Statens haverikommission
Swedish Accident Investigation Board

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Final report RL 2011:16e

Serious incident to aircraft SE-MAP at Helsinki/Vantaa Airport in Finland, on 11 January 2010

Case L-07/10

The report is also available on our website: www.havkom.se

Statens haverikommission
Swedish Accident Investigation Board

EASA
ICAO

Final report RL 2011:16e

The Swedish Accident Investigation Board (Statens haverikommission) has investigated a serious incident that occurred on 11 January 2010 at Helsinki/Vantaa Airport in Finland, involving an aircraft with the registration SE-MAP.

The Board hereby submits, in accordance with Regulation (EU) No. 996/2010 on the investigation and prevention of accidents and incidents in civil aviation, the following report on the investigation.

The Board looks forward to receiving, by 1 Mars 2012 at the latest, particulars concerning what measures have been taken in response to the recommendations included in this report.

Carin Hellner Stefan Christensen

1 FACTUAL INFORMATION 1
1.1 History of the Flight 1
1.1.1 Background 1
1.1.2 The Flight 1
1.1.3 The Incident 1
1.1.4 Previous Incidents – General 2
1.1.5 Known similar incidents – Summary 2
1.1.6 Serious Incidents 4
1.2 Injuries to persons (SE-MAP) 4
1.3 Damage to the aircraft 4
1.4 Other damage 5
1.5 Personnel Information (SE-MAP) 5
1.6 The Aircraft (SE-MAP) 5
1.6.1 General 5
1.6.2 Aircraft type 5
1.6.3 Elevator System 6
1.6.4 Pressure Distribution – Stabiliser 6
1.6.5 Elevator disengagement and emergency control system ... 7
1.6.6 Cockpit Warning Systems 10
1.6.7 Elevator Clearance 10
1.7 Meteorological Information 11
1.8 Navigation Aids 11
1.9 Radio Communications 11
1.10 Aerodrome Information 11
1.11 Flight Recorders 11
1.11.1 Flight Data Recorder (FDR) 11
1.11.2 Cockpit Voice Recorder (CVR) 13
1.12 Site of Occurrence 13
1.12.1 Site of Occurrence 13
1.13 Medical Information 13
1.14 Fire 13
1.15 Survival Aspects 13
1.15.1 General 13
1.15.2 Actions of Rescue Services 13
1.16 Tests and Research 13
1.16.1 Technical Examination of Individual Aircraft 13
1.16.2 Measurement of Elevator Clearance 14
1.16.3 Practical Full-Scale Tests – Series 1 15
1.16.4 Practical Full-Scale Tests – Series 2 17
1.16.5 Practical Full-Scale Tests – Series 3 17
1.16.6 Documentation of Deicing Fluid Flows on Stabiliser and Elevator 18
1.16.7 Research by Type Certificate Holder 22
1.16.8 Examination of Deicing Fluids – Practical Tests 22
1.16.9 Examination of de- and antiicing Fluids – Laboratory Tests 24
1.17 Organisational and Management Information 25
1.17.1 Organisation 25
1.17.2 Management of Incidents 25
1.17.3 Reporting of Incidents 25
1.17.4 Regulating Authority's Management of Reports 26

1.18 Additional Information 27
1.18.1 De- and antiicing – General 27
1.18.2 Procedures and Rules 27
1.18.3 De- and antiicing Fluids 28
1.18.4 Properties of the Fluids 29
1.18.5 Measures Taken – SHK 30
1.18.6 Measures Taken – TC Holder 31
1.18.7 Measures Taken – EASA 32
1.18.8 Measures Taken – Swedish Transport Agency 33
1.18.9 Measures Taken – Operators 33
1.18.10 Previous AIB Recommendations 34
1.18.11 Environmental Aspects 34
1.18.12 Equal Opportunities Issues 34
2. ANALYSIS 35
2.1 Background 35
2.1.1 General 35
2.1.2 De- and antiicing 35
2.2 Practical Management 36
2.2.1 Take-Off Procedure – Operational 36
2.2.2 Deicing Procedure – Suppliers 36
2.2.3 Technical Inspections Following the Incidents 37
2.3 Deicing Fluids 37
2.3.1 General 37
2.3.2 Analysis of the Fluids Used 38
2.3.3 Practical Tests 38
2.3.4 Chemical Analyses 39
2.4 Authorisation and Use of Fluids 39
2.4.1 General 39
2.4.2 Certification 40
2.5 The elevator restrictions 41
2.5.1 Elevator Functioning 41
2.5.2 Gap 41
2.5.3 Practical Tests 42
2.5.4 Connection between Fluid - Gap - Pressure Changes 43
2.6 Measures Taken 44
2.6.1 General 44
2.6.2 Operators 45
2.6.3 Regulating Authorities 46
2.7 Flight Safety Consequences 47
2.7.1 Operational Management 47
2.8 Conclusions 47
3 CONCLUSIONS 50
3.1 Investigation Findings 50
3.2 Causes of Incidents 50
4 RECOMMENDATIONS 51

Enclosures:

1. Operational report West Air
2. Operational report West Air
3. Operational report Next Jet
4. Operational report Next Jet
5. Letter to the Swedish Transport Agency (Swedish only)
6. Minutes of Meeting
7. Report from Exova AB (Swedish only)
8. Operational info FAA
9. Report from BAe Systems
10. EASA SIB
11. EASA AD
12. Letter from the Swedish Transport Agency

General

The Swedish Accident Investigation Board (Statens haverikommission – SHK) is a state authority with the task of investigating accidents and incidents with the aim of improving safety. SHK accident investigations are intended so far as possible to determine both the sequence of events and the cause of the events, along with the damage and effects in general. An investigation shall provide the basis for decisions which are aimed at preventing similar events from happening again, or to limit the effects of such an event. At the same time the investigation provides a basis for an assessment of the operations performed by the public emergency services in respect of the event and, if there is a need for them, improvements to the emergency services.

SHK accident investigations try to come to conclusions in respect of three questions: *What happened? Why did it happen? How can a similar event be avoided in future?*

SHK does not have any inspection remit, nor is it any part of its task to apportion blame or liability concerning damages. This means that issues concerning liability are neither investigated nor described in association with its investigations. Issues concerning blame, responsibility and damages are dealt with by the judicial system or, for example, by insurance companies.

The task of SHK does not either include as a side issue of the investigation that concerns emergency actions an investigation into how people transported to hospital have been treated there. Nor are included public actions in the form of social care or crisis management after the event.

The investigation of aviation incidents are regulated in the main by the Regulation (EU) No 996/2010 on the investigation and prevention of accidents and incidents in civil aviation. The investigation is carried out in accordance with the Chicago Convention Annex 13.

Limitations

The investigation presented in this report is based on a specific occurrence at the airport mentioned, involving one particular operator. However, during the investigation facts have come to light concerning other occurrences, in which another operator was also involved. This report from SHK has therefore not focused solely on the specific occurrence in Helsinki; it can instead be viewed as a general investigation of the phenomenon that caused these occurrences.

No grounds emerged in the course of the investigation of the incidents which would justify a detailed examination of the crew members; consequently, SHK has chosen to limit the report so that it does not include information about individual crew members.

A further delimitation of the scope of the report is the fact that it has not been SHK's aim to examine in detail the causes of the phenomena noted in these incidents: it is not part of SHK's remit to carry out basic scientific research and/or to conduct highly detailed, in-depth analyses of all the problem areas – or possible solutions to them – associated with the occurrences investigated.

The investigation has focused on problem areas including aerodynamics, hydrodynamics, technology and mechanics, and construction issues. SHK's role with regard to the incidents is to point out what problems exist, and to explain under what circumstances they arise. The solution eventually adopted for tackling the problems is a matter for the type certificate holder and the authorities concerned.

The Investigation

The Swedish Accident Investigation Board (SHK) was notified on 15 January 2010 that an aircraft with registration SE-MAP was involved in a serious incident on 11 January 2010 at 19.00 hrs, at Helsinki/Vantaa Airport in Finland.

On delegation from the Finnish Accident Investigation Board, the incident has been investigated by SHK, represented by: Åsa Kastman-Heuman, Chairperson until 6 December 2010, succeeded thereafter by Carin Hellner; Stefan Christensen, Investigator in Charge; and Henrik Elinder, technical Investigator until 31 December 2010, succeeded thereafter by Staffan Jönsson.

The Board was assisted by Björn Brink as operative expert on decicing issues.

The investigation was followed by the Swedish Transport Agency through their representative Britt-Marie Kärlin until 15 August 2010, thereafter Ola Johansson.

Preliminary Findings

In accordance with Article 16.7 of Regulation (EU) No. 996/2010 on the investigation and prevention of accidents and incidents in civil aviation, on 11 January 2011, SHK presented an interim statement report on the preliminary findings of its investigation.

Report RL 2011:16e

L-07/10

Report finalised 23 November 2011

Aircraft: registration and model	SE-MAP, British Aerospace Systems Ltd.
Class/Airworthiness	Normal/Certificate of Airworthiness and valid Airworthiness Review Certificate (ARC).
Owner/Operator	Trident Aviation Leasing Services, P.O. Box 727, St. Paul's Gate, New Street, St Helier JE4 8ZB, Jersey, England/West Air Sweden AB, Box 5433, 402 29 Göteborg.
Time of occurrence	11-01-2010, 19.00 hrs, in darkness. Note: all times given in Swedish standard time (UTC + 1 hour)
Place	Helsinki/Vantaa Airport, Finland (pos. 6019N 02458E; 51 m over sea level)
Type of flight	Commercial air transport (cargo)
Weather	According to METAR EFHK at 18.50 hrs: Wind 170°/12 kts; visibility over 10 km in snow; broken clouds with base at 1100 ft; temp./dp M02/M04 °C, QNH 1001 hPa
No. of persons on board:	
crew members	2
passengers	–
Injuries to persons	None
Damage to aircraft	None
Other damage	None

Summary

A cargo aircraft of type BAe ATP was to fly from Helsinki to Copenhagen. Owing to the prevailing weather conditions, the aircraft had undergone a two-step deicing prior to departure. In the two-step deicing procedure, hot water is mixed with glycol (Type I fluid) to remove ice, frost and snow from critical surfaces on the aircraft; after this, a fluid containing thickening agent (Type II/IV) is applied, to prevent ice from reforming.

At takeoff, the control column could not be pulled back when the rotation speed was reached, and the pilot felt that the elevator movement was restricted. Takeoff was aborted and the aircraft taxied back to the apron. Once SHK's investigation had started, it was discovered that several similar incidents involving the same type of aircraft and similar conditions had occurred. Following an initial technical inspection, it could be noted that the individual craft which had experienced these incidents shared certain common denominators: deicing with Type II/IV, combined with too narrow a gap between the stabiliser and elevator, were determining factors in the incidents. In collaboration with one of the operators, SHK has carried out a series of tests to recreate and document the phenomenon. The test results verified the connection between too small an elevator hinge gap and elevator restrictions, in situations where deicing had been carried out using fluids containing thickening agents.

The investigations also showed that the process for drawing up specifications and requirements for deicing fluids is, to a certain extent, controlled by trade organisations. The investigation found, too, that at present no monitoring or specific inspection activities relating to these fluids are carried out by any pan-European aviation safety body. Neither is there any authorisation process, or

any set certification rules, with regard to the types of aircraft which can/may use different types of deicing fluids.

The incidents involving elevator restrictions were caused by a phenomenon which, for unknown reasons, occurs following the use of anti-icing fluids containing thickening agents, on individual aircraft where the stabiliser and elevator are too close together. One contributory factor was the fact that there were shortcomings in that part of the aircraft's type certification exercises that concerned anti-icing.

Recommendations

It is recommended that EASA should:

- Work for an extension of EASA's remit to include certification of fluids used for ground de- and antiicing of aircraft. *(RL 2011: 16e R1).*
- Investigate the possibility of tightening requirements on aircraft design organizations in terms of demonstrating that the aircraft has full manoeuvrability during all phases of the takeoff procedure after the application of de- and anti-icing fluids. *(RL 2011: 16e R2).*
- Actively consider the value of a wider use of Type III fluids, (or correspondant fluids), within the field of European Civil Aviation. *(RL 2011:16e R3).*

It is recommended that ICAO should:

- Within the international flight safety community, work to ensure that in the future, the issuing of requirements, specifications and definition of areas of use, aircraft de- and anti-icing fluids are made the responsibility of airworthiness authorities. *(RL 2011:16e R4).*

1 FACTUAL INFORMATION

1.1 History of the Flight

1.1.1 Background

The airline concerned – West Air Sweden – was to carry out a scheduled flight from Helsinki/Vantaa Airport in Finland, with a cargo of air freight. The aircraft, a BAe Systems ATP with registration SE-MAP, was permanently converted as a cargo carrier.

The flight was to be the return leg on the route in question, to Copenhagen/Kastrup Airport in Denmark. Earlier on the same day the crew had flown the aircraft from Copenhagen to Helsinki, and after a break were to carry out the return flight.

1.1.2 The Flight

After running through the operational conditions in accordance with standard routines, the crew checked and approved the cargo that had been loaded against the mass and balance sheet. The cargo consisted of freight with a total mass of 5100 kg. There was no record of the aircraft having any unrectified technical defects or malfunctionings. There were no reported difficulties or problem areas – of traffic-related or operational nature – affecting the planning or carrying out of the flight.

Owing to the prevailing weather conditions, the commander requested deicing of the aircraft prior to takeoff. In view of the fact that it was snowing, the decision was taken to carry out a two-step deicing, which means that firstly, a deicing fluid of Type I (for the removal of ice, frost and snow) is applied, after which Type IV fluid is used (to prevent ice from reforming).

Once the deicing procedure was completed, SE-MAP requested taxi clearance and was cleared to taxi to the holding position for runway 22R. While taxiing out the pre-flight checklist was completed, including, inter alia, a check for full mobility and full response of all flight controls. It had been decided that the co-pilot – who in this case was the pilot in the right-hand seat – would be PF (Pilot Flying) for the actual flight.

1.1.3 The Incident

SE-MAP was cleared for take-off on runway 22R. The first part of the take-off run was normal, with no sign of any faults or abnormalities. When calculated rotation speed (Vr) was reached, PF noticed that the control column could not be pulled back using normal effort for rotation. According to the pilot's report, there was a significantly increased level of resistance from the neutral position; and although PF pulled the column as far back as possible, the aircraft did not respond. The commander decided to abort the take-off, and the aircraft taxied back to the parking stand.

After the aircraft had parked, a check was made of the load and its distribution. No faults or deviations could however be identified. The Commander cancelled the flight.

The incident occurred at location 6019N 02458E, 51 m above sea level.

1.1.4 Previous Incidents – General

In addition to the incident in question here, a number of similar occurrences have taken place involving the same aircraft model – both in Sweden and in other countries – where there have been problems in rotating the aircraft under certain conditions. SHK had, on two previous occasions, received information from another country's national accident investigation authority concerning incidents involving ATP; these incidents had, however, not been judged to be sufficiently serious in the state where the incidents occurred for an investigation to be initiated, and for this reason SHK did not, at the time, deem there to be grounds for any further action to be taken in response to these occurrences.

That being said, in connection with the incident in Helsinki a pattern started to emerge: the operator concerned in this case was able to refer to a number of similar incidents, all of which had occurred abroad; and it also transpired that a series of events had occurred in Sweden without coming to SHK's attention.

These other events had occurred in aircraft being flown by a different operator, which operates commercial passenger flights. When SHK contacted this operator it emerged that the incidents – some of which were very serious – had been reported to certain offices at the Swedish Transport Agency, but the reports had not been forwarded.

The occurrences experienced by this other operator could be put together with the events reported to the first operator. Once SHK had carried out an initial analysis of the events, a number of common factors could be identified:

- the elevator movement was restricted and/or felt very stiff to manoeuvre in connection with takeoff rotation;
- the problems arose at speeds around Vr;
- the incidents were often accompanied by "Standby Controls" and/or "Split" warnings;
- all the occurrences took place during winter conditions;
- the aircraft had been deiced in preparation for flying;
- fluid of Type II or Type IV had been applied;
- full elevator travel had been confirmed in rudder checks before and after the incidents;
- no known balance problems had played a part in the occurrences;
- no technical/mechanical faults could be identified in the aircraft;
- the fault differed in character depending on whether the pilot performing take-off was seated on the right-hand or left-hand side.

In one of the incidents, an aftercheck found that the aircraft was more nose-heavy than the weight and balance sheet stated. The reason for this was that only part of the ballast ordered had been loaded for the preceding flight; on this preceding flight (where there was thus the same balance deviation) the crew had felt the aircraft to be a little nose-heavy, but stated that in all other respects takeoff and rotation had been normal.

1.1.5 Known similar incidents – Summary

When summarizing the events that have occurred involving similar symptoms, the following list can be compiled (the list embraces incidents from two operators). No other incidents experienced by other operators have come to SHK's attention.

Some of the operational reports for the occurrences are appended as attachments, (1-4), to this report.

Date	Aircraft	Airport	Event	Consequence	Deicing	Other
25 Jan 2007	LPV	BGO	Heavy rotation. ES	Flight	I + II	
16 Mar 2009	LNX	BGO	Manoeuvring problems in flight	Flight	Unknown	Landed at alternate airport
30 Nov 2009	LLO	AJR	Heavy rotation. ES	Flight	I + II	Serious
10 Dec 2009	MAP	CPH	Heavy rotation. ES	Aborted takeoff	I + IV	
22 Dec 2009	MAP	HEL	Heavy rotation. ES	Aborted takeoff	I + IV	Two takeoff attempts
23 Dec 2009	LLO	AJR	Heavy rotation. ES	Takeoff aborted, then completed	I + II	
11 Jan 2010	MAP	HEL	Heavy rotation. ES	Aborted takeoff	I + IV	
18 Mar 02010	LLO	HMV	Heavy rotation. ES	Flight	I + II	

Fig. 1. Incidents

Note 1: The abbreviation "ES" in the "Event" column stands for activation of the "Elevator Split" warning indicator on the aircraft's warning panel.

Note 2: The incident 16 March 2009 has partly been explained by findings of ice in the gap between stabiliser and elevator.

Note 3: At a technical check after the incident 18 March 2010, a misalignment in the synchro position transition system was detected.

In addition to the incidents in this list, a further incident involving the same symptoms occurred on 20 October 2010; on takeoff from Arvidsjaur – with the co-pilot as PF – rotation of the aircraft, (SE-MAL), could only be achieved with difficulty, at the same time as the "Elevator Split" warning was activated. Takeoff was continued, but after a short time in holding the commander decided to return to the takeoff airport to land. The aircraft had been two-step deiced prior to takeoff.

After thirty minutes waiting in the holding, the aircraft landed. The aircraft was checked, and a system reset carried out on the alternative system for elevator control (SCS – see 1.6.5, below). Thereafter a renewed attempt to take off with the passengers onboard was carried out. This takeoff was aborted after the system split when the craft reached rotation speed.

After the aircraft had taxied back to the ramp, the passengers disembarked, and another technical check and system reset were carried out. Another takeoff was attempted – this time with the left-hand pilot as PF – with the crew and technicians as the only persons aboard. This time the takeoff could be continued without any problems.

The gap between the elevator and the stabiliser had been measured four days before this incident occurred, and was found to be within the permitted limits in nearly all positions; the only measurement that was below the minimum level was a position on the left side with trailing edge down, where the gap was measured at 2.3 mm. When checks were carried out directly after the incident, however, all measurements were found to be above the fixed minimum levels. See also 1.16.5, below.

1.1.6 Serious Incidents

The occurrence entered in Figure 1 as having taken place on 30 November 2009, and which is classified as "serious", unfolded as follows:

Takeoff was from Arvidsjaur. Heavy snow was falling at the airport, and the commander had requested deicing with Type I and Type II. While the plane was taxiing out, checks were carried out on full travel of all the flight controls, in accordance with normal routines. It had been decided that the co-pilot would be PF for the flight in question. The individual aircraft was SE-LLO.

When rotation speed, Vr, was reached (99 kts), the co-pilot pulled the control column back to rotate the aircraft. The aircraft not showing any sign of responding, the co-pilot pulled harder on the column, and at the same time informed the commander that something was "wrong". At this point, the aircraft's speed was estimated to be 10–15 kts above takeoff decision speed, V1.

The commander took over the controls, and pulled back the throttles in the aim of aborting takeoff. At the same moment, however, the "Standby Controls" warning indicator on the central warning panel (CWP) was activated, and the aircraft lifted off from the runway.

When the aircraft left the ground the commander set full power again in order to keep the aircraft airborne. The co-pilot resumed the controls from the commander, and when the aircraft had reached a safe altitude they started going through the emergency checklist. As weather conditions were bad at the takeoff airport, the commander decided to continue flying to the destination airport, Stockholm/Arlanda. The flight proceeded without further incidents, and after arrival in Stockholm, technicians discovered that the elevator, for some reason, had stuck, and that an automatic disconnection (split) had therefore occurred during the flight (see 1.6.4, below).

1.2 Injuries to persons (SE-MAP)

	Crew members	Passengers	Others	Total
Fatal	–	–	–	-
Serious	–	–	-	-
Minor	–	–	–	–
None	2	–	–	2
Total	2	–	–	2

1.3 Damage to the aircraft

No damage to the aircraft occurred in any of the incidents referred to.

1.4 Other damage

No other damage occurred in any of the incidents referred to.

1.5 Personnel Information (SE-MAP)

The commander and the co-pilot had valid licences and were qualified to fly the type of aircraft in question.

1.6 The Aircraft (SE-MAP)

1.6.1 General

AIRCRAFT		
TC holder	British Aerospace Systems Ltd	
Model	ATP, cargo version	
Serial number	2037	
Year of manufacture	1991	
Gross mass	Max take off/landing mass 23680 kg, actual 21685 kg	
Centre of gravity	Within limits	
Total flying time	13242 hrs	
Number of cycles	16893 hrs	
Flying time since latest check	A-check: 192 hrs, C-check: 1995 hrs	
Fuel loaded before event	2750 kg Jet A1	
ENGINE		
TC holder	Pratt & Whitney	
Model	PW126A	
Number of engines	2	
Engine	No 1	No 2
Total operating time, hrs	11135	11035
Operating time since overhaul	5198	5868
Cycles since overhaul	5576	6496
PROPELLER		
TC holder	Hamilton Standard	
Model	6/5500/F-1	
Operating time since latest overhaul:		
Propeller 1	4873 hrs	
Propeller 2	310 hrs	

The aircraft had a valid Certificate of Airworthiness and a valid ARC (Airworthiness Review Certificate).

1.6.2 Aircraft type

The BAe ATP is a twin-engine turboprop aeroplane with a pressurised cabin. In its passenger version it can accommodate up to 72 passengers, and in its cargo version can carry up to 8 tonnes of cargo. A total of 64 aeroplanes of this model were built, between 1988 and 1996. A large number of the aircraft produced are operated by two Swedish operators and/or their subsidiary companies. The ATP is a development of an older type of aircraft, the HS748, which was built in the late 1950s. The HS748 has turboprop engines of an older kind, and is smaller than the BAe ATP, its fuselage being for example 5.5 m shorter.

Before it began to be used by Swedish operators, this type of aircraft only featured sporadically in Scandinavian airspace. BAe ATP is approved by the type certificate holder (TC) for winter operations, and for use of anti-icing fluids of Types II and IV. No restrictions, or warnings, have been issued by TC or any of the operators with regard to the use of anti-icing fluids. The only information available was found in the ATP MOM, Part 9, (Manufacturers Operating Manual), stating:

“*Operators should be aware that when using Type II or Type IV ground de/anti-icing fluid no performance adjustments are necessary, although higher stick forces than normal may be expected at rotation*”

BAe ATP was tested in 1991 with regard to the use of Type II fluid. The tests showed that increased stick force was needed on rotation after application of the fluid used in the test. The aircraft was certified for use with Type II, and in 1998 was also certified for use with Type IV fluids. However, Type IV testing was not carried out on the ATP, but on a different type of aircraft – the Jetstream 41 – as this type was considered to be more critically sensitive to effects arising from Type IV fluid.

Fig. 2. BAe ATP

1.6.3 *Elevator System*

The stabiliser with elevator is situated on the tail, at the same height as the engines. The elevator consists of two sections, the left elevator and right elevator, which normally are connected. The control column system in the cockpit consists of two parts, the right column and left column, and these, are also normally connected.

Transmission of elevator commands from the control column to the elevator is effected mechanically via a cable system in which the main components are cables, pulley clutches and control arms. The cable system is connected from the left-hand control column to the left-hand elevator, and linked to the right-hand control column as shown in the sketch, Figure 3.

1.6.4 *Pressure Distribution – Stabiliser*

The main task of the stabiliser is to control the aircraft's longitudinal stability in all flight positions. The air-flow around the stabiliser creates forces which, depending on factors such as the distance from the centre of gravity, produce a moment of force which stabilises the aircraft. The forces – and therefore the moment – vary with the air-flow. The aircraft's speed, and the propeller slipstreams, are two factors which affect air-flows, and thus the air forces around the stabiliser during takeoff acceleration. The elevator breaks these air-flows, thus making it possible to control the pitch of the aircraft. Part of these air-flows also pass through the gap between the stabiliser and the elevator.

SHK has asked TC to provide access to data from aerodynamic wind-tunnel tests of the ATP's stabiliser; the reason for this is to study the values of air-flows – and their changes – during takeoff acceleration. TC responded by explaining that there was no data available relating to pressure distribution around the stabiliser and elevator. TC referred SHK instead to estimated figures calculated for another type of aircraft, the ATP's predecessor, HS 748, which has the same stabiliser as the ATP.

This absence of data concerning the pressure distribution around the tail of the aircraft means that there is an absence of important factual input for studying this aspect of the investigation.

