
Severe icing, Serious incident occurring January 28, 2000 near Berlin-Tegel, involving an Aerospatiale-Alenia ATR 42-300.

Micro-summary: This ATR 42-300 entered an area of extreme icing.

Event Date: 2000-01-28 at 1547 CET

Investigative Body: Federal Bureau of Aircraft Accidents Investigation (BFU), Germany

Investigative Body's Web Site: <http://www.bfu-web.de/>

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Investigation Report

EX001-0/00
October 2002

Factual Information

Type of occurrence: serious incident
Date: 28. January 2000
Location: near Berlin-Tegel
Aircraft: Transport category aeroplane
Manufacturer/Model: Aerospatiale - Alenia / ATR 42-300
Injuries to Persons: no injuries
Damage: aeroplane not damaged
Other Damage: none

History of the flight

The aeroplane had departed at 15:47 hrs ¹from Berlin-Tegel for a scheduled flight to Bremen under instrument flight rules (IFR). 3 crew members and 42 passengers were aboard the aeroplane.

The pilot-in-command (PIC) was the pilot flying (PF). The aeroplane was flown manually. During the initial climb to the cleared flight level (FL) 130 the aeroplane entered instrument meteorological conditions (IMC) in appr. 3000 ft. Shortly afterwards the aeroplane ice evidence probe indicated icing.

The anti-icing equipment as well as the airframe de-icing equipment were switched on and were functioning normally.

The crew had preselected the climb out speed to

¹ Unless otherwise specified all times are indicated in Central European Time (CET).

160 kt and the rate of climb was 800 to 1000 ft/min.

Later on, after the icing of the aeroplane had been determined, the climb-out speed was increased by 10 kt.

From FL 60 the crew noticed freezing rain and ice accumulation on the wing leading edges and the propeller spinners.

The rate of climb was gradually decreasing. Both powerplants had maximum climb torque (Climb).

At FL 80, the accumulation of ice had increased to such a degree that the aeroplane was no longer capable of continuing the climb.

The crew assumed that the aeroplane had got into an area of severe icing.

The crew informed ATC about the severe ice accumulation on the aeroplane and requested a clearance for an immediate descent.

At first a clearance to descend to FL 60 and later on to 4000 ft and 3500 ft (QNH) was granted. Even at this altitude the aeroplane was still in the zone of icing. Thus the crew was forced to further continue the descent. Only at an altitude of 2000 ft (QNH) the aeroplane was clear of clouds and under visual meteorological conditions (VMC) as well as in a positive temperature range so that no further icing occurred.

After 5 to 10 minutes of flight in 2000 ft (QNH), the ice had separated from the aeroplane. The crew decided to continue the flight to the scheduled airport of arrival.

The aeroplane climbed to FL 100 and at 16:45 hrs it landed at Bremen airport without further problems.

Investigation

ATR 42-300 aeroplane

The aeroplane is certificated in accordance with FAR/JAR 25 as a transport category aeroplane for day and night operations. It is powered by two propeller turbines.

The aeroplane is fitted with an appropriate equipment and instrumentation for flights under icing conditions (certification in accordance with FAR/JAR 25 Appendix C).

The aeroplane is fitted with a pneumatic de-icing equipment on especially critical components (leading edges of wings and horizontal stabilizer, air intakes of powerplants) completed by the electric icing protection equipment for parts on which de-icing boots cannot be installed, such as rotating parts (propeller), wind screens, probes and control surface balance horns.

The LIMITATIONS SECTION – part ICING CONDITIONS (Chapter 2-06, pages 1 and 2, Dec 97) of the ATR 42 Aircraft Flight Manual (AFM) contains a warning that the aeroplane is not certificated for flights under severe icing conditions. It contains information about the visual cues for the crew to recognize severe icing of the aeroplane as well as the prohibition to use the autopilot (AP) if there are signs of severe icing.

Ice covering all or part of the unheated portion of either forward cockpit side window, possibly associated with water splashing and streaming on the windshield, is considered to be a visual cue identified with severe icing.

If this visual cue exists, the icing conditions must be left immediately by changing the flight route or altitude.

Crew

The oral statements concerning the course of the incident the crew made on 26. February 2000 during the enquiry by the BFU did not differ from the written report submitted after the incident.

The PIC said that he was in a position to determine the type of icing - freezing rain - and the cues for severe icing of the aeroplane (rapid accumulation of ice on the forward side and the front windows). He assumed a thickness of the ice of about 5 to 6 cm.

There was no mistrim message.

