INVESTIGATION REPORT

INCIDENT

OH-LYX

Douglas DC-9-51
Helsinki-Vantaa
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INTRODUCTION

On thursday, May 2, 1985 0655 am (local time) at Helsinki-Vantaa airport an incident occured to a passenger aircraft model Douglas DC-9-51 owned by the airline company Finnair ltd. Take off run was aborted because the right engine stalled. Ice had broken away from the upper surface of the wings and went to the engines.

The incident was investigated by the National Board of Aviation.

The investigation is mainly based on correspondence. The captain, the FO and the mechanic, who carried out the A-check for the aircraft were requested to submit their reports. Also the troubleshooting co-ordinator was heard.

Finnair ltd was requested to submit information about the occurences of same kind and a report of those measures that have been taken by the company in consequence of the incident now in question.

The company instructions concerning the matter are included in the manuals in which the NBA has a continuous amendment service.

Collecting and handling of the information relating to the incident and issuance of the investigation report were completed June 20, 1985.

1. FACTUAL INFORMATION

1.1. History of the flight

The airplane had arrived during the night at 0006 hrs (all times are local) on 2nd May from its previous flight from Barcelona, Spain. The flight had endured 3 h 38 min. The airplane had been standing at the apron during the night (about 6 hours). In that night it was raining at the first and then gradually changing to wet snow fall and further on to snow fall.

A de-icing was done between 0600 and 0610 hours and after that followed an A-check. Maintenance mechanic proceeded the inspection of the upper surface of the wing behind of it standing on the ground and through the cabin windows according to the A-check list, but did not observe any ice. The captain of the airliner completed his external check of the aircraft and he also checked the wings standing on the ground but did not observe any ice.

The airplane departed to its scheduled flight from the apron at 0649. Take-off run took place at 0655 on runway 33. While the airspeed had increased to 80 KTS the pilot-in-command felt interrupted acceleration, in addition he noticed that EPR-value of the right engine dropped momentarily. Therefore take off run was aborted immediately.

The airplane was taxied back to apron. In the inspection a clear ice layer were detected on top of both wing tanks at the wing root area. The ice was at its thickest about 20 mm extending about 80 cm outwards from the wing root getting thinner on the way. Some of the ice had come loose on both wings and gone to the engines.

1.2. Injuries to persons

There were no injuries to persons. On the plane there were 83 passengers and a 5 member crew.

1.3. Damage to aircraft

Both engines sustained damages as follows:

Right engine

Six of the 1st stage low-pressure compressor fan blades were bent so that one blade had also three craks. In addition to that a few of the midspan shrouds had been interlocked obviously as a result of compressor stall.

Left engine

Five of the 1st stage low-pressure compressor fan blade tips were bent and a couple of the midspan shrouds had become pressed.

1.4. Other damages

There were no other damages.

1.5. Personnel information

Pilot-in-command

Age:	38 years.
Licence:	Commercial pilot licence 21788 was issued December 4th, 1975 expiering August 17th, 1985.
Type ratings:	DC-9, December 4th, 1975.

Co-pilot

Age:	34 years.
Licence:	Commercial pilot licence 30932 was issued October 22th, 1975 expiering November 1st, 1985.

Mechanic

Age:	33 years.
Licence:	Certified mechanic licence 26601 was issued January 7th, 1981 expiering January 2nd, 1987.
Type ratings:	Single piston engine airplanes with max take-off

weight of less than 2000 kg issued January 7th, 1981. DC-9 aircraft issued March 25th, 1981, DC-10 aircraft issued November 12th, 1982.

1.6. Aircraft

The aircraft is a 139-seater transport category airplane powered by two jet engines.

Nationality and registration marks:	OH-LYX
Owner and operator:	Finnair ltd.
Manufacture:	McDonnell Douglas Corp.
Model:	DC-9-51
Serial No and year of manufacture:	48134, 1981.