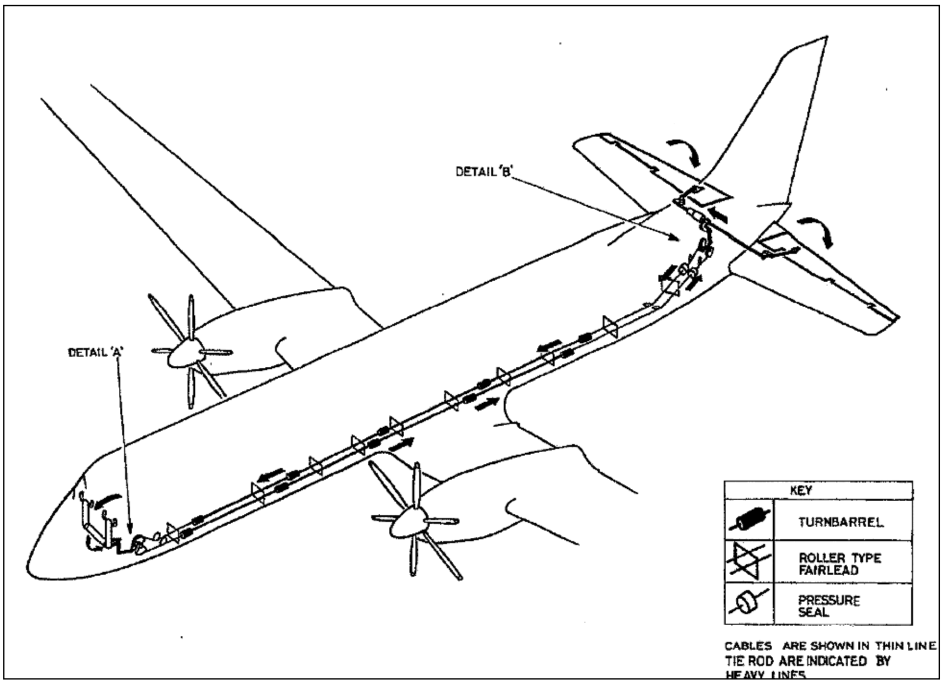

Fig. 3. Sketch of elevator mechanism

1.6.5 *Elevator disengagement and emergency control system*

To ensure that it is always possible for the pilots to control the aircraft's pitch with at least one elevator in the event of one part of the elevator sticking or jamming during flight, there is a disengagement and emergency manoeuvring system.

The elevator system is equipped with double disengagers and an emergency manoeuvring system called "Elevator Standby Control System" (SCS) which, in certain conditions, is activated when disengagement occurs in the elevator system.

The left-hand and right-hand control columns are connected via a mechanical disengagement unit called the Detent Mechanism. The connection is disengaged – without any intervention from the pilots – if opposing forces greater than 45 kp arise between the two control columns. SCS is activated when the control columns have been separated by means of the Detent Mechanism. This may be a consequence of sluggishness or jamming in the functioning of the elevator, or a result of the systems having been manually separated using the "Force Relief Handle", provided that the right-hand half of the elevator is not jammed.

Using the Force Relief Handle control, which is situated between the two pilot's chairs, the Detent Mechanism can be fully released; this disengages the control columns from each other, meaning that they can be manoeuvred without any resistance between them. Resetting the system after a manual disengagement of this kind is a measure that is carried out by technicians when the aircraft is on the ground.

SCS can also be activated when discrepancy arises between the angular displacement encoder on the right-hand control column, and the angular displacement encoder of the elevator position. This activation may, for example, occur in the event of a cable rupture in the elevator system.

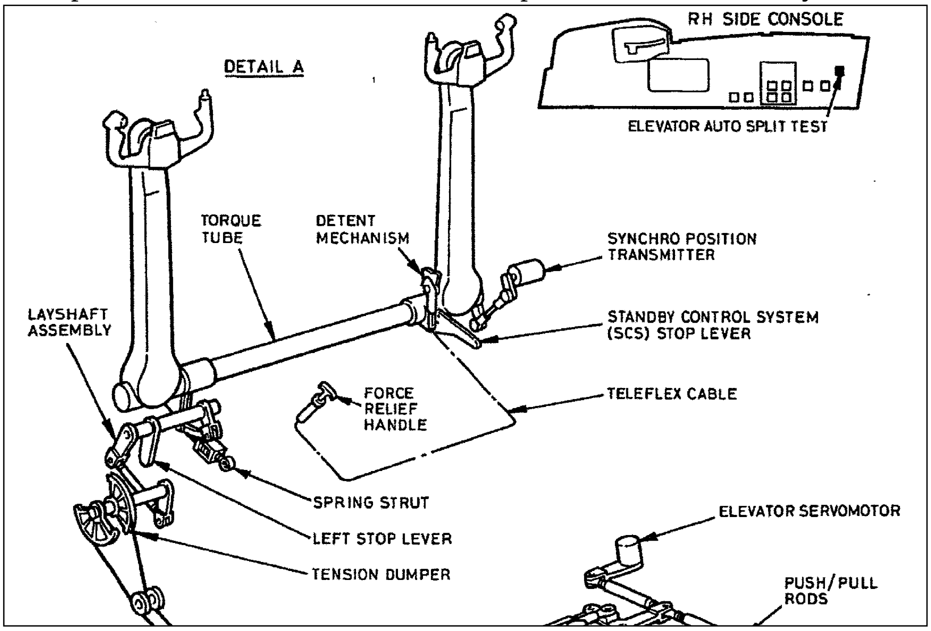

Figure 4. Control column in cockpit

The left-hand and right-hand elevator sections are connected via an electromechanical disconnect mechanism. This connection can only be disengaged via an electrical signal. Reset of a disengaged system can only be carried out when the aircraft is on the ground.

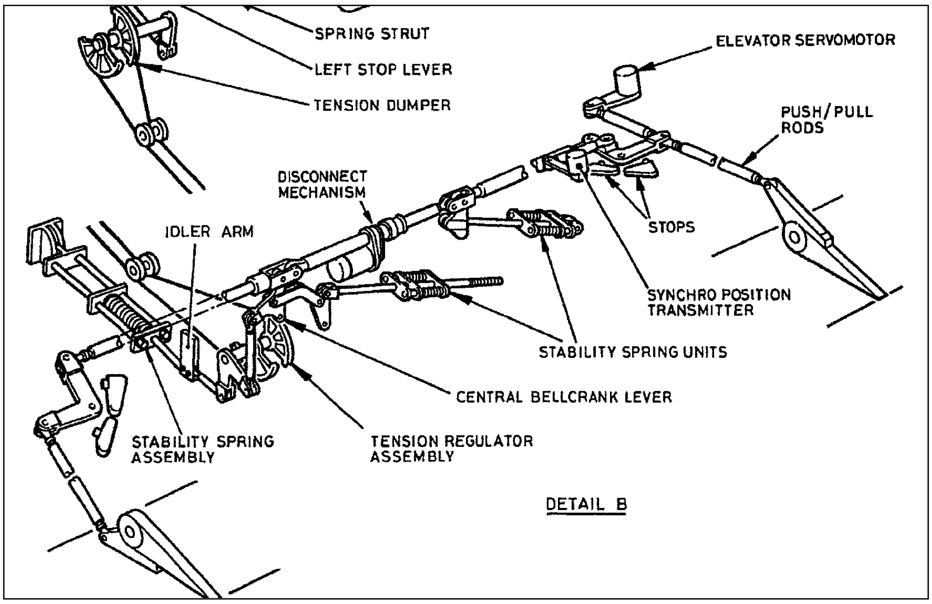

Figure 5. Elevator control and disconnect mechanism.

General Function
Depending on where jamming occurs in the elevator system, control over the aircraft's pitch motion can be retained using two alternative methods.

If jamming occurs in the left-hand system, the right-hand control column can be released from the left-hand column if sufficient stick force is applied, or if the detent mechanism is released manually using the Force Relief Handle. When this happens, an electrical circuit is closed which, if the aircraft's speed is less than 140 kts, activates the disconnect unit, releasing the right-hand elevator section from the left-hand one.

In such a situation SCS is activated automatically, and thereafter SCS ensures that the movements of the right-hand control column are electrically transmitted to the right-hand elevator. Transmission is effected via an electrical syncho position transmitter, which is situated on the right-hand control column, and the autopilot's ordinary elevator servo motor, which is connected to the right-hand elevator.

If jamming occurs in the right-hand system (i.e. in the right-hand control column or right-hand elevator), the left-hand control column can be released from the right-hand column in the same way as described above; this also entails that the left-hand elevator section will be disconnected from the right-hand one. Once the release procedure has been effected, the left-hand elevator can be manoeuvred from the left-hand control column via the regular cable system.

Manoeuvring from left or right side
The aircraft can be controlled from both pilot positions in the cockpit. However, differences in the control system mean that there are differences in how the controls work. The two control columns are connected by a torque tube. A clutch mechanism makes it possible to disconnect the right-hand column from the torque tube. The clutch mechanism is released by manoeuvring the right-hand column with the required degree of force. Or by the use of the force relief handle.

In cases where the elevator sticks or jams – with manoeuvring only being carried out via the right-hand column – and the required degree of force is applied, the clutch mechanism disengages. When manoeuvring the aircraft solely from the left-hand column, application of a corresponding degree of force does not release the clutch mechanism, provided that the right hand column is allowed to move freely.

If the aircraft is rotated with split elevators it might affect the aircraft performance, as the total lift forces of the elevator system will be degraded if only one half of the elevator can be used. Besides a marginal increase of take off roll distance, this could for example also affect the conditions in certain recovery situations.

1.6.6 *Cockpit Warning Systems*

Every type of disengagement or activation of SCS triggers different types of optical and acoustic warning signals to the pilots. In cases where the SCS (the emergency system) has been activated – automatically or manually – the STANDBY CONTROLS indicator on the central warning panel (CWP) lights up in amber, at the same time as indicators (Master Caution) are activated at the respective pilot position.

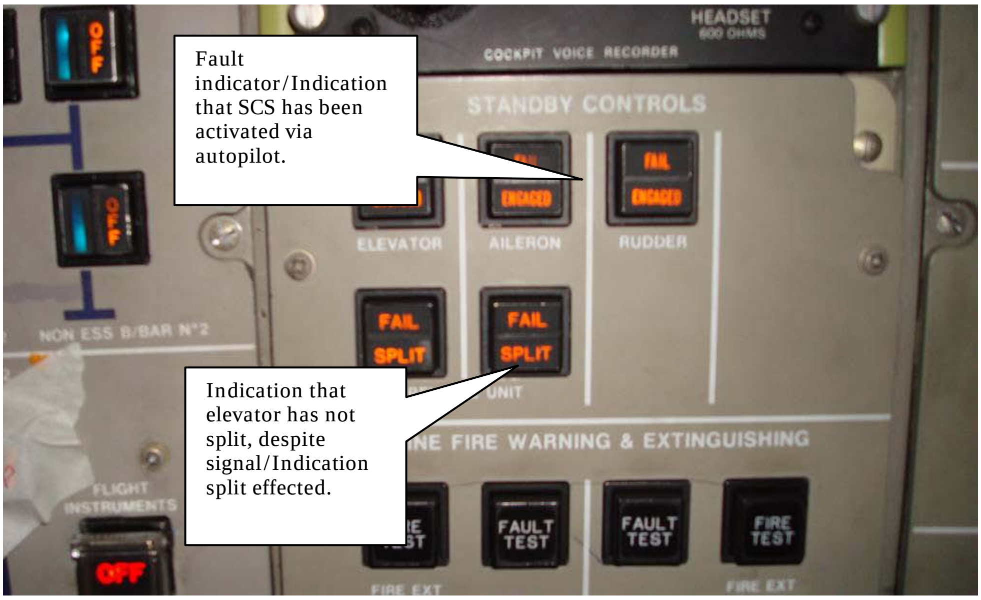

Fig. 6. Cockpit system panel

When SCS is activated an amber indicator/control button on the overhead panel illuminates, with the legend "ENGAGED". The panel also have indicators to inform the pilots when the right-hand and left-hand halves of the elevator have been separated from each other ("SPLIT"), and also fault indicators which illuminate if the systems have not separated despite a signal having been given.

1.6.7 *Elevator Clearance*

Each part of the elevator is hinged to the rear edge of the stabiliser using three bearings. There are specified tolerances for the permitted range of clearance of the elevator where it fits into the stabiliser's sockets, at both the front and side edges of the elevator, as shown in Figure 7. These measurements cannot be adjusted.

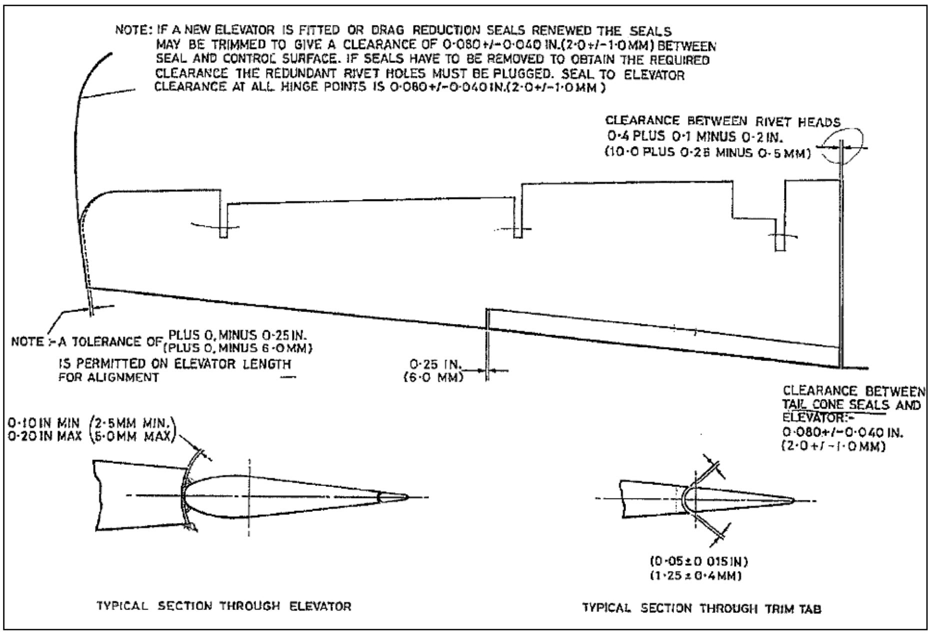

Figure 7. Tolerances for elevator clearance, according to AMM[1].

1.7 Meteorological Information

According to METAR EFHK, at 18.50 hrs: wind 170°/12 kts; visibility over 10 km in snow; broken clouds with base 1100 ft; temp./dp M02/M04 °C, QNH 1001 hPa.

1.8 Navigation Aids

Not applicable.

1.9 Radio Communications

Not applicable.

1.10 Aerodrome Information

Airport status was as per AIP[2] Finland. There was a certain amount of snow on the runway; runway friction at the time was recorded as 79/53/46 (friction coefficient relating to thirds of the runway's length).

1.11 Flight Recorders

1.11.1 Flight Data Recorder (FDR)

For some of the occurrences, data from the aircrafts' FDRs has been used in the analysis, although in SHK's judgement this data does not constitute factual material that is of determining importance for the investigation. It has nevertheless in certain cases been possible to use FDR data: to supplement the

[1] AMM: Aircraft Maintenance Manual
[2] AIP: Aeronautical Information Publication

statements submitted by crew members with regard to when and how the phenomenon arose; and to provide technical verification that a split occurred at a given speed.

The graphic in Figure 8 is an FDR extract from one of the incidents – takeoff from Arvidsjaur, 23 December 2009. The co-pilot, who on this flight was in the right-hand seat, was to be PF. Conditions at the airport were visibility 3000 m in snowfall, so a two-step deicing had been carried out.

From the extracts we can see that a split took place approximately 25 seconds after the takeoff procedure started and the aircraft started moving down the runway. The left/right elevator split occurred at a speed (CAS[3]) of 115 kts, which is 15 kts over the calculated liftoff speed, Vr.

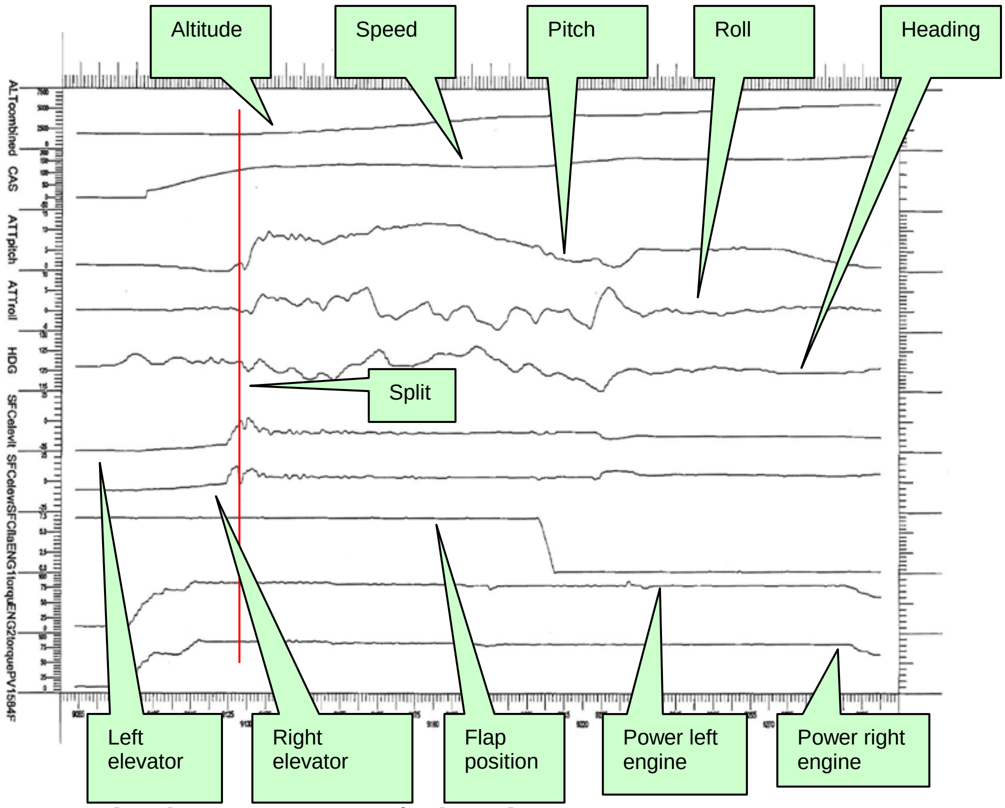

Fig. 8. Graphical representation of selected FDR parameters.

The angular difference between the two elevator halves was in this case 17.7 degrees at the moment when the systems separated (in this particular case it was the right-hand elevator half that was released). According to the pilot's report, the co-pilot, on reaching Vr, announced that something was wrong, at which point the commander took the decision to complete takeoff, and also helped in rotating the aircraft.

When the systems split, the warning indicator for "Standby Controls" illuminated, which meant that the system indicator on the overhead panel indicated "SPLIT" throughout the rest of the flight. After the emergency checklist had been completed, the crew took the decision to return to the takeoff airport to land, and this was achieved with no further complications.

[3] CAS: Calibrated Airspeed (Indicated speed corrected for reading and instrument errors)

1.11.2 Cockpit Voice Recorder (CVR)

No CVR recordings have been used in this report.

1.12 Site of Occurrence

1.12.1 Site of Occurrence

The incident which this investigation is primarily based on occurred during takeoff from runway 22R at Helsinki/Vantaa Airport in Finland. The other known incidents of a similar kind included in this report occurred at various airports in the Nordic region.

1.13 Medical Information

No information has come to light which might suggest that the physical or mental condition of the pilots was in any way impaired before or during the flight.

1.14 Fire

Not applicable.

1.15 Survival Aspects

1.15.1 General

Not applicable.

1.15.2 Actions of Rescue Services

Not applicable.

1.16 Tests and Research

1.16.1 Technical Examination of Individual Aircraft

Technical inspections were carried out following several of the incidents referred to. In those cases where a split occurred, the system was reset, and the aircraft could be immediately returned to service with no further technical measures being necessary.

In those few instances where no split occurred (in most of these cases, the pilot in the left-hand seat was PF), technical trouble shooting was carried out; as no faults were located the aircraft could be returned to service with no further technical measures being necessary. The only known exemption was the incident 18 March 2010, where a misalignment in the synchro position transition system was detected.

At several occasions, extensive technical checks were carried out on the systems involved; these checks embraced the ordinary elevator control system, standby systems, cable systems, the force required to disengage the systems, etc. However, these technical inspections did not identify any malfunctions or other abnormalities in the elevator control systems or stand by control systems.

1.16.2 Measurement of Elevator Clearance

In collaboration with one of the operators, West Air Sweden, SHK embarked on a more detailed control of the aeroplanes. The checks focused on the stabiliser and the elevator construction attached to it. As has been mentioned above, minimum values have been established for the clearance, or size of gap, between the fixed part (the stabiliser) and the hinging, movable part (the elevator). The minimum gap, according to the AMM, is 2.5 mm.

During the initial controls on certain aircraft, it was found that in certain positions, the gap between the stabiliser and elevator was less than the permissible minimum. In order to compare different individual aircraft, six measurement points were designated (P1 – P6 in Fig, 9) at certain positions along the gap.

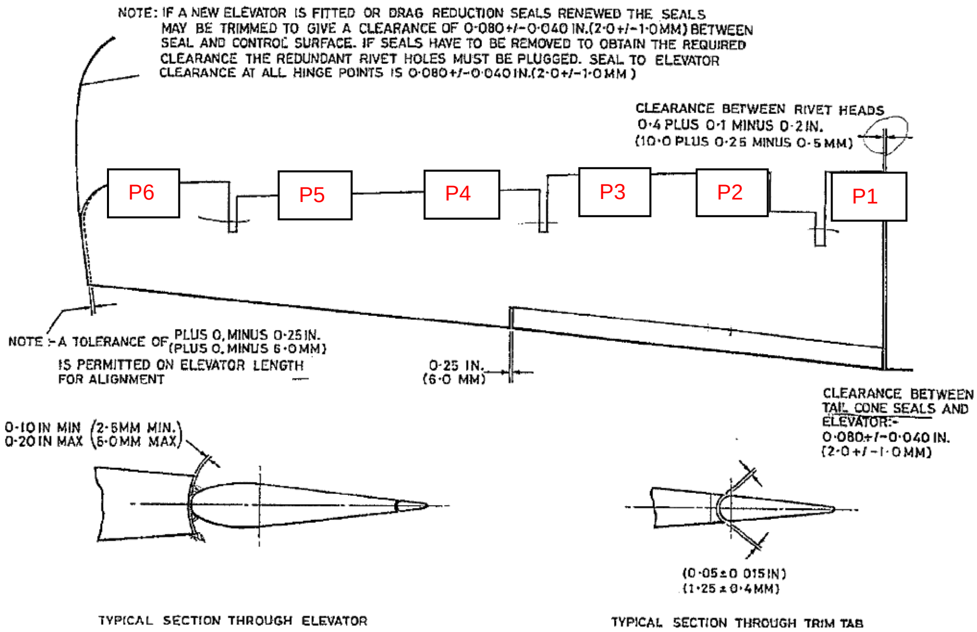

Fig.9. Measurement points

When checking the measurement results from individual aircraft where the gap was below the permissible minimum, and comparing with those individual aircraft which had experienced incidents of the kind referred to here, a probable correlation was identified: of the individual craft which had experienced problems at rotation, the majority displayed – at one or more of the measurement points along the elevator hinge gap – measurements which were below the permitted minimum value for the gap, as laid down in the AMM. The following table summarises the sets of measurements carried out on certain individual aircraft from the fleets of the two operators.

SE-MAP original (West Air)

Position	AMM min	MAP L/H	Diff (mm)	MAP R/H	Diff (mm)
1	2.5	2.1	-0.4	2.5	0.0
2	2.5	2.1	-0.4	2.0	-0.5
3	2.5	2.1	-0.4	2.3	-0.3
4	2.5	2.1	-0.4	1.9	-0.6
5	2.5	2.7	0.2	1.5	-1.0
6	2.5	1.0	-1.5	1.7	-0.8
Mean	**2.5**	**2.0**	**-0.5**	**2.0**	**-0.5**

SE-LLO original (Next Jet)

Position	AMM min	LLO L/H	Diff (mm)	LLO R/H	Diff (mm)
1	2.5	3.5	1.0	4.7	2.2
2	2.5	2.5	0.0	5.1	2.6
3	2.5	2.5	0.0	4.6	2.1
4	2.5	2.5	0.0	3.6	1.1
5	2.5	2.8	0.3	2.8	0.3
6	2.5	**0.7**	-1.8	2.9	0.4
Mean	**2.5**	**2.4**	**-0.1**	**3.9**	**1.4**

Fig. 10. Tables of measurement results, SE-MAP and SE-LLO.

The two aircraft which were checked for the tables above (SE-MAP and SE-LLO) were both the subject of incidents involving elevator restrictions at rotation speed. From the tables it can be noted that the measuring showed that, at one or more points, the elevator/stabiliser gap was smaller than the permitted minimum (L/H = left elevator, R/H = right elevator).

In light of the measurement results, SHK decided, together with West Air Sweden, to carry out a series of tests aiming to recreate the phenomenon that had occurred. The tests were also to be documented in an appropriate fashion.

1.16.3 *Practical Full-Scale Tests – Series 1*

A decision was taken to carry out the tests as high-speed tests on the runway at Malmö/Sturup Airport. Before testing started, the operator applied for – and received permission from the Swedish Transport Agency, via the Agency's technical Principal Inspector (PI) for the airline; and from Air Traffic Control at the airport. The National Civil Aviation Administration (LFV) at Malmö/Sturup, and the airport's emergency services, were also informed of the tests.

The pilots who were to carry out the test flights received special briefing, and used a specially formulated test protocol. The right-hand pilot was PF for the trials, and the date set for the first tests was 2 March 2010. The weather conditions at all test occasions were similar, temperature around freezing point and no precipitation.

Note:
The Swedish Transport Agency has during the draft process of this report stated the following:

“The technical PI gave a verbal acceptance from a technical perspective. Similar acceptance has not been requested from the operational PI. Verbal acceptance is not sufficient for modifications (installation of cameras), and for aircraft operations not associated with normal operations. For doing this a Permit to Fly with Flight Conditions approved by EASA is required, including modifications and operational aspects outside the type certificate.
The Transport Agency considers that tests of this nature should be carried out by the Type Certificate Holder.”

(Translated from Swedish by SHK).

To document the tests, two video cameras were mounted on the right-hand side of the aircraft's tail section; one of the cameras was directed towards the critical area between the stabiliser and elevator on the upper side, and the other camera was fixed to film the corresponding gap on the underside. Handheld cameras were used to document the application of deicing fluids and the course of events in the cockpit.


Fig. 11. Application of Type IV fluid in connection with the tests.

For the first test, Type IV fluid was applied to the aircraft. Prior to the tests, checks had been made by the handling agent to ensure that the fluids used conformed to the specifications given. The test was carried out using the aircraft SE-MAP, with a mass of 17250 kg and a centre of gravity index of 55. Rotation speed, Vr, had been calculated to 99 kts.

As the aircraft taxied out to the runway, the checklist was completed according to normal takeoff routines, including a check of full travel of flight controls with no abnormalities to report. The simulated takeoff was initiated as a normal takeoff, and to begin with everything went as normal.

