

RAPPORT

SL 2013/03



RAPPORT OM ALVORLIG LUFTFARTSHENDELSE PÅ BERGEN LUFTHAVN MED ATR-42-300, OY-JRY, 9. NOVEMBER 2007

 This report is also available in English

Statens havarikommisjon for transport (SHT) har utarbeidet denne rapporten utelukkende i den hensikt å forbedre flysikkerheten. Formålet med undersøkelsene er å identifisere feil og mangler som kan svekke flysikkerheten, enten de er årsaksfaktorer eller ikke, og fremme tilrådinger. Det er ikke havarikommisjonens oppgave å ta stilling til sivilrettslig eller strafferettslig skyld og ansvar. Bruk av denne rapporten til annet enn forebyggende sikkerhetsarbeid bør unngås.

RAPPORT

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SL Rapport: 2013/03

Denne undersøkelsen har hatt et begrenset omfang. Av den grunn har SHT valgt å benytte et forenklet rapportformat. Rapportformat i henhold til retningslinjene gitt i ICAO Annex 13 benyttes bare når undersøkelsens omfang gjør dette påkrevd.

Alle tidsangivelser i denne rapport er lokal tid (UTC +1 time) hvis ikke annet er angitt.

Luftfartøy:

- Type og reg.: ATR-GIE Avions de Transport Régional ATR 42-300, OY-JRY
- Produksjonsår: 1996
- Motor(er): 2 stk. Pratt & Whitney Canada PW120

Operatør:

Danish Air Transport

Radiokallesignal:

DX56

Dato og tidspunkt:

Fredag 9. november 2007, kl. 1606

Hendelsessted:

Bergen lufthavn, Flesland (ENBR)

ATS luftrom:

Kontrollert luftrom (Flesland CTR), klasse D

Type hendelse:

Alvorlig luftfartshendelse, temporære kontrollproblemer under stigning

Type flyging:

Ruteflyging

Værforhold:

METAR ENBR 091520Z 32016G30KT 9999 7000W VCSH
FEW015 SCT020CB BKN034 02/M01 Q1005 TEMPO 1500
SHSNRA VV008 RMK WIND 1200FT AMSL 31032G43KT=
Fartøysjefen har rapportert at det var frysende sludd og moderat
ising i forbindelse med den aktuelle flygingen.

Lysforhold:

Dagslys

Flygeforhold:

VMC-IMC-VMC

Reiseplan:

IFR

Antall om bord:

2 flygere, 1 kabinbesetning og 24 passasjerer

Personskader:

Ingen

Skader på luftfartøy:

Ingen

Andre skader:

Ingen

Fartøysjef:

- Kjønn og alder: Mann, alder ikke oppgitt
- Sertifikat: Ikke oppgitt
- Flygererfaring: Ikke oppgitt

Informasjonskilder: “NF-2007 Rapportering av ulykker og hendelser i sivil luftfart” fra fartøysjef, “Flight Safety Report” fra fartøysjef til Statens Luftfartsvæsen – Danmark, avisingslogg fra SAS SGS ENBR, samt SHTs egne undersøkelser.

FAKTISKE OPPLYSNINGER

Hendelsesforløpet

På hendelsesdagen betjente OY-JRY flyruten mellom Bergen og Florø. Hendelsen inntraff da flyet skulle starte fra Bergen Flesland for å returnere etter en forutgående ruteflyging fra Florø (ENFL). Besetningen hadde observert at det ble akkumulert snø på luftfartøyet under oppholdet på Flesland, og at det i tillegg var rester av klaris på vingene, den horisontale haleflaten og propellspinnerne fra forrige flyging. Før avgang ble det først utført en avising og deretter en antiisingsbehandling av flyet.

Klokken 1606 påbegynte OY-JRY avgangen fra Flesland. Fartøysjefen har skrevet i sin rapport at det ble brukt 15° flap. Masse og tyngdepunkt var innenfor gjeldende begrensninger. Autopiloten var ikke innkoblet. 10 kt før rotasjonshastighet var oppnådd, tok flyet av uten at det var blitt gitt noen utslag på kontrollene fra mannskapets side. Deretter fortsatte det i en slak stigning med lav hastighet.

I følge fartøysjefen fortsatte flyet den ukontrollerte stigningen til tross for at begge styrespakene ble beveget til fremre posisjon (stopp) og ekstra motorpådrag ble gitt. “Stick shaker” aktiverte og “cricket sound” hørtes i noen sekunder samtidig som hastigheten avtok. Etter hvert begynte imidlertid flyets nese å senke seg og hastigheten tok seg gradvis opp, hvoretter “Stick shaker” opphørte. Mens hastigheten økte opplevde besetningen at styrespakene oscilerte frem og tilbake, og var tunge å bevege.

Av rapporten fremgår videre at besetningen påbegynte en visuell sving for å returnere til Flesland, men oppgav dette da flyet kom inn i skyer. Klatringen var da stabil, og styreorganene ble gradvis lettere å bevege. Da flyet kom over skyene ble flygingen fortsatt til bestemmelsesstedet, uten bruk av autopilot. Etter landingen på Florø ble styreorganene kontrollert uten at noe unormalt ble funnet. I følge DAT Technical Flight Log ble det deretter fløyet ytterligere to turer på ruten samme dag.

