51:15	0	-20	0	0	0.0	0.0	0.0	0.0	0.0	-3.37	-1.083	-1.083	0.0	0	transt	trans	off	0	roll		mm		warn	sync	
	07:51:16	0	-20	0	0	0.0	0.0	0.0	0.0		-3.37	-1.083	-1.083	0.0		transt		off	0	roll	air	mm		warn	sync	QAR stops

Transcript from SK751 Cockpit Voice Recorder

Abbreviations

Mkr	-	Event marker
UTC	-	Coordinated Universal Time.
Rel rot	-	Time relative to rotation as specified in the data readouts.
Tk	-	Track from which the information is derived.
Src	-	Source of the information. See below
RP	-	Right pilot audio channel
LP	-	Left pilot audio channel
SI	-	Service interphone audio channel
AM	-	Area microphone audio channel
FC	-	Captain (he is also 1/P and L/P)
FO	-	First Officer (also FP and R/P and 2/P)
FC2	-	The Captain coming into cockpit to assist during flight.
CA1	-	Cabin attendant no 1 / purser. Normal pos; fwd jump seat
CA2	-	Cabin attendant no 2. Aft jump seat.
CA3	-	Cabin attendant no 3. Mid jump seat.
CA4	-	Cabin attendant no 4. Fwd jump seat, door side.
Mek	-	The mechanic on ground (heard via intercom)
CLR	-	Clearance Delivery ARN freq 121.7
GND	-	Ground Control ARN freq 121.95
TWR	-	Tower ARN freq 118.5
DEP	-	Stockhom Control freq 124.1
LF	-	Swedline (= Linjeflyg)
SK	-	Scandinavian (= SAS)

Notes;

[Brackets] surrounds interpreted information or additional information about the CVR content.

(Brackets) surround information that is highly uncertain

?? denotes information that has not been interpreted due to disturbances or for other reasons.

? either means a question is asked, or that the information is uncertain.

Transcript from SK 751 Cockpit Voice Recorder

Mkr	UTC	Rel rot	Tk	Src	Information
	07:18:42	-28:25.	AM		[Takeoff warning (checklist item no 36.)]
	07:18:57	-28:10.	AM	FO	Vi har flaps, slats ute!
	07:19:02	-28:05.	AM	FC	Du kan se mången gang om morgonen, så är de skredet og hänger ned
	07:19:06	-28:01.	AM	FO	Vågar jag slå till någonting i ?
	07:19:08	-27:59.	AM	FC	Det kan du gott göra... de köres ligeså stille og rolig op
	07:19:14	-27:53.	AM	FO	Ja, det gör de. Det händer ingenting på .., klämmer inte ihjäl nå'n därute?
	07:19:17	-27:50.	AM	FC	Når der er fem grader så sidder de i hängslet.. [Explaining that at small flap/slat angles there is no way to get hurt if flaps/slats are retracted]
	07:20:22	-26:45.	AM	FO	Han ligger i align fortfarande [refering to IRS (Inertial reference System)]
	07:20:28	-26:39.	AM	FO	Crew at their stations
	07:20:29	-26:38.	AM	FC	Ja, det är checked left side
	07:20:34	-26:33.	AM	FO	Ja,... checked right. FMS
	07:20:42	-26:25.	AM		[Oxygen mask mike test]
	07:20:44	-26:23.	AM	FC	Den är checked, den är bara icke, den har icke gått i....??..
	07:20:52	-26:15.	AM	FO	[Talking about Inertial Navigation System]
	07:21:30	-25:37.	AM	FC	Jag skall lige att checke departure, har vi fått en clearance?
	07:21:32	-25:35.	AM	FO	Nej jag har inte det
	07:21:33	-25:34.	RP	ATIS	[ATIS is on at a low volume all the time, but FO raises the volume at the indicated time and listens for 1 min 10 sec] Arlanda Information Papa, time 06:57, ILS approach runway 01 in use, braking action first part 39, second part 39, third part 36 contamination 100% dry snow and ice one millimeters, departure runway 08 braking action first part 35 second part 32, third part 31 contamination 100% dry snow and ice one millimeters, braking action on taxiways medium, contamination 50% wet or water patches dry snow and ice, one millimeter, TL55, Met special 360/10 knots wind variable between 330 and 030 degrees, visibility 5000 m rain and snow two octas 400 ft, six octas 600 ft temperature 0, dew point 0, QNH 1012 GRADU visibility 10 km weather nil, information out.
	07:21:41	-25:26.	LP		[Listening to ATIS Papa see CVR R/P]
	07:22:57	-24:10.	RP	FO	Delivery godmorgon, SK751, gate two with Papa, request clearance.
	07:23:01	-24:06.	LP		[Listening to R/P receiving clearance]
	07:23:04	-24:03.	RP	CLR	God morgon SK751, start up is approved, correct time 23 and QNH 1013, clearance Copenhagen Dunker four Delta departure, Romeo 1 squawk 7304.
	07:23:21	-23:46.	RP	FO	Cleared Köpenhamn Dunker four Delta, R1 and 7374 for SK751
	07:23:28	-23:39.	RP	CLR	SK751 confirm squawk 7304
	07:23:33	-23:34.	RP	FO	Confirming 7304, SK751
	07:23:37	-23:30.	RP	CLR	SK751, correct and over to ground for push, hejdå
	07:23:40	-23:27.	RP	FO	Hejdå
	07:23:58	-23:09.	AM	FO	FMS
	07:24:00	-23:07.	AM	FC	Den är checked
	07:24:02	-23:05.	AM	FO	Oxygen masks and supply
	07:24:03	-23:04.	AM	FC	Checked
	07:24:05	-23:02.	AM	FO	Parking brakes
	07:24:09	-22:58.	AM	FC	De är checked
	07:24:10	-22:57.	AM	FO	EFIS and compasses
	07:24:14	-22:53.	AM	FC	Two, four eight
	07:24:16	-22:51.	AM	FO	Two, fortyeight
	07:24:17	-22:50.	AM	FC	....Fortyeight
	07:24:32	-22:35.	AM	FO	Mach, airspeed, vertical speed. Checked left.., right

Mkr	UTC	Rel rot	Tk	Src	Information
	07:24:34	-22:33.	AM	FC	Checked right
	07:24:37	-22:30.	AM	FO	Altimeter 1013
	07:24:42	-22:25.	AM	FC	Plus 90
	07:24:45	-22:22.	AM	FO	One hundred
	07:24:47	-22:20.	AM	FO	Alti.., då tar vi trim tabs
	07:24:50	-22:17.	AM	FC	Ja de är set left, rudder zero five left.
	07:24:58	-22:09.	AM	FO	Crew papers and aircraft log
	07:25:02	-22:05.	AM	FC	Standby...
	07:25:32	-21:35.	AM	FC	Så har vi, 9803, small engines... [reading from aircraft log and briefing card]
	07:26:06	-21:01.	AM	FC	Tack skall du ha
	07:26:10	-20:57.	AM	CA1	Nu stämmer det med namn och lista, varsågod
	07:26:16	-20:51.	AM	FC	Så har vi fått maintenance release ud av Arlanda den 27, den har inte något som helst feijl, beautiful, beutiful...
	07:26:56	-20:11.	AM	CA3	Hej jag kom lite sent, Anders
	07:27:01	-20:06.	AM	FC	Hej
	07:27:06	-20:01.	AM	FC	Anders han kommer så sent att han inte vet att dörren skall stå öppen [ironically!]
	07:27:09	-19:58.	AM	CA3	Det är rätt, ja
	07:27:16	-19:51.	AM	CA4	..jättevarmt i kabinen, går det att stänga av värmen nu, nu har vi både värme och passagerare
	07:27:20	-19:47.	AM	FC	De kommer udefra [continued "smalltalk" about heating system]
	07:27:33	-19:34.	AM		[Chime (cabin to cockpit call - a message from aft cabin attendant to FO to switch on the auxiliary hydraulic pump)]
	07:27:38	-19:29.	AM	FO	Ja crew papers and aircraft log
	07:27:40	-19:27.	AM	FC	Checked
	07:27:41	-19:26.	AM	FO	Fuel, oil and hydraulic quantity
	07:27:43	-19:24.	AM	FC	Checked
	07:27:44	-19:23.	AM	FO	And signed [points out that FC has signed flightplan]
	07:27:46	-19:21.	AM	FC	Checked left
	07:27:47	-19:20.	AM	FO	Och den är resetted [Fuel used]
	07:27:48	-19:19.	AM	FC	Ja
	07:27:54	-19:13.	AM	FO	Stabilizer, har vi next
	07:28:04	-19:03.	AM	FC	Ulf, Zero Fuel Weight 48.7, yes takeoff weight 55 tons, index zero fuel weight 24, macto 17, we have 123 passengers, seated 8 in the front, 114 in the cafeteria and one elephant [=infant]
	07:28:58	-18:09.	RP	GND	SK503, Tower 118.5
	07:29:08	-17:59.	LP	CA2	Should an evacuation become necessary a line along the floor will light up and show you the way to the emergency exits. Look for you closest exit. A life vest is placed under your seat. Place your cabin baggage under the seat in front of you in order not to block your life vest and to prevent your baggage from sliding into the aisle. Electronic devices containing ....[recording disturbed by radio traffic]... must not be used on board. Mobile telephones must therefore be switched off. The seatbacks must be raised to an upright position and the tables secured so they don't obstruct the way for you and your fellow passengers. For further information have a look at the safety on board folder placed in your seat pocket. Please also fasten your seatbelts and keep them fastened whenever seated. Smoking is not permitted on this flight. Till sist ber vi att ni spänner fast säkerhetsbältet och alltid har det fastspänt så länge ni sitter i stolen. Rökning är inte tillåten ombord. Har ni flera frågor så var vänlig och kontakta kabinpersonalen [total time 12 min 02 sec. Can only be heard in L/P channel]
	07:29:32	-17:35.	AM	FO	Stabilizer 17