When rotation speed, Vr, was reached, PF began a normal rotation. According to the interview, the controls felt "heavy", and they "stuck" without the aircraft showing any tendency to rotate. Takeoff – and the test – were aborted before the systems had split, and the aircraft taxied back to the ramp.

The stabiliser area of the aircraft was rinsed clean using hot water. When the surfaces were judged to be absolutely clean, deicing fluid of Type I was applied. The test process was repeated, following the same procedure and under the same conditions. When rotation speed had been reached in this test run, PF was able to pull back the control column as normal and the aircraft rotated as normal. The crew discontinued takeoff once the nosewheel had left the ground, and taxied back to the ramp.

1.16.4 Practical Full-Scale Tests – Series 2

On 10 March 2010 the second part of the planned testing was carried out. The first test of this second series was carried out using the same individual craft, SE-MAP, the difference being that now, deicing fluids of Types I and II were applied to the aircraft. Centre of gravity and mass were the same as for the first test series.

When attempting takeoff, the same phenomenon occurred as in the previous test using Type IV fluid. PF felt a strong resistance when trying to pull the control column down at Vr, and felt that the column got "stuck" without the craft showing any tendency to rotate. The trial was aborted, and the aircraft taxied back in. The elevator showed full mobility in the checks both before and after the attempted takeoff.

For the next test another individual aircraft was used, SE-LPU, for which the distance between stabiliser and elevator had been found to be within the limits given in AMM – see table in Fig 12:

SE-LPU (West Air)

Position	AMM min	LPU L/H	Diff (mm)	LPU R/H	Diff (mm)
1	2.5	3.0	0.5	3.3	0.8
2	2.5	3.6	1.1	3.3	0.8
3	2.5	3.6	1.1	4.0	1.5
4	2.5	2.7	0.2	3.3	0.8
5	2.5	3.8	1.3	3.7	1.2
6	2.5	4.4	1.9	4.4	1.9
Mean	**2.5**	**3.5**	**1.0**	**3.6**	**1.1**

Fig. 12. Table of measurement results, SE-LPU.

For the testing involving SE-LPU, Type IV fluid was applied using the same routines as in previous tests. When Vr was reached, rotation proceeded more or less as normal; the pilots noted that a certain degree more force than usual was needed to pull back the control column. The aircraft's mass at the time of testing was 17000 kg. It was noted, however, that the CG index was 52, which meant that this individual craft was a little nose-heavier than the aircraft in the previous tests. In all other respects the crew felt this to be a normal takeoff, and once the nosewheel had left the ground, they discontinued the takeoff.

1.16.5 Practical Full-Scale Tests – Series 3

The third and concluding test series was carried out on 19 March 2010. Before this round, a decision had been taken to make a technical adjustment: the elevator on the aircraft on which tests were to be conducted, SE-MAP, was removed and replaced with the elevator from SE-LPU. This change meant that there was a much greater gap between the stabiliser and elevator. The measurements made after the switch gave the following values:

SE-MAP after change of elevator (West Air)

Position	AMM min	MAP L/H	Diff (mm)	MAP R/H	Diff (mm)
1.0	2.5	3.3	0.8	2.4	-0.1
2.0	2.5	4.2	1.7	2.4	-0.1
3.0	2.5	3.8	1.3	2.7	0.2
4.0	2.5	3.2	0.7	2.5	0.0
5.0	2.5	2.8	0.3	2.5	0.0
6.0	2.5	3.0	0.5	1.7	-0.8
Mean	**2.5**	**3.4**	**0.9**	**2.4**	**-0.1**

Fig. 13. Table of measurement results, SE-MAP

As can be seen from the table, the size of the critical gap was improved after the change of elevator. The biggest change was recorded on the left elevator, where the margin after the change showed an average gap of 3.4 mm, which is well above the minimum. The right elevator showed an average of 2.4 mm, which is 0.10 mm under the minimum permitted value. The clearance of the right elevator had nevertheless been significantly improved compared to the original right-hand elevator section, for which the average gap was 0.5 mm below the minimum.

The test run was carried out in accordance with the same procedure as in the previous test series, with Type IV fluid having been applied to the aircraft's stabiliser and elevator. CG index on this test was 55, and mass 17250 kg. Rotation speed was calculated at 99 kts.

After a normal takeoff run, PF initiated rotation at just under 99 kts, and experienced no increased resistance or any other abnormality in the control column. The aircraft rotated completely normally; the takeoff was discontinued once the nosewheel had left the ground, and the crew taxied back to the ramp.

1.16.6 Documentation of Deicing Fluid Flows on Stabiliser and Elevator

The pictures in Figures 14–16 are taken from the video films shot during the first test series, 2 March 2010. These takeoff tests involved the aircraft SE-MAP, after application of Type IV fluid.

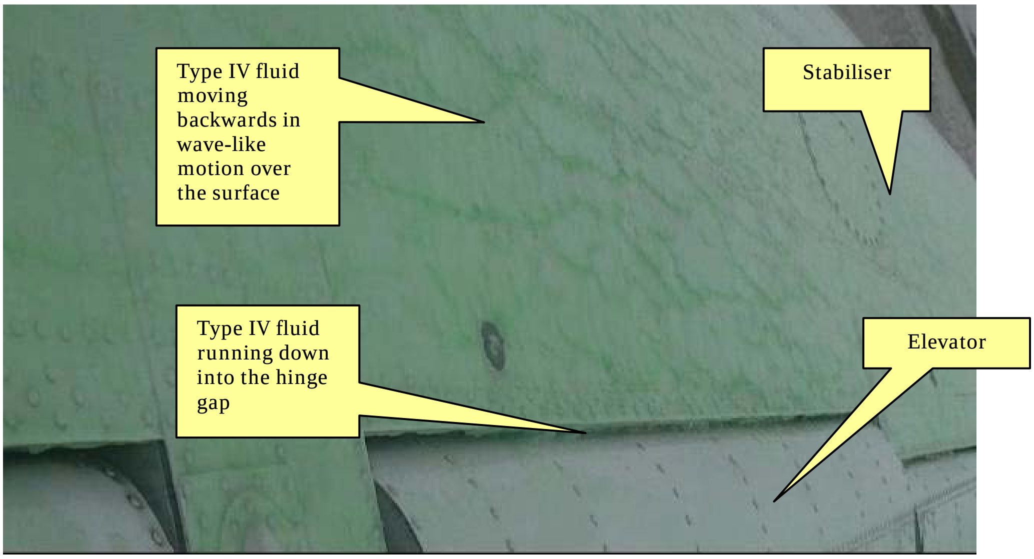

Figure 14. Picture from video while aircraft was taxiing out (upper surface). Speed approx. 20 kts.

In the first test it was observed via the upper camera that the fluid was moving backwards over the stabiliser's surface in a wave pattern. Most of the fluid that moved back across the stabiliser finished by running down into the elevator gap. The wave motion of the fluid during taxiing varied without there being any change in the aircraft's taxiing speed.

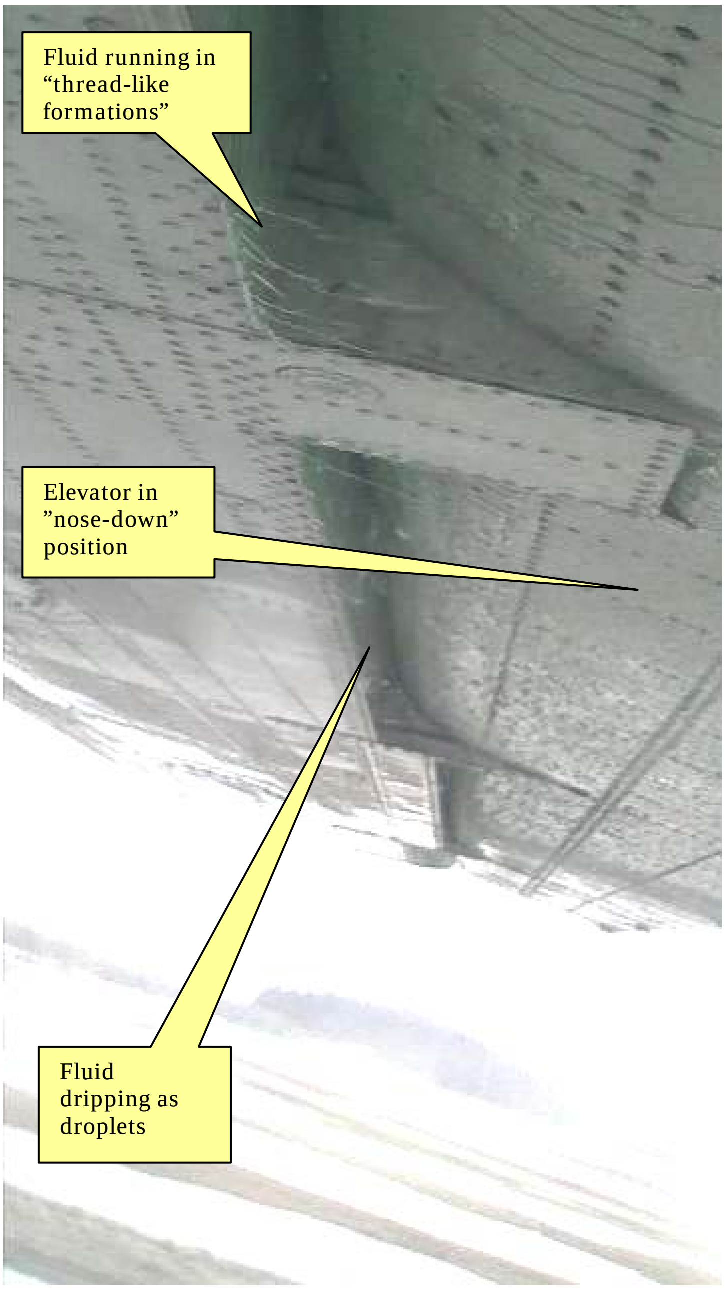

Figure 15. Picture from video while aircraft was taxiing out (underside). Speed approx. 20 kts.

On the underside of the stabiliser a fairly even dripping of fluid from the gap could be seen as the aircraft taxied out. The video also shows that the fluid drips from the gap both as droplets, and in longer, thread-like formations. It should be noted that during taxiing, the elevator is in "nose-down" position; in the cockpit this corresponds to the control column being in forward position. During the acceleration phase of takeoff – under the influence of increased air forces – the elevator's position moves towards the neutral position.

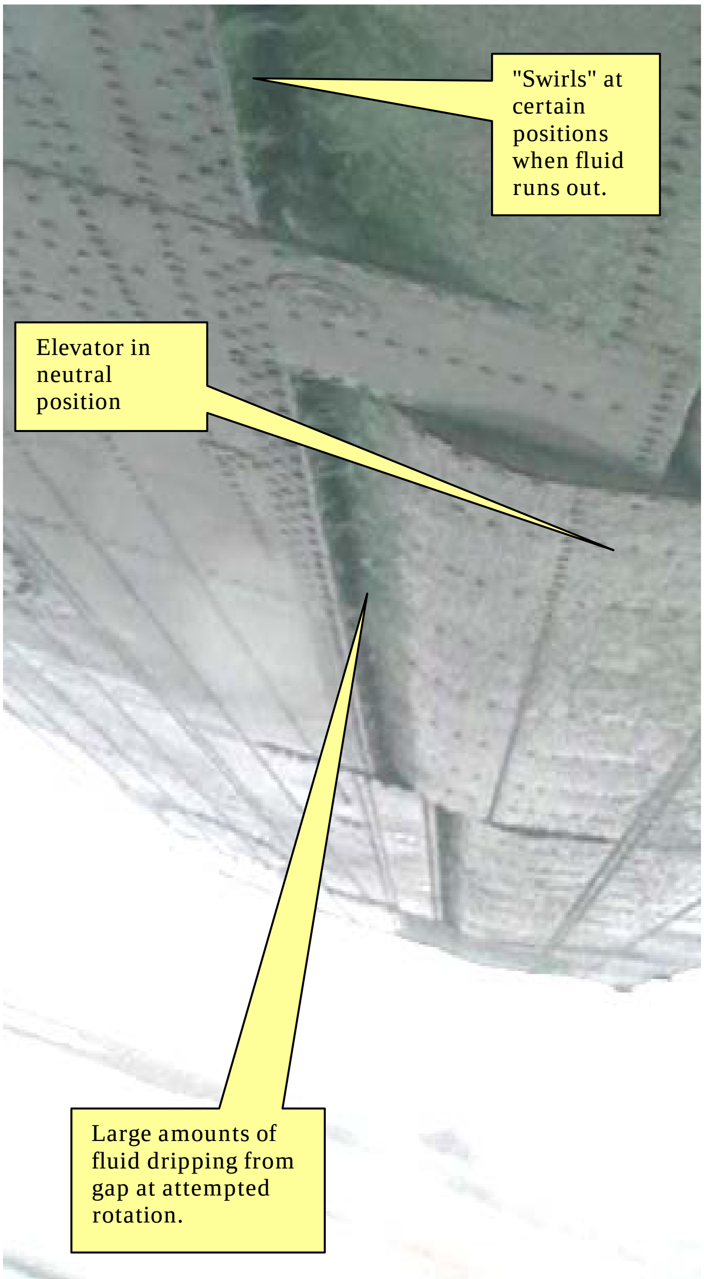

Figure 16. Picture from video at attempted rotation (underside).
Speed approx. 100 kts.

When rotation speed was reached the control column could not be pulled back further than the position corresponding to the neutral position of the elevator. As a result there was no rotation, and takeoff was aborted.

On the video film one can see large amounts of fluid running down through the gap when the column is pulled back and the gap is partly opened (see picture in Fig. 16). The angle between the stabiliser and elevator in the picture indicates that the elevator is roughly in the neutral position.

At the same time as large amounts of fluid are dripping off the surface, swirls of fluid can also be seen. At certain points these swirls move in an inwards–

upwards direction into the gap. The dripping of fluid, and the swirling motions, cease when takeoff is aborted and the control column is returned to its forward position.

Via the upper camera it could be documented that fluid continued to run backwards across the surface throughout the acceleration phase; no interruption to the motion of the fluid into the gap could be observed. The highest speed reached by the aircraft in the course of the test can be estimated at between 105 and 115 kts. Despite this, the whole of the stabiliser had a clearly visible film of residual fluid on all surfaces at the end of the test.

1.16.7 Research by Type Certificate Holder

In connection with a planned C check of the aircraft SE-MAL, the type certificate holder (TC), BAe Systems, carried out a series of tests in December 2010. The values for the elevator hinge gap were with one marginal exception, within the tolerances in the AMM.

The aircraft SE-MAL was involved in one of the elevator restriction incidents, Arvidsjaur 20 October 2010.

BAe therefore tested all those systems in the aircraft which could in some way be conceived to have been a factor in the incident. An inspection did not reveal any technical faults or other abnormalities. The forces that had been required to split the systems were measured, and found to be within the given tolerances.

It was also found that on the trailing edges of the aircraft's stabiliser, there were residual traces of grease which had been applied on a previous occasion; as a result the report made mention of a risk of particle accumulation in the grease.

The conclusion drawn by BAe after their inspection was, however, that the problems were probably connected with ice or deicing fluids. The BAe report is attached in its entirety as an annex to this report (enclosure 9).

TC has also engaged an expert on deicing issues, and SHK has been given access to certain items of the expert's information and research findings relating to these problems. The expert's opinion is that the cause of the problems is probably to be found in the properties of the deicing fluids used. Older fluids, of types such as Kilfrost, are for the most part no longer on the market.

The fluids used today, in the form of Clariant products, may under certain circumstances have much higher viscosity values than the corresponding values in the fluids which were used in the type certification process (see 1.18.4). According to the expert, this might both explain why the phenomenon occurs, and explain why the problems have been accentuated over the past two or three years.

1.16.8 Examination of Deicing Fluids – Practical Tests

The incidents referred to in this report occurred at a number of airports in different countries. With regard to the incident in Helsinki, SHK has taken part of the audit of the supplier of deicing services which was carried out on instruction from, among others, the operator of the aircraft involved. The audit found the supplier and services to be without remarks. Helsinki only uses fluids of Types I and IV. It has not proved possible to test the particular brand of fluid (Clariant "Safewing MP IV Launch") as was used on the aircraft at the time of the incident.

SHK has collected and analysed samples of fluids from two airports in Sweden – Arvidsjaur and Hemavan. These examinations were primarily aimed at verifying that the fluids met the specification requirements from the fluid manufacturer applying for the respective fluid type. The tests were made on fluid samples a), taken from a tank, and b), in which the fluid had been sprayed through a nozzle onto sheet metal positioned at a fixed distance.

Unless indicated otherwise, the test results in the table below refer to both tank and sprayed samples. The freezing point of the fluids was tested using a refractometer. Ascertaining freezing point can be seen as a method for determining the fluid's water content. Viscosity was tested both in test-tubes with reference fluids, and using falling spheres. The tests were carried out using Brookefield Type II+P equipment, at the premises of an authorised supplier of deicing services, under supervision by staff from SHK.

<u>Arvidsjaur</u>

The samples examined did not show any deviations from the fluids' specifications. However, the sample examined by SHK had a delivery date later than the latest incident to occur at the airport – although, that being said, the regular tests carried out at the airport on earlier dates did not identify any deviations from the specifications applying.

•Date samples taken:	15 December 2010
•Date of test:	21 December 2010
•Type of fluid:	Deicing fluid Type II
•Make:	Clariant Safe Wing MP II Flight
•Freezing point:	Within permitted limits
•Viscosity:	Within permitted limits
•pH:	Within permitted limits
•Contaminants	Without remarks

<u>Hemavan</u>

The samples examined did not – with one, marginal exception – show any deviations from the fluids' specifications. The examination of the fluids followed the same procedure as described above for Arvidsjaur.

•Date samples taken:	15 December 2010
•Date of test:	21 December 2010
•Type of fluid:	Deicing fluid Type II
•Make:	Kilfrost ABC 2000
•Freezing point:	Within permitted limits
•Viscosity:	Within permitted limits
•pH:	Within permitted limits
•Contaminants	Without remarks

The refractometer test of the fluid from the tank showed that the freezing point was outside the limits laid down. Index was measured at 1.396, whereas the limits are 1.390/1.393 (maximum and minimum, respectively). However, when the same fluid was tested after having been nozzle-sprayed onto sheet metal, an index value of 1.392 (i.e. a value within the limits) was measured. When SHK visited the airport it was noted that the tank of Type II fluid was stored next to the heated tank containing Type I fluid.

It can also be noted that the fluid from Hemavan – Kilfrost ABC 2000 – had, at the time of testing, been stored for roughly 1.5 years, with 2 years being the maximum recommended storage time. This type of fluid is no longer available on the market.

Other airports

SHK has not judged it necessary to test the fluids used at other airports where incidents have occurred (Bergen, Helsinki and Copenhagen). The results from the regular tests carried out at these airports, which SHK has checked, have not revealed any deviations from the specification requirements. Audits have also been carried out for service providers at these airports, and these audits have not highlighted any issues relating to deicing services.

From the Helsinki incident there is a deicing receipt from the deicing operation concerned, specifying fluid type and volume applied.

1.16.9 Examination of de- and antiicing Fluids – Laboratory Tests

On instruction from SHK, the company "Exova AB" has carried out a laboratory analysis of samples taken from the airports referred to in 1.16.6, above. From Arvidsjaur, fluids of Safewing MP type were tested, and from Hemavan fluids of Kilfrost ABC 2000 type.

•No significant deviations compared to the product safety data sheets were noted with regard to the products' density, refractive index, colour or freezing point.

•The main constituents of the fluids (99–99.8 mass%) are compounds that are volatile (below 150°C and 170°C, respectively).

•In the residues obtained from evaporating the products, it can be noted (from the colour of the residues) that the products contain colouring additives; and by means of Fourier transform infrared spectroscopy, FTIR, it was shown that the residues contained organic compounds (i.e. hydrocarbons). No further identification of the residues was possible with the methods available.

•The volatile components of the products contain, in addition to propylene glycol, a range of other hydrocarbon compounds. Using the available detection techniques (FID) it is not possible to characterise/identify what these compounds are, but it was possible to establish that the Type II fluids contained several compounds which were not present in the Type I fluids. In addition, it was found that these compounds were present in very low concentrations in comparison with the level of propylene glycol contained in the samples.

Other analyses – for example, to identify certain trace elements – would require further tests using other techniques. However, the laboratory testing of the fluids was primarily concerned with verifying that there were no deviations or faults in the fluids, and to ascertain whether they contained any foreign substances. SHK does not intend to carry out any additional or more detailed analysis of the fluids. The report from the laboratory tests is attached in its entirety as enclosure 7 to this report.

1.17 Organisational and Management Information

1.17.1 Organisation

The company, West Air Sweden, started its current operations in 1995. Its main area of business has been the provision of air mail and air cargo services. At first the business used the cargo version of the HS 748 type aircraft, but as operations have expanded they have successively switched to BAe ATP, which have a larger cargo capacity. Converting the ATP to a cargo carrier – including, among other alterations, a customised cargo door – was carried out by the company itself.

The company's fleet of aircraft also contains other types of aircraft, all of which have been converted to carry cargo. The company operates all over Europe, with the bulk of the operations being run by a subsidiary company in another EU country. The Swedish parent company has its headquarters in Göteborg, with technical maintenance activities located in Lidköping.

1.17.2 Management of Incidents

As mentioned above, the operator's aircraft have experienced a number of incidents involving elevator restrictions. According to interview responses given by representatives of the company's quality assurance and technical maintenance departments, the company feels that it has been difficult to get the TC to take the problems seriously enough. Similarly, they feel that the reports they have sent to the national regulating authority regarding the occurrences have not elicited a vigorous response.

The company's technical department has therefore repeatedly, on its own initiative, carried out inspections and checks of technical systems and functions, primarily concerning the elevator and the associated alternative control systems. However, these checks produced no concrete results which could lead the company forward in trying to explain the phenomena reported by pilots.

Following the Helsinki incident, the company contacted SHK to see if there was a possibility of receiving assistance in trying to tackle the problems. Following contacts with the Finnish accident investigation authority, a joint decision was reached that SHK would take responsibility for continuing the investigation of the issue. The Finnish accident investigation authority appointed an accredited representative to follow SHK's investigation.

1.17.3 Reporting of Incidents

As has been mentioned above, several of the incidents occurred in other countries; these incidents were reported to the safety inspection and accident investigation authorities of the country in question. The incidents were viewed as one-off occurrences without serious consequences, and not meriting further investigation. It can also be noted that the incidents were spread over so many different locations, and were so few in number, that they did not lead anyone – apart from the operator – to see any common denominator or common trend in the events.

On two disparate occasions, copies of reports on two of the abroad incidents were sent to SHK. According to the national investigating authorities involved, neither of these incidents gave grounds for initiating an investigation. At the time, SHK was not aware that a number of similar incidents had occurred on aircraft being operated by another airline in Sweden.

When SHK assumed responsibility for investigating the Helsinki incident, a dialogue was opened with the operator concerned, West Air Sweden. In connection with this, information concerning similar incidents experienced by another Swedish operator, Next Jet, came to light. SHK contacted this company as well, thereby gaining access to operational reports from three incidents. All the reports concerned problems with elevator control at takeoff following two-step deicing.

1.17.4 Regulating Authority's Management of Reports

Accidents and serious incidents can be reported to SHK in varying ways. When airline operators experience these kinds of occurrences in their operative activities, they are under the obligation to report to the inspection authority, which in Sweden is the Swedish Transport Agency. Reports which are judged to be potentially so serious that an investigation may be required are sent by the Agency to SHK, and SHK decides whether or not an investigation of the event in question is necessary. Reports may also reach SHK in other ways – for example, via direct reporting from operators.

With regard to the missing reports from Next Jet, it was found that not all reports had reached the Transport Agency, and had therefore not come to SHK's attention, either. For events of an operational nature which are judged to concern air safety, the company has a reporting system called ASR – Aviation Safety Report. The reports are normally written by the crew (Commander), and a copy is sent to the Transport Agency.

When SHK contacted Next Jet it transpired that reports concerning the incidents in question had in fact been written and submitted to the Agency. When the matter was looked into a little more closely, however, it was found that when Next Jet's reporting system was introduced, an access account was created via which the Transport Agency could read all the company's reports on events. During the winter of 2009/2010 the Transport Agency felt that the system was not working satisfactorily, and the procedure was changed to one whereby ASRs were to be sent, as a PDF file, to a set e-mail address at the Agency within 72 hours.

Three people at the Transport Agency had the operator's ASRs sent to them directly from the reporting system. These three persons had their own access accounts, enabling them to log in and read new reports; an automatic message was generated and sent to inform them when a new ASR had been posted. To ensure that the Transport Agency really did receive every ASR, after it was found that the system had not been functioning perfectly a PDF of the reports was also sent. One of the three persons at the Agency who received reports directly was the operator's Principal Inspector (PI).

None of the three reports on post-deicing elevator problems submitted by the company to the Transport Agency had, however, been sent on to SHK.

1.18 Additional Information

1.18.1 De- and antiicing – General

The rules governing deicing of aircraft on the ground are issued by ICAO[4] , and are published in the "*Manual of Aircraft Ground Deicing/Anti-Icing Operations"*. The manual describes the conditions and practical procedures for the ground de- and antiicing of fixed wing aeroplanes.

The central concern of the manual is that all operators are to follow the same provisions when carrying out measures to deice aircraft on the ground prior to takeoff. This is summarised in the stipulation that aircraft may not take off when ice, snow, slush or frost is present on, or may stick to, the wings, propellers, rudder surfaces, air intakes or other critical surfaces. This is called the "*Clean Aircraft Concept*".

The ICAO does not publish rules or recommendations concerning requirements, specifications or usage limitations for de- and antiicing fluids.

1.18.2 Procedures and Rules

The organisation SAE (Safety Automotive Engineers) is a trade organisation which is not affiliated to any inspection authority. The organisation consists, inter alia, of members from the aviation industry, and also has a small number of representatives from bodies such as the FAA (Federal Aviation Administration – the American civil aviation authority) and Transport Canada (the Canadian civil aviation authority). Fairly recently, a representative of the EASA[5] was also admitted.

In SAE the G-12 and AC-9C technical committees develop standards, specifications and recommended practices for ground de-icing and aircraft icing technology respectively. In particular, the G-12 ADF, (Aircraft De-icing Fluids), committee maintains the specifications for SAE Type I (AMS1424) and SAE Type II, III and IV (AMS1428) aircraft de-icing and anti-icing fluids.