Avising og antiising

Det første steget av behandlingen av OY-JRY før avgangen fra Flesland var avising som besto i å fjerne is og snø med varmt vann. I følge rapporten fra SAS SGS ble det brukt til sammen 193 liter vann til dette. Deretter ble anti-ising utført for å forhindre snø og is fra å legge seg på luftfartøyet før det kom i luften. I denne operasjonen ble det påført 69 liter type 2 antiisingsvæske med 100% styrke. I tillegg ble det i følge SAS SGS brukt 17 liter type 1 med 28% styrke på undersiden av haleflaten. Siste steg, påføring av anti-icing, ble i følge loggen til SAS SGS påbegynt klokken 1558. To deicerbiler deltok i behandlingen av OY-JRY. Basert på foreliggende informasjon har SHT anslått at HOT var på mer enn 30 minutter. Avgangen ble påbegynt 8 minutter inn i HOT.

Både fartøysjefen og SAS SGS har angitt at Danish Air Transport sin prosedyre for de-/anti-icing av ATR 42/72 ble brukt. Denne prosedyren, som besto av fire punkter og var illustrert med fotografier, ble kort tid etter hendelsen oversendt til SHT fra SAS SGS:

De/anti-icing av halen på ATR 42/72 gjeldende for Cimber Air og DAT

1. Alltid de-ice stabilizer som det er CLEAR ICE!

2. ELEVATORS OVERSIDE

Først de-ices elevator med **TRAILING EDGE** i **DOWN** position.



3. ELEVATORS UNDERSIDE

Kontakt Cockpit når klar til de-icing av undersiden. Elevator skal være i **TRAILING EDGE UP** position. Spray bakfra og ha spesiell fokus på området mellom elevator og stabilizer



4. ANTI - ICING med TYPE II - (på request fra cockpit) SPRAY KUN OVERSIDEN

Figur 1: Danish Air Transport sin prosedyre for de-/anti-icing av ATR 42.

I sin høringskommentar har fabrikanten ATR anført at det synes å ha vært brukt lite type 2 antiisingsvæske på OY-JRY. Fabrikanten har kommentert dette som følger:

“Taking into account the amount of Type II fluid used for the second step seems to be low. Usually the anti-icing fluid is applied through a uniform layer of at least 2mm thick that would correspond to roughly 120 liters of type II fluid. The amount of type II used for this case seems to be low.”

Erfaringer etter hendelsen

På forespørsel fra havarikommisjonen har DAT opplyst at selskapet ikke hadde opplevd lignende hendelser i årene som har gått siden denne hendelsen med kontrollproblemene i avgangen fra Bergen lufthavn Flesland. Selskapet har i hele perioden operert på norske flyplasser, og dermed også under vinterforhold.

DAT rapporterte også saken til fabrikanten som utga et eget ATR Airworthiness Review Sheet 131/2007 om hendelsen (se vedlegg A). Fabrikanten konkluderte med at:

“The event description fully matches with the behaviour an ATR would have in case of an improper de-icing of the horizontal stabilizer.”

ATR viste videre til en informasjonsbulletin som den franske havarikommisjonen BEA utga i 2004 etter et liknende tilfelle. I bulletinen beskrives hvordan is kan føre til at høyderoret dras opp til en nese-opp posisjon (se vedlegg B).

HAVARIKOMMISJONENS VURDERINGER

Havarikommisjonen mener at det var en reell fare for steiling før mannskapet til slutt fikk kontroll over høyderorsfunksjonen etter avgangen fra Flesland. Det at flyets steilevarslingsystem (stick shaker og cricket sound) kom på, tyder på at OY-JRY var nær ved å steile.

Tatt i betraktning at det samtidig var store problemer med å kontrollere flyets nesestilling, anser havarikommisjonen at det er usikkert om mannskapet eller flyets automatiske steilebeskyttelses-system (stick pusher) hadde klart å forhindre en steiling fra å oppstå dersom flynesen hadde hevet seg ytterligere. Det er også uvisst om det hadde vært mulig å rette opp flyet i tide dersom en steiling hadde inntruffet i denne lave høyden.

SHT har vurdert om andre faktorer som tyngdepunkts plassering, trimsetting eller fastfrosset høyderor kunne ha forårsaket hendelsen. Ut fra foreliggende informasjon synes alle disse scenarioene å være mindre sannsynlige en hypotesen om utilstrekkelig avising av haleflaten.

Havarikommisjonen har merket seg at avising av undersiden av stabilisatoren, og da særskilt bakre parti i overgangen mellom stabilisator og høyderor, er viet spesiell oppmerksomhet i prosedyren for avising av haleflaten på ATR 42/72. Dette for å forebygge fastfrysing av roret, som det har vært flere tilfeller av med disse flytypene. I prosedyren fremgår det riktignok også eksplisitt at oversiden av haleflaten skal avises, men SHT spør seg likevel om det spesielle fokuset på spalten mellom høyderor og stabilisator på ATR, og andre flytyper med liknende halekonstruksjon, kan ha medvirket til at avisingspersonalet kanskje ikke har vært tilstrekkelig oppmerksom på betydningen av også å holde oversiden av stabilisator og høyderor fullstendig fri for is og snø.

Statens havarikommisjon for transport

Lillestrøm, 23. januar 2013

Vedlegg A

ATR AIRWORTHINESS REVIEW SHEET

TI : 131 / 2007 Page 1 sur 1

MODEL: ATR 42-300 **ENGINE:** PW120

SUBJECT: PITCH CONTROL ANOMALY

OPERATOR: DANISH AIR TRANSPORT **MSN:** 63 **REG.:** OY-JRY

EVENT DATE: 09/11/2007 **LOCATION:** Bergen (Norway) **FL. PHASE:** ROLLING

SAFETY CONCERN:

EASA CLOSURE STATEMENT: 87th ARM : EASA concurs with ATR position.