Transcript from SK 751 Cockpit Voice Recorder

Mkr	UTC	Rel rot	Tk	Src	Information
	07:29:44	-17:23.	AM	FC	Det är 17 set 11 [flaps 11]
	07:29:49	-17:18.	AM	FO	Checked
	07:29:50	-17:17.	AM	FO	APU started
	07:29:52	-17:15.	AM	FO	Zero Fuel Weight, Aircraft Monitoring System is set
	07:29:55	-17:12.	AM	FO	Takeoff data
	07:29:57	-17:10.	AM	FC	Flaps eleven, 124 and 142, set [V1 for wet and/or slippery rwy]
	07:30:03	-17:04.	AM	FO	Checked
	07:30:05	-17:02.	AM	FO	Anti collision switch on
	07:30:06	-17:01.	AM	FO	Cabin report
	07:30:08	-16:59.	AM	FC	Standby
	07:30:10	-16:57.	AM	FC	Vores braking action figures, va myget er de
	07:30:15	-16:52.	AM	FO	Point five,.. point three five
	07:30:19	-16:48.	AM	FO	I guess no. derating?
	07:30:21	-16:46.	AM	FC	Nej [= No derating]
	07:30:28	-16:39.	RP	GND	SK006, contact Tower 118.5
	07:30:58	-16:09.	RP	GND	SK525, pushback approved
	07:31:04	-16:03.	AM	Mek	Har ni APU power available?
	07:31:07	-16:00.	AM	FC	Ja
	07:31:09	-15:58.	AM	Mek	Lampan lyser inte
	07:31:11	-15:56.	AM		[Sound from APU Generator Reset Switch]
	07:31:12	-15:55.	AM	Mek	Ja just det nu
	07:31:13	-15:54.	AM	FC	Varsågod. Och vi har effekt
	07:31:16	-15:51.	AM	FC	Hvor langt har vi kommit med deicing nu
	07:31:32	-15:35.	AM	CA1	Vingarna är kvar, dom har gjort (det) på undersidan nu gör dom översidan
	07:31:36	-15:31.	AM	FC	Tack ska du ha
	07:31:46	-15:21.	LP	FC	Ja god morgen mitt herrskaper, deres kaptein. Håper de har haft en trevlig jul och god fortsättning. Vi skall börja här med att flyga ner till Köpenhamn. Vi håller lige just på att få rensat våra vingar efter att det har varit lite snö här i kväll och när det är färdigt så drar vi iväg. Vi kommer att flyga snabbt till Köpenhamn idag på grund av kraftig vind og det vore fint om jag så lykkades att hitta några av vores beste kolleger i kabinen så dem räknar med att ge er hele serviceshowet. Jag ger dem ett ..[interrupt due to switch of CVR tape direction] .. Håper de får en trevlig rejse. [Total time 43 sec. Can be heard both in L/P and SI channel at about the same volume]
	07:32:16	-14:51.	RP	Mek	Ja cockpit, vi skall börja med avisning
	07:32:20	-14:47.	AM		[Interrupt due to change of CVR tape direction]
	07:32:22	-14:45.	RP	FO	Ja
	07:32:24	-14:43.	AM	FC	Har de börjat med deicing nu?
	07:32:26	-14:41.	AM	FO	Ja
	07:32:28	-14:39.	LP	FC	This is your captain, hope you´ve had a merry Christmas and wish you welcome this morning here on our flight towards Copenhagen. W'ere just about ready. Just need to clean our wings before we can depart towards the south to warmer country. I have managed this morning to pick our best cabins colleagues and they will take care of you en route. It is gonna be speedy because we have tremendous winds down over Sweden and therefore having a very short flight time this morning. We all hope you'll have a nice flight and wish you a nice morning once again. Thank you. [Total time 50 sec]
	07:32:58	-14:09.	RP	GND	God morgon SK148, 66
	07:33:21	-13:46.	LP	CA1	Cabin crew arm slides please [Only in L/P channel]
	07:33:25	-13:42.	AM	FC	Ja!
	07:33:27	-13:40.	AM	FO	Det var Cabin report next

Transcript from SK 751 Cockpit Voice Recorder

Mkr	UTC	Rel rot	Tk	Src	Information
	07:33:29	-13:38.	AM	FC	Vi har fått en Dunker four delta [departure], climb initially to 5000, det är set, climb gradient, make it 250 below flight level 100, vad säger Eva? [CA1]
	07:33:44	-13:23.	AM	CA1	Kabinen är klar nu,. det är 8 och 115 inklusive en infant och en UM [Unaccompanied Minor].
	07:34:06	-13:01.	AM	FC	..........ni må gärne ha dörren åpen...........
	07:34:10	-12:57.	AM	FO	Yes, cabin report
	07:34:11	-12:56.	AM	FC	Den var received
	07:34:12	-12:55.	AM	FO	Doors - closed
	07:34:13	-12:54.	AM	FC	Checked
	07:34:14	-12:53.	AM	FO	Checklist completed
	07:34:18	-12:49.	AM	FC	Och Aros, Dunker four delta det är four miles Arlanda,..??.. turn left 077 Aros....(twelve eight)... 077 det är 257 .(at.. 6 miles) turn left 034 Dunker..
	07:34:47	-12:20.	AM	FO	Du har tvåan på (Arlanda)
	07:34:49	-12:18.	AM	FC	Engine failure follow .(SID).. 2000, ... den er meget generell!
	07:34:59	-12:08.	AM	FO	Nu börjar dom med vingarna
	07:36:17	-10:50.	RP	GND	SK525, taxi to holding 08
	07:37:19	-09:48.	AM	FO	Nothing happens...
	07:37:20	-09:47.	AM	FC	Nej, de är vid att spruta ...., de skall också spruta på undersidan,... där var cirka så mycket [showing at his thumbnail]......cirka 3 mm......
	07:37:50	-09:17.	AM	FO	Jag tog god tid på mej i morse för jag skulle fixa detta med flygbiljetterna till min fru. Jag sätter mej i bilen och kör..slippery.. normalt tar det 40 minuter, det tog mej en timme och tio minuter att komma hit
	07:38:00	-09:07.	RP	GND	SK525, contact Tower 118.5
	07:38:08	-08:59.	AM	FO	Så det var tur hon hade glömt biljetterna på sätt och vis....
	07:38:16	-08:51.	AM	FO	Det har snöat och frusit och sen har det töat så att det blir som såpa va
	07:38:45	-08:22.	RP		[Identification signals from SSA -ILS runway 01 and OHT - NDB runway 01, are heard in the background].
	07:39:26	-07:41.	RP	ATIS	Arlanda Information Quebec, time 07:20, ILS approach runway 01 in use, braking action first part 39, second part 39, third part 36 contamination 100% dry snow and ice one millimeters, departure runway 08 braking action first part 35 second part 32, third part 31 contamination 100% dry snow and ice one millimeters, braking action on taxiways medium, contamination 50% wet or water patches dry snow and ice, one millimeter, TL55, Met report 360/11 knots, wind variable between 330 and 030 degrees, visibility 8 km snow two octas 500 ft, six octas 800 ft temperature minus 0, dew point minus 0, QNH 1013 GRADU 6 octas 1000 ft information Quebec.[Listening for 1 min 45 sec]
	07:39:46	-07:21.	RP	GND	Swedline 208, pushback is approved
	07:41:06	-06:01.	AM	FC	Ska vi begära en pushback
	07:41:13	-05:54.	RP	FO	Ground, god morgon SK751 with Quebec now and request push from gate 2
	07:41:20	-05:47.	RP	GND	SK751 push is approved
	07:41:21	-05:46.	LP	Mek	Ja klar med avisning
	07:41:24	-05:43.	RP	FO	Push approved SK751
	07:41:25	-05:42.	LP	FC	Ja vi är klare till att pushe, brakes är off
	07:41:31	-05:36.	LP	Mek	Ja
	07:41:33	-05:34.	LP	FC	Och vad sprutet vi med
	07:41:36	-05:31.	LP	Mek	Ja, vänta lite.... nu kan ni starta flyget å gå
	07:41:42	-05:25.	LP	FC	Ja starter vi to og en då
	07:41:46	-05:21.	AM	FC	Pressure, starting right engine
	07:41:53	-05:14.	AM	FO	Ja..............Valve open............Oil pressure, N1

Transcript from SK 751 Cockpit Voice Recorder

Mkr	UTC	Rel rot	Tk	Src	Information
	07:42:00	-05:07.	LP	CA2	Good morning ladies and gentlemen, captain Rasmussen and his crew would like to welcome you aboard this Scandinavian Airlines flight bound for Copenhagen and then continuing to Warsaw. The flying time to Copenhagen is estimated to ...[recording interrupted by Captains communication with the mechanic. Can only be heard in L/P channel]
	07:42:12	-04:55.	LP	FC	Och de fick renset fint med under vingen?
	07:42:16	-04:51.	LP	Mek	Ja det var mycket is och snö, nu är det fint, det är perfekt du
	07:42:22	-04:45.	LP	FC	Det lyder bra nok, tack
	07:42:25	-04:42.	AM		[Noise from high-energy ignition system in background]
	07:42:25	-04:42.	AM	FC	Checked, timing, fuel on, flow..light up
	07:42:28	-04:39.	LP	CA2	God morgon, kapten Rasmussen och hans besättning hälsar er hjärtligt välkomna ombord på denna flygningen med SAS till Köpenhamn och sen vidare till Warsawa. Flygtiden till Köpenhamn är beräknad till cirka 50 minuter. Vi är strax klara för start så vi ber att kontrollera att... [recording interrupted by captains communication with the mechanic]... och till sist önskar vi er en trevlig flygresa.
	07:42:35	-04:32.	AM		[(Right) generator relay closes]
	07:42:36	-04:29.	AM	FC	Left engine
	07:42:36	-04:31.	AM	FO	Valve closed
	07:42:37	-04:30.	AM	FO	Left valve open
	07:42:41	-04:26.	LP	Mek	Ja brakes on
	07:42:43	-04:24.	LP	FC	Ja brakes er on
	07:42:45	-04:22.	AM	FO	Oil pressure, N1
	07:42:56	-04:11.	AM	FC	Timing [FC talk disguised by high radio volume]
	07:43:04	-04:03.	LP	FC	Ja det är bra uppe här så du må disconnecta, ha en trevlig dag och gott nytt år
	07:43:07	-03:58.	LP	Mek	Ja detsamma. Hejdå
	07:43:08	-03:59.	AM		[(Left) generator relay closes]
	07:43:09	-03:58.	LP	FC	Hejdå
	07:43:14	-03:53.	AM	FO	After start checklist?
	07:43:19	-03:48.	AM	FO	Air Conditioning, APU auto and set, Electrical power
	07:43:21	-03:46.	AM	FC	Ja det var checked left side
	07:43:25	-03:42.	AM	FO	Flight controls
	07:43:32	-03:35.	AM	FC	Checked
	07:43:34	-03:33.	AM	FO	Hydraulic pressures and pumps - set and checked
	07:43:36	-03:31.	LP		[Identification signals ARL - Arlanda VOR- and OHT - NDB runway 01 - are heard in the background during takeoff]
	07:43:37	-03:30.	AM	FO	Ice protection and fuel heat
	07:43:39	-03:28.	AM	FC	Vad var temperaturen
	07:43:40	-03:27.	AM	FO	Zero/zero.......du har även på...
	07:43:44	-03:23.	AM	FC	Ja, engine ice on [one click from switch is heard]
	07:43:48	-03:19.	AM	FO	Pneumatic levers - closed
	07:43:50	-03:17.	AM	FO	Annunciator panel and lights
	07:43:51	-03:16.	AM	FC	De var checked
	07:43:53	-03:14.	AM	FO	Cabin report
	07:43:54	-03:13.	AM	FC	Received
	07:43:55	-03:12.	AM	FO	Clear signal and lights
	07:43:56	-03:11.	AM	FC	Received and on
	07:43:57	-03:10.	AM	FO	Flaps and slats
	07:43:58	-03:09.	AM	FC	Eleven
	07:43:59	-03:08.	AM	FO	..??..[Sound from switch interrupting]
	07:44:01	-03:06.	AM	FC	Thank you
	07:44:02	-03:05.	RP	FO	SK751 request taxi
	07:44:07	-03:00.	RP	GND	751 taxi to holding 08
	07:44:09	-02:58.	AM		[FC and FO talking about taxiing with regard to a snow bank]
	07:44:10	-02:57.	RP	FO	Holding 08, SK751
	07:44:29	-02:38.	AM	FO	Flight instruments