In connection with the Total Air Temperature (TAT) of -10°C at FL 80 it was clear to the PIC that they had entered a zone of severe icing. Thus he decided to immediately leave the icing zone by a descent.

The determination whether the ATR 42-300 was free of ice was made on the basis of the criteria defined by the manufacturer in the AFM (ice evidence probe, propeller spinners).

The decision to fly to the scheduled airport of arrival was based on the knowledge of the weather situation in the Berlin area.

The incident flight was the second cycle for the crew on this day.

The PIC had a total flight experience of appr. 3000 flight hours (appr. 3.5 years' flight experience on the ATR 42-300) and the co-pilot had accumulated appr. 1000 flight hours.

Air Traffic Control

The aeroplane had been identified on the standard departure route (SID) by BERLIN DEPARTURE (120.62 MHz) and cleared to climb to FL 130. Following the clearance "proceed direct to Bremen" the ATR 42 was handed over to BERLIN-RADAR (136.05 MHz).

On this frequency the crew requested to be cleared to continue the flight at FL 80 ("... that is due to heavy icing when we climb any higher"). The aeroplane was cleared for this flight level.

Shortly afterwards the crew requested to descend to FL 60 due to severe icing. This clearance was granted by ATC.

Afterwards the crew asked for information about the cloud base. ATC gave them the AIRMET (Airman Meteorological Information) valid until 16:00 UTC - moderate icing between ground and FL 60.

Following this information the crew requested to be cleared to descend to 4000 ft. For this altitude ATC also granted a clearance on the basis of the QNH (1012 hPa).

A clearance for a further descent ("further down below the clouds") because of continued icing could be granted by ATC only down to 3500 ft (QNH) as the Minimum Radar Vectoring Altitude (MRVA) for this area was 3500 ft. The crew was informed about that.

The MRVA is the minimum altitude above MSL within the controlled airspace which may be used for radar vectoring of IFR flights.

The Minimum Safe Altitude MSL for the 25 nm radius around the VOR TGL was 2400 ft. With the indicated altitude an obstacle clearance of 1000 ft is ensured.

The minimum flight altitude (Grid MORA) adjacent to the radius around the VOR TGL first was 1900 ft and later on when the aeroplane had descended to the lowest altitude of 2000 ft was 2300 ft.

The MORA also ensures a height of at least 1000 ft above the highest obstacle within a quadrangle defined by longitude and latitude on the JEPPESEN E(LO)10 navigation map used.

The crew told ATC that due to the severe icing they had to descend below 3500 ft.

On the basis of the data shown by the Transponder Mode C of the aeroplane ATC observed that they had descended to 2000 ft.

In view of this observation ATC asked the crew for the weather conditions. The crew reported that they flew under VMC. Following this report ATC continued to supervise the altitude and the heading of the aeroplane.

There was no other conflicting air traffic.

The crew never declared an emergency aboard the aeroplane.

Meteorological Information

Prior to the flight the crew received a written weather briefing which was necessary for the conduct of the flight. It was valid at the time of departure from Berlin.

According to the statement of the crew the weather briefing was a part of the crew pre-flight briefing.

Among other things the forecast contained the statement that for the departure from Berlin-Tegel and on the flight route to Bremen the significant meteorological phenomena of light to moderate icing as well as moderate turbulence had to be expected.

The ATIS (Automatic Terminal Information Service) of 15:20 hrs transmitted at the moment of departure also indicated possible light to moderate icing up to FL 80.

The following warnings for general aviation (AIRMET) had been received by the crew prior to the flight:

EDBB AIRMET 3 VALID 281200/281600 EDZB

BERLIN FIR MOD ICE INC BTN 1000 FT GND AND FL 060 OBS STNR, NC

BERLIN FIR BKN CLD 600 – 1000 FT GND/FL 060 OBS N PART, STNR

BERLIN FIR SFC VIS BLW 5000 M DZ BR OBS N PART, STNR

BERLIN FIR MOD TURB BLW 3000 FT GND FCST STNR, NC=

EDWW AIRMET 3 VALID 281130/281430 EDZH

BREMEN FIR SFC VIS OBS 2000/5000 M DZ BR IN N AND CENTRAL PARTS, NC

BREMEN FIR BKN TO OVC CLD 700/6000 FT OBS IN N PARTS, IMPR

BREMEN FIR RISK OF MOD LOC SEV ICE FCST UP TO FL 060, NC

BREMEN FIR SFC WSPD 220 – 250/30 KT FCST MAR AND COT, INTSF=

EDWW AIRMET 4 VALID 281430/281730 EDZH

BREMEN FIR SFC VIS OBS 2000/5000 M DZ BR MAINLY N AND CENTRAL PARTS, NC

BREMEN FIR BKN TO OVC 700/8000 FT OBS N PARTS, NC

BREMEN FIR RISK OF MOD LOC SEV ICE FCST BTN 2000 FT AND FL 080, NC

BREMEN FIR SFC WSPD 220 – 250/30 – 35 KT OBS MAR AND COT, INTSF=

Meteorological Expertise

The BFU ordered a weather expertise from the DWD (German Meteorological Service).

