Wing icing on a Boeing 737-500, LN-BRX, on December 12, 2002

Micro-summary: **Extreme icing overhwelmed the anti-ice capabilities of this Boeing 737-500.**

Event Date: **2002-12-12 at 1857**

Investigative Body: **Accident Investigation Board Norway (AIB), Norway**

Investigative Body's Web Site: **http://www.aibn.no/**

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REPORT

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This investigation is of limited extent. For this reason, the AIB/N has chosen to use a simplified report format. This report format, in accordance with the guidelines provided in ICAO annex 13, is only used when the scope of the investigation makes it necessary.

All of the times in this report are local time (UTC + 1 hour) unless otherwise stated.

Aircraft	
-type and reg.:	Boeing 737-500, LN-BRX
-year of manuf.:	1993
-engine(s):	2 CFM56-3C-1
Operator:	Braathens
Radio call sign:	BRA 487
Date and time:	December 12 2002 at time 1857
Incident location:	Oslo Airport Gardermoen, ENGM
Type of incident:	Serious air incident
Type of flight:	Scheduled commercial flight
Weather conditions:	Cold winter weather with freezing fog. No precipitation. Cloud cover was thin, around 200–300 ft thick, with clear weather above. METAR 121750Z 0000KT 0800S R19R/P1500N R01R/0175 V0250D FZFG BKN001 M16/M18 Q1030 TEMPO 0200 FZFG VV001
Light conditions:	Darkness
Flight conditions:	IMC
Flight plan:	IFR
Number on board:	Not stated
Personal injury:	None
Damage to aircraft:	None
Other damage/injury:	None
Commander	
-Sex/age:	Male, 49 years
-Certificate:	ATPL-A
-Flying experience:	Total flying hours 12,300 hours, 7,200 of which are in the service of the company
Information sources:	The commander's “Occurrence Report” and the company's “Investigation Board’s” incident report.

FACTUAL INFORMATION

This report is mainly based on the company's internal report. As the incident is of interest in a wider context, the AIB/N has decided to publish the report.

This was a scheduled flight from Oslo Airport Gardermoen (ENGM) to Bardufoss Airport (ENDU). The crew ordered de-icing. "WING ANTI ICE" was used during taxiing. Following the de-icing routine, and take-off from runway 19L Gardermoen, once the fog was cleared, the wings were inspected. The crew discovered that there was ice both on the leading edge and the upper surface of both wings. The ice could not be removed using "Wing Anti Ice". The arrival location, Bardufoss, was experiencing icing conditions. For this reason, the commander decided to carry out an unscheduled landing at Trondheim Airport Værnes (ENVA) to remove the ice. The weather conditions there were fine with above-zero temperatures. During approach the ice melted. No technical faults were discovered. The flight then continued to its destination.

Before this incident, the aircraft had flown from Barcelona (LEBL) to Oslo, with a flight duration of more than three hours. After around a half-hour stay at Gardermoen, the arriving crew entered the aircraft. At this time there was neither ice nor precipitation on the wings. Relatively large ice coatings were discovered on the rear of the engine fan blades. It was decided that this ice should be removed using warm air before the next take-off. The time between ordering and performing this de-icing was around one hour. During the wait, a skin of frost formed on the wings. It was decided that this should be removed before departure. Upon arrival at the de-icing platform (RWY 19L), the crew informed the Final Release Person (FRP) about removal of frost from the wings and tail. They also informed him that the fuel temperature was below zero Celsius (-3 ^{o}C). De-icing vehicle no. 24 was used.

De-icing of the wings and tail began at time 1738Z. First by removing frost/ice with heated "TYPE I" 37% (freezing point –13 ^{o}C, red coloured), then application of "TYPE II" 100% plus (freezing point –37 ^{o}C, with light/yellow colour), which was begun at time 1740Z. The aircraft was declared free of ice, in accordance with established routines. The crew calculated the "Hold Over Time" (HOT) to be 15 – 20 minutes, in accordance with the table. After having run the engines to 70% N1 for 45 seconds, a normal take-off took place at time 1757Z.

After take-off, and having cleared the cloud (fog), the wings were inspected. The crew then discovered large deposits of uneven, jelly-like fluid that had frozen to ice on the wings, both on the leading edge and further back on the wing. This was especially prevalent on the right wing. "WING ANTI ICE" was applied virtually all the way to Værnes. During approach, the temperature rose, TAT +2 ^{o}C, and the ice melted.