Transcript from SK 751 Cockpit Voice Recorder

Mkr	UTC	Rel rot	Tk	Src	Information
	07:44:30	-02:37.	AM	FC	De är checked
	07:44:31	-02:36.	AM	FO	Four five
	07:44:32	-02:35.	AM	FC	Fourty five, checked
	07:44:34	-02:33.	AM	FO	Nav aids and flight guidance
	07:44:35	-02:32.	AM	FC	Ja de är set as briefed, takeoff, takeoff å Dunker four delta, turn at four miles
	07:44:47	-02:20.	AM	FO	Transponder -7304
	07:44:50	-02:17.	AM	FC	Checked
	07:44:52	-02:15.	AM	FO	Brake temperature, zero, checklist completed to one minute warning
	07:44:56	-02:11.	AM	FC	Thank you
	07:45:20	-01:47.	RP	GND	SK751 call tower one eighteen five, hejdå
	07:45:23	-01:44.	RP	FO	Eighteen five SK751, hejdå
	07:45:26	-01:41.	AM	FC	Ja , eighteen five
	07:45:29	-01:38.	RP	FO	Tower god morgon SK751, approaching holding point runway 08
	07:45:34	-01:33.	RP	TWR	Roger 751, you are cleared for takeoff from runway 08, when airborne contact 124.1
	07:45:39	-01:28.	AM		[Chime (seat belts switch off-on -cabin one minute warning) and noise from arming spoilers]
	07:45:41	-01:26.	RP	TWR	Cleared for takeoff runway 08 and 124.1 when airborne, SK751
	07:45:45	-01:22.	AM	FC	Cleared for takeoff airborne twentyfour one
	07:45:51	-01:16.	AM	FO	Ja,.. cabin
	07:45:53	-01:14.	AM	FC	De var warned
	07:45:54	-01:13.	AM	FO	Spoilers
	07:45:55	-01:12.	AM	FC	De var armed
	07:45:56	-01:11.	AM	FO	Autobrake - takeoff and armed, runway update performed, checklist completed
	07:45:57	-01:10.	RP	LF	Hejsan, Swedline 208
	07:46:00	-01:07	RP	TWR	Swedline 208, god morgon, behind the MD80 line up 08, when airborne contact 123.75
	07:46:07	-01:00	RP	LF	Will line up behind the MD, 123.75, Swedline 208
	07:46:20	-00:47	AM	FC	Are you ready
	07:46:23	-00:44	AM	FO	Yes any time
	07:46:38	-00:29	AM		[Squeaking from nosegear?]
T1	07:46:41	-00:26	AM	FC	Timing
	07:46:42	-00:25	AM	FO	Checked
	07:46:47	-00:20	AM	FC	Autothrottle on
	07:46:49	-00:18	AM	FO	Autothrottles on
	07:46:50	-00:17	AM	FC	Set power
	07:46:53	-00:14	AM	FO	Power set, instruments checked, clamp, V1 is 124 [A snapping sound is heard when the FO says "clamp". The sound probably originates from the cockpit (near the microphone)]
	07:46:58	-00:09	AM	FC	Checked
	07:47:02	-00:05	AM		[A snapping sound is heard again]
	07:47:05	-00:02	AM	FO	V1,
T2	07:47:06	-00:01	AM	FO	Rotate
R	07:47:07	00:00.			ROTATION = Zero Relative Time
E1	07:47:10	00:03.	AM		[A weak humming noise can be heard for a few seconds. According to FC he noticed this sound before gear retraction but could not identify it]
	07:47:11	00:04.	AM	FC	Gear up
C1	07:47:12	00:04.87	AM	FO	[Chime] - Gear up selected
E2	07:47:19	00:12.	AM		[A faint "rumbling" noise can be heard. This was also noted by the FC after gear up]
T3	07:47:26.54	00:19.54	RP	DEP	Swedline 780 reduce to (old) speed
	07:47:30	00:23.	RP	LF	Seven eight zero reducing
S1	07:47:31	00:23.8	AM		[•1 first engine surge]

Transcript from SK 751 Cockpit Voice Recorder

Mkr	UTC	Rel rot	Tk	Src	Information
	07:47:34	00:27.	LP		[Middle marker is heard for 16 sec]
	07:47:36	00:29.	AM	FO	..??..??
S2	07:47:38	00:30.88	AM		[•2 surge]
	07:47:39	00:31.6	AM		[Two "clicks" (from wing anti-ice switches)]
S3	07:47:41	00:34.05	AM		[•3 surge]
T4	07:47:42	00:35.	AM	FO	Tror det är.... kompressorstall ["Believe it is.... compressor stall"]
S4	07:47:44	00:36.56	AM		[•4 surge]
S5	07:47:46	00:38.86	AM		[•5 surge]
S6	07:47:47	00:40.42	AM		[•6 surge]
S7	07:47:49	00:41.62	AM		[•7 surge]
S8	07:47:50	00:42.45	AM		[•8 surge]
S9	07:47:52	00:45.	AM		[•9 surge]
	07:47:54	00:47.	AM	FO	(Va är ..??...till det här..??)
S10	07:47:55	00:47.83	AM		[•10 surge]
S11	07:47:57	00:50.31	AM		[•11 surge]
S12	07:47:59	00:52.25	AM		[•12 surge]
S13	07:48:02	00:54.54	AM		[•13 surge]
S14	07:48:03	00:56.21	AM		[•14 surge]
W1	07:48:05	00:57.95	AM		[Warbler+ Autopilot (autopilot disengage warning. This warning remains on for the rest of the flight, except when interrupted by other warnings]
S16	07:48:07	01:00.	AM		[•16 surge]. Surge no 16 starts here and is followed by several surges, partly disguised by the warnings
C2	07:48:13	01:05.65	AM		[3x chimes (cabin to cockpit call)]
	07:48:15.41	01:08.41	SI	CA2	.....Hallå............ [≈10 sec of heavy noise from engine stalls in background. Only heard in this channel. Final engine breakdown heard at UTC 07:48:20 + 3 to 4 sec]
	07:48:16.66	01:09.66	RP	DEP	Swedline 780 turn left heading heading 030, cleared for approach runway zero one.
	07:48:21.42	01:14.42	RP	LF	Left heading 030, cleared approach zero one, Swedline 780
C3	07:48:22	01:15.02	AM		[One more chime (cabin to cockpit call)]
S17	07:48:23	01:15.72	AM		[Last engine surge that can be heard]
	07:48:27	01:19.57	RP	DEP	Swedline 780
T5	07:48:29	01:21.88	AM	FC	Engine relight, engine relight!
6	07:48:32	01:25.3	AM	FO	Checked
W2	07:48:37	01:30.50	AM		[Fire bell (5 short interval high pitch tones)+Fire left engine]
7	07:48:40	01:33.21	AM	FO	Ska jag dra?
C4	07:48:41	01:33.98	AM		[One chime immediately after "ska jag dra"]
E3	07:48:42	01:35.08	AM		[Switch of CVR tape direction]
	07:48:44	01:37.	AM	FO?	(Svarar vänstermotorn?)
T6	07:48:44.63	01:37.63	RP	FO	Arlanda.... Stockholm SK 74...751
T7	07:48:51.21	01:44.21	RP	DEP	Ja godmorgon SK751, climb to FL180, no speed restriction.
T8	07:48:56.11	01:49.11	RP	FO	We have problems with our engines, please....[clicks from switches, talk and autopilot disconnect warning in the background]...we need to go back to,... to go back to Arlanda
8	07:49:02	01:54.78	AM	FC	(Har vi en) restart procedure?
E4	07:49:04	01:57.05	AM		["Click" (from switch)]
T9	07:49:05.81	01:58.81	RP	DEP	751, Roger, turn right heading 18... [power interrupts] ...turn righ...
C5	07:49:06	01:59.	AM		[Two double chimes (bing-bong, bing-bong). CA2 calling CA1]
T10	07:49:09	02:02.02	AM	FC2	Titta [power interrupt] fram
P1	07:49:09	02:02.21	AM		[Electrical power interrupt no1]
	07:49:10	02:03.	SI	CA1	Jaa
P2	07:49:10	02:03.37		AM	[Electrical power interrupt no 2]
P3	07:49:11	02:04.09		AM	[Electrical power interrupt no 3]
P4	07:49:12	02:04.74		AM	[Electrical power interrupt no 4]
P5	07:49:12	02:05.25		AM	[Electrical power interrupt no 5]
	07:49:12	02:05.	SI	CA	Ja