Engines

Manufacture:	Pratt & Whittney
Model:	JT8D-17

The aircraft was provided with a certificate of airworthiness valid until August 31, 1985, on the basis of inspection carried out on February 12th, 1985.

Aircrafts' max take off weight is 55450 kg.

1.7. Weather

Actual weather during period 0630-0700 hrs was as follows: wind 200° 7-9 knots, visibility 4000-5000 m, obscure, vertical visibility 400 ft, temperature plus 1° C, dew point plus 1° C, relative humidity 99%.

Weather during previous night period 0000-0600 hrs was in general as follows:

- Period 0000-0300 hrs, wind 210°-230° degrees 2-7 knots, weak or moderate continuous rain, temperature about plus 3° C, dew point about plus 3° C, relativ humidity 99%.

- Period 0300-0430-0600 hrs wind 180°-230° degrees 5-10 knots, wet snow fall changing in the middle of the period first to moderate then to weak snow fall, temperature plus 3° C - plus 0° C- plus 1° C, dew point plus 3° C - plus 0° C - plus 1° C, relative humidity 98% -99%.

1.8. Aids to navigation

All operating normally; not involved.

1.9. Communications

The radio communication was not relevant to the incident.

1.10. Aerodrome

Take off run took place at Helsinki-Vantaa aerodrome on runway 33 which is 2900 m long and 60 m wide.

1.11. Flight data recorder

The information provided by the flight data recorder was not used in this incident.

1.12. Inspection of incident area

Inspection was not performed.

1.13. Medical information

No medical checks were done.

1.14. Fire

There was no fire.

1.15. Rescue operations and survival aspects

Rescue operations were not necessary.

1.16. Detailed investigation

After the aborted take-off run inspection of the wings was carried out by Finnair first at the apron and then continuing in the hangar. Ice on the wing root area was about 20 mm thick (still while measured in the hangar it was 17 mm thick) and it was extending outwards of about 80 cm from the wing roots getting thinner on the way so that thickness in the far end of the layer was about 10 mm.

There was at least 1 square meter of ice remaining on top of both wings. Now the ice layer was very easy to detect because some of it was broken away and the remaining ice had come loose. Ice broken away had gone into the engines during the take off run. About 1/5-1/4 square meters of ice might have broken away. Ice thickness in this area has been about 10 mm. From the right wing a bit bigger piece of ice had broken away than from the left wing.

The company inspected the engines, made repearings needed and performed test runs.

1.17. Previous corresponding occurrences

On March 3rd, 1981 a serious Foreign Object damage occurred at Zürich to a Finnair's DC-9-51 airplane while it was taking off. One engine had to be shut down and the airplane returned at Zürich with only one engine running. Two days later compressor fan blade damage was detected in a DC-9-51 airplane coming from Zürich. These incidents were handled in a meeting on March 5th, 1981 between Finnair ltd and NBA. The probable cause was suspected to be icing of the engine and on this basis an explanation was searched also for the previous FOD's.

Later during the investigations in 1981 the real cause for these icings begun to clear up. Occurrences were connected to humid weather conditions and to cold fuel on the wing tanks, then causing ice build up on the upper surface of the wing root area.

On April 1st, 1984 DC-9-82 airplane returned back to Helsinki-Vantaa airdrome due to engine disturbances after take off. Damages in the compressor fan blades were detected in the inspection.

In addition to the occurrences mentioned above, there have been some minor occurrences which might have been caused by ice broken away from the wings and gone into the engines.

2. ANALYSIS

2.1. Ice formation on wing root area

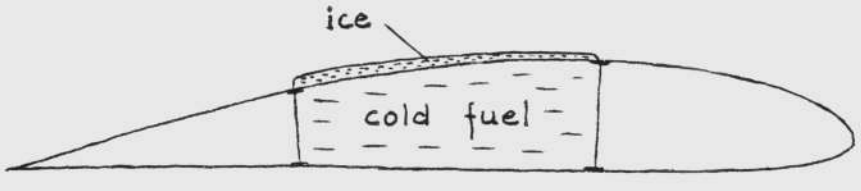
Experience gained over the similar incidents the mechanism of ice formation can be held certain. In this case weather conditions have been very typical for the ice formation.