Every year the FAA and Transport Canada publish a list of "qualified fluids" which have been tested according to the SAE's specifications. The EASA does not publish any similar kind of list. The recommendations issued by AEA (the Association of European Airlines), concerning use of de- and antiicing fluids are based on the FAA's list.

In FAA's lists of fluids there are, however, some entries where certain fluids only have been tested against aerodynamic specifications, but not with regard to the other requirements laid down. Fluid manufacturers claim that their products meet the demands of FAA's specifications, but there are no set rules or regulations to guarantee these claims. Neither are there any general rules governing which type of fluid may be used on different types of aircraft. The type certification procedure for aircraft does not require the aircraft manufacturer to demonstrate that the performance and manoeuvrability of the craft are compatible with various types of deicing fluid containing thickening agents.

The properties of the fluids in terms of when they "flow off" the surfaces to which they have been applied, are tested in accordance with specifications laid

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[4] ICAO: International Civil Aviation Organization

[5] EASA: The European Aviation Safety Agency (Authority responsible for the continuing airworthiness of the aircraft

down in SAE AMS 1424/1428. These tests have two main categories, a "High Speed Ramp Test" (1428) and a "Low Speed Ramp Test" (1424). The first category refers to (larger) aircraft with a rotation speed of 100 kts or above, and with an acceleration time from brake-release to rotation of at least 20 seconds; the second category refers to (smaller) aircraft with a rotation speed of 60 kts or above, and with an acceleration time from brake-release to rotation of at least 15 seconds.

The specifications are intended to test the durability of protection as dilution occurs, and the "flow-off" properties, of different fluids under different conditions. However, no recommendations are given with regard to whether or not certain types of aircraft can/should use certain types of fluid. It can be mentioned here that Type I fluids have to meet the requirements laid down in 1424; fluids of Type II, III and IV are primarily intended to correspond to the requirements of test 1428, but some of these fluids may also be tested according to the 1424 specifications protocol.

In the manual "*De-icing/Anti-icing of aircraft on the ground*", the AEA has published recommendations concerning fluid application and procedure with regard to aircraft deicing. The AEA also publishes a manual of "Training Recommendations" for the training of all categories of staff affected by the subject.

In the training manual (Chapter 6.1.5), the AEA mentions that Type III fluid is better suited than Types II and IV for use on aircrafts having a lower rotation speed (<85 kts). When asked, the organisation has not been able to explain what they base the stated rotation speed of 85 kts on.

The American civil aviation authority, FAA, points out, with reference to the limits established in SAE AMS 1428, that the recommended minimum rotation speed for the application of Types II and IV fluids is 100 kts. The FAA points to the risk that residual films of fluid may form – thus causing reduced lift – and also the risk that the forces needed for rotation may increase. Their recommendation refers to aircraft with non-powered elevator systems. The same document, (SAFO 01001), also recommends that operators of aircraft equipped with non-powered elevator systems and having a rotation speed of under, or only marginally over, 100 kts, should supplement their training programmes with regard to winter operations, so that pilots are aware that a higher level of force may be needed at rotation if the aircraft has been treated with deicing fluids containing thickening agents. The document – included here as enclosure 8 – also reports in general terms on similar incidents involving different types of aircraft.

1.18.3 De- and antiicing Fluids

Fluids of different kinds – deicing, and anti-icing, fluids – are used to remove ice, frost and snow from the aircraft, and to prevent ice from reforming, under various meteorological conditions. Contamination and films of various kinds may have negative effects on the aircraft's aerodynamics and performance, leading to reduced lift and increased resistance.

Glycol	Type I	Type II	Type II+	Type IV	Type III
Use	Deicing	Anti-icing	Anti-icing	Anti-icing	Anti-icing
Type of glycol	Propylene	Propylene	Propylene	Propylene	Propylene
Viscosity	No thickener	Thickener added	Thickener added	Thickener added	Thickener added
Colour	Orange	Colourless	Yellow	Green	Colourless
Normal application temperature	Min 60 °C	Room temp, 20°C	Room temp, 20°C	Room temp, 20°C	Room temp, 20°C
Freezing point	10° under OAT[6] and aircraft's skin temp.	10° under OAT and aircraft's skin temp.	10° under OAT and aircraft's skin temp.	10° under OAT and aircraft's skin temp.	10° under OAT and aircraft's skin temp.
Daily check	Freezing point	-	-	-	-

Fig.17. Table of de- and antiicing fluids

The table above describes the normal scopes of fluids. Fluids of Type II, III and IV may also be used as de-icing fluids with increased application temperature of the fluid. Type II+ is a commercial term not found in the SAE specifications.

All treatment of aircraft with deicing fluids is only intended to be effective up until the moment when the craft attains rotation on takeoff. Once the aircraft is airborne, its own onboard de- and anti-icing systems take over. When aircraft are certified they are presumed, per definition, to be "clean" and free from contamination at the moment of rotation.

There are two main types of fluids: Type I, which is primarily intended to remove frozen precipitation (contaminations and deposits) from the aircraft; and Type II/IV fluids, which are intended to keep the aircraft's critical surfaces – the wings and flight controls – free from contamination from ice and snow until rotation has taken place. Type III is a later product, which can be said to be a cross between Type I and Type II/IV, and is intended for use on aircraft with rotation speeds down to 60 kts. This fluid is however not as yet in widespread use in European aviation.

All the fluids are based on glycol. In Type I, the glycol is mixed with hot water prior to application. The anti-icing fluids are used in concentrated form, and are at roughly room temperature when applied. There are HOT[7] tables to show the effectiveness of the different fluids under different meteorological conditions.

1.18.4 Properties of the Fluids

Type I fluid is thin; it does not contain thickening agents. This means that the fluid dilutes relatively quickly in precipitation, for example, and runs off the surfaces to which it has been applied. This type of fluid therefore has a very short HOT in most kinds of weather conditions.

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[6] OAT: Outside Air Temperature
[7] HOT: Hold Over Time, HOT tables shows the calculated durability of the reicing protection afforded by a fluid under varying meteorological conditions.

To obtain reasonable HOT times in, for example, conditions where there is precipitation in combination with critical temperature ranges, anti-icing fluids (Type II/IV) need to be used. These fluids – which are what physicists term non-Newtonian fluids – have had polymeric thickening agents added, thus increasing the fluids' viscosity (polymers can be described as chemical compounds consisting of long molecule chains). The addition of thickeners has the following advantages:

- The fluid remains longer on the surfaces to which it has been applied;
- The rate of dilution on exposure to precipitation is slowed significantly.
- When diluted the viscosity properties of the fluid is maintained – or in some cases increased.

To ensure that the fluid does not remain on the aircraft's surfaces beyond rotation, the polymers in the thickening agent shear when the aircraft reaches a certain speed during takeoff acceleration. The viscosity of the fluid is thereby reduced, the fluid can be described as reverting to a Type I fluid, and it flows off the aircraft.

The measuring of a fluid viscosity could be defined as the drag caused by relative motion between the fluid and a surface. The viscosity of fluids are measured in milli-Pascal-seconds (mPa.s). From a general point of view it can be noted that viscosity of the Type I and Type II fluids has increased during the last twenty years period.

The differing labels used for anti-icing fluids correspond to differences in viscosity, and thereby in HOT. Type IV fluid is a development of the original Type II fluid, with higher viscosity – which, among other things, gives it longer protection from dilution. Certain types of precipitation lead to changes in the properties of the fluids – primarily their viscosity – since a gradual dilution takes place as water in some form or another mixes with the fluid. Most fluids containing thickeners reach their highest viscosity at degrees of dilution of 10–25 %. Changes in temperature also entail changes in viscosity: most anti-icing fluids have their highest viscosity at low temperatures.

1.18.5 Measures Taken – SHK

When the decision was taken that SHK would investigate the event, a first step was to inform all the operators and authorities concerned, and also the accident investigation authorities in UK, Norway and Finland. When the scale of the problem became clear, and after the tests in Malmö had been carried out, the SHK felt that there were potential air safety risks associated with continued use of this type of aircraft in certain weather conditions.

SHK informed the Swedish Transport Agency of the situation in a letter dated 19 March 2010 (attached as enclosure 5 to this report), and at the same time invited the Agency to a discussion meeting on the subject to be held on 22 March. The EASA were also invited to this meeting, but were unable to attend. At the meeting, the SHK presented all the known facts relating to the incidents, and also showed the video films taken during the tests in Malmö. SHK also announced at the meeting that a workshop was planned on 30 March, to which all interested parties and the operators were invited.

The workshop, held in Malmö on 30 March, included both a practical and a theoretical examination of the incidents involving BAe ATP craft; 14 people attended.

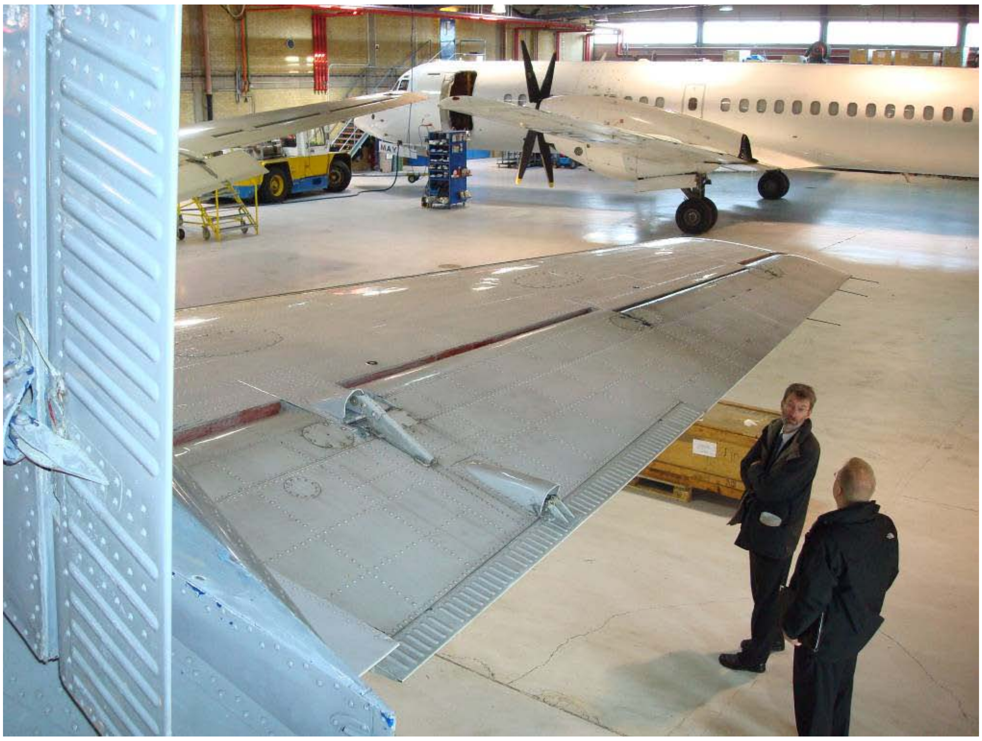
Fig. 18. Photo from the practical part of the workshop.

The conclusions reached by the workshop participants could be summarised as follows:

- All parties involved were agreed that the elevator problems was a high-priority flight safety issue.
- The type certificate holder and regulating authorities are to investigate the problem further, with the aim of identifying both short-term and long-term solutions.
- As a provisional solution, the operators are to evaluate the possibility of issuing operational restrictions in connection with the use of Type II and Type IV fluids.

As recorded in the minutes of the workshop meeting, SHK made it clear that the primary aim of its investigation into this matter is to point out what the problem is – not to solve it.

The minutes from the meeting are attached in their entirety as enclosure 6 to this report.

A final meeting was held at SHK in Stockholm 25 October 2010.
with all involved parties invited. At the meeting SHK presented the factual part of the report, and also outlined the findings and facts that had emerged during the investigation.

1.18.6 Measures Taken – TC Holder

The type certificate holder (TC) – BAe Systems Limited – has, in addition to the technical tests and examinations described in 1.16.5, above, also taken technical and operational measures to ensure the continued airworthiness of the aircraft.

In reaction to the incidents that have occurred, TC has prescribed measures a), with the aim of diagnosing the problems and their scope, and b), with the aim of eliminating the risks of a continuing negative trend. SHK has had ongoing contact with the company to ensure that both parties have up-to-date information on developments in the matter.

On 29 June 2010, TC issued a Service Bulletin – SB reference ATP-55-012 – entitled "Stabilisers – inspect and measure elevator clearance". The bulletin instructs all operators to measure the gap between the stabiliser and elevator, using a set template. The inspection was to be completed, and the results submitted to TC, by 30 September 2010.

On 21 October 2010, TC issued a Technical Operational Response (TOR), derived from the data submitted in response to the Service Bulletin. Based on the results from the checks, the TOR presented two lists: one which gave the serial numbers of the aircraft which were cleared for continued operation without restriction; and the other listing aircraft which were not cleared for continuing operation on occasions when they had been treated with deicing or anti-icing fluids – i.e. if they had been treated with any kind of deicing fluid.

The TOR entered into effect immediately, and at the same time formed the basis for the AD described in 1.18.7, below.

As an addition to the technical measures, on 1 November 2010, BAe published a revision of ATP Operations Manual, OP44 Issue 1. The revision had the title, "Elevator force increase on rotation for takeoff after de-icing with thickened fluids". The revised document prescribes a series of operative measures, and also requires the left-hand pilot to be PF when the aircraft has been deiced using fluids containing thickening agents. The document also states that following deicing with fluids of this type, pilots can expect "much higher than usual stick forces" at rotation.

1.18.7 Measures Taken – EASA

The European Aviation Safety Agency, EASA, is the authority responsible for the continuing airworthiness of the aircraft concerned in this report. SHK has kept EASA informed of developments in this matter on an ongoing basis, and has also received information from EASA regarding their work on this and similar cases involving problems arising from the use of thickened deicing fluids.

EASA representatives have taken part in meetings on this subject, and EASA was also represented at the meeting held in Stockholm on 25 October 2010.

Problems with thickened fluids have been in focus in the past, with regard to the fact that fluid residues may entail a risk of adverse effects on the flight control systems of certain types of aircraft. In consideration of the flight safety aspects of this problem, EASA published more stringent, and more clearly formulated, rules governing this aspect of the deicing procedure.

Taking into account SHK's investigation of the problems with BAe ATP aircraft, EASA has published the following:

- SIB (Safety Information Bulletin) No. 2010-28, issued on 17 September 2010. The information in the bulletin is addressed generally to operators of aircraft with unpowered elevator controls. The bulletin is based on the FAA document (SAFO) mentioned earlier, the prime aim of which was to make pilots and crews aware of the fact that application of Type II/IV fluids may result in greater stick force being necessary when rotating the aircraft. The bulletin is attached as enclosure 10 to this report.

- Airworthiness Directive (AD) No. 2010-0263, issued on 17 December 2010. This directive is to a large extent based on the TOR distributed by the type certificate holder, and prescribes both inspections and operational restrictions in connection with the use of deicing fluids containing thickening agents (the directive imposes no such measures for Type I fluids). The directive is attached as enclosure 11 to this report.

1.18.8 Measures Taken – Swedish Transport Agency

The Swedish Transport Agency is the national authority with responsibility for issuing AOCs[8] for commercial operators, and for inspecting their operations. The Agency does not issue specific regulations governing deicing, other than what is prescribed in EU OPS, Paragraph 1.345: "*An operator shall establish procedures to be followed when ground deicing and anti-icing and related inspections of the aeroplane are necessary*." Although these measures, being carried out on the ground, are part of the area of operations under the Agency's jurisdiction, the Agency seems not to have carried out any specific inspection activities – except information regarding the actions already decided by the TC and EASA - vis-à-vis any of the Swedish operators in response to the incidents.

In the case constituting the central element of this report, the Swedish Transport Agency wrote to the EASA PCM (Principal Certification Manager) for the type in November 2010, with questions on matters such as airworthiness and continuing operations with the particular type of aircraft without restrictions in accordance with the AOC issued. This communication is attached as enclosure 12 to this report.

1.18.9 Measures Taken – Operators

Following the incidents, the operators concerned have modified the procedure adopted after two-step deicing of the aircraft. They have provided information to pilots consisting of both a description of the problems, and practical recommendations. For instance, one of the companies published a Crew Information in spring 2010, which included the following:

"***Recommendation:***

- *Be aware of higher stick forces or no immediate respond to rotate action.•If rotate speed is at or below 100 kts add speed by using speeds from a higher take off mass. (Check for adequate runway length)*
- *Under above circumstances L/H pilot will preferable be the flying pilot."*

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[8] AOC: Air Operators Certificate (License required to perform commercial air operations)

1.18.10 Previous AIB Recommendations

Recommendations have been issued on previous occasions with regard to the use of deicing fluids containing thickening agents. The recommendations were attached to reports from the German and UK accident investigation authorities concerning investigations of inflight occurrences of elevator restrictions following repetitive use of Type II/IV antiicing fluids.

The problem in these cases was identified as having been caused by residues of dried fluids containing thickening agents – and the reports led EASA to tighten the rules pertaining to this area. The recommendations also contained, however, proposals for the introduction of certification criteria for these fluids. The incidents referred to in the following concern manoeuvring/control problems caused by dried residues of deicing fluids containing thickening agents:

<u>Incident in Germany (D-AEWA, 12 March 2005)</u>

The following is an extract from a recommendation issued by the German aviation accident investigation authority, BFU, on 21 November 2005:

"EASA should develop certification criteria to establish mandatory limits for and require evidence of unrestricted suitability of such fluids for aircraft with non powered flying controls."

EASA's response to this was to explain that the framing of rules and certification procedures for deicing fluids was not within its remit under current EU provisions; EASA did however point out that changes in this regard may be proposed to the EU in the future.

<u>Incident in UK (G-CFAC etc., Winter 2004-05)</u>

The following is an extract from recommendations issued by the UK investigation authority, AAIB (the Air Accidents Investigation Branch), on 17 March 2006:

"It is recommended that the European Aviation Safety Agency introduce certification requirements relating to de/anti-icing fluids for use on aircraft with both powered and non-powered flight controls."

EASA's response to this recommendation was identical to its answer to the German BFU in terms of the limits on the EASA's scope of responsibility.

1.18.11 Environmental Aspects

The incidents did not have any negative environmental effects.

1.18.12 Equal Opportunities Issues

The incident concerned has also been investigated from an equal opportunities perspective – i.e. has been analysed with reference to the question of whether there were any circumstances which suggest that the occurrence, or its effects, arose as a result of or were shaped by the men and women involved not having, on account of their gender, the same opportunities, rights and responsibilities. No such circumstances were identified.

2. ANALYSIS

2.1 Background

2.1.1 General

The analysis of these occurrences is shaped by the nature of SHK’s remit: the Swedish Accident Investigation Board is an authority tasked with investigating the background to, and chains of events constituting, accidents and incidents in civil aviation; it is also part of SHK's remit to frame recommendations in those cases where shortcomings and/or deviations have been noted which have impacted negatively on flight safety. It is however not part of SHK's terms of reference to carry out research, or to propose detailed solutions to the problems identified in the course of an investigation. It is the duty of the type certificate holder to draw up proposed solutions, which must then be submitted for approval to the relevant regulating authorities.

The incident in Helsinki involving SE-MAP was one of a series of occurrences featuring similar symptoms. In SHK's view, incidents which in some way affect the control systems of aircraft must be considered as extremely serious. In the cases investigated for this report, the action of the elevator was affected negatively – or the elevator ceased to function altogether – which can obviously have grave consequences on the manoeuvrability of the aircraft. That being said, the occurrences investigated did not cause accidents – which means that SHK's role in the investigation can be categorised as largely concerned with preventing future recurrence of this type of problem.

One of the incidents – at Arvidsjaur on 30 November 2009 – was however of such a nature that it can be classified as very serious. An aircraft that lifts off from the runway at the same time as there is a power reduction, implies a situation that is not dealt with in training manuals or described in operational handbooks. It is clear that there could have been extremely serious consequences had not the commander reacted with resourceful quick thinking and set full power, thereby managing to keep the aeroplane airborne and continue the take off. In this case, the safety margin at take off for this class of aircraft can be said to have been used to the very last degree.

2.1.2 De- and antiicing

Ice, frost and snow on aeroplanes have always posed, and will always pose, serious safety problems for aviation. To deal with the problem when airborne, aircraft have their own onboard deicing systems – but before they can become airborne, the ice and snow have to be dealt with on the ground. Pre takeoff de- and antiicing is intended to ensure that critical surfaces are kept clear up until the moment when the aircraft rotates. The consequences if an aircraft's control surfaces are contaminated with ice/frost/snow are generally much the same when in flight as when taking off, with the aircraft's performance being affected in a negative direction.

In the cases described in this report, has the objective of which is to keep the aircraft clean, to a large degree had the opposite effect. The efforts to eliminate contamination with ice and snow have led to the aircraft being affected by another form of contamination: deicing fluid containing thickening agents. The fluid – probably in conjunction with other conditions and parameters – has had negative effects on the aircraft's performance and manoeuvrability during takeoff.

SHK notes that the kind of aircraft concerned is certified to operate after being treated with deicing fluids containing thickening agents. The incidents investigated all took place in winter weather conditions, after fluids containing thickeners had been applied to the aircraft.

As far as SHK is able to judge, in the incidents investigated the operators followed the guidelines laid down by the ICAO with regard to ground deicing. The weather conditions prevailing at the time of the incidents meant that two-step deicing was necessary in order to adhere to the "Clean Aircraft Concept" established in the ICAO manual for ground deicing of aircraft.

2.2 Practical Management

2.2.1 Take-Off Procedure – Operational

The operational management of takeoff – or attempted takeoff, in those cases where incidents occurred – did not in any way deviate from the standard operational routines for the type of aircraft concerned. Rotation was effected at the correct speed, and the techniques used by the pilots did not deviate from normal routines.

It was a frequent characteristic of the incidents that in most cases where split occurred, the right-hand pilot was PF. This does not however have an operational explanation; instead, it is a logical consequence of the way the elevator system is designed in the aircraft (this connection is looked at in more detail in 1.6.5, above).

The checks carried out after the incidents with regard to mass and balance did not identify any faults or abnormalities of a kind or degree that could have been a factor in causing the incident. The one deviation noted was an incorrect loading of ballast, which led to the craft being more nose-heavy than calculated. The crew however reported that rotation was normal at an earlier flight with the same balance conditions , even though the aircraft "felt heavier" than usual

In all, SHK does not find any grounds for suspecting that operational errors in handling or management caused or contributed to any of the incidents studied.

2.2.2 Deicing Procedure – Suppliers

On all occasions when incidents occurred following two-step deicing, the aircraft were attempting to take off in snowfall of varying intensity. We can therefore not immediately dismiss the possibility that deicing was not carried out as thoroughly as intended, thus leading to a reduced level of protection. This would leave the aircraft more susceptible to re-icing on exposure to the precipitation, with a concomitant risk of contamination of flight controls and other critical surfaces, leading to impaired functioning and performance.

SHK has, however, not been able to identify any deviations from the established routines or safety regulations when deicing was carried out on the aircraft involved in these incidents. The accounts provided by crew members concerning deicing do not, either, suggest that the work may have been done incorrectly or incompletely. The audits that SHK took part of from certain providers of deicing services did not identify any shortcomings in their practices.

All in all, there are no grounds for suspecting any errors or insufficiencies in the deicing carried out on the aircraft involved in the incidents. SHK thus maintains that it is more likely that it was the presence of antiicing fluid that caused the incidents, not its absence.

2.2.3 Technical Inspections Following the Incidents

The companies carried out technical examinations, in varying detail, of their aircraft following the incidents. In some cases, the technical measures taken were limited to a reset of the disengaged elevator system, in conjunction with a technical check which showed that there was no malfunctioning of the system. Exemption was the incident 18 March 2010 where misalignment in the synchro position transition system was detected. This misalignment may have played a role when the split occurred, but is not likely to have caused the initial elevator restriction.

In some cases the aircraft were subjected to a more rigorous series of checks. In these inspections, most of the components and systems involved in controlling the elevator were examined and subjected to tests. However, none of these inspections located any technical/mechanical failures, or any other abnormalities which might have had a negative impact on the system.

A technical inspection of one of the aircraft, SE-MAL, was carried out by TC in connection with a more wide-reaching inspection – but again, the report from this inspection identified no failures or abnormalities which could be placed in relation to the incident. Checks were carried out on components and disengagement forces in the elevator system. The checks found that the systems were functioning without remarks.

That being said, one "deviation" that was noticed was that there were remains of grease on the trailing edge of the stabiliser, which TC says implies a risk that particles could get stuck in the grease and thus possibly affect performance parameters in a negative direction. The grease derives from a procedure whereby the deicing boots on the leading edges of the stabiliser (and wings) are impregnated with a special product. TC suggested that the grease used in this process deviated from the directives laid down in the AMM; SHK's investigation shows, however, that BAe itself has approved the grease in question for use when the product normally used is not available.

In the report summarising its investigation, TC states however that the cause of the incidents can most probably be sought in the area of ice formation and/or the use of de- and antiicing fluids.

In all, SHK does not find there to be any grounds for suspecting that the incidents were caused by deficiencies or malfunctionings in the aircrafts' technical systems.

2.3 Deicing Fluids

2.3.1 General

The specifications for the different types of de- and antiicing fluids are established by a trade organisation in which inspection authorities only have a limited degree of representation.

The fact that the specifications and requirements against which the fluids are tested are not directly determined by an flight safety authority is, in the view of SHK, a state of affairs that ought to be reviewed. There is always the risk of an integrity issue when commercial actors are an active party in referencing procedures which inspection authorities then have to deal with.

An approach generally applied in the international aviation industry is that certifying authorities lay down specification requirements, against which products are tested and verified. With regard to deicing fluids, a different procedure has developed, in which the manufacturers themselves to a great extent establish the specifications and requirements applying to their own products.

Although certain regulating authorities do have representation in this forum, SHK deems that the procedure differs significantly from the way other products in the field of flight safety are monitored. This study does not direct any criticism towards SAE with regard to de- and antiicing fluids, but SHK considers that the way the chain of responsibility running *manufacturer – product requirements – certification – use/inspection* looks for these products is not ideal from the point of view of flight safety. One reflection of this can be seen in the differing interpretations applied with regard to speed ranges.

In order to further improve flight safety, SHK believes that the problem should be looked into when the process for manufacturing, specification and certification of de- and antiicing fluids is next under review.