Transcript from SK 751 Cockpit Voice Recorder

Mkr	UTC	Rel rot	Tk	Src	Information
	07:49:12	02:05.	SI	CA2?	Ja
	07:49:13	02:05.67	AM	FC2	Titta rakt fram
	07:49:13	02:06.	SI	CA2	Det är en..Jag tror att det är en pilot som sitter här bak, han säger att höger motor stallar jag vet inte vad det betyder
9	07:49:13	02:06.40	AM	FC	Yes
P6	07:49:14	02:07.47		AM	[Electrical power interrupt no 6]
	07:49:17	02:10.	SI	CA1	Ja, höger motor stallar........[several power interrupts and chimes (due to interrupts) are heard. Microphone is "open" for about 17 seconds]
T11	07:49:18	02:10.64	AM	FC	(Prepare for emergency!)
T12	07:49:19	02:12.24	AM	FC2	Ja titta rak, titta rakt fram, titta rakt fram!
	07:49:22	02:14.75	AM	FC	Yes!
P7	07:49:24	02:17.06	AM		[One Power interrupt followed by stabilizer motion horn]
	07:49:27	02:19.58	AM	FC2	Titta rakt fram!
P8-16	07:49:27	02:19.96	AM		[≈9 more power interrupts during 7 seconds]
E5	07:49:30	02:23.35	AM		["Click" (from switch)]
T13	07:49:31.40	02:24.40	RP	DEP	SK751 are you able to turn right heading 090 radar vectoring for zero one...[several power interrupts]
P17	07:49:36	02:28.74	AM		[Last power interrupt that can be heard]
T14	07:49:36	02:29.33	AM	CA1	Höger motor stallar [heard in background]
T15	07:49:37.73	02:30.73	RP	FO	Roger..we are maintaining heading right now but we are trying to make a restart of the engines and make a slow turn to the left
	07:49:41	02:33.55	AM	FC	(Engine) restart checklist
T16	07:49:46.83	02:39.83	RP	DEP	Roger, you can maintain 2000 ft also.
	07:49:47	02:40.	SI		[Noise from high energy ignition. On for the rest of the flight]
	07:49:48	02:41.15	AM	FC2	Titta rakt fram, titta rakt fram!
	07:49:50	02:42.85	AM	FC	Yes
	07:49:50.82	02:43.82	RP	FO	We are not able to maintain 2000 ft, we are descending, we are now at 1600 descending
E6	07:49:55	02:47.65	AM		[Stabilizer motion horn]
T17	07:49:57	02:50.27	AM	FC	Prepare for an on ground emergency!
T18	07:50:02	02:55.37	AM	FC2	Ja titta rakt fram, titta rakt fram
	07:50:03	02:55.56	RP	LF	Swedline 780 established 01
	07:50:05	02:57.72	AM	FC	Checked
T19	07:50:06.90	02:59.90	RP	DEP	780 Tower 118.5
	07:50:10	03:02.95	RP	LF	118.5, hej
	07:50:10	03:03.43	AM	CA1	Sätt dig i cockpit! [Asks FC2 to sit down]
T20	07:50:12	03:04.78	AM	FC	Prepare for on ground emergency!
	07:50:13	03:06.26	AM	FC2	[Shouting] On ground emergency!!
	07:50:15	03:07.69	AM	FC	On ground emergency!
T21	07:50:16	03:09.11	AM	FC2	Titta rakt fr.., titta rakt fram!
T22	07:50:21.72	03:14.72	RP	DEP	Swedline 208, climb to Flight Level 190
	07:50:24	03:16.77	AM	FC2	Titta rakt fram
	07:50:24	03:17.47	AM	FC	Checked?
	07:50:25	03:17.71	RP	LF	Flight level 190, Swedline two three, correction 208.
	07:50:25	03:17.98	AM		[Horn + "landing gear"]
T23	07:50:28	03:20.54	AM	FC2	Titta rakt fram, ... ut
W3	07:50:30	03:23.24	AM		[Horn+landing gear (intermittently with auto pilot warning until end of flight)]
	07:50:31	03:24.29	LP	CA1	On ground emergency
	07:50:35	03:27.51	AM	FC	(Flaps eh eh)
T24	07:50:36	03:28.84	AM	FC2	Ja vi har flaps, vi har flap, titta rakt fram, titta rakt fram!
	07:50:39	03:31.78	AM	FC	Yes
	07:50:42	03:35.3	LP	CA1	Sätt dej ner
T25	07:50:43	03:35.78	AM	FC2	Du fly.., nej du flyger
	07:50:44	03:37.03	AM		[Sound from Switch?]
	07:50:44	03:37.17	AM	FC	Yes

Transcript from SK 751 Cockpit Voice Recorder

Mkr	UTC	Rel rot	Tk	Src	Information
T26	07:50:45	03:37.83	AM	FC2	Välj en plats, höger, höger, höger, höger, höger,.. höger, höger,.. styr höger, styr höger
	07:50:51	03:44.	LP	CA1	Keep your seat belts fastened
	07:50:51	03:44.36	AM	FC	..Checked..checked
	07:50:53	03:46.10	LP	CA1	Keep calm
	07:50:54	03:47.11	AM	FC2	Ja rakt fram där, rakt fram där, rakt fram (rakt mot skogen)
W4	07:50:55	03:48.42	AM		[Too low gear (from GPWS)]
	07:50:57	03:49.5	AM	FC2	Ja rakt mot skogen
	07:50:57	03:50.17	AM		[Too low gear]
	07:50:57	03:50.40	AM	FO	Ska vi ta ut hjulen.?
	07:50:58	03:51.	LP	CA1	Bend down, hold your knees..[chime]... ja
T27	07:50:58	03:51.25	AM	FC2	Ja gear down, gear down
W5	07:50:59	03:51.93	AM		[Whoop- whoop pull up (Continues for 11 seconds, and is then replaced by Sink rate)]
	07:50:59	03:52.05	AM		[Chime from gear down]
	07:51:01	03:53.8	AM	FC2?	(Nä gear down??)
	07:51:03	03:55.6	AM	FC2	Styr rakt fram
	07:51:04	03:57.42	AM	FC2	..??..?? [Could be; "Upp(ge plats), upp(ge plats)". Message ends rel time 04:01.92]
	07:51:05.00	03:58.0	RP	FO	Och Stockholm SK751, vi havererar i marken nu ["Havererar" UTC 07:51:06.88. "marken" UTC 07:51:07.45. Rel time 03:59.88 and 04:00.45 respectively]
E7	07:51:06	03:58.97	AM		[Stabilizer motion horn]
E8	07:51:10	04:02.83	AM		[Sink rate + 1 sec Stabilizer motion horn+Sink rate]
E9	07:51:12	04:04.58	AM		[3.40 seconds of sounds from crash]
	07:51:15	04:08.38	AM		[End of recording]

Christer Magnusson 930829

SAS

LINE MAINTENANCE

AVISNINGSINSTRUKTION

VINTERN 91/92

SVENSK UTGÅVA

STOTS-Q/LBG/NOV1991

GENERELLT

Begreppet avisning innefattar både "De-icing" och "Anti-icing".

Med "De-icing" avses avlägsnande av snö, is eller frost från flygplan.

Med "Anti-icing" avses skydd mot återfrysning.

Snö, is eller frost kan allvarligt påverka flygplanets stabilitet och kontroll.

Generellt gäller att hela flygplanet skall vara fritt från snö, is och frost före flygning.

Undantag:

- På flygplan med vingmonterade motorer tillåts ett tunt lager frost på flygplankroppens ovansida. Frostbeslaget får inte vara tjockare än att dekoren fortfarande kan skönjas.

- På vissa flygplan är det tillåtet med ett tunt lager is med en maximal tjocklek på 1,5 mm, eller ett tunt lager med frost med en maximal tjocklek på 3 mm på vingens undersida inom tankområdet om isen eller frosten bildats av kondensering av luftens fuktighet. Utanför tankområdet på vingens undersida tillåts ingen is eller frost.

Om flygplanet avisas i övrigt, skall is eller frost på vingens undersida också avisas.

Ansvarighet

Avsändande tekniker ansvarar för att korrekt och komplett avisning utförts. Om teknikern bedömer det som nödvändigt med ytterligare avisning utöver standardavisning skall detta framföras direkt till avisningspersonalen. Om den som utför avisningen bedömer det som nödvändigt med ytterligare avisning skall detta rapporteras direkt till den ansvarige teknikern.

Om besättningen begär avisning skall detta utföras. Om besättningen ej begär avisning men teknikern bedömer det som nödvändigt skall detta framföras direkt till besättningen och avisning utföras. Avisning får ej påbörjas innan klartecken givits från lastningen.

Besättningen måste alltid informeras innan avisningen påbörjas för att stänga av pneumatiken och luftkonditioneringen.

Kaptenen är ansvarig för avisningsskyddet under uttaxningen.

Kaptenen har det slutliga ansvaret för avisningen vid övertagandet av flygplanet.

Besättningen måste alltid informeras om vingarnas undersida är belagd med is eller frost som inte avisats.

AEA´s AVISNINGSKODER

AEA´s avisningskoder skall användas av markpersonalen när ett flygplan har avisats för att informera besättningen om vilken avisning som utförts.

Anti-Icing - AEA Type 1:

- Denna kod anger för besättningen att flygplanet sprutats med en Type 1 som skydd mot frysning (anti-icing), vilken uppfyller kraven enligt AEA. Tiden som vätskan beräknas skydda mot återfrysning (Hold-Over-Time) framgår av tabellen för AEA Type 1.

Anti-Icing - AEA Type 2/100:

- Denna kod anger för besättningen att flygplanet sprutats med en Type 2 vätska med en 100% glykolkoncentration som skydd mot frysning (anti-icing), vilken uppfyller kraven enligt AEA. Tiden som vätskan beräknas skydda mot frysning (Hold-Over-Time) framgår av tabellen för Type 2/100.

Anm. 1. Anti-icing vätska som ej uppfyller kraven för AEA´s Type 2 vätska skall alltid bedömas som Type 1 vätska.

Anm. 2. Nästkommande lägre anti-icing kod skall användas när den aktuella glykol/ vatten-blandningen avviker från den angivna i "Hold-Over-Time" tabellen.

Anm. 3. När AEA Type 2 används för anti-icing skall aktuell glykolkoncentration anges.

Anm. 4. Glykol/vatten koncentrationen anges alltid i volymprocent.

DEFINITION AV DE-/ANTI-ICING VÄTSKOR ENLIGT AEA´s SPECIFIKATION

AEA Type 1 (Lättflytande vätsketyp)
AEA Type 1 vätska kan användas både till de-icing och för anti-icing. Type 1 vätska skall påsprutas i hett tillstånd för att erhålla maximal effekt.

AEA Type 1 vätska används för anti-icing normalt endast vid uppehållsväder.

Typ 1 vätskan har låg vidhäftning till vingen och är dessutom utsatt för utspädning vid nederbörd varvid dess skydd mot återfrysning (Hold Over Time) är begränsat.

Som generell regel gäller att vid uppehållsväder skall flygplanet "vara i luften" inom 15 minuter efter det att Typ 1 vätskans påsprutats för anti-icing. I 15-minuters regeln har medtagits risk för nederbörd under uttaxning

Vid underkylt regn är återfrysningsskyddet för Typ 1 vätskan mindre än 3 minuter, varför den i praktiken är oanvändbar som anti-icing vid dessa tillfällen.

Type 1 vätskan är baserad på propylenglykol och vatten med ett blandningsförhållande som avpassats till rådande utetemperatur.

AEA Type 2 100/0 (Trögflytande vätsketyp)
AEA Type 2 anti-icing vätska ger skydd mot återfrysning även vid nederbörd.

AEA Type 2 vätskor är baserat på propylenglykol och dietylenglykol samt vatten med en tillsats av förtjockningsmedel. Förtjockningsmedlet ger Type 2 vätskan en tixotropisk konsistens vilket förhindrar att vätskan "rinner av" under markuppehållet och dessutom gör att Type 2 vätskan blir mindre påverkad av nederbörd (utspädd), varvid ett längre återfrysninsskydd (Hold Over Time) erhålles.

Vid start minskas Typ 2 vätskans trögflytande egenskaper av fartvinden och vid lättningsfart skall merparten av vätskan ha "blåsts av".

Typ 2 100 får därför ej användas på flygplan med en lägre lättningsfart än 85 knots.

Typ 2 används vid behov av förlängt återfrysningsskydd och alltid vid nederbörd.

Vid underkylt regn och vid clear-ice skall Typ 2 alltid användas för anti-icing.

DE-/ANTI-ICING TERMER

DE-ICING:
Med de-icing avses borttagande av snö, is eller frost från ett flygplan.

Borttagande av snö kan endera utföras mekaniskt med användande av en mjuk borste, med användande av hett vatten (85°C) eller med en blandning av hett vatten och glykol. De-icing vätskan skall påsprutas i upphettat tillstånd för att erhålla maximal effekt.

7° Regeln: De-icing vätskans frystemperatur får överstiga rådande utetemperatur med maximalt 7° C.

De-icing med endast hett vatten är begränsat till -3°C, utetemperatur.

Efter de-icing måste flygplanet alltid behandlas med anti-icing vätska.

ANTI-ICING
Med anti-icing avses att förhindra att snö, is eller frost bildas på flygplanet under uttaxning fram till take-off.