It was to be seen from the meteorological expertise that the flight route was between low pressure above the north of Scandinavia and high pressure above southern Europe in the area of the frontal zone above northern and central Germany. With a strong westerly high altitude flow cloudy maritime air was approaching from the Atlantic Ocean.

Whereas at the coast of Mecklenburg-Vorpommern and Schleswig-Holstein there was locally continuous precipitation in the form of rain and/or drizzle in connection with a warm front extending from the Baltic Sea to the British Islands, the area of the flight route was under the influence of only occasional snow grains, drizzle or snow/sleet with ambient temperatures between 1°C and 3°C. In the north west of Germany with temperatures of 3°C to 6°C it was already somewhat milder at this time.

At the time of departure of the ATR 42-300 slight snow grains occurred. At least on the first portion of the flight route there was slight precipitation in the form of snow grains or snow/sleet.

At the moment of the take-off, the base of the lowest clouds (5/8 stratocumulus) was at 2600 ft AGL. Above these clouds there were 7/8 stratocumuli whose base had been observed at 3800 ft AGL.

It is to be assumed that with reaching a height of appr. 2600 ft AGL the existing stratocumulus clouds were entered. Also on the further route section in the direction of Bremen scattered to closed stratocumulus clouds were encountered. The cloud base was mostly between appr. 2500 ft AGL and 3000 ft AGL.

At the time in question the freezing level was near

the ground. In the altitude interval up to appr. 8000 ft MSL the air temperature dropped to appr. -8°C to -10°C .

Thus it has to be assumed that on the flight route moderate to severe icing occurred when the aeroplane entered the existing stratocumulus clouds.

Commercial operator

In preparation for the winter period 1999/2000 (WINTER BRIEFING) the operations manager of the operator issued the FLIGHT CREW NOTICE (Flight Safety) dated 26. October 1999.

In this notice, the actions to be taken by the crew in case of unintentional entry into a zone of severe icing are described in detail (see attachment).

Digital Flight Data Recorder (DFDR)

The evaluation made by the BFU was based on the raw data recorded by the DFDR which had been secured by the operator concerned.

Generally the statements made by the crew were confirmed.

Up to the incident, the autopilot had never been engaged.

At 14:48:30 UTC at an altitude of appr. 3500 ft the de-icing device was switched to the maximum stage. The indicated airspeed (IAS) was 165 kt and the TAT -1.5°C .

During this flight phase the crew increased the climb out speed by 10 kt.

From 5000 ft at 14:50:15 UTC - the IAS had increased to 178 kt - the airspeed and the rate of climb began to decrease. The TAT had dropped to -3°C .

At an altitude of 7900 ft with a TAT of -10°C the IAS had decreased to 157 kt (14:56:10 UTC) and the rate of climb decreased towards zero.

At 14:57:15 UTC the crew initiated a descent down to 2000 ft.

The aeroplane remained at this altitude for appr. 12 minutes before climbing to FL 100.

Manufacturer AEROSPATIALE – MATRA (ATR)

For the purpose of analysis, the aeroplane manufacturer received a copy of the DFDR recording from the operator.

On the basis of a computer model elaborated from data of test flights with the ATR 42-300 it was

possible to determine in which way lift and drag of the aeroplane had changed during the incident flight.

Four arbitrary flight altitudes during the initial climb were selected from the DFDR.

- At 3500 ft no changes on the aeroplane were found.
- At 6700 ft the drag of the aeroplane had increased by 150 drag counts.
- At 7500 ft the increase was already 270 drag counts.
- At 7900 ft (the maximum flight height recorded during the incident) the drag increase was 400 drag counts.

During these four measurements there was no loss of lift to be measured.

From the analysis of the measurements it was to be concluded that at 7900 ft the drag of the aeroplane had increased by 80% but still without any loss of lift.

According to the judgement of the manufacturer the increase of drag was caused by ice accumulation on the wing leading edges as well as ice accumulation far aft of the protected surfaces below the wings.