2.3.2 *Analysis of the Fluids Used*

The analyses made of the fluids used at two of the airports – Arvidsjaur and Hemavan – had the following main purposes:

- checking and analysing the specifications of the fluids,
- verifying that there were no foreign substances in the fluids
- test of the properties of the fluids.

The tests were divided into chemical analyses, and trials of the stated properties by means of practical tests. The findings of these tests are not necessarily representative of the status of the actual fluids used on the aircraft at the time of the incidents.

2.3.3 *Practical Tests*

The tests of the fluids from Arvidsjaur did not identify any deviations from the specifications. It should, though, be noted that the samples on which tests were carried out were from a later batch of the fluid delivered to the airport. However, taking also into account the audits previously carried out at the airport, there are no grounds for suspecting that the handling of the fluids or any other conditions were any different at the airport in the past.

The tests of the fluids from Hemavan revealed certain deviations from the specified properties. The Type II "Kilfrost" fluid had a freezing point below the established minimum values; however, the deviation was only marginal, and can probably be explained by the fact that the tank containing Type II fluid had been stored next to the truck carrying the heated Type I fluid, and this may have resulted in a certain degree of heat transfer.

The heat transfer may have increased the rate of evaporation of the fluid, with changed properties arising as a consequence. This fact – perhaps in combination with the age of the fluid – may have affected the fluid's freezing point. However, when measurements were taken from fluid that had been nozzle-sprayed onto sheet metal, the freezing point values were found to be within the set limits.

The other airports where incidents occurred are larger airports, with considerable through-flow volumes of deicing fluids. SHK's overall judgement is that there were probably no deviations from the fluids' specified properties which contributed to causing the incidents.

2.3.4 Chemical Analyses

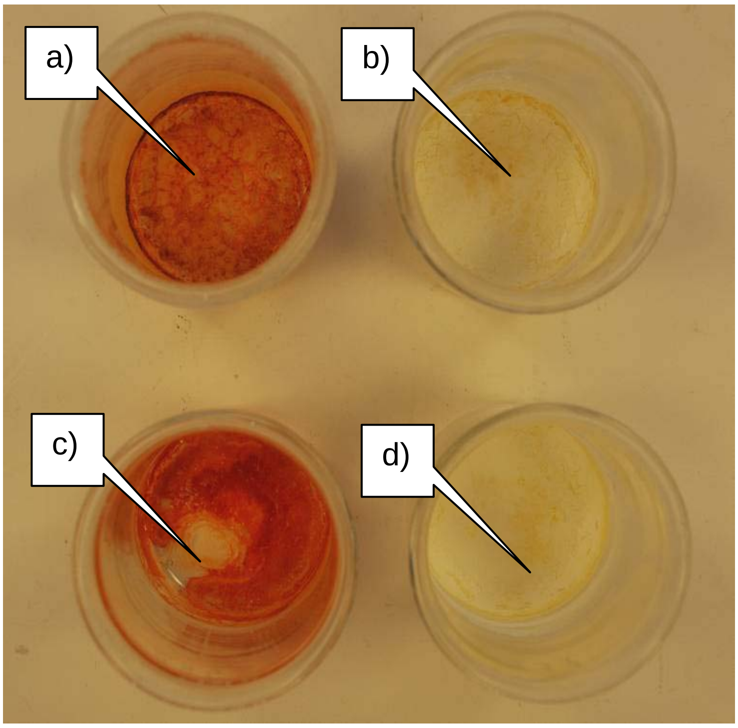


Fig. 19. Fluid testing.

a) Safewing® MP I Eco Plus
b) Safewing® MP II Flight
c) Type I fluid, Kilfrost ABC 2000
d) Type II fluid, Kilfrost ABC 2000

The laboratory analyses commissioned by SHK did not locate any deviations from the specifications, or the presence in the fluids of any traces of foreign substances. It is therefore unlikely that the chemical composition of the fluids was a contributory causal factor in the incidents.

2.4 Authorisation and Use of Fluids

2.4.1 General

It can be noted that the intervals within which the fluids are tested are to a certain degree derived from the speed ranges at which the aircraft involved rotate. The limits used for tests are 60 kts and 100 kts, respectively, these being speeds at which the fluids' run-off properties are decisive. Since there is not, today, any regulatory framework governing which fluids may be used with which types of aircraft, it is up to the TC itself to authorise the use of a given type of deicing fluid on a given aircraft.

Opinions also differ as to the spectrums of use for the fluids: both within the aviation industry, and between authorities (the FAA) and the industry, there is disagreement as to which lowest rotation speed should be used after application of particular fluid types. In SHK's assessment, this situation is a consequence of the fact that no common set of regulations for deicing fluids and their use has been drawn up within the framework of the ICAO. A further example of the lack of regulatory control is provided by Type III anti-icing fluids; this type of fluid is intended for use on aircraft with lower rotation speeds, but owing to low demand it only has a negligible market share.

At larger airports where long taxiing times can be expected, it is justifiable to use high-viscosity anti-icing fluids (Types II and IV) in order to attain the required HOT values. At smaller airports however – which are often used by aircraft types with lower rotation speeds – it is not as justifiable to use fluids of this kind. The smaller airports often have traffic volumes which enable them to keep taxiing times down, meaning that Type III fluid would provide sufficient anti-icing protection. It can be noted here that, equally, larger aircraft with higher rotation speeds would be able to use Type III fluids at this kind of airports.

Although Type III fluid has been on the market for quite some time, its market share has always been low. SHK believes that a common regulatory framework – in which rotation speed could be made an important parameter for the certification of different types of fluids for different types of aircraft – would probably lead to Type III fluids gaining a foothold on the market.

With regard to the type of aircraft concerned in this report – BAe ATP – TC has carried out tests with Type II fluid. These tests identified increased stick force at rotation. This important information has not, as far as SHK is aware, been included in the approved AFM (Aeroplane Flight Manual) for the aircraft, but only in the MOM. Type IV fluid has been approved for use on another type of aircraft produced by the same TC, but has not been tested on the ATP. This must be considered to be a shortcoming in the certification process for an aircraft used in commercial aviation.

SHK recognises that there is a large number of different brands of fluid on the market, and that it would therefore, initially, be an exacting and lengthy process to change the current system so that it included a "type certification" process, governing which kinds of fluid were authorised for use with which kinds of aircraft. However, taking as a reference the way other products and services in the aviation industry are managed (components, certification of personnel, limitations, etc.), it would seem reasonable for deicing fluids, too, to be included in a controlled and uniform regulatory framework.

2.4.2 Certification

As has been mentioned above, there is no certification of the de- and antiicing fluids used in commercial aviation. There are, however, documented safety problems connected with two-step deicing, where other countries' accident investigation authorities have pointed out shortcomings and also drawn up recommendations. While it is true that these recommendations have come about in response to issues of a slightly different kind, involving anti-icing fluids, it is nevertheless probably the case that the underlying problem is the same as the one that caused the incidents dealt with here.

SHK finds it somewhat strange that materials used in aviation – in the form of deicing fluids applied to aircraft – do not have to go through a certification process. Besides the formal requirements which would seem to suggest that such a certification process should be a self-evident control mechanism in commercial civil aviation, the incidents dealt with in this report should provide additional grounds for the initiation of a revision of the current EU regulations in this area.

2.5 The elevator restrictions

2.5.1 Elevator Functioning

In all the incidents covered in this report, all flight controls had been checked for full mobility prior to takeoff, in accordance with the pre-takeoff checklist. In none of these checks did the crew note any stiffness or restriction in the manoeuvrability of the elevator to its end positions. In certain of the cases, flight controls were checked again after the incident, and found to have regained full mobility. This would suggest that one contributory factor in the temporary restriction of manoeuvrability was the airflows around the stabiliser caused by airspeed and propellers.

The takeoff procedure for the actual aircraft model is that the control column, in the initial phase of takeoff, is in the forward position – i.e. the elevator is deflected down. During acceleration, as the aircraft picks up speed along the runway the air flow forces increases, the position of the elevator – and the control column in the cockpit –successively moves towards their respective neutral positions.

At the calculated rotation speed, Vr, PF pulls back on the column, causing a corresponding movement on the elevator. The distribution of air pressure around the stabiliser changes, and the aeroplane lifts off. In some of the tests carried out, the first stage was a simulated takeoff after application of Type II fluid, followed by an identical takeoff procedure with Type I fluid applied. The limitations in elevator manoeuvrability noted on rotation when Type II had been used were completely eliminated in the following takeoff run where Type I fluid had been used.

It is therefore not probable that the cause of the restricted manoeuvrability can be found in the elevator itself – i.e. in factors other than the antiicing fluid in conjunction with the increased air flow forces. In SHK's view there are no grounds for believing that the specific technical functioning of the aircraft's elevator – and of the control column via which the elevator is controlled – played a causal part in the incidents in question.

2.5.2 Gap

The construction of the aircraft's tail section can be said to be of conventional type, with a fixed stabiliser and a moving elevator. The left-hand and right-hand halves of the elevator are attached to the stabiliser via three bearings, and the size of the gap between the units is not adjustable. In the light of the findings of our investigation, this non-adjustability can be seen to be a design factor that makes certain technical measures more difficult.

The aircraft's AMM stipulates maximum and minimum values for the permitted size of the gap, or clearance, between the stabiliser and the elevator. The permitted range of measurement can be said to lie between the limits for too narrow a gap (with a risk for mechanical contact, and thus physical restriction of movement), and too wide a gap (risk of aerodynamic changes which may affect performance). These relationships apply to operations under normal conditions.

Fig. 20. Elevator clearance at position 1.

The fact that measurements of the clearance were made in connection with the incidents has, however, changed the importance accorded to the size of the gap. The measurements made after the incidents suggest that there is a connection between too narrow a gap and the restricted manoeuvrability of the elevator experienced by the pilots concerned. In the vast majority of the cases, the gap measured was, at one or more points, narrower than the permitted minimum of 2.5 mm.

2.5.3 Practical Tests

In the aim of recreating the phenomenon, and of illuminating the importance of the size of the elevator hinge gap in this context, SHK carried out the tests in Malmö described above. The previous theory, that individual aircraft with too small an elevator gap were probably at greater risk of experiencing jamming, could not be unreservedly verified. However, in the tests carried out it was possible to recreate the phenomenon with such clear results that the link between on the one hand too narrow an elevator gap in combination with deicing fluids containing thickening agents, and on the other hand restricted elevator manoeuvrability, could be considered to be proved.

With the aim of further confirming this theory, a test was carried out with a replaced elevator fitted to the same aircraft individual. While the clearance of the new elevator from the stabiliser was, at one point, less than the permitted minimum, on average the clearance was much wider, taken over the whole length of the elevator. The tests carried out after the elevator replacement showed that there was full mobility of the elevator at rotation, even after the aircraft had been treated with deicing fluid containing thickening agents.

The tests carried out cannot be taken as providing a scientific basis for drawing definitive conclusions, but SHK nevertheless maintains that the test results, taken together with the technical examinations of the aircraft involved in the incidents, constitute a sufficiently firm foundation for claiming that such a connection does exist.

2.5.4 Connection between Fluid - Gap - Pressure Changes

The incidents involving restricted elevator manoeuvrability, taken together with the results of the practical tests carried out, strongly suggest that there is in these incidents a connection between the use of deicing fluid containing thickening agents, and there being too small a hinge gap between the stabiliser and elevator at rotation.

The pressure changes around the stabiliser are not a subject that this report can comment on, because there are no data available concerning aerodynamic tests carried out on this type of aircraft. The data to which TC refers, calculated for the HS 748 aircraft type, cannot be used since there are differences between the two types of aircraft in terms of both engine power, and the distance from the engines to the stabiliser. These factors affect the way the propeller slipstream hits the right-hand and left-hand side of the stabiliser, respectively.

Those factors which are, however, known – and which can be considered to be the main factors influencing the phenomenon under investigation here – can be summarised as follows:

- Residual deicing fluid of Type II or IV,
- average elevator clearance below permitted minimum for aircraft type,
- unknown impact of propeller slipstream around the stabiliser,
- remnant fluid in the hinge gap, where the polymers probably have not been fully affected by the airflow's shear forces,
- altered/restricted flow of air through the gap,
- altered aerodynamic pressure conditions around the stabiliser.

SHK cannot assess the composition or conditions of these factors – merely point out that they can be assumed to interact, in unknown relative proportions, to produce the phenomenon in question.

Fig. 21. Picture from the rotation phase (underside). Speed: approx. 100 kts.

This report will not be able to spotlight the exact course of events, or those parameters which have played an active part in triggering the phenomenon; further scientific studies, both type-specific and general, need to be carried out in an appropriately configured test environment.

2.6 Measures Taken

2.6.1 General

Deicing has long been a problem area in commercial aviation. For understandable reasons, work on this flight safety issue has tended to focus on the removal of meteorological contamination, with less attention directed towards better understanding the products used for that objective.

The type of aircraft in question is authorised for winter operations, and for the use of deicing fluids containing thickening agents. This authorisation has been issued despite the fact that neither of the actors involved in the process – the authority responsible for the continued airworthiness (EASA) and the type certificate holder (BAe Systems Ltd) – are in possession of comprehensive information regarding the aerodynamics of the aircraft's stabiliser. Moreover, there is insufficient information concerning how the aerodynamics are altered when different types of deicing fluid are applied.

The reference produced by TC in response to SHK's questions regarding pressure conditions around the stabiliser refers to theoretical calculations carried out for the ATP's predecessor, the HS 748, in the late 1950s. As has been mentioned above, the HS 748 does not have the same aerodynamics as the ATP, primarily owing to the fact that it has different engines and propellers, and a different distance between the engines and the stabiliser.

The incidents referred to in this report also feature an additional parameter which probably has to be present for the elevator restriction phenomenon to occur: an elevator clearance (i.e. the gap between the fixed stabiliser and the hinging elevator) that is less than the permitted minimum. That being said, SHK cannot guarantee that the phenomenon could not occur on individual aircraft where the gap has none – or small - margins to the prescribed tolerances.

Type certification of aircraft should therefore, in future, include the requirement that the manufacturer demonstrate that the aircraft has full manoeuvrability through all phases of the takeoff procedure after the application of deicing fluids containing thickening agents (non-Newtonian fluids).

The analyses of the deicing expert commissioned by TC, which SHK has taken part of, indicate that fluids, and changes in the viscosity of fluids, were probably the primary cause of the incidents. The fluid tests that have been carried out do not provide 100-per-cent corroboration of these theories. The elevator restrictions has occurred after use of both “old” fluids (Kilfrost) and newer types of fluids (Clariant). SHK can however not completely rule out that the increased viscosity may have affected some of the events.

2.6.2 *Operators*

Technical Considerations
The measures taken by the operators in connection with the incidents can be deemed reasonable and expected in light of the information available. The technical checks that were made following the incidences of elevator split followed the instructions laid down in the AMM. Since no other symptoms or malfunctioning could be identified, no further, or more detailed, technical inspections have been required or carried out.

Following the incidents that occurred most recently, inspections of a more in-depth nature were carried out, in some cases in consultation with TC. However, none of these investigations led to any new conclusions. The other measures of a technical nature that have been taken have followed the prescribed routines, for example with regard to measuring the clearance between elevator and stabiliser. In SHK's judgement, the companies concerned have dealt with the technical aspects of the problem satisfactorily.

Operational Considerations
A precondition for the occurrence of situations involving restricted elevator manoeuvrability is weather conditions that make it necessary to carry out deicing using Type II/IV fluids. SHK has received no indication that operational management practices – and/or operational restrictions in certain weather conditions – have been changed in response to the incidents covered in this report.

One of the operators sent out operational information to pilots, prescribing changes to routines and calculations of takeoff data after deicing with Type II/IV. The message contained information on the possibility of experiencing increased stick force at rotation, and also instructed pilots to increase rotation speed and select the left-hand pilot as PF.

SHK can note that the operator's measures might have a positive effect on the pilots' ability to deal with the phenomenon. Higher rotation speed is likely to lead to a larger volume of fluid leaving the critical surfaces. The performance effects (increased take off roll distances) of these arrangements are, however, issues that must be considered in connection with higher rotation speeds. It should also be mentioned here that the aircraft's actual CG probably affects the speed/force required to achieve a "normal" rotation.

It is probably not the case that the decision to manoeuvre the aircraft through takeoff from the left-hand pilot's seat affects rotation forces; however, bearing in mind the aircraft's design there is a much lower risk of system split when the aircraft is being controlled from the left side. In those cases where the elevator jams, and all manoeuvring is being carried out via the right-hand control column at the same time as the necessary force is applied, the clutch mechanism will disconnect. Where the aircraft is being manoeuvred exclusively via the left-hand column, this release of the clutch is avoided, i.e. no separation of the two elevator halves ensues.

It should also be pointed out in this context that the tests carried out by the manufacturer when the Type II fluid was being type-tested found, inter alia, that increased stick force could be felt in connection with rotation. This information has however not been reflected in amendments to the guidelines for takeoff procedure in the manuals concerned, or the provision of operative information to pilots. The only information has been in the MOM where it was mentioned that higher forces than normal may be expected. This must be seen as a shortcoming which may have had negative effects on flight safety.

Note
The final paragraph above does not extend to the revised material sent out by TC on 19 November 2010.

2.6.3 Regulating Authorities

There are two regulating authorities involved in the case investigated for this report, each having differing areas of regulator competence: the EASA is responsible for the continuing airworthiness of the aircraft in question; and the Swedish Transport Agency is responsible for issuing Air Operators Certificates, and for inspecting those operators possessing national licences.

With regard to EASA's role and actions in the case at question here, SHK notes that the Agency reacted clearly and quickly when the problems were brought to its attention. Via an Airworthiness Directive, grounding orders (within 30 days) were issued for those individual aircraft which do not meet the minimum permissible measurements established for the hinge gap between the stabiliser and elevator.

The Swedish Transport Agency is responsible for inspecting the operations of those commercial actors which operate the type of aircraft in question. This responsibility includes the duty to act in response to reports concerning air safety issues. These situations can be dealt with in two ways:

- The Transport Agency can act independently when air safety problems are identified;

- The Agency can activate SHK to examine in closer detail events which have affected air safety.

Both these alternatives presuppose that the chain of events consisting of reporting to the Transport Agency, assessment of the occurrence, and where necessary a referral to an investigating body, is properly functional along the whole of its length. In the case under investigation here, reports concerning serious occurrences, instead of being referred on along the chain, were left without response "somewhere within the system" at the Transport Agency. SHK considers that this is to be seen as a serious deficiency in the functioning of routines at the Agency.

We can add to the above the information which SHK, at an early stage of the investigation, passed on to the Agency concerning the incidents – and their likely cause – which had occurred in aircraft flown by Swedish operators. The reaction we noted on the part of the Agency was a written communication, more than six months after SHK brought the Agency's attention to the problems. This written communication contained, inter alia, a question to the EASA as to what that body thought about permitting continued operations of the aircraft in question with no restrictions.

2.7 Flight Safety Consequences

2.7.1 Operational Management

The incidents at issue here occurred in an area that can be seen as vital in terms of maintaining levels of flight safety. The ability to manoeuvre an aircraft through the whole of its register is an absolute sine qua non for the maintenance of operational safety margins and maximum flight safety levels. Most of the incidents concerned involved takeoffs – or aborted takeoffs – where flight safety was negatively affected.

It should also be emphasised that most of the aborted takeoffs took place at speeds above the takeoff decision speed established for the aircraft in question, with the consequence that performance requirements (such as runway length required) no longer were complied with. This probably means that safety margins were compressed for these takeoffs. On several of those occasions when takeoff was continued, there was a split (i.e. separation) of the two halves of the elevator; the safety implication of this is, of course, that pitch control of the aircraft is compromised.

The most serious of the incidents was the one that occurred at Arvidsjaur, when the aircraft left the ground at the same time as power was reduced on both engines; it was only thanks to good fortune, and the resourceful quick thinking of the Commander, that a serious aviation accident could be averted. Taking all the incidents into account, SHK can note that operators and the pilots involved have been exposed to situations which were unpredictable, and which are not, either, covered in the routines published in the operative manual of the aircraft concerned.

2.8 Conclusions

It can be concluded that some of the incidents covered here were serious, but that none of them resulted in an accident. This investigation has also shown that the operators whose aircraft were affected by the incidents did not themselves contribute to the occurrences through technical or operational omissions or deficiencies. The conditions leading to the occurrence of the incidents probably arose as a result of the fact that the regulatory framework governing the application of thickened deicing fluids is not stringent or clear enough to guarantee safe operation of this type of aircraft during all weather conditions.

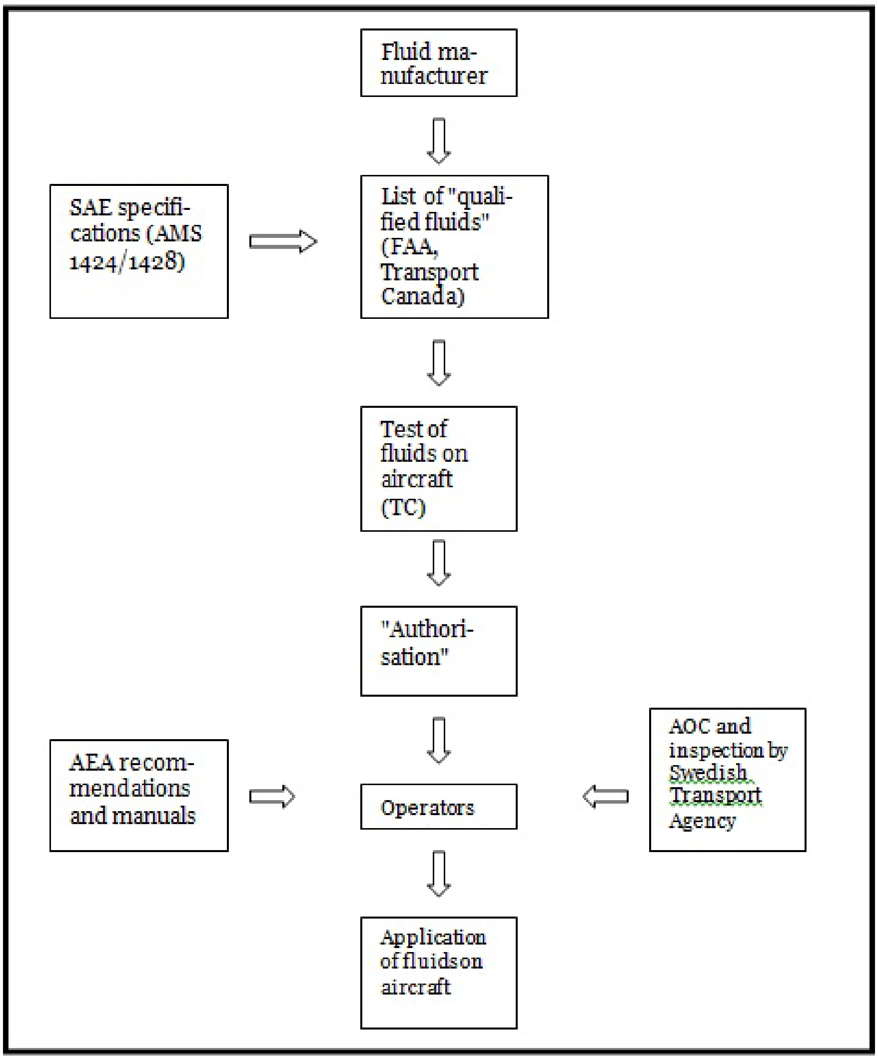
The exact reason why elevator restrictions occurs has not been definitively demonstrated, but the hydrodynamic phenomena which occur under the conditions described throughout this report are, with all certainty, linked to the construction of the tail of the aircraft. The reason why these problems have not occurred – and been diagnosed – before is probably that in recent years, there has been a concentration of this type of aircraft at northern latitudes.

As mentioned earlier there has also been claimed that increased viscosity of the fluids might have affected the late debut of the phenomenon. The increased viscosity over the years is however mostly obvious when the fluid is diluted. The fluids used in the test series were “undisturbed”, meaning that they were poured on the surfaces and not diluted in any way. SHK find it therefore not probable that the change in viscosity values should have any greater impact on the late appearance of the events.

The flight safety gains that have been achieved through implementation of the "Clean Aircraft Concept" in commercial civil aviation can, in the overall view, be seen as considerably outweighing the risks which, in a small number of cases, may arise in connection with deicing. The amount of accidents that have been caused by the formation of ice on aircraft is innumerable, while the number of incidents caused by deicing fluids are extremely small. SHK will therefore not be issuing any further recommendations with regard to the type of aircraft in question; we note that the measures taken by TC and the inspection authority concerned are sufficient.

That being said, SHK considers that there is a need for an overhaul of the current regulatory framework relating to the management of aircraft deicing. In the long term, it is not to be recommended that trade organisations with commercial interests are in control of significant parts of the process of testing, setting specifications for and granting "authorisation" to deicing fluids.

Process chain for fluids



The figure above describes in diagram form the current situation with regard to the path taken by deicing fluids from manufacture to their use on aeroplanes. This process has become a standardised routine, but it is not based on any common regulations applying to the commercial civil aviation industry. It is the view of SHK that instead, these questions should be regulated under the aegis of the ICAO, with monitoring of the observance of the regulations entrusted to relevant authorities. Responsibility for some elements of the process can probably be delegated to the trade organisations involved. On top of this, additions should be made to the certification criteria for new aircraft, with regulations to determine which fluids may be used on which types of aircraft in order to guarantee maximum air safety in all kinds of weather conditions.

It should also be noted in this context that problems with deicing fluids have also been given attention to by other national European accident investigation authorities in connection with inquiries into aviation incidents. These investigations led, inter alia, to recommendations being made to EASA that a certification procedure for deicing fluids should be introduced. SHK feels that the incidents which have now occurred involving BAe ATP aircraft highlight the need for more stringent means of monitoring and regulating aircraft de- and antiicing fluids.