Frystemperaturen på vätskan som används för anti-icing måste vara minst 10°C lägre än aktuell utetemperatur. För anti-icing används endera glykol/ vatten vätska av AEA Typ 1 i ett blandningsförhållande som avpassats till rådande ute-temperatur enligt 10° regeln, eller glykolvätska av AEA Typ 2 med beteckningen 100/0.

Om ytterligare avisning erfordras efter det att anti-icing vätskan är pålagd, skall en komplett de-/anti-icing utföras.

10° Regeln: Anti-icing vätskans frystemperatur skall understiga rådande utetemperatur med minst 10° C.

Hold-Over-Time
Med Hold-Over-Time avses den beräknade tid som anti-icing vätskan förhindrar att snö, is eller frost bildas på avisade ytor på flygplanet.

Den beräknade Hold-Over-Time för AEA Type 1 och AEA Type 2/100 framgår av Hold-Over-Time tabellen.

Den beräknade Hold-Over-Time beror på vilken typ av vätska som använts för anti-icing, aktuell utetemperatur, rådande och förväntade väderleksförhållanden under mark-uppehållet fram till take-off.

Återfrysningsskyddet skall räknas ifrån det att anti-icing vätskan påsprutas som anti-icing skydd på det första stället.

OBS! Vid underkylt regn reduceras Hold-Over-Time kraftigt. Av det skälet skall Type 1 vätska ej användas för anti-icing vid underkylt regn.

DE/ANTI-ICING METODER

1 - Stegs Avisning:
Med "en-stegs-avisning" avses borttagande av snö, is eller frost och skydd mot återfrysning i ett och samma steg. Frystemperaturen på vätskan som används för en-stegs-avisning måste vara minst 10°C lägre än rådande utetemperatur.

2 - Stegs Avisning:
Med "två-stegs-avisning" avses:

Steg 1 – Borttagande av snö, is eller frost med användande av en mjuk borste, hett vatten eller en blandning av hett vatten och glykol. Frystemperaturen på de icing vätskan får inte överstiga rådande utetemperatur med mer än 7°C

Hett vatten får inte användas för de-icing vid en utetemperatur lägre än -3°C.

Steg 2 – Skydd mot återfrysning. Anti-icing vätskan som används i det andra steget skall bestå av en blandning av glykol och vatten eller 100% glykol, beroende på aktuell utetemperatur och rådande väderleksförhållanden.

Det andra steget, anti-icing, skall påbörjas inom 3 minuter från det att det första steget utförts. Om nödvändigt måste en komplett de-/anti-icing utföras område för område. Frystemperaturen på anti-icing vätska måste vara minst 10°C lägre än rådande utetemperatur.

1 - Stegs Anti-Icing
Med en-stegs-anti-icing avses att i ett steg påspruta AEA Type 2 anti-icing vätska på ett "rent" flygplan för att förhindra att snö, is eller frost bildas på flygplanet under markuppehållet fram till take-off.

Anm. Om 1-stegs anti-icing utförs innan besättningen har anlänt, skall Anti-icing form-3533 ifyllas och fastsättas på 2:e pilotens karthållare på höjdroderspaken.

TEMPERATURGRÄNSER

Hett Vatten:
Hett vatten får användas för de-icing ner till -3°C.

AEA Type 1:
Frystemperaturen för AEA Type I vätskan vid en-stegs-avisning och när den används i det andra steget som anti-icing vid två-stegs-avisning, måste vara minst 10°C lägre än aktuell utetemperatur.

Frystemperaturen på AEA Type I vätskan som används som de-icing i det första steget vid två-stegs-avisning får inte vara högre än 7°C över aktuell utetemperatur.

AEA Type 2:
AEA Type 2/100 (100%) har en nedre temperaturgräns på -25°C när den används för anti-icing.

OPERATIONELLA BEGRÄNSNINGAR

Take-Off Speed"
För att tillförsäkra att avisarvätskan "blåst av" före lättning är användande av AEA Type 2 vätska begränsad till flygplan med en minsta lättningsfart på 85 knots.

"Derated Take-Off":
För vissa flygplan får s. k. "derated take-off" ej användas om flygplanet avisats.

Utförd anti-icing skall rapporteras till besättningen med angivelse av använd vätska, Typ 1 eller Typ 2/100.

Frost eller is under vingarna som ej avisats skall rapporteras till besättningen.

AVISNINGSMETODER

Flygplanskroppen:
Avisarvätska får inte sprutas in i pitotrör, statiska intag eller direkt på stallvarningsgivare, temperaturgivare, kabinfönster eller cockpitrutorna.

Snö eller is på toppen av flygplanskroppen måste alltid avlägsnas före flygning.

Om flygplanskroppen är belagd med snö eller is måste detta avisas först. Om vingarna avisas före flygplanskroppen kommer anti-icing vätskan på vingarna att spädas ut, varmed återfrysningsskyddet går förlorat.

På flygplan med kroppsmonterade motorer tillåts ingen frost på flygplanskroppen.

På flygplan med vingmonterade motorer är ett tunt frostskikt tillåtet på kroppens ovansida. Frostbeslaget får inte var tjockare än att dekoren fortfarande kan skönjas.

När flygplanet uppvärms kommer frosten bitvis att smälta och rinna ner efter flygplans-kroppen. När den smälta frosten kommer i kontakt med kvarvarande frusen frost längs med spanten, återfryser det och bildar ett islager som kan sugas in i motorerna.

Snö, is eller frost på nospartiet framför cockpitrutorna och på cockpitrutorna måste avisas före flygning. Kvarvarande avisarvätska på nospartiet måste avlägsnas före flygning.

Typ 2 vätska skall aldrig användas för avisning av nospartiet eller flygplanskroppen.

Vingar och stabilisator.
Ett tunt lager is (max 1,5 mm) eller ett tunt lager frost (max 3 mm) på vingarnas undersida inom tankområdet är tillåtet om flygplanet inte avisas i övrigt och om isen eller frosten bildats på grund av kondensering av fuktigheten i luften.

Om flygplanet avisas i övrigt skall även is eller frost på vingarnas undersida avisas.

Om is eller frost på vingarnas undersida ej avisas skall besättningen informeras. All is eller frost utanför tankområdet på vingarnas undersida måste avisas före flygning.

Stabilisatorn och vingarna skall alltid erhålla samma avisningsbehandling.

Om vingarna är belagda med ett tjockt is- eller frost-lager erhålles den bästa effekten om en koncentrerad stråle riktas mot en punkt, intill isen eller frosten har smält och vingytan exponeras. När vingytan sedan uppvärms smälter isen underifrån och "släpper" från vingen och kan sedan "spolas" av i svepande rörelser. Observera att strålen inte får riktas direkt mot panelerna utanför tankarean. Dessa är utförda i kompositmaterial och kommer att skadas om de utsätts för ett för högt tryck eller en för hög temperatur.

AVISNINGSMETODER, forts.

Roder
Undvik att spruta avisarvätska direkt på linor, lager eller länkar för att förhindra att korrosionsskyddet och smörjmedlet "tvättas av". När så är möjligt, spruta framifrån och bakåt, från toppen och neråt och från vingspetsen och inåt.

Undvika att spola snö- eller is-slask in i utrymmet mellan roder och struktur.

Utspädning av glykol/vatten-blandningen med smält snö eller is kan resultera i en för tunn blandning vilken kan återfrysa och blockera roderfunktioner under flygningen.

När upphettat vatten används för de-icing måste anti-icing vätskan påsprutas omedelbart efter för att förhindra återfrysning i utrymmet mellan roder och struktur.

Om flygplanet är belagd med mycket snö och/eller is får rodren inte opereras från cockpit eller manuellt för hand innan snön och/eller isen avlägsnats.

Om snö, is eller slask inträngt i utrymmet mellan mellan roder och struktur måste detta avlägsnas innan hydraulsytemen trycksätts. Funktionskontroll av rodren måste alltid utföras av besättningen efter det att avisningen slutförts för att tillförsäkra fulla roderrörelser.

APU
APU´n får vara igång när avisningen utförs. För att förhindra att glykol tränger in i kabinen skall APU´ns luftavtappning och luftkonditioneringssystemen vara avslagna under avisningen.

Undvik att spruta avisningsvätska i närheten av, eller direkt in i APU´ns luftintag eller utblås.

Avisningspersonalen måste vara extra uppmärksam på säkerhetsområden omkring APU´ns luftintag och utblås om avisningen utförs när APU´n är igång.

AVISNINGSMETODER, forts.

Motorer

Motorerna får vara igång när avisningen utförs. För att förhindra att glykol tränger in i kabinen skall motorernas luftavtappning och luftkonditioneringssystemen vara avslagna under avisningen. Spruta aldrig avisningsvätska direkt in i motorernas luftintag eller utblås.

Avisningspersonalen måste vara extra uppmärksam på säkerhetsområden omkring motorernas luftintag och utblås om avisningen utförs när motorerna är igång.

Om flygplanet parkerats utomhus vid snöfall eller vid underkylt regn skall motorernas luftintag förses med skydd. Innan luftintagskydden installeras måste luftintagen checkas för för snö eller is. Om snö eller is har bildats i luftintaget skall det borttas så fort som möjligt efter det att motorerna stoppats och innan luftintagskydden installeras.

Efter det att motorerna stoppats kommer eventuellt snö eller is att smälta av restvärmen från motorn och därvid rinna ner till luftintagets lägsta punkt. När sedan motorn nedkyls, återfryser den smälta snön eller isen och låser fast de nedre fanbladen, vilket kan förorsaka allvarliga skador på motorn vid nästa motorstart.

Om motorn körts på tomgång vid underkyld väderlek bildas ett islager på baksidan av fanbladen. Innan motorstart skall motorernas luftintag checkas för snö eller is och fanbladens baksida för eventuell is. Checka motorn för frigång. Checka tryck- och temp-givare i luftintagen för eventuell isbildning.

Snö eller is i luftintagen och på fanbladen skall avlägsnas med hetluft. En blandning av UREA och vatten kan användas som skydd mot återfrysning ner till -10°C,utetemperatur.

Landningsställ

Landningsställen, hjulbrunnarna och landställsdörrarna, inkluderande switchar och mekanism skall checkas för is eller snöslask. Is eller snöslask på landningsställen skall avisas med upphettad AEA Type1 vätska.

Undvik att spruta avisarvätska direkt på lager, etc., för att förhindra "avtvättning" av smörjmedel.

Anm. Enbart vatten får aldrig användas för avisning av landningsställen.

SLUTKONTROLL EFTER AVISNING

Inspektion av avisningen
Vingarna och stabilisatorn skall vara fria från snö, is eller frost.
Undantag: Ett tunt lager is (max 1,5 mm) eller ett tunt lager frost (max 3 mm) är tillåtet på vingarnas undersida inom tankområdet om isen eller frosten bildats av kondensering.

Om flygplanet avisats i övrigt skall is eller frost på vingens undersida också avisas.