Aircraft OH-LYX had arrived from its previous flight on 1st May from Barcelona, Spain. During the long flight the fuel had cooled down well under 0° of centigrades. There were still 2400 kg fuel on both wing tanks after the flight. In the wing root the fuel had been in touch with the upper surface of wing skin plate.

Between the flight from Barcelona, Spain to Helsinki, Finland and intended flight next morning the aircraft had been standing on the apron. Ambient temperature had been between plus 3° and 0° centigrades and therefore warming up of the fuel have been considerably slow.

According to weather briefing during 0000-0300 hrs it had been raining and during 0300-0430 hrs there was wet snow fall and further on from 0430 hrs to 0600 hrs it was snowing. Because of the cold fuel the water on the wing root area transformed into a clear ice. The ice layer grew thicker because of the wet snow fall and afterwards it was covered by the snow.

The shape of ice is illustrated on the picture on the bottom of this page when the ice formation is as described previously. Humidity and rain freeze on the top of wing tanks. Because the freezing cannot happen instantaneously the excess water flows towards the trailing edge and wing root. When the ambient temperature is above freezing point ice is appears only on the area of wing tanks so that the aft edge of the ice layer is very steep. From this point towards the trailing edge the wing is free of ice. Ice is as thickest on the aft part of the wing tank and on the wing root. Outwards from the wing root ice gets a bit thinner.



Around the landing gear the ice might be thicker as the massive parts of landing gear may stay very cold after a long high altitude flight.

2.2. Take-off and ice breaking away

Take-off from runway 33 was normal until the speed about 80 knots. At that moment the crew felt an instantenious pause in the acceleration and also the EPR value of the right engine went down to 1.3.-1.4. for a moment. Therefore the Pilot-In-Command aborted the take off run. At the first it was suspected that a bird or bleeding air malfunction had caused the stalling of compressor. The airliner was taxied back to apron where it was inspected and ice was detected on top of both wing roots.

In previous cases it has been concluded that ice brakes away in rotation phase while the wing have begun to lift and therefore it is bent. In this case liquid glycol has most probably loosen some of the ice from wing surface. In addition partial loosening of the ice layer might have been caused by jolting during taxing and take off run while the thinnest parts of ice might have cracked. Ice have sled and/or lifted away while the airspeed have increased and at least some of it has gone to the engines.

2.3. Instructions and requirements for airworthiness

Finnairs' maintenance manual Chapter 12-31 "Deicing and anti-icing on the ground" contains instructions and background information about deicing. The section 3 of this chapter contains title "The need of deicing and responsibility for airworthiness" and it begins as follows:

"The need of aircraft's deicing is determined by a type rated mechanic or by a person who holds a certificate for A-check, or the head of start or the pilot-in-command who has superior authority.

The chauffer of deicing truck is in radio contact with pilots during spraying because of needed control of air conditioning. Usually he also informs pilots about performed deicing. However, a person who is either type rated mechanic or holding a valid certificate for A-check inspects and is responsible for the result of the deicing. He request for a new deicing if needed because of weather conditions or delay in departure. Consequently he is responsible for that aircraft

is at the moment of the engine start free of ice, snow and frost."

A-check instruction, chapter 2.7 which concerns checking for snow, ice and frost is as follows:

"Check that the top of fuselage, wings and stabilizers are free of snow, ice and frost. Check also that deicing if necessary is adequately performed. On the lower surface of wing, at the area of fuel tanks, 3 mm frost or 2 mm ice layer may be left due to cold fuel. Pilots have to be informed of it.

ATTENTION: If ambient temperature is plus 10°C or below and ice or frost is formed on the lower surface of wing at the area of fuel tanks and if there is visible moisture (rain, fog, haze) then the upper surface of wing, especially the wing root area, must be checked using ladders to detect possible clear ice and if so it must be removed."