3 CONCLUSIONS

3.1 Investigation Findings

The following findings from our investigations derive both from the incident on which this report is primarily based, and also from the other incidents involving the type of aircraft in question which are mentioned in the report.

a) The pilots were authorised to carry out the flight.
b) The aircraft had a valid Airworthiness Certificate.
c) The incidents occurred during winter weather conditions.
d) The incidents occurred following deicing with Type II or Type IV antiicing fluid.
e) Reduced manoeuvrability – or restrictions – of the elevator was experienced as the aircraft reached rotation speed.
f) No operational errors were committed.
g) No technical failures of the aircraft could be detected.
h) Practical tests of the fluids used were unable to detect any decisive deviations from the specifications in place.
i) Chemical analyses of the fluids used were unable to detect any traces of foreign substances, or any other deviations.
j) Tests have shown that elevator clearance measurements (i.e. the size of the hinge gap between the elevator and stabiliser) below the permitted minimum were a factor in the appearance of the phenomenon.
k) Tests have shown that fluid collected in the gap during acceleration for takeoff.
l) All flight controls were checked for full travel before – and in most cases also after – the moment when restricted elevator manoeuvrability occurred.
m) A "split" of the elevator system occurred in several of the incidents.
n) The phenomenon produces different consequences depending on whether the aircraft is being flown from the right-hand or left-hand pilot's seat.
o) The manufacturer has tested the aircraft for the application of Type II fluids, and these tests showed a certain increase in the stick force required for takeoff.
p) The aircraft has not been tested for the application of Type IV fluids.
q) Authorisation for certain types of aircraft to use certain types of fluids is not a matter that gets referred to any independent authority.
r) Deicing fluids for use on aircraft are not subjected to a certification process by EASA.
s) European accident investigation authorities have previously recommended that a certification process for deicing fluids should be introduced.

3.2 Causes of Incidents

The incidents involving elevator restrictions were caused by a phenomenon which, for unknown reasons, occurs following the use of anti-icing fluids containing thickening agents, on individual aircraft where the stabiliser and elevator are too close together. One contributory factor was the fact that there were shortcomings in that part of the aircraft's type certification exercises that concerned anti-icing.

4 RECOMMENDATIONS

It is recommended that EASA should:

- Work for an extension of EASA’s remit to include certification of fluids used for ground de- and antiicing of aircraft. *(RL 2011: 16e R1).*

- Investigate the possibility of tightening requirements on aircraft design organizations in terms of demonstrating that the aircraft has full manoeuvrability during all phases of the takeoff procedure after the application of de- and anti-icing fluids. *(RL 2011: 16e R2).*

- Actively consider the value of a wider use of Type III fluids, (or correspondant fluids), within the field of European Civil Aviation. *(RL 2011:16e R3).*

It is recommended that ICAO should:

- Within the international flight safety community, work to ensure that in the future, the issuing of requirements, specifications and definition of areas of use, aircraft de- and anti-icing fluids are made the responsibility of airworthiness authorities. *(RL 2011:16e R4).*

Enclosures:

1. Operational report West Air
2. Operational report West Air
3. Operational report Next Jet
4. Operational report Next Jet
5. Letter to the Swedish Transport Agency (Swedish only)
6. Minutes of Meeting
7. Report from Exova AB (Swedish only)
8. Operational info FAA
9. Report from BAe Systems
10. EASA SIB
11. EASA AD
12. Letter from the Swedish Transport Agency

Received date: 2009-12-15 FOR No: 223

WEST AIR SWEDEN

FLIGHT (FOR, VR)
TECHNICAL (TOR)
QUALITY
SECURITY
DANGEROUS GOODS
GENERAL

REPORT

Dispatch this report immediately to the Quality Department, for classification.

I, (the issuing person), refer this report to concern :

☒ FOR ☐ VR ☐ TOR ☐ Quality ☐ Security ☐ Dangerous Goods ☐ General

A/C Type:	A/C Reg:	Flight No:	Date:	Occurrence place:	PIC (block letters):
BAe ATP	SE-MAP	PT 2HE	2009-12-10		
Departure Airport:	T/O time UTC:	Dest. Airport:	Ldg. Time UTC:	Occurrence time:	Flight / Ground phase
Flight Level:	Diverted to:	MET conditions:	Other:	Additional report:	

Flight data relevant to the occurrence and description of occurrence, probable cause and information. If technical, do not forget the Flight Log.

At rotation from rwy 04r I noted a heavy resistance in the yoke in pitch mode. The yoke was stuck so I applied a lot of force and it felt like something gave and the yoke moved back and we rotated. I have been in this situation twice before, once it resulted in a split elevator and the other occasion was similar to this report. On all 3 occasions the take offs have been after completion of a 2 step deice with wet snow on the ground. A control check for full movement was completed while lining up on the RWY. A previous response from to a similar report was "Pilots should complete a control check while lining up". I have never lined up a WAS A/C without performning a control check. It comes as surprise to find the controls stuck when you have checked them for full movement 30 sec earlier; maybe worth mentioning during training.

Date:	Issuing persons full name:	Other involved personnel:	Do you want feedback?
2009-12-15			☐ YES ☐ NO

Received by:	Date:	Sign:
Peter Eklund	2009-12-15	

Classification by the Quality Manager:

☒ FOR ☐ VR ☐ QR ☐ Dangerous Goods ☐ General ☐ Minor Incident ☐ CC NAA
☐ TOR ☐ Maint. Request ☐ Security ☐ Info ☐ Major Incident ☐ CC TC H

Reviewed on meeting, date:	Responsible for action/answer:	Reported to CSO
	MM-OPS	2009-12-16

Report perform date:	Report closed date:

Instructions: Classify the report by marking in the squares at the top portion. Fill out the report as detailed as possible. Fax the report to QM.(031-7030455)

This portion is for the QM ONLY!

Received date: 2009-12-23 FOR No: 225

Instructions: Classify the report by marking in the squares at the top portion. Fill out the report as detailed as possible. Fax the report to QM.(031-7030455)

WEST AIR SWEDEN

FLIGHT (FOR, VR)
TECHNICAL (TOR)
QUALITY
SECURITY
DANGEROUS GOODS
GENERAL

REPORT

Dispatch this report immediately to the Quality Department, for classification.

I, (the issuing person), refer this report to concern :

☒ FOR ☐ VR ☐ TOR ☐ Quality ☐ Security ☐ Dangerous Goods ☐ General

A/C Type:	A/C Reg:	Flight No:	Date:	Occurrence place:	PIC (block letters):
BAe ATP	SE-MAP	PT 7046	2009-12-22	EFHK	
Departure Airport: EFHK	T/O time UTC:	Dest. Airport:	Ldg. Time UTC:	Occurrence time: 18.10	Flight / Ground phase: Flight
Flight Level:	Diverted to:	MET conditions:	Other:	Additional report:	

Flight data relevant to the occurrence and description of occurrence, probable cause and information. If technical, do not forget the Flight Log.

When cleared to T/O in HEL we started our roll. AT 80kts the F/O (PP) noticed that the yoke moved slowly backwards. AT Vr PF ( ) took the yoke to rotate. The yoke was difficult to move backwards and the A/C felt too nose heavy. The T/O was aborted and when clear of R/W we checked the loading figures and saw that the A/C was within the CG limits (index of 57). We decided to make a 2nd T/O, now with the F/O ( ) as PF to see if the problem appeared again. A new T/O was carried out and this time we got a CWP warning of "standby controls" at V1 and "elevator split" was illuminated. We went back to parking and called LMC. We went back to position 8 and checked the ballast and noticed that we only had 250kg instead of the planned 525kg. This gave us an index of 45 instead of the planned 57.

In Copenhagen this morning (8046) we were told by the OP that the A/C had a total of 400kg of ballast. Due to wrongful loading, caused by FedEx, we asked them to load another 125kg of ballast in section 8, a total of 525kg. We made a normal T/O, slightly nose heavy but still normal, and a normal flight and landing in HEL. But after 2 aborted T/O for 7046 we checked the ballast and noticed that we only had 250kg onboard.

A FDR Download has been requested and performed.

Date:	Issuing persons full name:	Other involved personnel:	Do you want feedback?
2009-12-23			☒ YES ☐ NO

This portion is for the QM ONLY!

Received by:	Date:	Sign:
	2009-12-23	

Classification by the Quality Manager:

☒ FOR ☐ VR ☐ QR ☐ Dangerous Goods ☐ General ☐ Minor Incident ☒ CC NAA
☐ TOR ☐ Maint. Request ☐ Security ☐ Info ☐ Major Incident ☐ CC TC H

Reviewed on meeting, date:	Responsible for action/answer:	Reported to CSO
	FOM	2009-12-23
Report perform date:	Report closed date:	

NEXTJET

Aviation Safety Report (ASR) - 55
Printed by
Printed 2009-12-23

Issuer part

Occurence Date
2009-12-23

Status
Registered

ASR-Receiver
ASR-receiver

Aircraft and Reg and type
SE-LLO - ATP

To/Diverted to
ESNX

Ias/Mach
100

Flight phase
Take Off

Alt/FL
Take off

Crew workload level
Medium

From
ESNX

Met Conditions
100/ 4kts –SN vis 3000m temp-16/-18 ovc 700feet QNH 991 and braking action 85-80-75

*Description of Facts and Causes
Take off from AJR rwy 12 with FO as flying pilot

After call out ”V1 ROTATE” FO indicated something was unusual.
I called out ”CONTINUE” and also helped to rotate the aircraft.

This triggered the stand by system and we got indication STAND BY CONTROLS on warning panel (CWP).

Roof panel showed ENGAGED and SPLIT and later on only SPLIT.

We continued straight ahead and entered AS holding according to our pre-departure briefing.
Established in holding we informed CC1 (and asked if she could inform the passengers.
The EMC checklist ended with LAND AT NEAREST SUITABLE AIRFIELD and in this case we considered it to be AJR.
Before starting the approach we changed controls and I was the flying pilot.

Last part of the approach was flown manually the get familiar with the different response to flight control. Also we flew down to ground with Vat +15 before closing the throttles.
In conclusion the aircraft flew normally with larger input and a little swampy feeling.
Back on stand the technician confirmed that we had an split situation on the elevator.

Additional info.

WX ESNX 100/ 4kts –SN vis 3000m temp-16/-18 ovc 700feet QNH 991 and braking action 85-80-75
TOW 18 487 kg / Index 58 /Pax 7 /Take off 05:08 landing 05:29
Warm aircraft was pulled out of the hangar and because of the temp diff snow attached to the wing .
Aircraft was de-iced before take off with 300 l Typ I and 100 l Typ II.
HOT started at 04:58
Crew:

Planning-/actions part

Forward to

Extra field

Correctional action- what should be done to prevent the nonconformance to occur again?

Actions estimated completion date

Reminder (email)

Actions carried out by

Action Completed Date

NEXTJET

Company Report - 1139
Printed by
Printed 2010-01-13

Issuer part

Reg no.
1139

Reg date
2009-12-01

Status
Resolved

Report Area
Flight Ops

Anonymous/Feedback
Ok for distribution

IATA delay codes

Occurrence Date
2009-11-30

Delay min

Flight Number
NTJ449A

Aircraft Registration
SE-LLO - ATP

Airport ICAO code (Four letter code)
ESNX

Short summary of description
Jammed elevator

Description
I was the pilot flying on our third flight of the day, from Arvidsjaur to Stockholm Arlanda. As passengers boarded there was (heavy) snowfall which resulted in the captain ordering the ground staff to de- & anti-ice the aircraft.
As we taxied to the runway the normal flows and checklists were performed, flight controls were checked as usual.

The first part of the take-off run was normal but as we passed V1 (99 kts) and I pulled back on the control column the aircraft didn't respond. When realizing nothing happened I pulled back on the control column even more and advised the captain something was wrong. Speed was now past V1 (probably by 10-15 kts) but as the aircraft was not lifting of the captain decided to abort the take-off. As he started to close the power levers the attention getter started flashing and an audible warning sounded, STANDBY CONTROLS illuminated on the Central Warning Panel. At the same time the aircraft lifted off.

The captain increased to take-off power and the aircraft climbed away normally. I continued as pilot flying and as we passed safe altitude the captain performed emergency checklist card 30 "Standby Controls Warning". On the standby flying control indicators on the overhead panel we noticed the ELEVATOR SPLIT light was illuminated. I also noticed the elevator trim command indicator was illuminated and that the elevator out-of-trim indicator showed a large deflection.

We discussed the problem and what options we had. As weather was really bad at our departure aerodrome and the aircraft was now performing normally we decided to continue to our destination. The captain then advised the cabin crew of the situation, they were a bit worried as they had noticed the abnormal take-off.

During cruise we once disconnected the auto-pilot and flew the aircraft manually, the aircraft responded normally. The approach and landing was normal, we decided to add 10 kts to our threshold speed as we didn't know how the aircraft would perform at low speed.

As we came to stand we advised the technician of what had happened. After he had examined the aircraft he told us one of the elevators had been jammed, probably due to snow or ice that had frozen. The technician then reset the elevators and the auto-split system and declared the aircraft fit to fly.

Suggestion

Process/actions part

Correctional action- what should be done to prevent the nonconformance to occur again?
This is a very unusual fault. NEXTJET has put down a serious and deep investigation which is presented in ASR 53

Forward by e-mail

Actions carried out by

Action Completed Date
2009-12-07

Notes about corrective actions

Bilaga /Enclosure 5

Statens haverikommission
Swedish Accident Investigation Board

Stockholm 2010-03-19
Ref: L-07/10-SC

Transportstyrelsen
Luftfartsavdelningen

Tillbud med Bae ATP

SHK utreder ett tillbud med luftfartyg av typen Bae ATP. Tillbudet inträffade i samband med start från Helsingfors där flygplanets höjdroder upplevdes sakna rörlighet i rotationsögonblicket. Vid närmare efterforskning har SHK funnit att detta fenomen har inträffat vid ett flertal tillfällen med denna flygplanstyp.

I flertalet fall har höjdrodret upplevts som helt fast, i andra fall har ett onormalt motstånd upplevts. Vid vissa av tillbuden har en ”split” inträffat, dvs, höga krafter i linstyrverket har resulterat i att höger och vänster system separerat. Detta är design på typen och är avsett att förhindra förlust av höjdroderverkan vid exempelvis en låsning av den ena sidans höjdroder. Resultatet efter en split är att höger pilots styrkolumn kontrollerar höger höjdroderhalva och vänster pilot den vänstra.

Tillbuden har inträffat hos två svenska operatörer med frakt respektive passagerarversion av flygplanstypen. Vid ett av tillfällena – med passagerare ombord – var höjdrodret låst vid rotationen varvid befälhavaren omedelbart drog av. I samma sekund ”splittade” dock systemen varvid höger pilot fick höjdroderverkan och flygplanet lättade. Befälhavaren drog då på max power igen och starten fortsattes. Det kan även nämnas att ett nytt tillbud inträffade på kvällen den 18 mars vid start från Hemavans flygplats. Denna flygplansindivid är nu groundad.

Närmare undersökning av förutsättningar gav vid handen följande resultat:

- Fenomenet är inte av teknisk/mekanisk karaktär. Inga fel har hittats på individerna och full roderverkan har funnits vid kontroll före start.
- Tillbuden har samtliga inträffat under vinterförhållanden.
- Vid alla tillbuden har flygplanen avisats.
- Avisningarna vid tillbuden har varit av tvåstegstyp, dvs. antiice vätska av typ II eller IV har använts
- Tillbuden har inträffat på flygplansindivider där avståndet mellan stabilisator och höjdroder – vid vissa mätpunkter – understiger det minimimått som tillverkaren föreskriver.

För att kunna bekräfta ovanstående har SHK låtit utföra ett antal tester på en av de individer som drabbats av fenomenet. Testerna har utförts på Malmö/Sturup och i form av take off runs till rotationsfart. Stabilisator och höjdroder belades med olika typer av avisningsvätskor före testerna. Vid användning av typ II och IV uteblev höjdroderverkan och flygplanet kunde inte roteras. Testerna skedde med kameror monterade på ovan- respektive undersida av stabilisatorn. Vid studie av filmerna har SHK kunnat dokumentera vad som händer med vätska respektive höjdroderspalt under acceleration och rotation.

SHK anser att problemet är mycket allvarligt ur flygsäkerhetssynpunkt och vill därför informera Transportstyrelsen, dels om de inträffade händelserna, dels om resultatet av de tester som utförts i SHK:s regi. Med hänsyn till att eventuella åtgärder och/eller restriktioner omedelbart bör diskuteras kallar därför SHK Transportstyrelsen till möte i frågan med kort varsel enligt följande:

Datum:	Måndag 22 mars 2010
Tid:	13:00 – 15:00
Plats:	Westmanska palatset, lokal Bellman, Holländargatan 17 Stockholm

Vid uppstart av detta ärende informerades EASA enligt de rutiner som SHK följer vid denna typ av utredningar. I samband med detta anmälde EASA intresse att följa utredningen och ta del av eventuella resultat. SHK har idag därför bjudit med EASA:s representant i detta ärende på mötet den 22 mars. På grund av tidsbrist har man dock avböjt deltagande.

SHK planerar dock – oavsett resultat från måndagens möte – att hålla ytterligare ett möte i form av en ”work shop” med deltagande från tillverkare, ackrediterad representant UK, berörda operatörer samt tillsynsmyndigheter. Mötet planeras preliminärt att hållas i Malmö, där tillgång till en av de berörda flygplansindividerna kommer att finnas.

Med vänlig hälsning

Stefan Christensen
Utredningschef
SHK

Statens haverikommission
Swedish Accident Investigation Board

SHK Case, L-07/10

Minutes of meeting

Workshop in Malmö, March 30 2010, regarding BAe ATP elevator restriction at T/O.

Participants:

Stefan Christensen	AIB Sweden	Alistair G Scott	BAe
Henrik Elinder	AIB Sweden	Robert Drews	West Air
Björn Brink	AIB Sweden	Peter Eklund	West Air
Julian Firth	AAIB UK	Bengt Holmqvist	West Air
Nigel Davis	CAA/EASA	Anders Åkesson	Next Jet
Britt-Marie Kärlin	CAA Sweden	Christian Lindberg	Next Jet
Mats Ersbrant	CAA Sweden	Odd Heier	Next Jet

Notes:

1) AIB Sweden presented the background for its engagement in this issue and the main objectives for the Workshop. It was clearly stated that this is a meeting during an ongoing investigation within the AIB, where the main objective is to point out a serious operational issue. Requisite further actions will be handled by the appropriate regulator(s) and the aircraft manufacturer.

2) The events of BAe ATP elevator restriction problem at V_R (T/O) was presented;

- West Air and Next Jet have experienced several incidents.
- In all cases the elevator restriction has occurred in connection with normal winter operation and the usage of Type II or Type IV anti icing fluid.
- The problem has resulted in several aborted T/O and in some cases continuous flight with elevator split.
- At least one of the cases is considered to be a serious incident.
- Actual EASA actions regarding de/anti-icing problems (NPA 2009-09) do not adress this type of problems.

3) The operators informed specifically about their respectively incidents, West Air/100111, Next Jet/100318, and the difficulties they have experienced to get necessary support from the manufacturer and the authorities regarding the problem.

4) Information was presented regarding de/anti-icing fluids characteristics and performance.

5) A general technical review of the elevator control- and split-system was given, including the Aircraft Maintenance Manual (AMM) minimum limits for elevator installation clearances.

6) Set up and preparations for the high speed simulated T/O tests with different types of de- and anti icing fluids on the stabilizer upper surface were presented for the meeting. The test runs were accomplished by West Air in coordination with the Swedish AIB.

- Before the tests the average clearance between the elevator leading edge and the facing stabilizer trailing edge was measured.
- Two video cameras, one for top view and one for bottom view, were installed for the tests.

7) Results of test performed are presented as summarized below:

		Gap-margin to AMM min.				
Test no	A/C	L/H elevator	R/H elevator	Fluid	Elevator	Result
1	SE-MAP	-0,5 mm	-0,5 mm	Type IV	Original	Stuck Elevator at V_R
2	SE-MAP	-0,5 mm	-0,5 mm	Type I	Original	Free Elevator at V_R
3	SE-MAP	-0,5 mm	-0,5 mm	Type I+II	Original	Stuck Elevator at V_R
4	SE-LPU	+1,0 mm	+1,1 mm	Type IV	Original	Free Elevator at V_R
5	SE-MAP	+ 0,9 mm	-0,1 mm	Type IV	Changed	Free Elevator at V_R

8) Result of measurements and inspection performed on Next Jet A/C SE-LLO after incident 100318 are presents as summarized below:

		Gap-margin to AMM min.				
Incident	A/C	L/H elevator	R/H elevator	Fluid	Elevator	Result
100318	SE-LLO	-0,1 mm	1,4 mm	Type I+II	Original	Stuck Elevator at V_R

9) Possible causes and circumstances for the sudden elevator restriction at V_R were discussed;

- "Modified elevator aerodynamics"
- "Hydro restriction"
- "Stabilizer trailing edge curvature"
- "Backward" initiation of elevator split.

10) A sum-up of the Workshop was made as below:

- All involved parties agreed that the elevator restriction problem is a high priority flight safety issue.
- The regulating authorities and the A/C manufacturer will investigate the problem further in order to come up with short- and long term solutions to solve the problem.
- As a temporary solution the operators will evaluate the need to implement some type of operational restrictions in connection with the usage of Type II and Type IV anti icing fluid.

12) The Workshop was closed.

Stockholm April 9, 2010

Stefan Christensen
Investigator in Charge
Swedish AIB (SHK)

Teknisk rapport **TEK11-0061**
Utgåva 2
Infoklass I

Beställare	Beställningsdata	Granskad/godkänd av	Rapportfördelning
Statens haverikommission Att. Stefan Christensen Box 12538 102 29 STOCKHOLM	Avtal dnr A-92/09 2010-11-11 Urban Kjellberg Teknisk handläggare Stefan Christensen	Per-Åke Skoog	Statens haverikommission Stefan Christensen 1 org. + 1 elektr. ex

Analys av antiis- och antifrysvätskor

2011-02-24

Handläggare	Telefon	E-post
Rickard Jansson	013-169067	rickard.jansson@exova.com
Ao nummer	**Id nummer**	
A05635		

Denna utgåva 2 av rapporten ersätter tidigare utgåva 1. Ändrade avsnitt är streckmarkerade. TEK201100612.DOC

Sammanfattning

Efter flera flygincidenter där styrningsmekanik på flygplan inte fungerat tillfredsställande, analyserades antiis- och antifrysvätskor som eventuellt skulle kunna vara orsaken till mekanikstörningarna. Fyra produkter ingick i utredningen; Safewing® MP I Eco Plus (80) och Safewing® MP II Flight från Arvidsjaur, samt typ I och typ II vätska av fabrikatet Kilfrost ABC 2000 från Hemavan. Produkterna används i en tvåstegsprocess där den första vätskan (typ I) sprutas på planen för att smälta eventuell is. Därefter appliceras den andra produkten (typ II) som skapar en skyddande hinna på planet för att inte is skall kunna bildas på planet medan det står på marken. När planet accelererar på startbanan skall denna produkt (till följd av luftströmmar) försvinna från planet.

I utredningen har produkterna analyserats med avseende på enklare fysikaliska egenskaper som anges i produktdatabladen, samt även med avseende på karaktärisering av produkterna.

Slutsatserna är att produkterna till största del består av flyktiga komponenter, men att en liten del (mindre än en massprocent) erhålls som rest vid indunstning. I denna rest ingår bland annat färgadditiv. Övrig identifiering av komponenter i resten var ej möjlig med tillgängliga tekniker. Den flyktiga delen av produkterna (resterande 99 mass%) består till största del av propylenglykol, men även föroreningar och/eller additiv i mycket små koncentrationer. Det förekommer skillnader i sammansättning mellan typ I och typ II-vätskorna, där den senare typen innehåller flera komponenter som inte påträffas i den första. Ingen identifiering av dessa föreningar var möjlig med tillgänglig teknik.

Inledning

I denna utredning har kemiska och fysikaliska egenskaper undersökts hos två prov av avisningsvätskor och två prov av antifrysvätskor. Vätskorna används på flygplatser i en tvåstegsprocess: först avisas flygplan med avisningsvätska (steg 1, typ I vätska), därefter skyddas planet från isbildning med hjälp av ett skyddande lager med antifrysvätska (steg 2, typ II vätska). Vid flygplanets start skall antifrysvätskan, till följd av luftströmmar, försvinna från planet. I Haverikommissionens utredning undersöks incidenter där dessa vätskor kan ha haft en negativ inverkan på planens styrningsmekanik.

Enligt SAE AMS 1424, avseende typ I vätskor som används för steg 1 enligt ovan, skall avisningsvätskan baseras på en fryspunktsnedsättare (exempelvis glykol) tillsammans med additiv. Inga förtjockare får ingå i produkten. Krav på produktens tekniska egenskaper specificeras även enligt SAE AMS 1424. En motsvarande specifikation, SAE AMS 1428, gäller för vätskor av typ II som används i steg 2 ovan. Till skillnad från typ I vätskor innehåller vätskor av typ II även förtjockare. Alternativ till tvåstegsprocessen enligt första stycket förekommer, men berörs ej vidare i denna rapport.

Produkterna som undersöktes var av fabrikaten Safewing® MP I Eco Plus (80) och Safewing® MP II Flight från Clariant, som använts vid flygplatsen i Arvidsjaur, samt typ I och typ II vätska av fabrikatet Kilfrost ABC 2000, som använts vid flygplatsen i Hemavan. Typ I-proverna hade olika spädningsfaktorer med vatten, en koncentrerad produkt (80 % glykol) samt en spädd (40 % glykol) i vatten. Typ II-proverna var koncentrerade. Referensvärden för produkternas tekniska egenskaper (gäller fabrikat Safewing®) kommer från produktdatabladen[1]. Enligt produktdatabladen baseras båda vätskorna på propylenglykol. Typ I vätskans koncentrat skall innehålla minst 80% propylenglykol, medan typ II vätskan skall innehålla minst 50% propylenglykol.

Föremål

Beskrivning:	4 prov; 2 st avisningsvätskor (de-icing, Type I) och 2 st antifrysvätskor (anti-icing, Type II)
Märkning:	Exova-nr 2010-9178 – Type I Safewing MP I Eco Plus (80), Arvidsjaur Exova-nr 2010-9179 – Type II Safewing MP II, Arvidsjaur Exova-nr 2011-797 – HMV Typ I, 40% Bil Tank, Hemavan Exova-nr 2011-798 – HMV Typ II, Bil Tank, Hemavan
Ankomstdatum:	2010-9178 och 2010-9179 ankom nov 2010 2011-797 och 2011-798 ankom jan 2011

[1] Safewing® MP I ECO PLUS (80), Clariant Produkte (Deutschland) GmbH, May 2009 samt Safewing® MP II FLIGHT, Clariant Produkte (Deutschland) GmbH, May 2009

Undersökning

På den första omgångens prov (nov 2010) undersöktes fryspunkt, färg, densitet vid 20°C samt brytningsindex vid 20°C. Värdena jämfördes med angivna värden på produktdatabladen. Dessutom undersöktes produkternas flyktighet med hjälp av termogravimetrisk analys (TGA). I denna analys utvärderas provet gravimetriskt (vikt) medan det värms i en kammare med tillförsel av kvävgas. Analysen ger en temperaturprofil för viktsförändringar hos provet, vilket kan kopplas till flyktighet i den inerta miljön som kvävgasen ger upphov till. Mätningen utfördes med en temperaturramp från RT till 900°C, värmning 10°C/min.