Vid snöfall, snöblåst eller underkylt regn kan snö eller smält is tränga in i utrymmet mellan rodren och strukturen och där återfrysa. Speciell uppmärksamhet skall därför ägnas åt nämnda områden när ovanstående väderförhållande existerar.

Detsamma gäller för landningsställen, hjulbrunnarna, landställsmekanism, switchar och låsmekanism samt ramluftintag.

Om clear-ice konstateras på vingarnas ovansida skall en förnyad , fysisk inspektion utföras efter det att avisning utförts för att konstatera att all is avlägsnats.

Flygplankroppen framför cockpitrutorna måste vara fri från snö, is och frost. Rester av avisningsvätska på cockpitrutorna måste rengöras före flygning.

Generellt gäller att hela flygplankroppen skall vara fri från snö, is och frost.
Undantag: På flygplan med vingmonterade motorer tillåts ett tunt lager frost på flygplankroppens ovansida under förutsättning att dekoren kan skönjas.

APU´ns luftintag och utblås, luftintag för luftkonditioneringen, etc., samt omkringliggande områden skall vara fritt från snö, is och frost.

Funktionskontroll av roderfunktioner
En funktionskontroll av roderfunktionerna måste alltid utföras av besättningen efter det att avisningen är slutförd.

Check av motorluftintag och givare
Vid kraftig snöfall eller underkylt regn och stark vind måste motorernas luftintag och givare checkas för eventuell snö eller is innan motorstart.

Vid underkylt väder måste fanbladens baksida checkas för eventuell isbeslag innan motorstart. Underkylt väder råder när daggpunkten understiger aktuell utetemperatur.

Het luft skall användas för att smälta eventuell snö eller is i motorernas luftintag. En blandning av UREA och vatten kan användas ner till -10°C för att förhindra att is återbildas på fanbladen under motorkörning på marken.

CLEAR-ICE

Clear-Ice (DC9/MD80):
Clear-ice bildas på vingarnas ovansida i närheten av vingroten när vingarna blivit nedkylda av bränslet under en längre flygning i kombination med förhöjd utetemperatur och hög luftfuktighet efter landning, eller om flygplanet parkerats utomhus i minusgrader under natten och utetemperaturen och luftfuktigheten sedan stiger på morgonen.

Clear-ice på vingarnas ovansida har upptäckts vid temperaturer över +15°C.

Varning! Snö eller snöslask kan dölja clear-ice.

Betecknande för clear-ice är att den är helt genomskinlig och i vissa fall mycket svår att upptäcka. Fysisk handkontakt med vingens ovansida och knackning med baksidan på en mejsel är de enda pålitliga metoderna för att upptäcka clear-ice.

Frostbeslag under vingarna är en indikation på eventuell clear-ice på vingens ovansida.

Om vingarnas undersida är fria från frost är detta dock ingen garanti för att clear-ice inte finns på vingarnas ovansida.

Fyra varningsskyltar med texten ”ICE” och tillhörande snoddar, vilka är monterade på vingarnas ovansida, är avsedda som en påminnelse för check av clear-ice för den som utför ”departure check” och som en indikation på att vingarna är belagd med clear-ice om en snodd frusit fast.

En lös snodd är dock ingen garanti på att vingen i sin helhet är fri från clear-ice.

Efter utförd de-icing av clear-ice skall förnyad check av vingens ovansida utföras samt efterföljas av anti-icing med Typ 2 vätska.

Om de yttre omständigheterna ger anledning till misstanke om clear-ice måste bägge vingarnas ovansida inspekteras, även om den först inspekterade vingen är fri från clear-ice. Det har tidigare rapporterats att clear-ice upptäckts på den ena vingen samtidigt som den andra vingen varit ”helt ren”. Anledningen har vara att solen smält isen på den ”rena” vingen under intaxningen och under markuppehållet.

Bilaga gällande information om SAS avisning på Arlanda flygplats vintern 91/92

Allmänt

Denna information gäller SAS och främmande flygbolag med vilka SAS har tecknat handlingsavtal.

Information innefattar ej avisning som utföres vid SAS inrikes terminal, Pir D, eller avisning av Linjeflygs flygplan eller andra flygbolags flygplan med vilka SAS ej tecknat handlingsavtal.

SAS anlitar Nordic Aero för att utföra avisningen under tiden från och med den 1 oktober 1991 till och med den 30 april 1992. Under övrig tid utföres avisningen av SAS egen personal.

SAS svarar för underhåll av avisningsfordon och installationer.

Nordic Aero svarar för daglig tillsyn av avisarfordonen och utför leveranskontroll av avisarvätskor.

Nordic Aero anställer och ansvarar för avisningspersonalen och SAS utarbetar metodinstruktioner.

STOTS-Q/LBG/NOV1991

AVISNINGSFORDON ELEPHANT

Elephant: ELEPHANT avisarbilar är försedda med separata tankar för vatten och för Typ 1 vätskan, samt en tank för Typ 2 vätska. Hett vatten (85° C) kan användas för de-icing ner till –3°C. Ett automatiskt blandningssystem för Typ 1 vätskan ger korrekt glykolkoncentration i förhållande till rådande utetemperatur baserat på 10° regeln för anti-icing ner till –25°C.

Typ 2 vätskan har beteckningen 100/0 där de första siffrorna anger glykol-koncentrationen, d v s vätskan är av 100% koncentration. Typ 2 vätska 100/0 får endast användas för anti-icing ner till –25° C. För att Typ 2 vätskans tjockflytande egenskaper ej skall förstöras är avisarfordonet utrustad med en membranpump för Typ 2 vätskan.

AVISNING MED ELEPHANT.

VID UPPEHÅLLSVÄDER

1-Stegs avisning med Typ 1. (Vid snö–, frost– eller isbelagda vingar)
Typ 1 påsprutas i ett steg för att avlägsna snö, is eller frost (de-icing) och som skydd för återfrysning (anti-icing). Typ 1 vätskans glykolkoncentration i ELEPHANT avisarbil med automatiskt blandningssystem är baserad på aktuell utetemperatur enligt 10° regeln.

1-Stegs avisning med Typ 2. (Vid rena vingar).
Typ 2 100/0 påsprutas i ett steg som skydd mot frysning.
Typ 2 med beteckningen 100/0 får användas för anti-icing ner till –25° C.

VID NEDERBÖRD

2-Stegs avisning med Typ 1 och Typ 2.
Typ 1 påsprutas för att avlägsna snö, is eller frost (de-icing). Typ 2 påsprutas efteråt som skydd mot återfrysning (anti-icing).

2-stegs Avisning med Hett Vatten. (Vid en större mängd snö, is eller frost)
Hett vatten får användas ner till –3° C för att spola av stora snömängder eller "smälta ner" kraftiga isbeslag eller frostbeslag för att därmed vinna tid och spara glykol. Vid användande av hett vatten skall anti-icing vätskan anbringas inom 3 minuter efter det att de-icing med hett vatten *påbörjats,* för att förhindra återfrysning i "gömda" utrymmen. Detta medför att varje område, respektive vinge och stabilisator, måste avslutas med anbringande av anti-icing vätska innan nästa område påbörjas.
Vid nederbörd skall Typ 2 alltid användas för anti-icing.

AVISNINGSFORDON TRUMP

Trump: TRUMP avisarbilar är försedda med en uppvärmd tank för Typ 1 vätska och en tank för förvärmd Typ 2 vätska.

Typ 1 vätskan har ett fast blandningsförhållande med beteckningen 40/60, där de första siffrorna anger glykolkoncentrationen. Typ 1 vätska med beteckningen 40/60 har en frystemperatur på –21° C och får användas för anti-icing ner till –11° C enligt 10° regeln och för de-icing ner till –25° C enligt 7° regeln.

Typ 2 vätskan har beteckningen 100/0 där de första siffrorna anger glykolkoncentrationen, d v s vätskan är av 100% koncentration. Typ 2 vätska 100/0 får endast användas för anti-icing ner till –25° C. För att Typ 2 vätskans tjockflytande egenskaper ej skall förstöras är avisarfordonet utrustad med en membranpump för Typ 2 vätskan.

AVISNING MED TRUMP.

VID UPPEHÅLLSVÄDER

1-Stegs avisning med Typ 1 (Vid snö–, frost– eller isbelagda vingar)
Typ 1 påsprutas i ett steg för att avlägsna snö, is eller frost (de-icing)
och som skydd för återfrysning (anti-icing). Typ 1 vätskan i TRUMP avisarbil
har ett fast blandnings-förhållande på 40/60 med en frystemperatur på –21° C.
Får användas för anti-icing ner till –11° C enligt 10° regeln.

1-Stegs avisning med Typ 2 100/0. (Vid rena vingar).
Typ 2 påsprutas i ett steg som skydd mot frysning.
Typ 2 vätskan med beteckningen 100/0 får användas för anti-icing ner till –25° C.

VID NEDERBÖRD

2-Stegs avisning med Typ 1 och Typ 2.
Typ 1 påsprutas för att avlägsna snö, is eller frost (de-icing).
Typ 2 påsprutas efteråt som skydd mot återfrysning (anti-icing).

RUTINER FÖR BESTÄLLNING AV AVISNING

Beställning av avisning görs endera av "Red-Cap" eller av teknikern när bekräftelse på aktuell avgångstid erhållits. Om uppgift om aktuell avgångstid dröjer skall beställning av avisning göras om möjligt minst 10 minuter före beräknad avgångstid. Om avgångstiden ändras måste detta omedelbart meddelas till Nordic Aero´s avisningskoordinator. Detta för att avisarfordonen skall kunna nyttjas maximalt och därmed förhindra förseningar på grund av sen avisning.

Direktbeställning av avisning till Nordic Aero´s avisarkoordinator.
Radio......SK-ICE 1
Telefon....3767
Snabb.....5492

Beställning av avisning genom SAS
Radio......SK-TS-W
Telefon....3201

Vid beställning anges följande:

1. Linjenummer. Alt uppges flygplanets registrering när detta används som linjenummer.
2. Ordinarie avgångstid.
3. Eventuell försening och beräknad ny avgångstid.
4. Eventuell "slot-tid".
5. Gate nummer eller platsnummer.
6. Om annat än standardavisning önskas.
   Ex: vingklaffarnas undersida, flygplanskroppen eller clear-ice.
   Standardavisning: Vingarna och stabilisatorn.