STATUS CLOSED

DESCRIPTION:

During ground stop on apron in ENBR snow accumulated on plane caused by the vicinity showers. The plane also had remained of accumulated clear ice on wings, stabilizer, nose & propeller spinners from previous flight. As precipitation was still present a one step type 1&2 de-icing was performed according to company procedures at remote de-icing apron. During take-off roll the plane lifted off without any inputs on the flight controls by the crew at a speed of approx. 10 Kts below rotation speed.

Airspeed indications were fluctuating due to gusting wind conditions and therefore difficult to determine exact readings. The plane maintained a steady shallow climb at low speed, despite both control columns were moved to the forward stop and extra power added. The stick shaker was activated and the cricket sound heard. Level 2 anti-icing was "ON" from before take-off. The plane maintained this altitude for a few seconds where the airspeed kept decreasing. Eventually the aircraft began leveling the nose and the airspeed increased slowly whereat the stick shaker also stopped. As the airspeed increased, the control columns were oscillating in pitch and were very heavy to move. A visual return to landing was attempted but discontinued when the flight entered in I.M.C conditions. The plane was now performing a steady climb and gradually the flight controls become easier to move. V.M.C conditions on top was entered and flight continued to destination without the use of A/P.

ACTIONS:

During post flight inspection of the flight controls, no abnormalities were found.

SAFETY CONCERN COMMENTS AND AIRWORTHINESS IMPACT (IF ANY):

SIMILAR EVENTS:

TI 41/07

ANALYSIS/CONCLUSION:

87th ARM:

The event description fully matches with the behaviour an ATR would have in case of an improper de-icing of the horizontal stabilizer.

B.E.A has issued in January 2004 an information bulletin that explains this phenomenon.

Presence of frozen contaminants over the horizontal stabilizer and elevator, change the aerodynamic characteristics of this surface leading the elevator to a nose up tendency.

To re-establish the balance it is thus necessary to put more trim to nose down, reducing the capacity of trim to stabilise the aircraft when the speed increases. Nevertheless upon natural ice shedding from the surface, an out of trim may suddenly appear.

The most probable scenario is that the plane was either badly de-iced on ground or that the holdover time was exceeded with subsequent contamination on the horizontal stabilizer/elevator.

ATR POSITION:

Operational issue. The ATR operational documentation already addresses adequately the issue

BEA Incidents en transport aérien Numéro 1 – janvier 2004 - engelsk versjon:

**Incidents in Air Transport
Special Issue**

ICING

CONTENTS

Flaps blocked during approach
Icing of horizontal stabiliser and elevator control
Elevator control blocked by rehydrated residues of anti-icing fluid
Difficulties in controlling pitch axis due to ice around elevator control cables
Takeoff after incomplete de-icing of horizontal stabiliser

AIRCRAFT ICING

We must not underestimate the risk, on the ground as well as in flight. Snow and ice have been the cause of many accidents throughout the world.

Cases in point:

B737 Washington, USA, 13 January 1982
F28 Dryden, Canada, 10 March 1989
MD-81 Götorra, Sweden, 27 December 1991
ATR 42 Roselawn, USA, 25 October 1998

Although the risks have been clearly identified and are widely known, some circumstances can lead to decisions influenced by under-assessments or confirmation bias, resulting in unexpected situations for the crew. This issue illustrates such situations.

ITA bulletins are available on the BEA site
www.bea.aero

Flaps blocked during approach

History of Flight

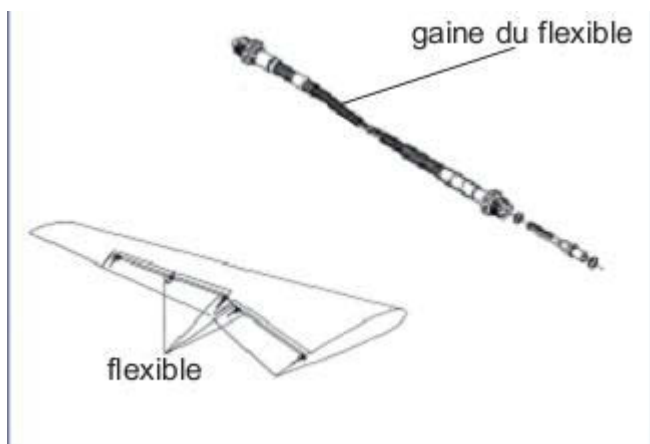
An Embraer 135 was performing a flight in winter. It was snowing and the temperature on the ground was 0°C. The aircraft was de-iced at the ramp with a solution composed of 75% type II fluid and 25% water. The aircraft was in contact with a walkway on the left side, and the de-icing vehicle moved to the rear side of the wing, which it sprayed starting from the trailing edge. The crew extended the flaps about five minutes after this operation, and took off. The flaps were retracted with no problems and the flight continued smoothly.

During the approach, a “FLAP FAIL” message reporting total loss of the flap system appeared on the EICAS when the crew commanded extension of the flaps. The corresponding checklist was run through. It was impossible to land during the first approach because this failure was being processed at the same time. The crew applied full throttle for another go-around, notified ATC about the failure and started a new approach followed by a landing with flaps retracted (0°).

Additional Information

The failure message was related to a failure in the mechanical flap system: hoses, worm screws, transmission brakes. The transmission of movement is made by hoses composed of steel / carbon cables passing through Teflon ducts.

Water had entered when these hoses were removed. This water froze during the flight, which took place entirely at negative temperatures, and caused blockage of the flap movement transmission. The operator launched an inspection campaign of all hoses in flap systems. Services responsible for monitoring of airworthiness were informed about this event and its circumstances.