Analysis

By the weather briefing documentation as well as an existing warning (AIRMET 3, FIR BERLIN) it could be realized by the crew prior to the take-off that light to moderate icing could be expected on the planned departure route .

Severe icing conditions for FIR BERLIN had not been forecast by DWD for the time of take-off.

Moderate locally severe icing could to be expected within FIR BREMEN (AIRMET 3 and 4).

There was no occasion for the crew to cancel the planned flight for meteorological reasons.

The meteorological expertise showed that the atmospheric conditions for moderate to severe icing existed for the departure from Berlin and that the aeroplane was in clouds during the whole climb except for the first phase up to 2600 ft.

The crew had noticed freezing rain on the aeroplane.

The icing of the forward side windows of the cockpit was recognized correctly as a significant visual cue for severe icing of the ATR 42-300.

Severe icing is beyond the certification criteria for transport category aeroplanes powered by propeller turbines.

The severe icing led to a considerable reduction of

the climb performance of the aeroplane.

According to investigations by the aeroplane manufacturer the ice accumulation on the aeroplane caused a drag increase of up to 80% without visually affecting lift.

The PIC decided to leave the icing zone by initiating a descent. They had to descend down to 2000 ft (QNH) in order to leave the atmospheric conditions for icing.

The aeroplane flew below the minimum flight altitude (2300 ft) for aircraft operated under IFR.

However, as the aeroplane flew under VMC at this altitude, the crew members according to their statement were in a position to judge the obstacle situation on the flight route by themselves.

ATC continued to observe the aeroplane as to its heading and flight altitude.

After having established the severe icing of the aeroplane (freezing rain with temperatures below the freezing level, rapid ice accumulation, dropping airspeed) the crew acted in accordance with the AFM issued by the manufacturer and the Flight Operations Manual (FOM) of the operator (manual piloting of the aeroplane, increase of airspeed by 10 kt, leaving of the icing zone).

Due to the correct analysis of the situation as well as the appropriate decision taken the crew succeeded in coping with the critical situation.

Conclusions

The incident was due to the fact that the aeroplane had entered atmospheric conditions of severe icing for which it was not certificated.

Application of the AFM procedures implemented for such encounter, allowed the flight crew to exit these severe icing conditions and to continue a safe flight and landing.

Investigator-in-charge	Krupper
Flight operations	Müller

Encl.

ITEMS FOR INADVERTENT ENCOUNTER WITH SEVERE ICING

▶ **RISK OF FROZEN GEAR**

If the take off has been performed on a slush contaminated runway, this slush may seize the landing gear during cruise.

After take off

LANDING GEAR (if performance allows)

CYCLE

▶ **PROCEDURES FOR INADVERTENT ENCOUNTER WITH SEVERE ICING**

▶ **SEVERE ICING DEFINITION**

The rate of accumulation is such that deicing/anti-icing equipment fails to reduce or control the hazard. Immediate flight deviation is necessary.

▶ **SEVERE ICING DETECTION**

Visual cue identified with severe icing is characterized by ice covering all or a substantial part of the unheated part of either side window, possibly associated with water splashing and steaming on the windshield.

And/or

Unexpected decrease in speed or rate of climb.

And/or

Unusually extensive ice accreted on the airframe in areas not normally observed to collect ice.
Accumulation of ice on the lower surface of the wings aft of the protected areas.
Accumulation of ice on the propeller spinner farther aft than normally observed.

▶ **BY HEART ITEMS FOR INADVERTENT ENCOUNTER WITH SEVERE ICING**

- ▶ **Firmly holding the control wheel disconnect AUTO PILOT.**
- ▶ **Increase all minimum speeds by 10 kt. Using MCT if needed.***
- ▶ **Avoid abrupt and excessive manoeuvring. Use small control inputs.**
- ▶ **Leave the area. (Decend if necessary as climb may be impossible)**
- ▶ **Refer to QRH 1.09**

▶ **BY HEART ITEMS FOR RECOVERY FROM ICE RELATED CONTROL PROBLEMS**

- ▶ **Simultaneously**
 - ▶ **Firmly holding the control wheel disconnect AUTO PILOT**
 - ▶ **Lower the nose**
 - ▶ **Select Flap 15° (Disregarding Vfe)**
 - ▶ **Increase power to MCT***
- ▶ **Refer to QRH 1.09**

* MCT power is achieved by selecting PWR MGT to MCT and CL to MAX RPM and increasing TQ to FDAU target bugs, on ATR 42/72-500 TQ is automatically set to MCT provided PL is in the notch and Np is automatically set to 100 % when selecting PWR MGT MCT.