SAS LINE MAINTENANCE – ARLANDA – STOTS

Ute Temp	AVISNINGSINSTRUKTION – ELEPHANT	STOTS-Q Okt 1991
Ner till	**1 – STEGS AVISNING – Vid uppehållsväder** **STEG 1: Typ 1* vätska påsprutas för de-icing och anti-icing.** ***Vid risk för nederbörd skall Typ 2 alltid påsprutas efteråt för anti-icing.***	
	2 – STEGS AVISNING – Vid nederbörd **Steg 1: Typ 1* vätska påsprutas för att avlägsna snö, is eller frost.** **Steg 2: Typ 2** Anti-Icing vätska påsprutas efteråt som skydd mot återfrysning.**	
-25°C	**1 – STEGS AVISNING – Vid rena vingar** **Steg 1: Typ 2** vätska påsprutas som skydd mot återfrysning.**	
Ner till -3°C	**2 – STEGS AVISNING MED HETT VATTEN** **När en större mängd snö, is eller frost skall avlägsnas** **Steg 1: Hett vatten*** påsprutas för att avlägsna snö, is eller frost.** **Steg 2: Typ 1* eller Typ 2** vätska påsprutas <u>*omedelbart*</u> efter som skydd mot återfrysning.** ***Vid risk för nederbörd skall Typ 2 alltid påsprutas för anti-icing.***	
Ner till -17°C	**MARKSLANG Typ 1 50/50: För att avlägsna snö, is eller frost från landningsställ, vingarnas undersida och vingklaffarnas undersida.** ***VARNING! Enbart vatten får aldrig användas för de-icing av landningsställ.***	

*** Typ 1 vätskan består av propylenglykol och vatten med en frystemperatur på 10°C lägre än rådande yttertemperatur. Får användas för de-icing och anti-icing ner till -25°C.**

**** Typ 2 vätskan består av propylenglykol och dietylenglykol i 100% koncentration, 100/0. Får användas för anti-icing ner till -25°C.**

***** Med "hett vatten" avses en vattentemperaturen på 85 - 90°C.**

Utförd anti-icing skall rapporteras till besättningen med angivelse av Typ 1 eller Typ 2 100.
Frost under vingarna som ej avisats skall rapporteras till besättningen.
Om flygplanet avisas i övrigt skall vingarnas undersida också avisas.
Tillse att utrymmet mellan roder och struktur är fritt från snö och is.

Checka för clear-ice på vingarnas översida.
Clear-ice uppkommer vid hög luftfuktighet i kombination med starkt nedkylda vingar.
Clear-ice kan förekomma vid temperaturer upp till +15 °C.
Om vingarna är belagda med clear–ice skall de-icing utföras med Typ 1 och anti-icing med Typ 2.
Efter de-icing av clear-ice skall en förnyad check utföras.
Typ 2 skall alltid användas för anti-icing om clear-ice har konstaterats.

SAS LINE MAINTENANCE - ARLANDA - STOTS

Ute Temp	AVISNINGSINSTRUKTION - TRUMP	STOTS-Q Okt 1991
Ner till | -11°C	**1 - STEGS AVISNING - Vid uppehållsväder** Steg 1: Typ 1* vätska påsprutas för de-icing och anti-icing. *Vid risk för nederbörd skall Typ 2 alltid påsprutas efteråt för anti-icing*	
-11°C | -25°C	**2 - STEGS AVISNING** Steg 1: Typ 1* vätska påsprutas för att avlägsna snö, is eller frost. Steg 2: Typ 2** Anti-Icing vätska påsprutas efteråt som skydd mot återfrysning.	
Ner till -25°C	**1 - STEGS AVISNING (Vid Rena Vingar)** Steg 1: Typ 2** vätska påsprutas som skydd mot frysning.	
Ner till | -11°C	MARKSLANG Typ 1*: För att avlägsna snö, is eller frost från landningsställ, vingarnas undersida och vingklaffarnas undersida.	

*** Typ 1 vätskan består av propylenglykol och vatten i proportionerna 40/60 med en frystemperatur på -21°C. Får användas för de-icing ner till -25°C och för anti-icing ner till -11°C.**

**** Typ 2 vätskan består av propylenglykol och dietylenglykol i 100% koncentration, 100/0. Får användas för anti-icing ner till -25°C.**

Utförd anti-icing skall rapporteras till besättningen med angivelse av Typ 1 eller Typ 2 100.
Frost under vingarna som ej avisats skall rapporteras till besättningen.
Om flygplanet avisas i övrigt skall också vingarnas undersida avisas.
Tillse att utrymmet mellan roder och struktur är fritt från snö och is.

Checka för clear-ice på vingarnas översida.
Clear-ice uppkommer vid hög luftfuktighet i kombination med starkt nedkylda vingar.
Clear-ice kan förekomma vid temperaturer upp till +15 °C.
Om vingarna är belagda med clear-ice skall de-icing utföras med Typ 1 och anti-icing med Typ 2.
Efter de-icing av clear-ice skall en förnyad check utföras.
Typ 2 måste alltid användas för anti-icing om clear-ice har konstaterats.

SAS *LINE MAINTENANCE – ARLANDA – STOTS*

Ambient temperature C	Weather Conditions					Hold Over Time Guide Line	
	Frost or Rim	Freezing Fog	Steady Snow	Rain on Cold Wings	Freezing Rain	AEA Type 1	AEA Type 2 100/0
+0 and above	*					45 min	12 hours
		*				30 min	3 hours
			*	*		15 min	1 hour
					*	5 min	20 min
–0 to –7	*					45 min	8 hours
		*				15 min	1 1/2 hour
			*			15 min	45 min
					*	3 min	20 min
–7 to –25	*					30 min	8 hours
		*				15 min	1 1/2 hour
			*			15 min	45 min

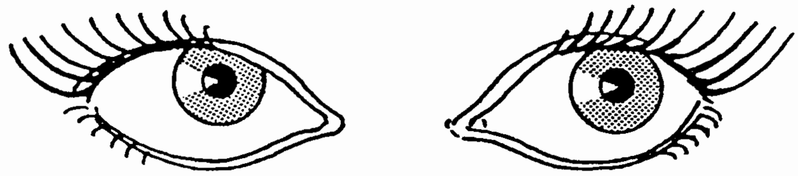
CAUTION! **The time of protection will be shortened in heavy weather conditions. Jet blast and high wind velocity may cause degradation of the protection film. A visual check of the wings before take-off is recommended as a back-up in these cases.**

The upper wing surface at the "cold corner" on the MD80 must be checked by hand-touch for clear-ice. Clear-ice can be suspected at temperatures up to 15° C at high humidity when the wings has been cold soaked by super-cooled fuel after a long flight, or if the airplane has been parked outside in freezing temperature during a night stop.

After de-icing the "cold corner" must be re-checked by hand-touch before Type 2 anti-icing fluid is applied.

NOTE: The given Hold Over Time guide-lines for AEA Type 1 fluids when used for anti-icing are valid when the freezing point of the fluid is at least 10° C below OAT. In freezing rain precipitation, Typ 1 fluid must not be used as anti-icing due to the extremely short Hold Over Time.

”CLEAR-ICE”.



Clear-ice på vingarnas översida uppmärksammades i samband med introduktionen av MD80, även om fenomenet tidigare förmodligen varit orsak till ett flertal oidentifierade ”Foreign Object Damage” på DC9 ”Classic” och DC9-51.

Att ”clear-ice” på senare år blivit uppmärksammat i så hög grad är orsakat av de allvarliga följder det medför, samt att det vid flera tillfällen uppmärksammats före take-off. Tidigare kunde man ibland bara ana sig till orsaken till FOD, nu vet vi.

De varningsskyltar med tillhörande snodd som är monterade på vingarnas ovansida är avsedda som indikatorer på att vingen är belagd med ”clear–Ice” om snodden frusit fast. En lös snodd är däremot ingen garanti på att vingen i sin helhet är fri från ”clear-ice”.

Frostbeslag under vingarna är också en indikation på eventuell ”clear-ice” på vingens ovansida. Frånvaron av frostbeslag på vingens undersida är däremot ingen garanti för att ”clear-ice” inte finns.

Vad är nu orsaken till att ”clear-ice” bildas och varför är det mer påtagligt just på MD80.

Faktorer som påverkar uppkomsten av ”clear-ice” är hög luftfuktighet eller regn i kombination med starkt nedkylda vingar efter långa flygningar eller vid övernattningar vid låga utetemperaturer.

Vid långa flygningar då mycket bränsle är upptankat i centertanken, och på MD80 rymmer centertanken närmare tio ton bränsle, kommer bränslet i vingtankarna att förbrukas under den senare delen av flygningen och därmed nedkylas kraftigt. Om sedan luftfuktigheten på landningsplatsen är hög eller att det regnar bildas ett genomskinligt islager på vingarnas ovansida.

Vingens V-form i kombination med välvningen åstadkommer att bränslenivån i vingtankarna kommer att vara som högst vid vingtankens skiljevägg till centertanken. På MD80 är den placerad ca 1,5 meter ut på vingen, vilket är i direkt linje med motorerna. Det har konstaterats att även om bränslenivån inte når upp till tankens ovansida så ”transporteras” kylan från bränslet upp till vingens ovansida via skiljeväggen mellan vingtanken och centertanken och via vingtankens bakre livplåt, det område som man kallar för ”cold-corner”.

"CLEAR-ICE", forts.

Utrymmet ovanför bränslenivån i vingtanken utgör förvisso en "isolering" för nedkylning av vingens ovansida och tillåter en snabbare uppvärmning av vingen. Så en liten mängd bränsle i vingtanken och följaktligen en större volym luft minskar risken för "clear-ice".

Det har dock kunnat konstaterats, att för att luften ovanför bränslet skall kunna ge tillräcklig "isolering", så får bränslenivån i vingtanken inte överstiga ca 1 000 kg. Och inte ens en så låg bränslenivå är en 100% garanti mot "clear-ice". Om en mindre mängd bränsle är "super"-nedkylt, så kommer ändock vingens ovansida vid "cold corner" att bli nedkyld genom "köldtransporten" via skiljeväggarna tanken.

Metoden att fylla på "varmt" bränsle för att stoppar "köldtransporten" från det nedkylda bränslet till vingens ovansida via tankväggarna under kortare markuppehåll ger inte heller någon garanti. Dels därför att vi under vintersäsongen inte har bränsle i tankningsanläggningen som kan betecknas som "varm", även om den är på plussidan, och dels därför att det "varma" bränslet inte förmår att att blanda sig med det nedkylda bränslet utan omrörning, och dels därför att att det "varma" bränslet påtankas utanför skvalpskotten, vilket förhindrar att det blandar sig med det nedkylda bränslet i vingroten. Så påtankning av "varmt" bränsle hjälper kanske för en del av vingen, men inte nödvändigtvis där det är som mest kritiskt, vid "cold corner".

För att "clear-ice" skall bildas erfordras också vatten, endera i form av öppet regn eller bundet till varm luft vid hög luftfuktighet. Varm luft kan innehålla högre luftfuktighet än kall luft. Detta medför att varm, fuktigt luft, "fäller ut" vattnet vid kontakt med en nedkyld vinge, varvid "clear-ice" bildas. Vilket kan inträffa vid så höga utetemperaturer som upp till +15´C. "Clear-ice" på MD80 har konstaterats på platser som Las Vegas och Palm Springs och vid temperaturer då man inte väntar sig att finna is på vingarna på ett flygplan och då tanken på "clear-ice" är som mest avlägsen.

Sammanfattning.

Som synes så är det en mängd faktorer som kan påverka bildandet av "clear-ice" och någon enkel och rak linje går inte att följa. Några saker bör dock få "klockan att ringa".