För att kontrollera hur mycket rest som erhålls indunstades samtliga prov (vid 120°C). 50 ml prov överfördes till invägda provglas. Dessa glas placerades sedan i värmeblock med ett lågt flöde av luft över ytan på provet. Efter indunstningen erhölls en rest som vägdes ut genom att väga glasen.

De indunstade resterna analyserades med hjälp av Fourier Transform Infrared Spectroscopy (FTIR). Tekniken bygger på att kemiska bindningar kan absorbera infrarött ljus i specifika väglängder och omvandla energin i ljuset till kinetisk energi (vibrationer m.m. i molekylen). Beroende på strukturen hos molekylen kommer olika molekyler att absorbera ljus av olika våglängder. Ett FTIR-absorbansspektrum kan jämföras med ett kemiskt fingeravtryck för molekylen.

Proven undersöktes även med gaskromatografi (GC). Inom organisk analys används kromatografi för att separera olika föreningar från varandra, för att på så sätt kunna identifiera och kvantifiera vilka typer av föreningar som finns i ett prov. Gaskromatografi innebär att molekylerna är i gasfas då de separeras från varandra. Vid undersökningen användes följande försöksuppställningar:

1. ***GC med direktinjektion[2], flamjoniseringsdetektion (GC-FID)***

   Kolonn: DB-WAX, 30 m, I.D. 0,32 mm, film 0,5 µm

   Injektionsvolym: 1,0 µl

   Injektionstyp: Split 175:1

   Injektortemperatur: 250°C

   Detektortemperatur: 250°C

   Temperaturprogram kolonn:

Ramp	Temp.	Hålltid
	100°C	2 min
30°C/min	130°C	10 min
10°C/min	150°C	4 min
30°C/min	220°C	6 min

   Bärargas/flöde: Helium konstant flöde 20 ml/min

[2] Provet injiceras direkt på analyskolonnen utan förvärmning av provet

2. *GC med headspace-injektion[3], flamjoniseringsdetektion (HS-GC-FID)*

Kolonn: DB-WAX, 30 m, I.D. 0,32 mm, film 0,5 µm

Injektionstyp: Split 10:1

Headspaceugn: 150°C, 30 min

Injektortemperatur: 200°C

Detektortemperatur: 250°C

Temperaturprogram kolonn:

Ramp	Temp.	Hålltid
	60°C	4 min
10°C/min	130°C	6 min
15°C/min	220°C	6 min

Bärargas/flöde: Helium konstant tryck 9,60 psi

[3] Provet förvärms i en ugn, varefter flyktiga komponenter som befinner sig i gasfas injiceras på analyskolonnen

Resultat

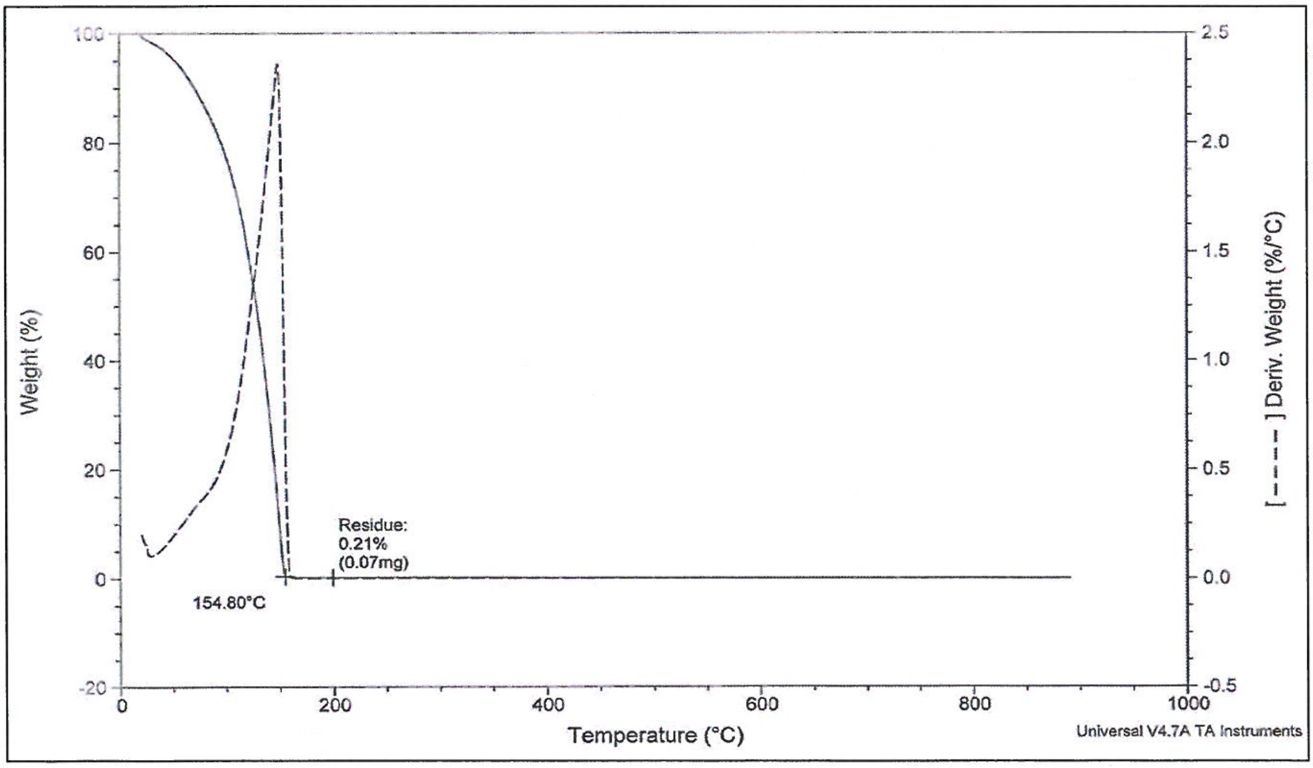
I tabell 1 redovisas analysresultaten för fryspunkt, färg, densitet samt brytningsindex för den första provomgången (nov 2010), tillsammans med referensvärden från produktdatabladen.

Tabell 1. Egenskaper hos Safewing® MP I Eco Plus (80) och Safewing® MP II Flight.

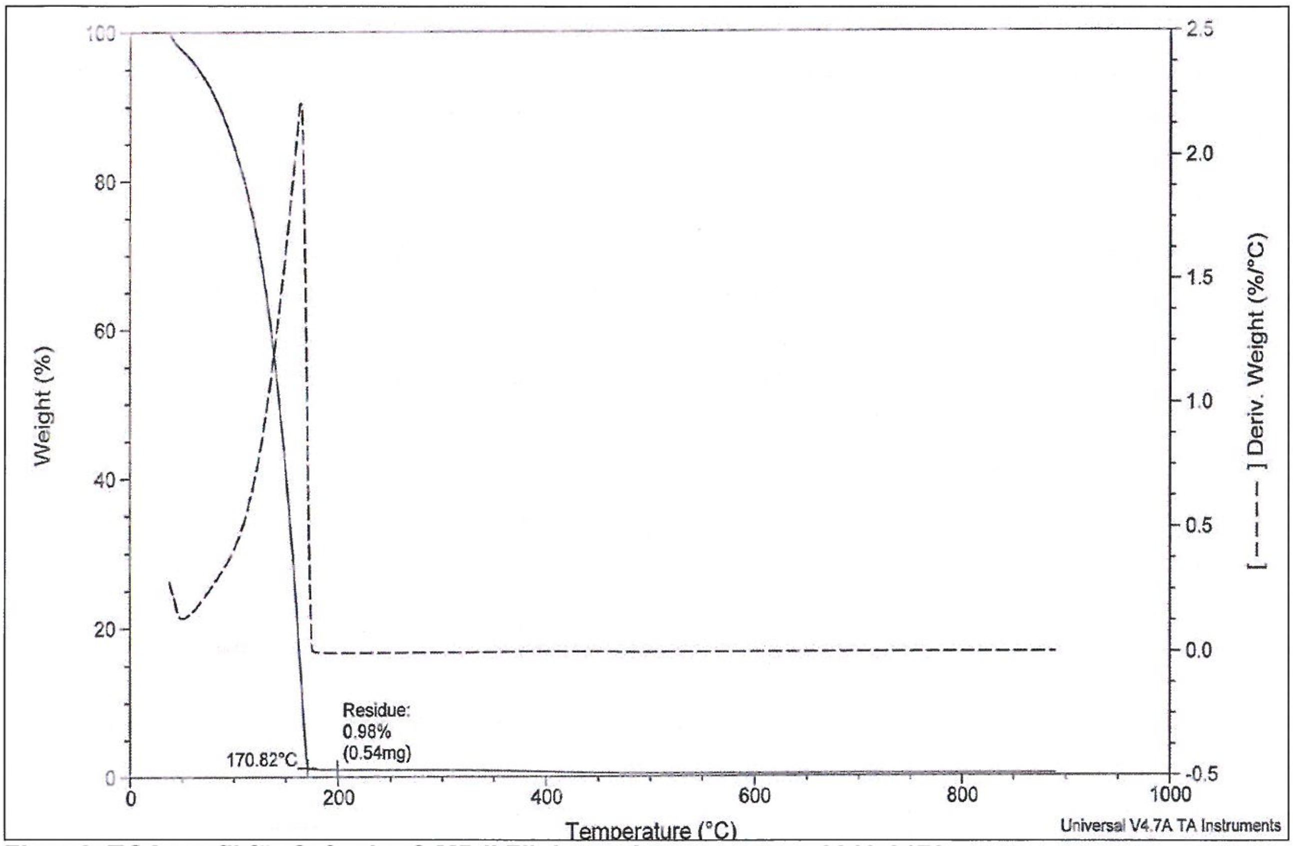
Egenskap	Enhet	Safewing® MP I Eco Plus (80) Labresultat (2010-9178)	Safewing® MP I Eco Plus (80) Referensvärden produktdatablad	Safewing® MP II Flight Labresultat (2010-9179)	Safewing® MP II Flight Referensvärden produktdatablad
Färg		Orange	Orange	Gul	Gul
Densitet vid 20°C	kg/m^3	1,046	1,035-1,055	1,041	1,038-1,040
Brytningsindex vid 20°C		1,418	1,416-1,419	1,391	1,389-1,392
Fryspunkt	°C	-23 *	-23 *	-29 **	-36

* 50% lösning i vatten
** Otydligt p.g.a. grumligt prov

TGA-analyserna generade temperaturprofilerna som redovisas i figur 1 respektive figur 2.

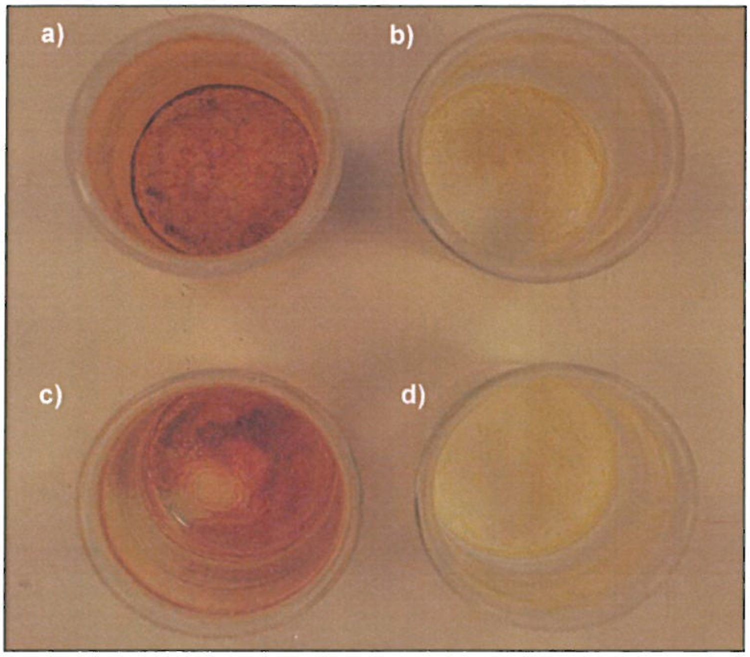


Figur 1. TGA-profil för Safewing® MP I Eco Plus (80) med provnummer 2010-9178. Provmängd var ursprungligen 35,032 mg. Den heldragna kurvan visar provets vikt under värmningen. Den streckade kurvan visar derivatan för vikten, d.v.s. viktförändringar, under värmningen. Resultaten visar att majoriteten av provet dunstar bort under värmning från RT till 154,80°C, varefter det återstår en rest (0,21 mass%, 0,07 mg). Denna rest påverkas inte av värmning upp till 900°C.



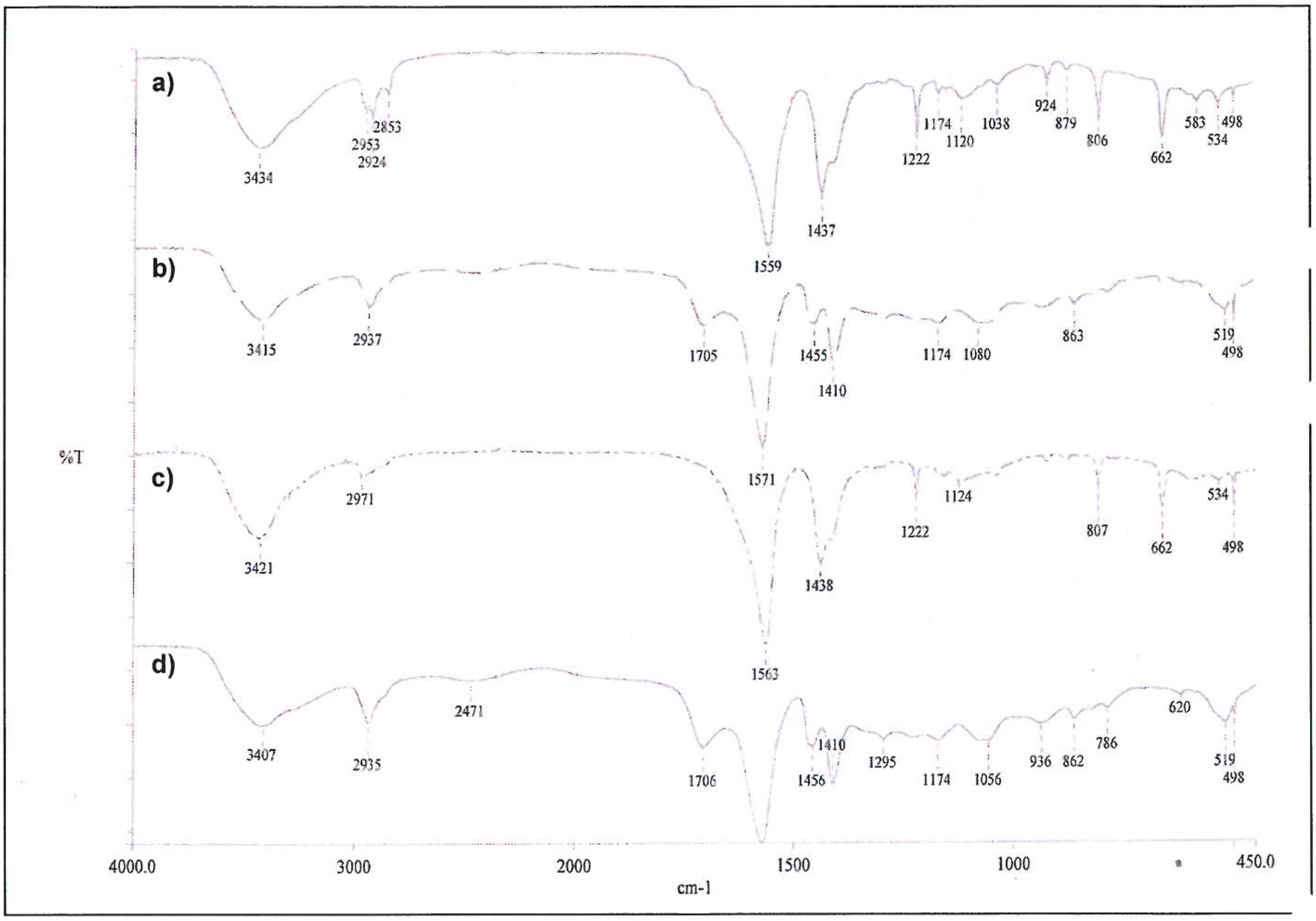
Figur 2. TGA-profil för Safewing® MP II Flight med provnummer 2010-9179.
Provmängd var ursprungligen 54,849 mg. Den heldragna kurvan visar provets vikt under värmningen. Den streckade kurvan visar derivatan för vikten, d.v.s. viktförändringar, under värmningen. Resultaten visar att majoriteten av provet dunstar bort under värmning från RT till 170,82°C, varefter det återstår en rest (0,98 mass%, 0,54 mg). Denna rest påverkas inte av värmning upp till 900°C.

Indunstning av de fyra proven vid 120°C ledde fram till en rest som visas i figur 3.



Figur 3. Indunstningsrester.
a) Safewing® MP I Eco Plus (80) med provnummer 2010-9178, resten motsvarade ca 0,2 mass% och var orangeröd.
b) Safewing® MP II Flight med provnummer 2010-9179, resten motsvarade ca 0,7 mass% och var gulvit.
c) Typ I vätska av fabrikatet Kilfrost ABC 2000 med provnummer 2011-797, resten motsvarade ca 0,1 mass% och var orangeröd.
d) Typ II vätska av fabrikatet Kilfrost ABC 2000 med provnummer 2011-798, resten motsvarade ca 0,7 mass% och var gulvit.

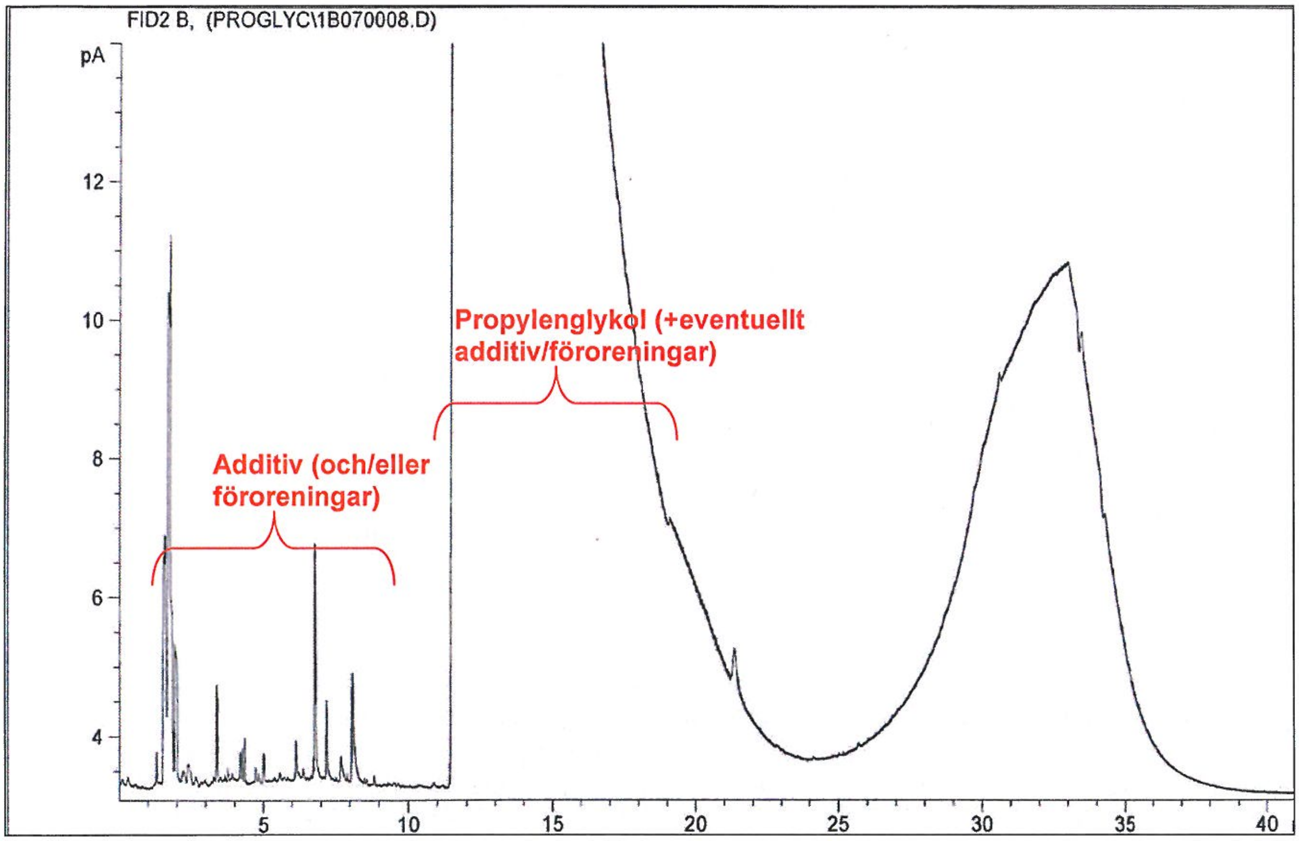
Indunstningsresterna undersöktes med hjälp av FTIR. Spektra från dessa analyser visas i figur 4.



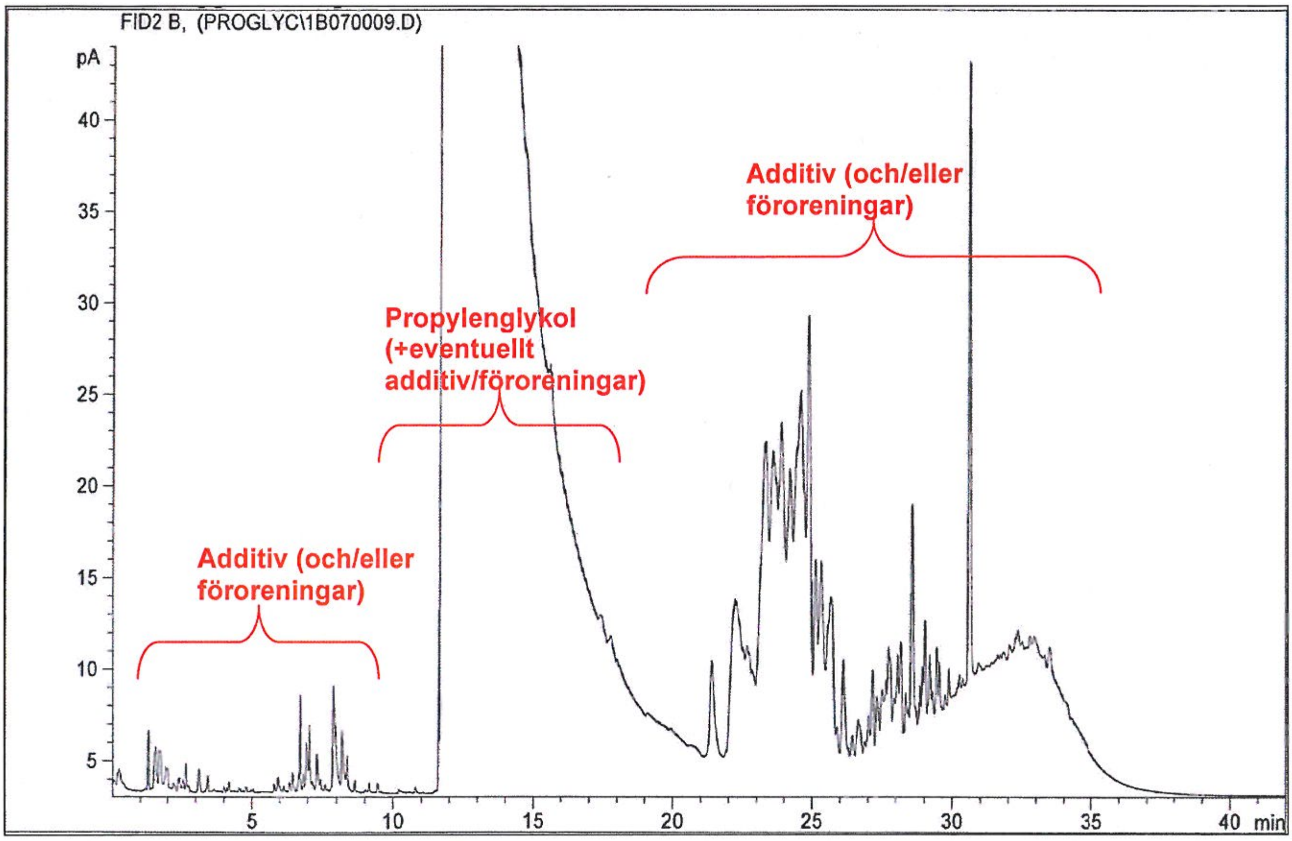
Figur 4. FTIR spektra för indunstningsrester.
a) Safewing® MP I Eco Plus (80) med provnummer 2010-9178
b) Safewing® MP II Flight med provnummer 2010-9179
c) Typ I vätska av fabrikatet Kilfrost ABC 2000 med provnummer 2011-797
d) Typ II vätska av fabrikatet Kilfrost ABC 2000 med provnummer 2011-798

FTIR-spektran visar inga stora skillnaden mellan 2010-9178 och 2011-797 respektive 2010-9179 och 2011-798. Samtliga spektran tyder på att resterna består av organiska föreningar. Vad gäller skillnader mellan vätskorna av typ I och typ II kan man konstatera att de största skillnaderna avser absorbans vid 1705 cm^{-1}- och 1410 cm^{-1} som är mer tydligt för typ II jämfört med typ I. Absorbans vid 1705 cm^{-1} tyder på att karbonylgrupper (eventuellt karboxylsyra, keton, aldehyd) förekommer i resten. Ingen identifiering av föreningarna var möjlig.

GC-FID med direktinjektion på kolonn gav inget bra resultat och diskuteras inte vidare i rapporten. GC med headspaceinjektion (HS-GC-FID) gav bättre resultat, se figur 5-6.