Hose

Hose duct

Note: It is possible that high pressure injection of the de-icing fluid from the trailing edge facilitated this condition. The ICAO manual on ground de-icing and anti-icing operations describes the usual wing and stabiliser de-icing / anti-icing procedure that consists of spraying fluid from the leading edge to the trailing edge and from the highest point of the camber to the lowest point.

Icing of horizontal stabiliser and elevator control

History of Flight

A twin turboprop with a crew composed of an instructor in the right seat (TRE/TRI) and a Captain on line oriented flight training (LOFT) in the left seat, with a total of 1,100 hours combined experience on this type of aircraft, left the ramp at the beginning of the afternoon and taxied towards the holding point. There was a snow shower during taxiing, lasting for about five minutes. The pilots in the cockpit could see that the snow was melting and did not settle on the aircraft. After discussion, it was decided not to ask for de-icing of the aircraft and to continue taxiing. The crew changed the holding point due to congestion at the originally planned holding point. The snow shower stopped three to four minutes before arrival at the new holding point. After observing that the snow really was melting, the crew took off twelve minutes after leaving the ramp.

The instructor was the PF. The autopilot was engaged after the flaps were retracted at an altitude of 3,500 feet. The "Caution icing" message appeared as the plane climbed, shortly after reaching flight level 90. The crew performed the "De-icing" procedure and stabilised the plane at flight level 90. After being cleared to climb to level 110, climb was resumed less than one minute later. Then the "Pitch Mistrim" message appeared during level 100 actions, and the crew searched in vain for the "Pitch Mistrim" checklist in the flight control chapter in the Quick Reference Handbook (QRH). Since the aircraft did not stabilise at level 110, the PF disconnected the autopilot. He had difficulty in levelling the aircraft and had to apply strong nose-down forces on the elevator control, with the Pitch Trim at the "down" stop.

In order to get out of the icing conditions and with clearance from ATC to do so, the crew climbed to flight level 150. Since forces to be applied on the flight controls were still high, a request was made to return to the departure aerodrome. The descent took place with the Pitch Trim at the down stop and the same forces on the elevator control. It was planned to land with 15° flap deflection. The excessive forces reduced and disappeared on final approach when the speed dropped to 130 knots.

On the ground, it was found that there was a 0.5 cm layer of rime ice covering the upper part of the elevator and the horizontal stabiliser (no rime ice on the trim tab).

Additional information

Flight preparation

The crew had collected the following weather information during flight preparation 45 minutes before departure:

- risk of snow in Paris
- moderate to high risk of icing in Paris (end of SIGMET one hour and thirty minutes before the flight)
- three accessible aerodromes on arrival.

During the pre-flight inspection of the aircraft that had remained at the ramp for three hours, the instructor had observed that:

- there was no snow or ice on the aircraft,
- the ground and the aircraft were damp

The crew had taken account of icing conditions in determining parameter limitations and for calculating parameters.

Interpretation of the Pitch Mistrim warning

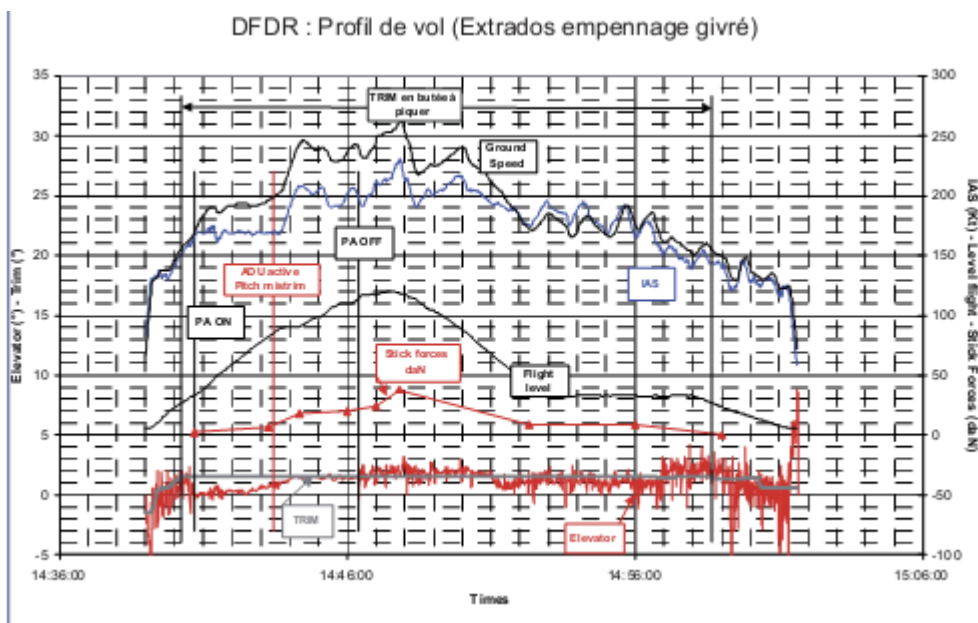
An analysis of the parameters showed that the pitch trim had begun to move nose down at the beginning of the rotation. It reached the down stop before the flaps were retracted while climbing at a height of 2,500 feet. It stayed in this position until the speed was reduced for the approach.

The Pitch Mistrim message appears when the torque output from the elevator servomotor is greater than an equivalent force of 5 daN for more than ten seconds. It indicates that a “mistrim” situation will exist when the autopilot is disconnected. This can occur when the pitch trim is “mechanically” blocked, or when it has reached a stop (down or up) and its action is insufficient to compensate for forces applied on the elevator by the autopilot motor.

