INCIDENTS

Aircraft Type and Registration:	Avro 146-RJ100, G-CFAC and others
No & Type of Engines:	4 Lycoming LF507-1F turbofan engines
Year of Manufacture:	Various
Date & Time (UTC):	Various dates and times
Location:	Various
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - Various Passengers - Various
Injuries:	None
Nature of Damage:	None
Commanders' Licences:	Airline Transport Pilot's Licence
Commanders' Ages:	Various
Commanders' Flying Experiences:	Various
Information Source:	Aircraft Accident Report Forms submitted by pilots and subsequent enquires by the AAIB

Synopsis

During the winter of 2004/2005, UK-based airline operators experienced numerous incidents of restricted elevator and aileron controls on their Avro 146-RJ100 fleets. One operator also reported occurrences of restricted elevator controls on its Embraer 145 and Bombardier DHC-8 aircraft. These aircraft types are similar in having non-powered flight controls. Other European operators of Avro 146/RJ-series aircraft also reported flight control restriction events during the same period.

Many of these events were found to be associated with residues of 'thickened' de-icing fluids, that had accumulated in the aerodynamically 'quiet' areas of the elevator and aileron controls. These residues rehydrate on exposure to precipitation and can freeze at altitude, with the potential for restricting control movement. In most of these incidents, the control forces returned to normal after the aircraft had descended into warmer conditions. Despite recent industry efforts at addressing the problems posed by such residues, an effective solution remains to be found.

This bulletin reiterates the safety recommendations issued in a recent AAIB bulletin, which stated that the build-up of such residues must be avoided through a tightly controlled regime of inspection and cleaning, and that new types of thickened fluids must be developed, whose residues do not cause flight control restrictions on aircraft with non-powered flight controls.

Recent flight control restriction events

A previous AAIB bulletin report (EW/C2002/12/02) listed occurrences of flight control restriction events believed to have been caused by the freezing of thickened de-icing fluid residues. In 2005, numerous other similar events were reported in the UK and elsewhere in Europe. The majority of these incidents involved Avro 146/RJ-series aircraft, but other aircraft with non-powered flight controls such as the Embraer 145 and Bombardier DHC-8 were also affected.

The descriptions of these events and the subsequent findings are presented in Table 1 (see page 14). In many of these events, subsequent inspection of the aircraft highlighted the presence of de-icing fluid residues in locations and quantities that could have caused control restrictions. At the time, the affected operator had a scheduled maintenance task to inspect its aircraft for de-icing fluid residues every 31 days.

The AAIB consulted other accident investigation bodies in Europe for information on flight control restriction events. The information obtained is presented in Table 2 (see page 19). Although some events are still being investigated, de-icing fluid residues appear to be implicated in some cases. Following these events, the operator of the Swiss-registered (HB-) aircraft 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.

Effects of thickened de-icing fluid residues

In recent years there has been a tendency towards the greater use of 'thickened' de/anti-icing fluids, because of the improved holdover times that they provide. Industry experience has shown that the repeated use of 'thickened' de-icing fluids (specifically ISO Type II, III and IV fluids) for de-icing or preventative anti-icing can result in a gradual accumulation of fluid residue in the aerodynamically 'quiet' areas in the control surface gaps. As these fluids are applied with a high pressure spray, the fluid can also enter cavities in the control surfaces (eg, control rod apertures).

With time, the glycol antifreeze component of the fluid evaporates, leaving a dry, grey or blackish residue, comprised largely of the thickening agent, which is very hygroscopic and has little or no antifreeze properties. The repeated application of thickened fluid causes the residues to accumulate in increasing quantities, unless removed by regular cleaning. On exposure to moisture, for example, during rain showers, the residues will absorb water and swell to many times their original volume, to form a thick gel which can bridge the gaps between flight control surfaces and adhere to control mechanisms.

When the aircraft climbs above the freezing level the residues may freeze, with the potential for causing partial restriction, or in the worst case, complete jamming of the affected controls. If the autopilot is engaged at the time, symptoms may include: pitch oscillation, failure to level off at the selected flight level, or failure to capture the selected heading. The control forces usually return to normal after the aircraft has descended and the residues have thawed.