Figur 5. HS-GC-FID för Safewing® MP I Eco Plus (80) med provnummer 2010-9178.
Flyktiga föreningar (vid 150°C) injicerades på GC-kolonnen. Kromatogrammet visar att produkten dels innehåller flyktiga komponenter (de första topparna) samt propylenglykol. Med FID-tekniken är det ej möjligt att identifiera vilken typ av föreningar som förekommer i provet. Det är således möjligt att föreningarna i inledningen av kromatogrammet består av både additiv och/eller föroreningar. Propylenglykoltoppen är bred, vilket kan innebära att additiv och föroreningar förekommer i toppen.



Figur 6. HS-GC-FID för Safewing® MP II Flight med provnummer 2010-9179.
Flyktiga föreningar (vid 150°C) injicerades på GC-kolonnen. Kromatogrammet visar att produkten dels innehåller flyktiga komponenter (de första topparna) samt propylenglykol. Till skillnad från kromatogrammet i figur 5, förekommer här flera toppar efter att propylenglykolen eluerat. Med FID-tekniken är det ej möjligt att identifiera vilken typ av föreningar som förekommer i provet. Det är således möjligt att föreningarna i kromatogrammet består av både additiv och/eller föroreningar. Propylenglykoltoppen är bred, vilket kan innebära att additiv och föroreningar förekommer i toppen.

Diskussion

Den första provomgången (nov 2010) av produkterna Safewing® MP I Eco Plus (80) respektive Safewing® MP II Flight analyserades med avseende på enkla fysikaliska parametrar (densitet, brytningsindex, o.s.v.). Inga större avvikelser noterades jämfört med produktdatabladen för produkterna.

Proven från första omgången analyserades även med tekniken termogravimetrisk analys (TGA). Denna analys visar att Safewing® MP I Eco Plus (80) till stor del (99,8 mass%) består av relativt lättflyktiga komponenter (flyktiga vid <150°C). Resterande del (0,2 mass%) påverkas inte under värmning upp till 900°C i kvävgasmiljö. De lättflyktiga komponenterna (exempelvis glykol och vatten) går ej att urskilja från varandra. Liknande resultat erhölls för Safewing® MP II Flight. 99 mass% är flyktigt under 170°C. En något större rest erhålls för detta prov (ca. 1 mass% med TGA) som inte heller påverkas under fortsatt värmning upp till 900°C.

För att undersöka de mindre icke-flyktiga komponenterna ytterligare, indunstades samtliga prov. Resterna som erhölls kan ses i figur 3. Typ I vätskorna ger en orange rest, medan typ II vätskorna ger en ljusgul och vit rest. Det orangea inslaget för typ I vätskans rest tyder på att färgämnet (som tillsätts i produkten för att ge en orange färg på produkten) ingår i resten. På samma vis är det sannolikt att ett gult färgämne återstår i resten för Safewing® MP II Flight och typ II vätskan av fabrikat Kilfrost ABC 2000 efter indunstning. Resterna analyserades med FTIR, vilket visar att resten innehåller organiska föreningar (kolväten). Någon vidare identifiering var ej möjlig, men man kan konstatera att skillnaderna mellan produkterna är små.

För att kontrollera vad som ingår i produkternas flyktiga del nyttjades tekniken gaskromatografi. Resultaten visade sig vara intressantast för gaskromatografi med headspace-injektion (HS-GC-FID). Kromatogrammen från denna analys visade att den flyktiga delen av produkterna innehåller både propylenglykol och små mängder av additiv alternativt orenheter. Tyvärr kan inte flamjoniseringsdetektorn användas för att karaktärisera föreningarna som detekteras. Det viktiga här var skillnaderna för kromatogrammen mellan produkterna, vilket visar att Safewing® MP II Flight innehåller flera ämnen som eluerar senare än propylenglykolen vid kromatografin. Dessa ämnen noterades inte vid analys av Safewing® MP I Eco Plus (80).

Slutsatser

Utifrån erhållna resultat gäller:

- Inga stora avvikelser noterades vad gäller produkternas densitet, brytningsindex, färg och fryspunkt jämfört med produktdatabladen.
- Safewing® MP I Eco Plus (80) och Safewing® MP II Flight innehåller till största del (99-99,8 mass%) föreningar som är flyktiga (under 150 resp. 170°C).
- I de rester som erhölls efter indunstning av produkterna kan man konstatera (utifrån restens färg) att färgadditiv förekommer, samt (utifrån FTIR) att resten innehåller organiska föreningar (d.v.s. kolväten). Ytterligare identifiering av resterna var ej möjlig med tillgängliga metoder.

- De flyktiga komponenterna hos produkterna innehåller förutom propylenglykol flertalet ytterligare kolväteföreningar. Med tillgänglig detektionsteknik (FID) är det ej möjligt att karaktärisera/identifiera vilka föreningar det är, men man kan konstatera att Safewing® MP II Flight innehåller flera föreningar som inte påträffas i Safewing® MP I Eco Plus (80). Dessutom kan man konstatera att föreningarna förekommer i mycket låga koncentrationer jämfört med halten propylenglykol i proven.

Förslag till fortsatt verksamhet

Utredningen visar att ytterligare tekniker krävs för att karaktärisera spårämnen som förekommer i de produkter som undersökts.

Man kan konstatera att färgämnen som tillsätts i produkterna generar en icke-flyktig rest. Denna rest kan även innehålla flera andra komponenter som vi inte klarat av att identifiera med de tekniker som användes vid utredningen. Tekniker så som NMR (Nuclear Magnetic Resonance) och SEM (Surface Electron Microscopy) kan ge ytterligare information om vad de icke-flyktiga komponenterna består av.

De flyktiga komponenterna kan separeras med HS-GC, men med FID-tekniken är det ej möjligt att karaktärisera föreningarna. Detektion med MS (masspektrometer) istället för FID skulle ge värdefull information och möjligheter att avgöra vilka komponenter som ingår i den flyktiga delen av respektive produkt. Därefter skulle man även kunna kvantifiera de olika komponenter som ingår i produkten.

Exova AB
Fuel and Lubricant Testing, Chemical Analysis

Rickard Jansson

Rapportfördelning:

Företag	Namnreferens	Antal ex.
Statens haverikommission	Stefan Christensen	1 org. + 1 elektr.

U.S. Department
of Transportation
Federal Aviation Administration

SAFO

Safety Alert for Operators

SAFO 01001
DATE: 2/4/10

Flight Standards Service
Washington, DC

http://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/safo

A SAFO contains important safety information and may include recommended action. SAFO content should be especially valuable to air carriers in meeting their statutory duty to provide service with the highest possible degree of safety in the public interest. Besides the specific action recommended in a SAFO, an alternative action may be as effective in addressing the safety issue named in the SAFO.

Subject: Possible effects of Thickened Anti-icing Fluids on Takeoff Rotation for Airplanes with Unpowered Elevator Controls

Purpose: To alert operators and pilots of airplanes with unpowered elevator control surfaces that increased elevator control forces may be required for proper rotation to the takeoff attitude after treatment with Type II or IV anti-icing fluids.

Background: The Federal Aviation Administration (FAA) has received several reports of flightcrews that have conducted rejected takeoffs after their airplanes were treated with thickened anti-icing fluids. The flightcrews have reported that the aircraft did not respond to normal, or even slightly above normal, control column back pressure inputs for rotation to the takeoff attitude. The flightcrews assessed the need for unusually high back pressure forces to be a flight control failure and elected to reject the takeoff at speeds in excess of V_R or V_1 as applicable. Fortunately, these rejected takeoffs did not occur on runways of limited length.

Discussion: A common factor in these incidents is that the rotation speeds were below, at, or only slightly above the 100 knot minimum rotation speed recommended for application of Type II or IV anti-icing fluids. In addition, the transport category aircraft involved all had unpowered elevator flight controls. In all of the reported cases, the use of thickened anti-icing fluids was approved for the airplane, and the flightcrews reported following the airplane manufacturer's procedures for takeoff after the aircraft was treated with thickened anti-icing fluids. In many of these reported cases, the rejected takeoffs occurred during the flightcrew's first takeoff, or their first takeoff for that winter season, when the airplane had been treated with thickened anti-icing fluids.

It appears that the flightcrews were not familiar with the added control column pressure that could be needed to rotate the aircraft to the takeoff attitude after the aircraft was treated with thickened anti-icing fluids. These added forces, if not properly identified, could lead a pilot to reject a takeoff from speeds above V_R or V_1 as applicable and exceed the available runway length during the rejected takeoff.

Flightcrews must be trained on and be aware of the airplane manufacturer's procedures for operation after application of de/anti-icing fluids. Training needs to cover any added control column forces that may be necessary to achieve the appropriate takeoff pitch attitude. There are several theories to the cause of this above normal control elevator force requirement including the possibility that the thickened anti-icing fluid is being applied too heavily, above the thickness recommended by the fluid manufacturer and the SAE standard, to the horizontal tail surfaces. Only the de/anti-icing fluid Types (I, II, III, IV) approved by the airplane manufacturer should be applied to the airplane. The airplane must be operated in accordance with the airplane manufacturer's procedures specified for operations after being treated with de/anti-icing fluids.

Recommended Action: For operators of aircraft with unpowered elevator controls and rotation speed below, at, or only marginally above 100 knots, directors of training, directors of operations, directors of safety, chief pilots, check airmen, pilot instructors, and training providers should review winter operations training to ensure that pilots are trained on the control column forces that may be necessary to rotate the aircraft to the takeoff attitude when the airplane is treated with thickened anti-icing fluids. Simulator programming for the aircraft to be representative of the affects of anti-icing fluid application and an appropriate takeoff scenario during simulator training would be one way to effectively address this training need. Operators should include in the flightcrew operating procedures the airplane manufacturer's procedures for operation of the airplane after being treated with de/anti-icing fluids.

Additionally operators should ensure that all de/anti-icing service providers are aware of the potential impact of applying anti-icing fluids on the horizontal tail surfaces in excess of that needed to provide adequate ice protection. Operators should ensure that de/anti-icing service providers have processes and procedures in place to prevent thicker anti-icing fluid applications to the horizontal surface areas than recommended by the fluid manufacturer and SAE standard.

Multi-pilot crews should, as part of the pre-takeoff crew briefing, single pilot crew as part of the takeoff procedures review should brief/review the airplane manufacturer's procedures regarding the possible need for added control column back pressure if the aircraft is treated with thickened anti-icing fluids. Flightcrews should adhere to the manufacturer's operating procedures for the aircraft when their aircraft is treated with de/anti-icing fluids.

Contact: Questions or comments concerning this SAFO should be addressed to the Air Carrier Operations Branch, AFS-220, Attn: Mr. Jerry Ostronic (412) 886-2580 Ext 332.

BAE SYSTEMS BAE SYSTEMS Regional Aircraft BAE SYSTEMS (Operations) Limited EASA Part 21 Approval No. EASA.21J.047	NUMBER : SETR/ATP/1572	
	ISSUE : 1	PAGE : 1 OF 6
	ISSUE DATE 17/12/2010	SITE : Prestwick
	COMPANY CLASSIFICATION :	

Systems Engineering Technical Report
SETR/ATP/1572
Visit to E.A.M, Ronaldsway
to investigate SE-MAL Pitch Control Issues

Summary

Following three reports of pitch control difficulties whilst in operation in Sweden with Nextjet, SE-MAL was flown to European Aviation Maintenance on the Isle of Man for a scheduled "C" check. During the maintenance input, BAe personnel visited to carry out a number of checks on the aircraft systems as part of a wider investigation into control difficulties.
Although several deficiencies were found, they did not appear, in themselves, capable of causing the reported difficulties.

Distribution

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		West Air	
		Atlantic Airlines	

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PREPARED BY	APPROVED	AUTHORISED BY
Project Engineer Mech. Systems	Project Engineer Mech. Systems	Chief Designer (RA Products)

Amendment Record Sheet

Issue	Date	Amendment	Reason
1	17/12/2010	None	Original issue

Contents

	Page
Introduction	**4**
Aircraft Investigation	**4**
Discussion	**6**
Conclusions	**6**

1. Introduction

During 2009-2010, the ATP fleet reported a series of events best described as a failure to rotate when operated in conjunction with thickened de-icing fluids. A West Air aircraft, SE-MAP, had repeated reports of heavy pitch controls at rotation. West Air performed a series of high speed taxi trials which showed that de-icing fluid was pooling in the gap between the elevator leading edge and the tailplane. Further investigation showed that these gaps were below the AMM limits. The reduced gap was thought to originate from the rectification of hail damage to several aircraft at Zaragosa. The aerodynamic effect of this gap being blocked or sealed is to increase the force required to rotate. Following this phase of the investigation, Service Bulletin 55-12 was issued to check these gaps.
SE-MAL was inspected in accordance with SB 55-12, and the gaps were found to be acceptable. However, following the SB inspection, there were three reports of pitch control difficulties whilst in operation in Sweden with Next Jet. All three reports concerned operation with thickened de-icing fluid. SE-MAL was then flown to European Aviation Maintenance on the Isle of Man for a scheduled "C" check. BAE personnel
attended to carry out a number of checks on the aircraft systems as part of the continuing wider investigation into control difficulties.
Although several deficiencies were found, they did not appear, in themselves, capable of causing the reported difficulties.

2. Aircraft Investigation

The pilot reports on the three flights from ESNX reported elevator split at rotation, when flying from the right hand side, and heavy forces when flying from the left hand side, all in conjunction with thickened de-icing fluids. The following tests were carried out on the aircraft in order to establish if there were any deficiencies which could contribute to the incidents;

These first few checks were to establish correct operation of the aircraft synchros and the section of the autopilot which compares the synchro position readings, which cater for primary circuit disconnects or cable failures.

a. The control column was taken through its range of pitch movement, and the output from column and surface synchros was recorded and plotted on return to Prestwick. A series of other measurements were taken, with gust locks engaged, and column loading working against the gust lock to stretch the cable circuit. Despite various deliberate attempts to engage the SCS circuit, the synchros remained sufficiently aligned to prevent SCS engagement, only approaching half of the required alignment error for an SCS engagement to take place.

b. The elevator primary cable tension was measured, and found to be 20lb. Later, it was confirmed that the correct setting at the hangar temperature was 30lb, see next item.

c. The elevator tension regulator was exercised, and found to work smoothly, though the setting was incorrect for the temperature.

d. The surface synchro was detached from the circuit, and the column was moved to check engagement of the SCS function of the autopilot. This was correct, with the autopilot engaging, but no control split.

e. A service bulletin, 27-49, had been issued in 1994, to remove the potential for stray earths causing SCS engagements. This repositioned diodes in the circuit. The embodiment of the SB was checked, and the diodes were checked and found satisfactory.

The following checks target the force mode, which is designed to cater for control circuit jams.

f. The force breakout on the right hand column was measured at over 100 lb. This confirms the measurements taken earlier by Next Jet.

g. Microswitches at the base of the control column were examined. A rubber trim piece was found to be jammed at the side of the aft pair. It is thought that this was unlikely to have affected its operation. Operation of both pairs of microswitches were checked and functioned satisfactorily, giving the correct indication.

h. The wiring loom close to the microswitch was found to have been squashed. The spywrap was removed, and the wiring checked, and found acceptable.

i. The gust lock levers on the aileron and elevators were checked , and both found to be fully off. This was to eliminate the possibility of a re-engagement causing a temporary restriction as seen on the 748.

j. The primary control circuit pressure seals were examined, and found to be correctly installed, with no signs of snagging.

k. A visual examination showed the starboard elevator to be 1 ½ degrees out of alignment with the port elevator. There were no signs of rubbing or contact.

l.. Visual inspection showed the stability springs to be lightly greased, and unlikely to have caused a restriction.

m. In view of the low cable tension, the cable troughs were inspected for signs of the turnbarrels snagging, these were found to be clear.

n. A qualitative assessment of the circuit frictions showed them to be acceptable.

o. The tailplane trailing edge was found to be coated with Mobil 28 grease which had attracted and held grit. The grease was said to have been applied as a part of the winterisation checks. A review of the AMM at Prestwick confirmed that this was incorrect. This is a potential contributor to restrictions in two ways, larger particles of grit can cause physical restrictions, though there was no evidence of this remaining. In addition, the combination of grease and grit will reduce the effective gap at the leading edge of the elevator available for fluid to run through.
During discussions with EAM, it was confirmed that areas of the aircraft such as the landing gear bay were heavily contaminated with grit on arrival at EAM, but this had been removed prior to entry into the hangar. This implies that the tailplane trailing edge contamination was probably worse when the aircraft was in service.

3. Discussion

Two pilot reports, when flying from the right hand seat, mentioned a control split and light control forces. Control splits are only caused by a force mode engagement, which was confirmed on this aircraft as requiring 100 lb, with no evidence of any circuit faults which could cause an engagement at a reduced load. It is possible that a pilot would under-assess this force under the circumstances of a control restriction and rapidly reducing runway length. In the event of a force mode engagement, following the initial application of the 100 lb breakout force, light control forces would be explained by the pilot controlling one elevator, possibly with the autopilot controlling the second as the SCS mode may engage once the right hand elevator has been separated from the rest of the circuit. In this situation, full control authority is available, but the pilot will apply a reduced load after the breakout.
The pilot report of the third event, flying from the right hand seat, describes heavy forces to rotate. No aircraft build related reason for this could be found, though the trailing edge contamination is a possible contributor as discussed above.

4. Conclusions

It is reasonable to conclude that all three incident reports stemmed from the same source. The pilot reports and the tests tend to rule out initial SCS engagement, leading to the conclusion that the incidents were related to a force mode issue. No reason for high circuit loads related to the aircraft build could be found, and no reasons for the force mode engagement to occur at lower loads could be found. The implications of this are that the cause was icing or de-icing fluid related. The investigation into this aspect will continue.
The winterisation section of the aircraft maintenance manual will be reviewed to ensure that the tailplane trailing edge treatment is clearly specified.
Thanks are due to European Aviation Maintenance for the excellent assistance provided during our visit, which enabled a considerable amount of work to be completed in a short period of time. Thanks also to Next Jet for allowing access to the aircraft, and providing cover.

EASA Safety Information Bulletin

SIB No.: **2010-28**
Issued: **17 September 2010**

Subject: **Possible effects of Thickened Anti-icing Fluids on Take off Rotation for Airplanes with Unpowered Elevator Controls**

Ref. Publication: Federal Aviation Administration (FAA) Safety Alert for Operators (SAFO) 10001, dated 04th February 2010.

Description: The FAA published the above-reference advisory document (which is attached to this bulletin) after being aware of rejected take off of aeroplanes that had been treated with type II or IV anti-icing fluids and under the circumstances described on the SAFO.

Additionally to the events in the US, EASA has been made aware of events in similar circumstances (rejected take off at V_R of BAE Systems ATP aeroplanes anti-iced with type II or IV fluid) that took place in northern Europe, being currently under investigation by SHK (Swedish Accident Investigation Board).

After reviewing the information, EASA supports the recommended actions contained in FAA SAFO 10001. Once completed, should the ongoing investigations lead to additional recommendations in respect of those given with the SAFO, this SIB would be revised and re-issued.

This Safety Information Bulletin is published to ensure that all owners and operators of aircraft, registered in European Union Member States or associated countries, are made aware of these important recommendations.

Applicability: All aeroplanes with unpowered elevator controls during winter operations.

Contact: For further information contact the Airworthiness Directives, Safety Management & Research Section, Certification Directorate, EASA; E-mail: ADs@easa.europa.eu.

This is information only. Recommendations are not mandatory.

EASA	AIRWORTHINESS DIRECTIVE
	AD No.: 2010-0263 **Date: 17 December 2010** Note: This Airworthiness Directive (AD) is issued by EASA, acting in accordance with Regulation (EC) No 216/2008 on behalf of the European Community, its Member States and of the European third countries that participate in the activities of EASA under Article 66 of that Regulation.

This AD is issued in accordance with EC 1702/2003, Part 21A.3B. In accordance with EC 2042/2003 Annex I, Part M.A.301, the continuing airworthiness of an aircraft shall be ensured by accomplishing any applicable ADs. Consequently, no person may operate an aircraft to which an AD applies, except in accordance with the requirements of that AD unless otherwise specified by the Agency [EC 2042/2003 Annex I, Part M.A.303] or agreed with the Authority of the State of Registry [EC 216/2008, Article 14(4) exemption].

Type Approval Holder's Name:	**Type/Model designation(s) :**
BAE Systems (Operations) Ltd	ATP aeroplanes

TCDS Number:	EASA.A.192
Foreign AD:	Not applicable
Supersedure :	None

ATA 55	**Stabilisers – Elevator Clearance – Inspection / Measurement / Report**
Manufacturer(s):	British Aerospace plc, British Aerospace (Commercial Aircraft) Ltd
Applicability:	ATP aeroplanes, all serial numbers.
Reason:	Incidents have been reported concerning ATP aeroplanes where, after the application of thickened anti-icing fluids, increased elevator control forces were experienced during take-off. The ATP elevator has an elliptical nose balance over part of the span (from the root to mid-span and out towards the tip). Investigation of these occurrences showed that thickened anti-icing fluid may close the gap between the leading edge of the elevator and the horizontal stabilizer and contaminate the lower surface of the elevator. This condition, if not detected and corrected, could lead to loss of the aerodynamic balance over the affected elevator section, changing the elevator and tab hinge moments and increasing the necessary control forces to achieve rotation. In turn, this may prompt the flight crew to reject take-off, possibly resulting in a runway excursion, consequent damage to the aeroplane and/or injury to the occupants. For the reasons described above, this EASA AD requires an inspection of both elevators for evidence of rubbing, measurement of the gap between elevator and horizontal stabilizer, the reporting of findings to BAE Systems (Operations) Ltd. and, depending on findings, repair actions.
Effective Date:	31 December 2010.

Required Action(s) and Compliance Time(s):	Required as indicated, unless accomplished previously: (1) Within 30 days after the effective date of this AD, inspect the left (LH) and right (RH) elevators for evidence of rubbing and measure the gaps between the leading edge of the LH and RH elevators and the horizontal stabilizer in each of the three defined elevator positions in accordance with the instructions of paragraph 2.B (1) of BAE Systems Service Bulletin (SB) ATP-55-012 Revision 1. (2) Within 2 days after the inspection and measurement as required by paragraph (1) of this AD, record the results on Appendix 1 of BAE Systems SB ATP-55-012 Revision 1 and send a copy of the completed Appendix 1 to BAE Systems (Operations) Ltd, address indicated in the Remarks section of this AD. (3) For aeroplanes previously inspected in accordance with BAE Systems SB ATP-55-012 at original issue dated 24 June 2010 and declared by BAE Systems in their Technical Operational Response (TOR) 2381 to be approved for continued operation without restrictions, only the inspection and measurement for the elevator trailing edge on chord case are required by paragraph (1) of this AD. (4) If, during the measurement as required by paragraph (1) of this AD, any gap is found that exceeds the maximum limit as specified in the Aircraft Maintenance Manual (AMM), within 2 days, contact BAE Systems for approved repair instructions and, within the time period specified in those instructions, accomplish the repair accordingly. **Note 1:** The aeroplane may be returned to service with no restrictions while waiting for BAE Systems response. (5) If, during the measurement as required by paragraph (1) of this AD, any gap is found that is below the minimum limit as specified in the AMM, within 2 days, contact BAE Systems for approved repair instructions and, within the time period specified in those instructions, accomplish the repair accordingly. (6) Before next flight after finding a gap that is below the minimum limit as specified in the AMM, and detailed in paragraph (5) of this AD, install a placard in the cockpit, in full view of the pilots, having the following statement: **THIS AEROPLANE IS NOT APPROVED FOR OPERATIONS THAT REQUIRE THE APPLICATION OF THICKENED DE-ICING FLUIDS OR THICKENED ANTI-ICING FLUIDS.** REFERENCE EASA AD 2010-0263 and insert a copy of this AD into the Limitations section of the Aeroplane Flight Manual (AFM). **Note 2:** This AD does not restrict the use of **un-**thickened Type 1 **de-**icing fluids. (7) After modification of an aeroplane as required by paragraph (5) of this AD, the operational limitation regarding application of thickened anti-icing fluids is no longer required. The placard may be removed from the cockpit and the copy of this AD may be removed from the AFM.

Ref. Publications:	BAE Systems (Operations) Limited ATP SB ATP-55-012 Revision 1, dated 11 November 2010. The use of later approved revisions of this document is acceptable for compliance with the requirements of this AD.
Remarks :	1. If requested and appropriately substantiated, EASA can approve Alternative Methods of Compliance for this AD. 2. The required actions and the risk allowance have granted the issuance of a Final AD with Request for Comments, postponing the public consultation process after publication. 3. Enquiries regarding this AD should be referred to the Airworthiness Directives, Safety Management & Research Section, Certification Directorate, EASA. E-mail ADs@easa.europa.eu. 4. For any question concerning the technical content of the requirements in this AD, please contact: BAE Systems (Operations) Ltd, Customer Information Department, Prestwick International Airport, Ayrshire, KA9 2RW, Scotland, United Kingdom; Telephone +44 1292 675207, Facsimile +44 1292 675704; E-mail: RApublications@baesystems.com.

SWEDISH TRANSPORT AGENCY
Civil Aviation Department

Designation	Your designation	Document type	Page
TSL 2010-1943-2		LETTER	1(1)
Date	**Your date**	**Administrative officer**	
2010-11-11		Ola Johansson	

EASA
PCM BAe ATP
Nigel Davis

Questions regarding BAe ATP flight control restrictions.

During the last years there have been several incidents related to anti-icing fluids with the aircraft type BAe ATP operated by the two Swedish operators West Air Sweden and Next Jet. The use of anti-icing fluid type II/IV seems to result in a considerable increase in elevator stick force during rotation. The theory presented is that the increased force is caused by the fact that the gap between the stabilizer and the elevator is to narrow (not as designed) on the aircraft individuals subject to incidents. As you know this issue is currently being investigated by the Swedish Accident Investigation Board.
BAE SYSTEMS have issued a Technical Operational Response, 2381 issue 1, where they divide the ATP fleet into one list of aircraft individuals approved for continued operation with further restriction and one list of aircraft individuals not approved for continued operation with de-icing or anti-icing fluids applied.
2010-10-20 a similar incident occurred with ATP SE-MAL, constructors number 2045, which is on the list of aircraft with no restrictions by BAE SYSTEMS according Technical Operational Response above.
Our questions to you are:
Can the ATP fleet be considered to be in compliance with type design?
What measures have been taken by EASA to prompt BAE SYSTEMS to address the problem and establish a solution?
Is it the EASA standpoint that the Swedish Transport Agency shall allow continued unrestricted operation with BAe ATP for operators under Swedish AOC?

We consider this an urgent matter and would appreciate a quick response.

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