Aerodynamic explanation of the phenomenon

The FCOM (manufacturer’s operations manual) specifies that during a takeoff with residual ice or during severe icing, the elevator hinge moment may be affected. This is what happened during this flight, and the consequence was a mistrim of about 2°.

The analysis of flight parameters verified that the aircraft stability was not affected because the elevator deflections recorded showed no significant differences with deflections calculated for a non-contaminated aircraft, with identical mass and centre of gravity.

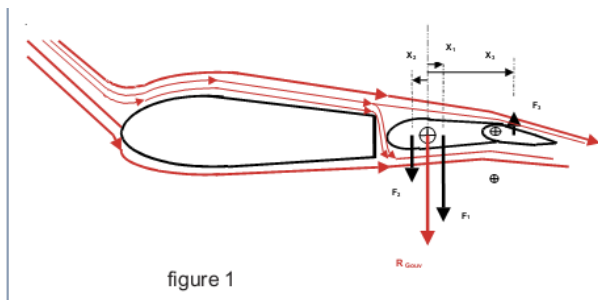


DFDR: Flight profile (tail assembly upper surface iced up)

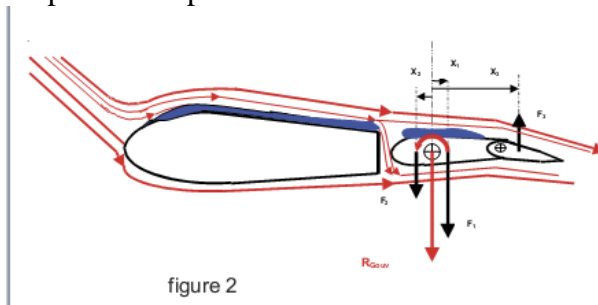
Description of the phenomenon

The aircraft pitch is controlled by a horizontal stabiliser, an elevator and a trim tab.

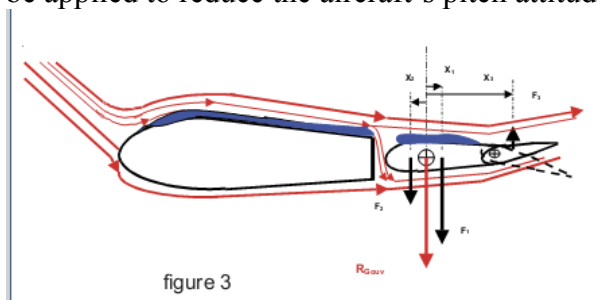
To move or balance the elevator, the pilot or the autopilot needs to create a force which will be applied through the kinetic system to oppose the aerodynamic forces applied onto the elevator and the trim tab. This force is contrary to the elevator hinge moment.



If ice forms on the upper part of the horizontal stabiliser and the elevator, the boundary layer in the aft part of the profile is modified with the result that the elevator tends to pull up.



Therefore, to restore equilibrium, the nose-down trim has to be increased which reduces the capacity of the trim to stabilise the aircraft when the speed increases. When the "down" trim stop is reached, the elevator hinge moment can no longer be compensated for, which increases the forces to be applied to reduce the aircraft's pitch attitude (see Figure 3).



Dangers of an elevator mistrim

Apart from the difficulties in piloting mentioned in the description of the event, a sudden disappearance of the cause of the elevator mistrim (for example if the ice on the upper part of the tail unit drops off suddenly), this will cause the elevator to pull down, thus increasing the aircraft speed. Recovery forces may be large and this situation can cause loss of control.

Note: The FCOM provides the following clarifications: the hinge moment on the elevator may be affected by external conditions. Experience shows that the most probable case is takeoff with residual ice on the aft part (de-icing/anti-icing fluid retention time exceeded). Icing may also be a factor.

Lessons learned

The operator implemented the following corrective action plan after this event:

- Reminders to crews about application of the de-icing / anti-icing procedure during snowfall or snow shower while parking or taxiing;

- Modification to Part B of the operations manual so that flight crews can easily find the checklist corresponding to the “Pitch Mistrim” message. The crew had looked for it in the flight controls chapter, although it was actually in the autopilot chapter. It was also noted that, for another aircraft in the same family but from a different series, this information was actually in the flight controls chapter;
- Increase awareness of flight crews on this type of event during recurrent training sessions.

Note: The operator also determined that the mass of rime ice on the horizontal stabiliser and on the elevator moves the centre of gravity in the aft direction by 5%, and the aircraft remains within the limits of the flight envelope.

Elevator control blocked by rehydrated residues of anti-icing fluid

This incident was the subject of an investigation report published by BEA (reference [hb-r990129](#)) and available on its internet site.

History of Flight

A twin-jet aircraft was making its first flight of the day on a winter morning. The temperature was 2°C and it was raining slightly. The Captain checked that there was no deposited rime ice or ice during the pre-flight inspection. After take-off, the aircraft went into the clouds at about 4,000 feet and came out at about 15,000 feet.

The autopilot “Pitch Trim” warning appeared when the aircraft reached level 250. The copilot was then PF.

The Captain changed the distribution of tasks in the cockpit. He took over piloting and navigation and asked the copilot to deal with radio communications.

The autopilot was disconnected; the elevator control column was very hard to manoeuvre. The column became completely blocked at level 240.

The crew notified ATC about the flight control problems and requested a return to the departure aerodrome.