Aviation Act chapter 1 section 24 issued december 11th, 1964 states about the pilot-in-command and his duty at service while in aircraft as follows:

"The pilot-in-command shall ascertain before the commencement of the flight that the aircraft is airworthy as well as properly manned and loaded, and supervise the airworthiness of the aircraft during flight and ensure that in all other respects the flight is prepared and carried out in accordance with current regulations."

Airplane Flight Manual DC-9-41/51 contains in chapter 2.1.1 instructions for pilots external check:

"Pilots' external check

The pilots' external check must be performed prior to the reading of the BEFORE FIRST TAKEOFF check list or if deemed necessary also prior to the BEFORE ENGINE START check list.

1.1. Captain

The captain switches the wheelwell light on and checks the condition of:

.....

- Right wing: slats, cleanliness of leading edges, fueling doors, fuel level sticks,

landing and position lights, static dischargers and ice, snow or slush
.....
- Left wing: slats, cleanliness of leading edges, fueling doors, fuel level sticks, landing and position lights, static dischargers and ice, snow or slush
....."

2.4. Deicing and inspections

During 0600-0610 hrs a deice spraying was performed to the lower and upper surfaces of the wings and to the tail. Ice and snow on top of the fuselage had melted when APU and cabin heat was turned on. As a result from deice spraying there were no snow or slush on the aircraft but the clear ice on the wing root had probably thawed only a little and had been "polished".

The mechanic had checked the spraying. He had checked the upper surface of the wings through the cabin windows but failed to detect ice. While performing the external inspection the mechanic had checked the wings from ground but he had noted that it was impossible to go near the wing because of excessive flow of glycol.

The weather conditions described in chapter 2.7 of the A-check intructions existed and therefore the mechanic should have been used ladders to check the upper surface of wing, which he failed to do. Detecting the ice is extremely difficult without getting up with ladders.

The pilot-in-command states that while he was doing external check before getting in the plane he acknowledged that de-icing was completed. Checking the wings from back side their upper surface seemed to be clean and because of the glycol they were clear and smooth. Pilot-in-command notes that the cause of failing to detect any ice was a result of excessive trust to airworthiness of the aircraft after the A-check and the de-icing.

Pilot-in-command had noticed that A-check and deicing were performed. After completing his external check he trusted to that the created system would work according to given instructions.

The co-pilot states that he had went to the plane while PIC stayed outside for external check. While checking the cabin co-pilot had glanced to both wings and they seemed to be "washed up".

3. CONCLUSIONS

3.1. Findings

1. The pilot was appropriately qualified and licenced to undertake the flight.

2. The co-pilot was appropriately qualified and licenced to undertake the flight.

3. The mechanic was appropriately qualified and licenced to carry out the A-check.

4. There were current certificates of airworthiness and registration for the aircraft.

5. PIC made an incident report to the NBA according to given regulations. The stalling of the right engine and the abortion of the take-off run were mentioned in the report.

6. Deicing was performed half an hour before the scheduled departure.

7. Mechanic had done the A-check but had failed to check the wings as required in chapter 2.7. of the A-check instructions (using the ladders). He did not detect ice when looking from ground and through cabin windows.

8. PIC had performed the external check and he had noticed that the A-check and the de-icing were performed but even he did not detect ice when looking from ground.

9. Corresponding incidents have occurred previously and the causes of the problem begun to resolve in 1981. Thereafter it has been acknowledged. This has been taken in the consideration in staff training and advising. The remark in chapter 2.7 of the A-check instructions has been added November 1984.

3.2. Causes

The ice layer in the wing root had not been observed during the A-check. Some of the ice broke away during take-off run and went to the engines causing stalling of the right engine and damages to the first stages of both engines.