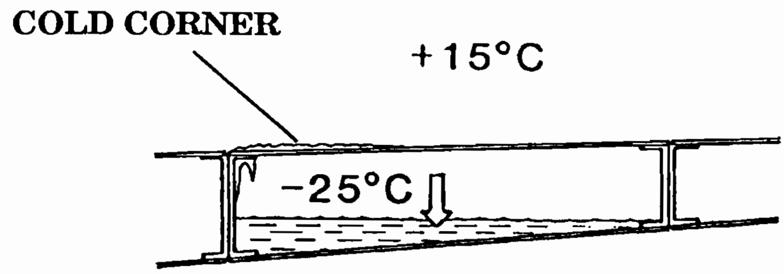
Som långa flygningar i kombination med plusgrader och hög luftfuktighet eller regn på landningsplatsen, eller övernattningar utomhus i stark kyla i kombination med plusgrader och hög luftfuktighet eller regn på morgonen.

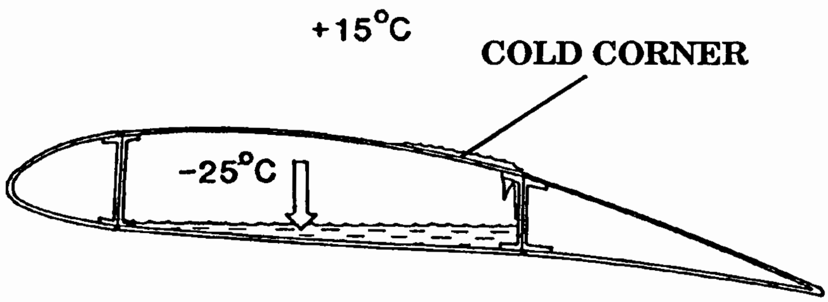
Frost under vingarna är en indikation på möjlig "clear-ice" på vingarnas ovansida.
Frånvaron av frost är dock ingen garanti på att "clear-ice" inte finns.

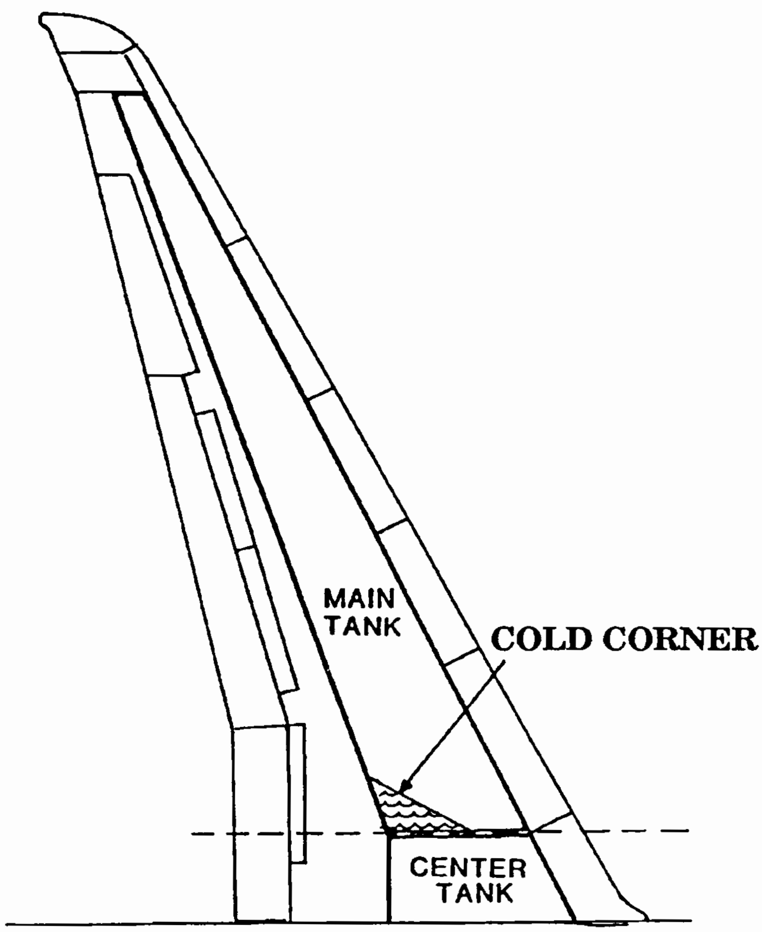
En fastfrusen snodd är en klar indikation på "clear-ice".
Lösa snoddar är dock ingen garanti för att "clear-ice" inte finns.

Idag och förmodligen också under de närmaste åren, finns det ingen säkrare metod att upptäcka "clear-ice" än genom fysisk kontakt med "handpåläggning".

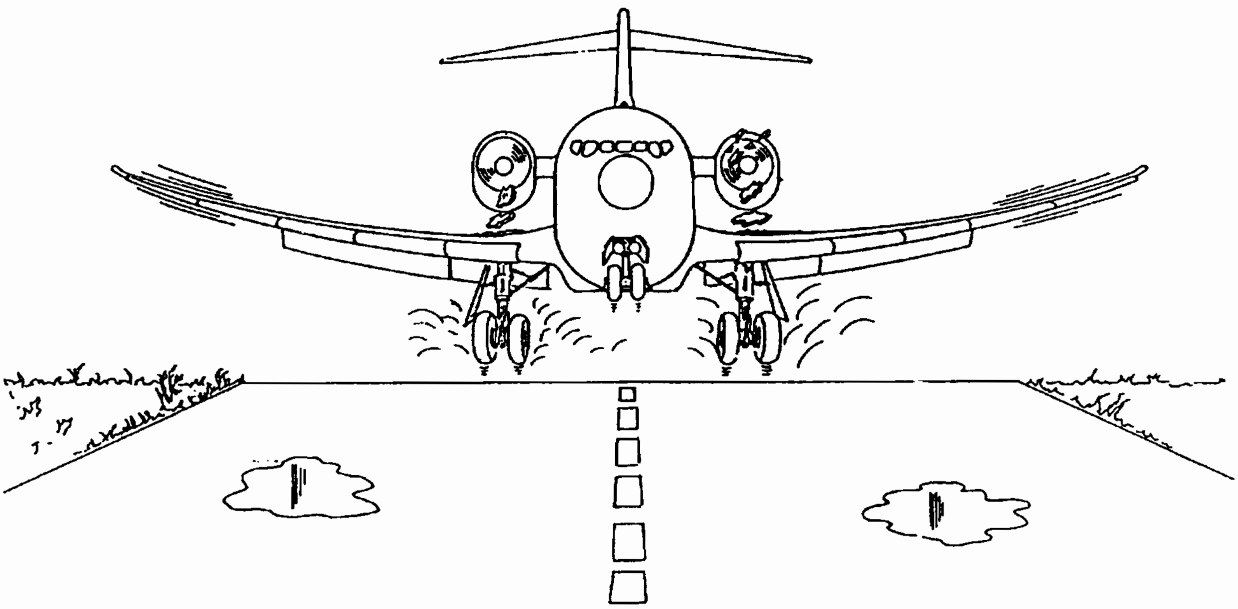
"CLEAR-ICE".


COLD CORNER
+15°C
-25°C


+15°C
COLD CORNER
-25°C


MAIN TANK
COLD CORNER
CENTER TANK

"CLEAR-ICE".



WHEN THE AIRCRAFT ROTATES, THE ICE WILL BREAK LOOSE DUE TO THE NATURAL FLEXING OF THE WINGS, AND WILL BE SUCKED INTO THE ENGINES AT THE MOST CRITICAL PHASE OF THE FLIGHT!

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National Transportation Safety Board
Washington, D.C. 20594

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380.

9 September 1993

Mr. Henrik Elinder
Chief Technical Investigator
Statens Haverikommission
Vasterbroplan
P.O. Box 12538
S-102 29 Stockholm
Sweden

Re: Accident involving SAS flight SK-751, OY-KHO

Dear Mr. Elinder;

The U.S. team sincerely appreciates the opportunity and privilege to assist in the investigation and to comment on this very comprehensive report. Enclosed are all of the comments that I have received on the draft report. As you will see, most of the comments are editorial in nature and probably have been corrected by your staff. I believe that some of the editorial comments are because of the inherent problems in translating from one language to another.

Douglas Aircraft Company (DAC) provided substantive comments to the report. I believe that most of DAC's comments are worthy of consideration and would expand upon the factual information in the report. I agree that the analysis section should include that the flightcrew did not properly use the SAS EMERGENCY/MALFUNCTION CHECKLIST. Considering the rapidity of the events, it may have been that they were overwhelmed and forgot the checklist, However, if they had used the checklist, the ATR system would have been deactivated and thereby reduced the damage to the engines.

I was surprised that report states that the flightcrew was not trained to identify and eliminate engine surges as this information is contained in the pilots operating manual. The CVR transcript clearly indicates that the first officer recognized that an engine was surging. Additionally, two non-revenue SAS pilots in the passenger cabin immediately identified the engines as surging. Therefore, it would appear that SAS had trained its pilots to recognize engine surges. Additionally, as the throttle lever was initially reduced in an apparent attempt to clear the surge, it would appear that the pilots had been trained in engine surge recovery techniques.

It would appear, from the documentation supplied to SAS when it purchased the MD-80 series airplanes, that the function of the ATR system was contained in the maintenance manual and the pilots operating handbook. Therefore, it would seem that SAS should have been aware of ATR system and its function. Additionally, the pilots operating manual contains information on flap settings and speeds for emergency conditions, which includes two engine out. It may be possible that SAS's translation of the manuals did not contain this information.

I disagree with DAC's comments regarding the overhead bins. The bins failed in areas where passengers received no injuries and the fuselage maintained its shape. I agree that tests show that the bins comply with the static load requirements. However, this accident is a clear indication that the dynamic loads in an accident are not correctly simulated by the required static load tests. Therefore, the Safety Board has recommended that the certification criteria be modified to require dynamic tests of overhead bins. I believe that fuselage bending should be anticipated in a survivable accident and the interior furnishings designed to accommodate such an event. In that many people had no injuries, including one person who was not properly seated and restrained at the time of impact, it would appear that in many areas of the fuselage the impact forces were below the design limits.

I agree with your report that the placement of the jump seat in the aft cabin could impede the evacuation of the airplane as the seat could block the aisle for those in the rear of the airplane.

Regarding the conclusions, I find no support for conclusions 9, 11, 17, or 23. These issues have been address above. Regarding the probable cause, I believe that there is sufficient information to state that the flightcrew's actions were contributory to the accident. There is adequate factual information to state that the flightcrew recognized that an engine was surging. Additionally, it is well known in the jet transport community, and most likely at SAS, that the classic, and appropriate response, to a surging engine is to manually reduce the power lever to clear the surge. As the flightcrew did not take such necessary action they contributed to the severity of the engine damage possibly to the extent that the engines failed. There is no doubt that the flightcrew did an outstanding job in landing the airplane once it lost all power. However, the flightcrew's response to the engine surges was not appropriate and contributed to the accident.

I regret the delay in getting these comments to you. Once again, I appreciate the opportunity to review the draft report. It is obvious that you have done considerable research and examination of the data. Please let me know if the Safety Board can be of further assistance.

Best Regards

Thomas E. Haueter
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