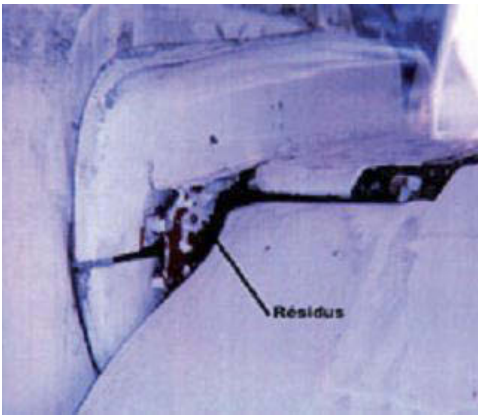
The controller to whom the aircraft was transferred redirected traffic and told the crew not to hesitate to ask him for any assistance that they would like. The crew then requested priority for approach.

When control was transferred again, ATC asked the crew if they wanted to declare an emergency; the answer was yes; ATC then asked them to squawk 7700 on the transponder and once again asked the crew to change radio frequency.

The new controller proposed radar vectoring for an ILS and asked for the number of passengers on board. The crew replied stating that the emergency was due to blockage of the elevator and that the aircraft could only be controlled through the trim; in manual control, the Captain controlled the aircraft pitch using the trim tab. The crew suspected an icing problem, and performed several de-icing procedures during the descent.

Radar vectoring for a long final approach was suggested to the crew who then asked for line-up at 12 NM.

The crew recovered use of the elevator at about 1,000 feet and landed without damage 17 minutes after the warning appeared. On the ground, residues from the de-icing fluid that were still melting were found in the joints between the elevators and the control tabs.



Additional information

Elevator system

On the aircraft type considered, the two elevators are controlled by the displacement of the control tabs connected to the control columns via cables.

If these control tabs can no longer move freely, the control column can no longer be moved to control the pitch of the aircraft.

The change in the angle of attack of the trimmable stabiliser also provides the means of controlling the pitch of the aircraft. The control system of this trim is conventional and uses control column switches.

Since the primary pitch control was blocked, the crew could no longer control the pitch of the aircraft except by using the stabiliser trim.



Residue taken from the aircraft before and after hydration.



Type IV fluid before and after hydration

Characteristics of anti-icing fluids

The residues found were analysed. They comprised a gel originating from an acrylic polymer used as a thickener in type II and IV de-icing/anti-icing fluids and a very small quantity of propylene glycol (less than 1%), and paint debris and water (photo 1).

The process for formation of these residues was reproduced; type II and IV fluids lose 90% of their mass in 40 hours, by evaporation of water and glycols in a dry air stream at ambient temperature. The dry extract formed following this evaporation was composed predominantly of the acrylic polymer and the thickener.

When this dry extract is subsequently hydrated (for example by drizzle), it produces a large volume of gel (98% water, sponge effect photo 2). The freezing temperature of this gel is close to 0°C.

Maintenance operations

Note: Maintenance procedures drew attention to the possibility that this type of residue might be present, but can be so thin that it is difficult to detect it visually. It is also impossible to detect the dry extract formed during a pre-flight inspection using usual available means.

Lessons Learned

This incident was due to the presence of residues of anti-icing fluid thickeners in the hinges between the elevators and trim tabs. These residues had dried and were then rehydrated by rain, and then froze while climbing at negative temperatures, with the result that they blocked the elevators. The operator modified the inspection procedure after the incident. The procedure consists of spraying water to rehydrate any residues that might be present so that they become more easily detectable, as can be seen in photo 1.

Intervals between inspections were reduced to make a periodic check that depends on the number of times that type II and IV fluids are applied.

The duration of the inspection is about 30 minutes and a two-step cleaning and de-icing / anti-icing procedure (which requires about 2 hours) will have to be undertaken if any residues are found.

Note: At the moment, there is no standard procedure for inspections related to the use of anti-icing fluids on aircraft guaranteeing the detection of dry residues (intervals between inspections, rehydration principle, detection methods, etc.).

Difficulties in controlling pitch axis due to ice around elevator control cables

History of Flight

The event took place in early April. After two legs, the crew of a twin-turboprop needed to make a very short leg starting from an aerodrome with very little assistance. A snow shower then fell on the aerodrome, and lasted for about an hour.

The wings and the airframe were covered with snow shortly before departure. The de-icing equipment had not been maintained in working order for the previous two weeks because the winter period was over. It was impossible to start it up quickly because it would require warming up for several hours. The airline operations service announced a delay. At the same time, a passenger put pressure on the crew to make the flight.

The crew searched for a way of removing snow from the aircraft. Snow was removed from the wings using a brush. The snow was thus cleared away and melted quickly. Since the aerodrome had so little equipment, there was not even a ladder because the only ladder was on the de-icing unit. Since there was no station manager present, it was impossible to access this equipment. The method used to clear snow from the horizontal stabiliser that was at a height of 8 meters above the ground was to manoeuvre the elevator, making sure that the snow slid off and that water flowed between the horizontal stabiliser and the elevator.

