The Dutch Safety Board

Occurrence #: 2003035 **Classification: Serious incident**

FACTUAL INFORMATION

Date of the occurrence:	02-04-2003	POB flight crew:	2
Place of occurrence:	Dutch airspace	POB cabin crew:	4
Aircraft registration:	HB-IXN	POB passengers:	63
Airline company:	Swiss International Air Lines	Injuries:	None
Aircraft model:	BAe 146-300		
Type of aircraft:	Passenger aircraft		
Type of flight:	Scheduled airline flight		
Phase of operation:	En route	Lighting conditions:	Daylight
Damage to aircraft:	None		

The flight and the occurrence

The aircraft was en route from Zurich (Switzerland) to Amsterdam. While holding over Amsterdam Airport Schiphol the crew noticed that the elevator trim was blocked although the elevator itself functioned normally. Because it appeared to be impossible to (re)trim the aircraft around its lateral axis the captain decided to issue a 'MAYDAY' call to air traffic control (ATC) and to inform the passengers and cabin crew. Due to the expected higher control forces the captain also decided to make a landing without the use of flaps. The consequence of a flapless landing is a substantial higher landing speed with possible damage to tires and brakes. Therefore the crew decided to remain longer in the holding in order to burn more fuel and thus reduce the landing weight, and the captain requested emergency services near the landing runway. Before landing the passengers and cabin crew were instructed to assume the 'brace for impact' position. The landing itself was uneventful but, due to the high landing speed of 186 knots and the subsequent hard braking, the wheel brake temperatures rose to 650 degrees Celsius. The safety plugs in the tires remained intact and the aircraft taxied to the platform without any assistance. All occupants could safely disembark the aircraft.

Investigation & Analysis

The Dutch Safety Board received the notification of the occurrence one day later. At that time the crew and the aircraft had already left the Netherlands and an investigation on the spot was not possible. Therefore this report is based upon the factual information and investigation results received from the involved airline company.

Already during the early stages of the investigation the attention was drawn to a gel-like residue of 'de-icing' fluid which had accumulated in the mechanical part of the left-hand elevator trim mechanism. The residue found contained a high percentage of water and it was suspected that blocking of the left-hand elevator trim was caused by freezing of this residue. The right-hand elevator trim mechanism was found to be clear of this substance. After cleaning and testing the entire elevator trim mechanism proved to be functional again. The aircraft was serviceable again without the need for parts to be replaced and was ferried back to Switzerland.

According to the airline company the HB-IXN was not ‘de-iced’ on the day of the incident. The last time was 23 days before on March 10th. In the months preceding the incident and depending on the airport of departure the HB-IXN was ‘de-iced’ with ISO Type I or Type II fluid (single-phase procedure) sometimes diluted with water.

At the time of the occurrence the airline company involved used an inspection and cleaning cycle of 28 days. This inspection was last executed two days before the incident flight. According to the procedure the access hatches to the flight control steering mechanisms must be removed for inspection and cleaning. The possibility that the left-hand access hatch was overseen during the last inspection might explain that residue was still present on this side.
Another possible explanation was found after the 2004/2005 winter. It was detected that residual ‘de-icing’ fluid had filled the internal elevator and trim tab structures. Those areas were not inspected nor cleaned by the common inspection and cleaning process. Consequently, in both scenarios the hazard that the elevator trim mechanism could still freeze had not been taken away.

During the investigation it was discovered that this occurrence was not an isolated case. Due to several previous reports concerning problems with the elevator control on aircraft with non-powered flying controls like Avro 146-RJ100, DC-9/ MD80 and DHC-8, the (British) Air Accidents Investigation Branch (AAIB) did extensive research into aircraft icing, among others including freezing of ‘de-icing’ fluid residue. The Safety Board considers the reports and recommendations issued by the AAIB, the Joint Aviation Authorities (JAA), the Association of European Airlines (AEA) and the European Regions Airline Association (ERA) of importance for this occurrence (see references).

In this paragraph a brief description is given of aircraft ‘de-icing’ and ‘anti-icing’. ‘De-icing’ and ‘anti-icing’ are applied by spraying special fluids on the critical aerodynamical areas of an aircraft to clear and keep them clear of snow and/or ice. Several types of ‘de- and anti-icing’ fluids exist each with its own characteristics. The main differences between the fluids are the viscosity and holdover time. A relatively thin fluid (ISO Type I) will run off surfaces more readily and does not leave significant residues but has a limited holdover time. Condensed types of fluid like ISO Type II, Type III and Type IV contain thickening agents and other chemicals that are not present in Type I fluids. The purpose of the agents is to encourage the fluid to remain longer on the treated aircraft surfaces to extend the holdover time.

Ideally all fluid will flow off the airframe during acceleration at take-off. However, due to aircraft specific aerodynamic effects this is not always the case. Viscous “anti-icing” fluid may remain on external surfaces (including critical areas) and “aerodynamically quiet areas” such as the gaps between wing/tail plane, aileron/elevator and control surface trim tabs. Because it is applied under high pressure fluid can also infiltrate inside the elevator and trim tab structures.

When exposed to dry air for long periods, glycol and water evaporate from the fluid. This generally leaves the thickening agents and other chemicals in a dry powdery form. When these dry residues are exposed to moisture, such as rain or high humidity, the chemicals absorb the water/moisture and expand into a colorless gel-like substance. This gel residue can swell multiple times its original volume and will freeze at temperatures below zero. If the gel is frozen within the gaps between control surfaces, then certainly for non-powered control systems, these control surfaces may be difficult or impossible to move from the flight deck until the gel melts in warmer air. Similarly, gel that freezes inside the airframe can interfere with control systems and have the same effect.

On European airports normally the single-phase ‘de-icing’ procedure with Type II or Type IV fluid is applied. It is understood that operators in North America prefer to use a two-phase ‘de-icing” procedure, with an initial application of Type I fluid, followed by the application of a thickened fluid to “anti-ice”, if required. In the USA and in Canada few reports indicate problems with ‘de-icing’ fluid residue and this is mainly attributed to the use of the two-phase ‘de-icing’ procedure. Both the JAA as well as the AEA recommend to use the two-phase ‘de-icing’ procedure. The problem however is a limited availability of Type I fluid on European airports. To avoid problems a thorough and regular inspection and, if necessary, cleaning are required of all critical areas.

The involved airline company changed its maintenance practices to inspect for “de-icing” fluid residues every 14 days (reduced from 28 days) and inspection and cleaning is now required within two/three days following an application of thickened “de-icing” fluid. The airline company has further developed new tools, inspection and cleaning procedures to identify and remove ‘de-icing’ fluid residues in internal structures.

Several meetings and workshops regarding the subject were held during the past years. Following is a summary of initiatives which, if implemented, would help to reduce the buildup of fluid residues:

- Minimising the use of preventative “anti-icing” with thickened fluids;
- Where possible, use of Type I fluids for “de-icing”;
- Exploring the possibility of greater availability of Type I fluids at operator’s hub stations;
- Seeking assistance from the fluid manufacturers on cleaning/solvents and the use of residue identification dye.

References:

- *AAIB Bulletin: 4/2006, Avro 146-RJ100, G-CFAC and others*, www.aaib.dft.gov.uk/home/index.cfm.
- *JAA SIC No.2, 15 September 2005, Ground de/anti-icing of Aeroplanes*, http://www.jaa.nl/index.html.
- *AEA Publication: Recommendations for De-Icing/Anti-Icing of Aircraft on the Ground,* http://www.aea.be/.
- *ERA,* http://www.eraa.org/.

Note: This report has been published in English and Dutch language. If there are differences in interpretation the Dutch text prevails.