4. SAFETY RECOMMENDATIONS

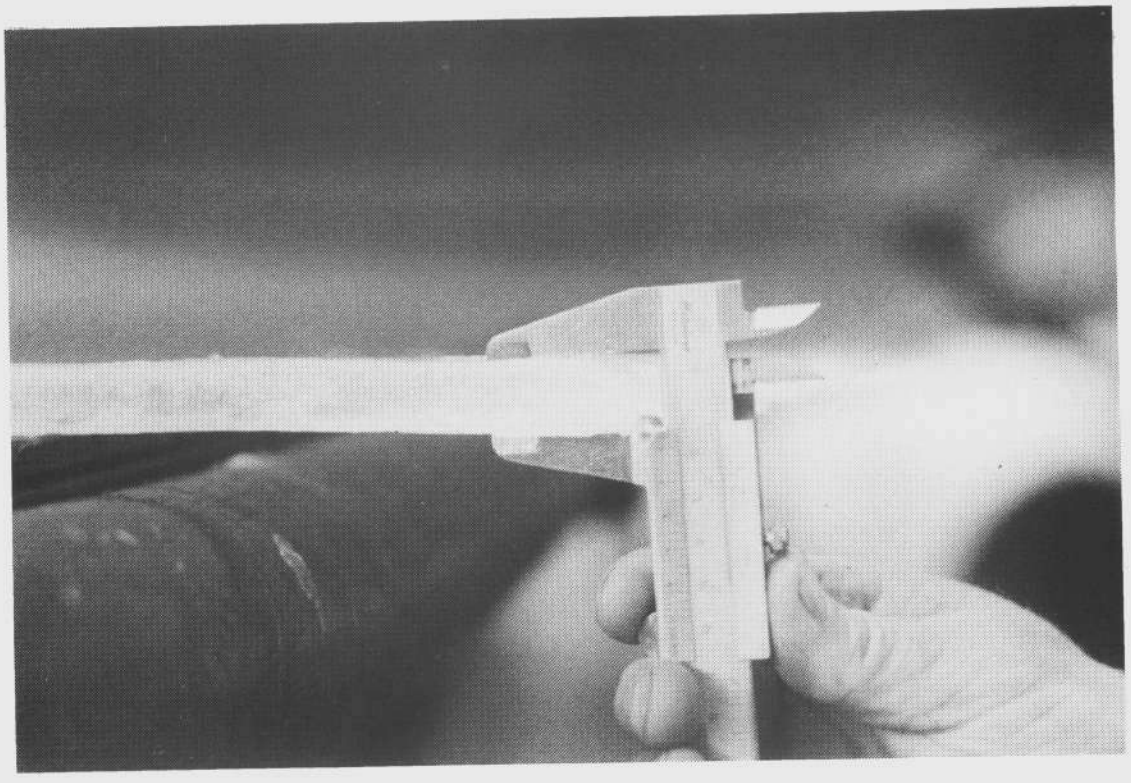
In the meeting of Finnair Ltd's Problem Action Board on May 23rd, 1985 a project was launched the main purpose of which is to prevent this kind of incidents in the future. Investigators suggest that NBA should be informed of the development and results of the project.