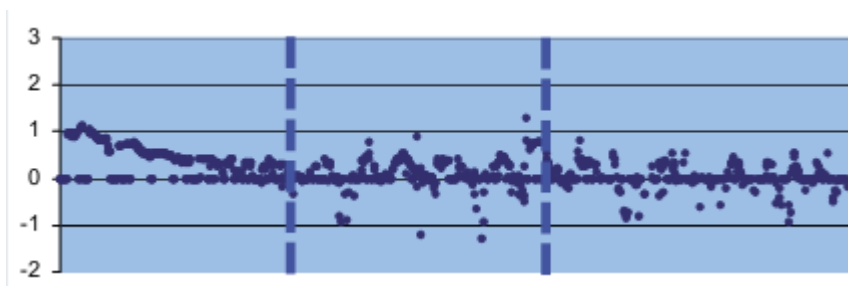
Takeoff and climb took place normally in cloud cover. Once above 3,000 feet, the crew observed that rime ice was beginning to form on the aircraft. The autopilot was on and climb continued. 3 minutes after takeoff, the aircraft was in clear sky at approximately level 100. After commanding a modification to the pitch attitude to accelerate the aircraft, the copilot who was PF saw the elevator control move backwards towards him. The crew reacted by undertaking the pitch trim procedure. Once the autopilot was disconnected, the elevator control was difficult to move and the aircraft tended to climb. The crew issued a distress message and decided to descend to level 60. The meteorological analysis made before the flight had told them that the 0°C isotherm was at this level and that they would once again be in clear sky at a distance of about twenty nautical miles from the departure aerodrome. Therefore by choosing this altitude, they would be able to eliminate any rime ice deposit. Normal operation of the elevator control was in fact restored at about this level. The remainder of the flight proceeded normally and the landing was made without further incident. No malfunctions were found during an inspection of the aircraft elevator system on the ground. There were no longer any ice deposits. The flight recorders were removed.

Additional information

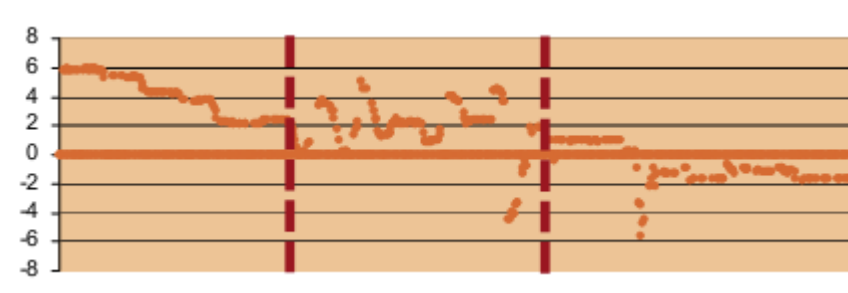
A subsequent inspection of the area behind the pressurized bulkhead revealed the presence of debris (rivets) on the floor of the airframe. This is the area in which there are two water evacuation drains from this part of the aircraft.

Note: An airworthiness directive was made about the installation of a second drain following events in which freezing of stagnant water had caused blockage of elevator cable crossings. The maintenance manual also states that an inspection of this zone should be made. The pre-flight inspection also includes a check on the condition of the drains.

The following figure shows variations of FDR parameters at about the time of the event reported by the crew. The recording was not of very good quality, and there are several aberrant points. However, the trend in changes to these parameters can be seen.



Position of the elevator control



Position of the pitch trim

Three distinct sequences can be identified, as illustrated on the graphs by dashed separation lines:

- Initially, it can be seen that the positions of the elevator control and the trim vary in the same direction, tending to reduce the pitch attitude. This corresponds to the action of the autopilot to control the pitch attitude. Since climb thrust is applied during this phase, the speed increases.
- Subsequently, without any action by the crew, the autopilot commands a more pronounced nose-down action using the trim, but without any movement of the elevator control. Oscillations in the trim and elevator control then occur. These oscillations are characterised by phase opposition between the trim and the elevator control, in other words the trim appears to act first, followed by an opposite order from the elevator control.
- The third phase is characterised by relative stabilisation of the trim, while oscillations of the elevator control around the neutral are observed. Rapid displacement of the trim towards a nose-down position then occurs, immediately followed by a return to a slightly negative position.

The backward movement of the elevator control and the sensation of stiffness in the controls can be interpreted by considering a scenario determined after work done in cooperation with the manufacturer and the operator. Based on the parameters, system characteristics and reported or supposed actions by the crew (considering procedures and practices) and subsequent inspections made on the aircraft, the event can be explained as follows:

- The phenomenon occurred while the speed was increasing from 170 kts to 200 kts.
- The autopilot was activated in a pitch attitude hold mode. The autopilot was disconnected at a time that cannot be identified with any certainty. In attempting to control the pitch, the autopilot uses electric motors to control the position of the elevator control, immediately followed by trim compensation.



Passage of flight control cables at the aft pressurized bulkhead

The snow covering the aircraft before departure was probably heavy and sticky. It stuck to the fuselage particularly and consequently to the horizontal stabiliser. As the outside temperature was increasing before takeoff, the snow was transformed into water which penetrated into the tail fin box, probably through the vent panel. This water could not all escape through the drains provided for this purpose before takeoff, because this area of the aircraft was more or less covered with debris. The climb under freezing conditions caused this stagnant water to freeze. Friction phenomena at the cable passage generated large forces on the elevator control. Consequently, operation of the autopilot was abnormal, creating particular difficulties in stabilising the aircraft, thus causing the oscillations observed in phase 2. Observing unusual movements of the elevator control, the crew disconnected the autopilot and performed the pitch trim procedure. The high forces felt on the controls could also be the result of this abnormal friction.

Lessons Learned

The descent to an altitude at which the temperature was positive explains the disappearance of this phenomenon.

The preponderant factor in this event is incomplete de-icing of the aircraft. The Captain decided to undertake the flight despite uncertainty about the condition of the horizontal stabiliser surface, due to the context. It was possible that flight conditions below 0°C IS0 would be encountered. However, the occurrence of unexpected phenomena put the pilots in an unusually stressful situation.

The presence of debris close to the drains contributed to the retention of water. The possible consequences of an obstruction illustrate the importance of being vigilant in these matters.

The operator took the following measures following the incident:

- The period during which de-icing equipment was available at this aerodrome was prolonged until the end of the month of April.
- A means of checking the condition of the elevator was installed in all stopover aerodromes.
- Crews were provided with information and more extensive knowledge about icing and de-icing.