The flight recorder (DFDR) was read but nothing abnormal was revealed. The selected parameters showed that the relevant systems functioned according to specification. The DFDR also showed that the time from completion of the de-icing until commencement of take-off was within HOT. It took 18 minutes from the commencement of de-icing with "TYPE II" until the aircraft was in the air.

Other crews who took off at the same time, and who had carried out the same de-icing routines, did not observe any ice on their wings following passage through the clouds.

As a result of this incident, de-icing vehicle no. 24 subsequently became the object of great attention. It was taken out of service for closer examination of the refractive index (freezing point) of the fluids that were used. The values that were measured were within tolerance. It was later decided to take all of the de-icing vehicles out of service to test the fluids. All of these tests were passed and normal service was resumed. Vehicle no. 24 was "quarantined" pending further investigation. Faults were found in the counter. The vehicle was thoroughly

investigated by the factory, looking for possible faults, emphasising pressure at the nozzles and pumps, without discovering anything abnormal. Nor were any other faults found on the vehicle that could have impacted on the incident. Extensive attempts to provoke the fault with the counter after the couplings and transmissions were checked were unsuccessful. The factory concluded that a poor connection between the gauge head and the counter's electronics was the probable reason for the fault on the counter.

The company's internal board (the group) provides the following information about the de-icing fluids that were used in the incident:

> Kilfrost DF PLUS 80 (TYPE I), which was used in the first stage of the de-icing, should have a freezing point that must be, at maximum, 3 °C higher than OAT. At the actual OAT of -16 °C, the fluid must have a freezing point of -13 °C or lower. This must be taken into account if the "fuel/wing" temperature is lower than OAT. In this incident the fuel temperature was -3 °C. A mixture of fluid and water (37%) was used, which, according to the table, should have a freezing point of -13 °C. As the vehicle's pump/computer systems are constructed to always give a "positive" margin, the actual concentration of the fluid sprayed, according to the counters, was 38% "TYPE I", i.e. a freezing point of -13.5 °C.
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> Kilfrost ABC-II Plus (TYPE II) 100%, which was applied in the second stage, has a freezing point of -37 °C. The fluid must, however, not be used at lower temperatures than - 26 °C for aerodynamic reasons. The requirements for the "TYPE II" concentration at OAT below -14 °C and down to -25 °C are 100%, according to the application table. At lower OAT, a freezing point margin of minimum -7 °C must be maintained.
>
> The fluids that were used in this incident were basically correct for the prevailing meteorological conditions, and in accordance with the fluid properties, international standards and specifications for the service. The group does, however, ask questions of general interest about why the mixing ratios for the "TYPE I" in such cold conditions do not specify a freezing point closer to OAT, which in addition varies to a certain degree. The group understands the environmental consequences of aircraft de-icing and the pressure that is imposed on the performing unit, but considers that the margins will be greater, and the possibly the result of the de-icing improved, by using a "TYPE I" freezing point close to OAT. The temperature of the wing will also be significant when it is cold.

Concerning the causal connection, the internal board says that it has not been able to indicate anything concrete in this incident. Many theories and factors have been investigated and considered without having contributed to any answer. What remains is a theoretical scenario that can be summed up as follows:

> "Correct de-/anti-icing" was performed, in which the freezing point of the TYPE 1 FLUID and the quantity of fluid used (TYPE II), as well as the time factor, all contributed in the worst possible manner, resulting in the fluid mixture freezing on the wings. Use of "WING ANTI ICE" on the ground may also have had a negative impact."

THE CONSIDERATIONS OF THE ACCIDENT INVESTIGATION BOARD NORWAY

The incident occurred during comparatively extreme conditions. There was freezing fog on the ground and the temperature and dew point were -16 °C/ -18 °C. Valid de-icing routines were followed. The AIB/N considers that

the company's internal board has taken this incident extremely seriously and has carried out all possible investigations. It is probable that a visual inspection of the wings carried out by the crew in the period between completion of the de-icing and take-off would have revealed the same thing as was discovered after the aircraft had climbed above the fog. It is, however, also possible that some of the ice formed during take-off in the fog.

AIB/N is in agreement with the considerations of the company.