Vantaa, June 6, 1985

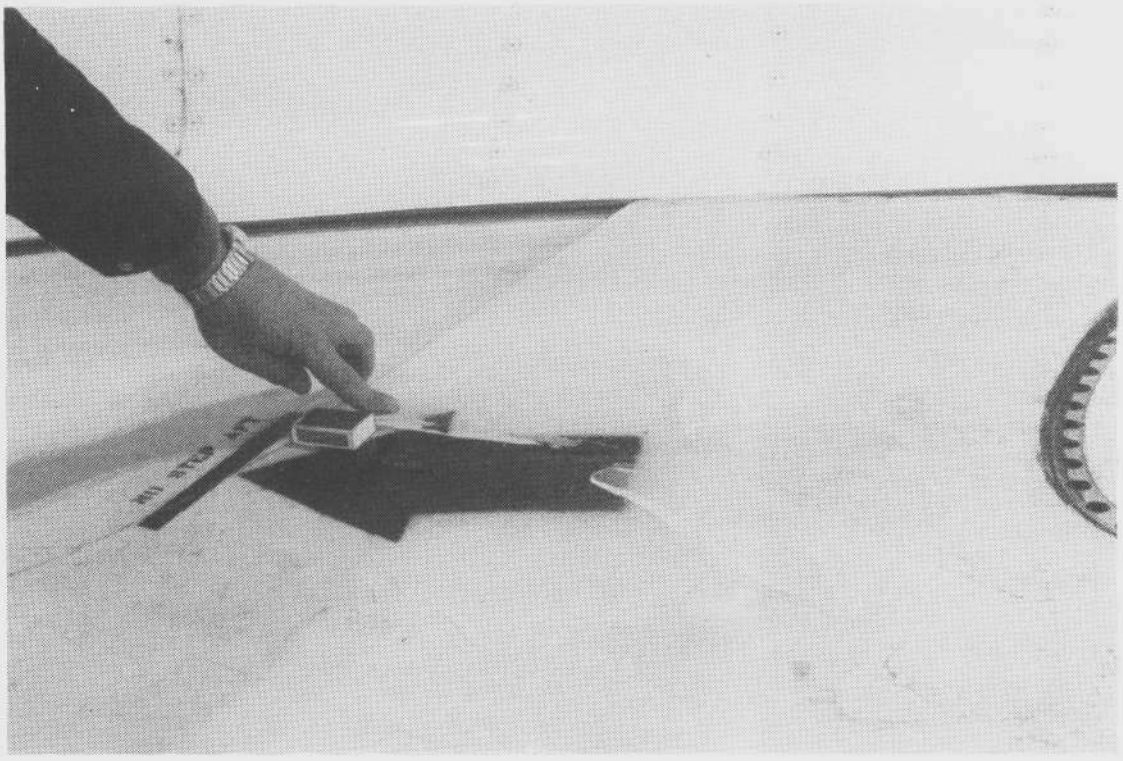
J. Porttila V. Pekkola

L37 54/ /AKo

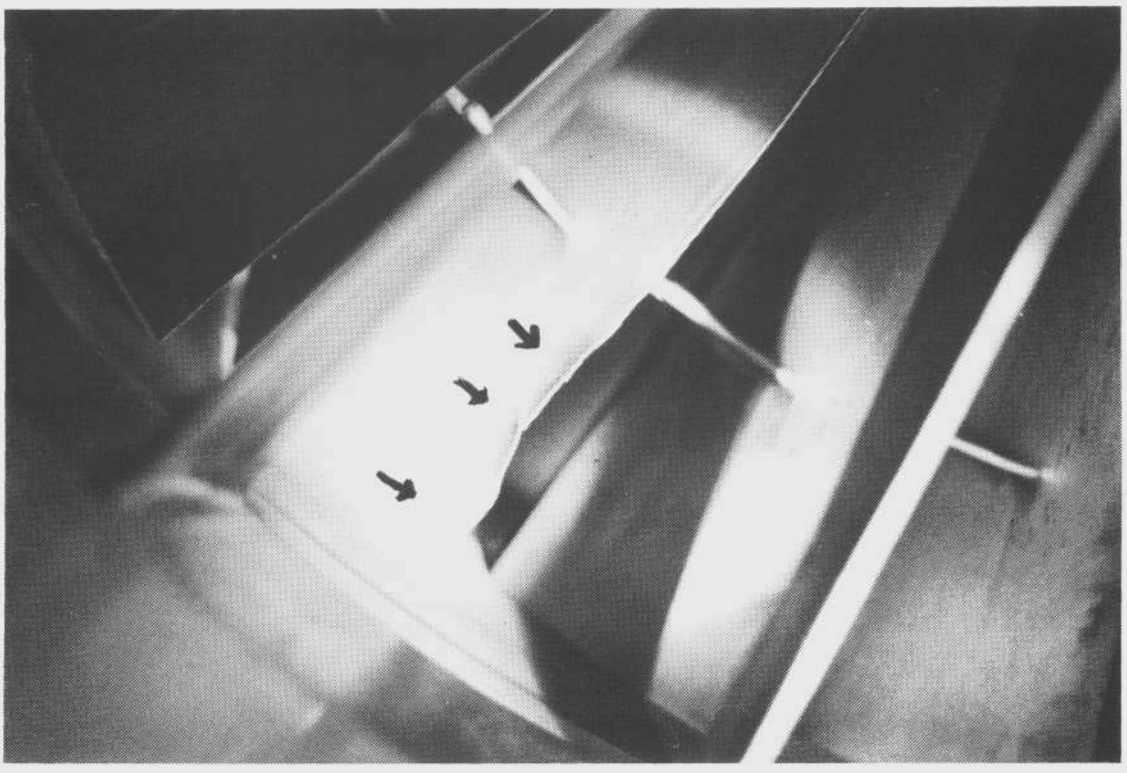
1. Ice layer on the right wing, seen from the back of the wing. Observe the dent at the rear wing spar. (Photographed in the hangar).