Takeoff after incomplete de-icing of horizontal stabiliser

History of Flight

An ATR 42 was making its first flight of the day on a March morning. The temperature was close to 0°C and the dew point was – 1°C. It snowed moderately for about ten minutes, half an hour before the planned departure time¹ and the crew decided to have the aircraft de-iced. Passengers were allowed to board. The de-icing operation was performed by a runway agent, working for the service company, in about fifteen minutes² while the crew in the cockpit pushed the control column to the forward stop in accordance with the de-icing procedure. The equipment used was a mobile crane tanker with a tank containing a heated mix of type II fluid and water. The tanker was parked at the side of the aircraft between the trailing edge of the wing and the tail unit.

The ground operations coordinator was in contact with the runway agent using a walkie-talkie, and notified the crew when the operation was over, from the control station. The copilot noticed that the leading edges of the wings were still contaminated. He notified the coordinator who performed the remaining de-icing himself, but only on the wings. The crew did not perform the special flight control deflection test procedure after de-icing and before start-up.

The PF found the elevator control fairly heavy to manoeuvre during normal flight control tests at the holding point. He informed the Captain who did not feel the phenomenon. It was then concluded that the residues of de-icing liquid were the cause and that it would disappear with the relative wind during the takeoff roll.

The aircraft adopted a significant nose up attitude shortly after rotation. The crew had to bring the aircraft nose down to compensate for the nose up attitude. The maximum movement of the trim tab was reached and the crew had to push even more on the elevator control.

The crew stabilised the aircraft at FL 70 at a speed of 180 kts after several attempts, and diverted to its alternate field. The behaviour of the aircraft improved slightly. It landed with no further problems.

Additional information

Aerodynamic explanation of the phenomenon

The elevator hinge moment may be affected by the presence of residual ice or another contaminant on the tail. The boundary layer at the aft part of the profile is then modified. This phenomenon can force the elevator upwards. The crew must put the aircraft nose-down to restore equilibrium. If contamination is severe, the trim tab limit stop at the maximum nose down position can be reached before the elevator hinge moment is neutralised, and additional nose down forces have to be applied on the stick to reduce the aircraft attitude. More detailed explanations are given in the “Icing of fixed stabiliser and elevator” article in this issue.

De-icing procedures

The operator must define procedures to be followed for de-icing or anti-icing on the ground, and for checks of the condition of the aircraft after these operations. To achieve this, the instructions must be included in the operations manual.

The following procedures are extracted from separate parts of the operator’s manual.

The General part contains the following:

“Responsibilities

The Captain is responsible for the decision to deice and / or anti-ice [...].

The service provider responsible for de-icing and/or anti-icing (Airline runway agents, assistance contractor, CCI (Chambers of Commerce & Industry), other players, etc.) is responsible for:

¹ This was the only precipitation recorded before the aircraft took off.

² This was the first time that the agent had performed this operation.

- *making sure that the treatment is done properly and for the result obtained;*
- *training of assistance personnel [...].*

The mechanic shall make a visual and tactile inspection of the two wings, or the Captain shall make it if there is no mechanic, particularly after the treatment has been applied and before starting up the engines [...].

Checks

The person doing the work is responsible for checking the de-icing / anti-icing fluid and means (self-check) [...].

The authorised mechanic or the Captain makes a visual and tactile inspection after the operations. This check can determine if the treatment was effective and if all critical areas of the aircraft are free of rime ice, ice or snow before the push-back or taxiing [...].

After de-icing / anti-icing, the crew makes sure that all control surfaces deflect correctly, and it repeats this verification before the aircraft goes onto the runway.”

The Utilisation part of the Operations Manual contains other instructions about de-icing:

“The elevator control must be held firmly to the front stop during application of the fluid [...], so as to achieve the best possible de-icing / anti-icing of the horizontal stabiliser.

Forces higher than normal on the elevator control may be encountered after a de-icing / anti-icing procedure.

These forces can be twice as high as normal. This must not be interpreted as a blockage of the elevator control leading to an unnecessary decision to abort the takeoff beyond V1. Although this phenomenon is not systematic, it must be anticipated and it must be mentioned during the pre-takeoff briefing every time that a de-icing / anti-icing procedure has been applied. This increase in force on the elevator control is strictly restricted to the rotation phase³ and it disappears after takeoff.”

The assistance service provider

Each service provider is responsible for training its own personnel. An annual audit is made by the Quality Assurance department of the air operator who hires this service provider.

In this particular case, agents who might be required to perform the de-icing / anti-icing operations had attended a training course at the end of which a global authorisation to initiate, perform and check these operations had been issued.

This training course lasts one day and is purely theoretical. No practical training is given.

Lessons Learned

There are still some uncertainties about the procedure used for de-icing. The runway agent performed the operation for the first time without having received any practical training. This is why it was not easy for him to realise that he had not done it correctly. Since then, the assistance company has set up practical training for its agents. The visual and tactile check required by the operator after de-icing was not performed. Firstly, the mechanic was not present. Secondly, if a pilot were to make this check, he would have to put on a safety harness to climb onto the crane, which is not very practical at the time of departure. It is thus obvious that procedures for making inspections are not appropriate for all situations that can occur during a stopover. Furthermore, the

³ This phenomenon cannot explain a sensation of abnormal forces on the elevator control during deflection tests on this control.

ground de-icing / anti-icing procedures are described in two different manuals ⁴, which can explain why not all of them were applied, particularly the tests on controls after de-icing.

⁴ A simplified guide may be helpful for crews because these operations are not very frequent