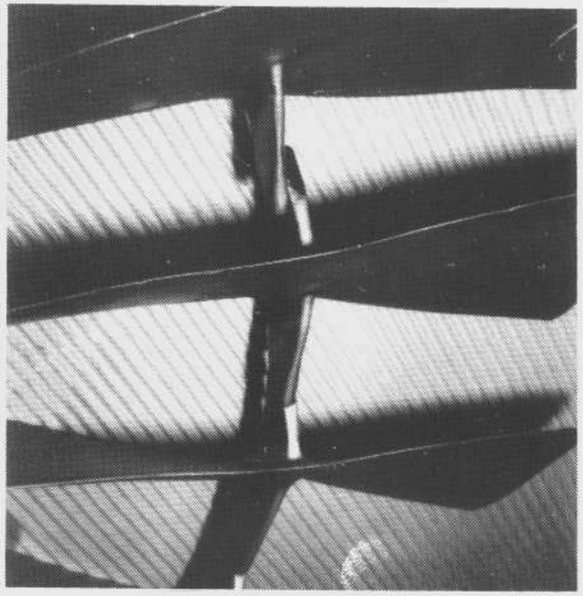
2. Ice layer at the wing root, thickness 17 mm. (Measured and photographed in the hangar).

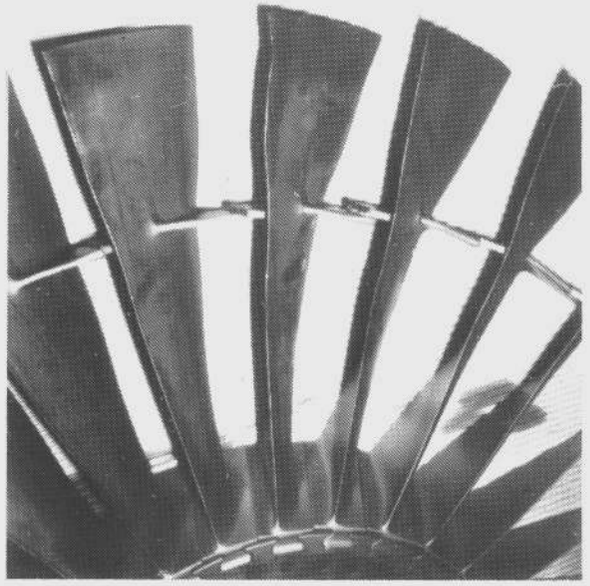


3. Ice layer on the right wing (photographed in the hangar).



4. Compressor blade cracks in the right engine. (Arrows).





5. Compressor blades in the right engine. Some of the blades show bends and some of the midspan shrouds have been interlocked.