Normally this problem only affects aircraft with non-powered flight controls, because the power control units on aircraft with hydraulically-powered flight controls can overcome any such restriction caused by frozen residues.

Previous AAIB bulletin: 146-200 G-JEAX incident

The problems posed by the increasing use of 'thickened' de-icing fluids on aircraft with non-powered flight controls were highlighted in a recent AAIB bulletin report (EW/C2002/12/02) published on 5 February 2004, which reported on an incident of restricted elevator controls on BAe 146-200 G-JEAX, on 12 December 2002. This report highlighted the dangers posed by de-icing fluid residues and consequently the following Safety Recommendations were made to the United Kingdom CAA:

Safety Recommendation 2003-119

'It is recommended that the Civil Aviation Authority require operators of aircraft with non-powered flying controls that are vulnerable to the effects of freezing of re-hydrated de-icing fluid residues, to establish engineering procedures for the inspection and removal of such residues from critical flying control surfaces'.

Safety Recommendation 2003-82

'The Civil Aviation Authority should consult with anti-icing fluid manufacturers with a view to encouraging them to develop fluids, with suitable 'holdover' times, that incorporate gelling agents that are not rehydratable.'

De-icing procedures

Within the United Kingdom, and variously around Europe, the de-icing and anti-icing[1] of aircraft is usually performed by contracted service providers, with few airline operators possessing their own equipment. There is currently no requirement for the training or licencing of de/anti-icing personnel and so there is no direct control over the manner in which fluids are applied[2]. A key requirement from operators is for de-icing fluids with long holdover times to provide protection from ice for the longest possible time and thus minimise departure delays. This drove the development and introduction of so called 'thickened' Type II, III and IV fluids (to specification SAE AMS 1428A), which are much more viscous than the Type I fluids. The former provide increased protection by forming a much thicker layer of fluid over the aircraft surfaces. The thickened fluids are also commonly used for preventative anti-icing.

In-service experience with the thickest (Type IV) fluids showed that they produced significant amounts of residues which caused control restrictions on aircraft with non-powered flight controls. This led to recommendations from the aircraft manufacturers that Type IV fluids should not be used on such aircraft, and ultimately, the issuing of an Operations Directive from the Joint Aviation Authorities (JAA) containing similar advice.

In the UK the use of Type II fluids, one in particular branded as 'Type II+', has become predominant. These fluids, in theory, contain less thickening agent and should be less viscous than Type IV fluids, but in practice they can have similar viscosities. Industry experience has shown that Type II de-icing fluid residues can produce similar problems of flight control restrictions.

These problems may be alleviated by de-icing with Type I fluids which, being considerably less viscous,

Footnote

[1] Anti-icing of aircraft normally occurs some time prior to a departure, typically, the night before when snow, ice or frost is anticipated, and usually involves the use of a 'thickened' fluid. De-icing will typically be carried shortly before departure when accumulations of ice, snow, etc, need to be removed from the airframe, and may be performed using both thickened and unthickened fluids, depending on the holdover time required.

[2] If not applied appropriately, anti/de-icing fluids may easily enter flight control mechanisms within control surfaces, through actuator rod apertures, for example, where it is difficult to subsequently inspect for, and remove, residues.

tend to run off surfaces more readily and do not leave significant residues. It is understood that operators in North America prefer to use a two-stage de-icing procedure, with an initial application of Type I fluid, followed by the application of a thickened fluid to anti-ice, if required. Whilst some European airlines consulted by the AAIB stated that they would prefer to de-ice in this way, the availability of Type I fluid in Europe is extremely limited, given the far greater demand for the thickened fluids, and de-icing service providers are reportedly reluctant to stock this fluid.

Notwithstanding this, in Europe, some operators have guaranteed their own stock of Type I de-icing fluid for use at some airports, but they are still very much in the minority.

Regulatory information pertaining to aircraft de/anti-icing

Aviation fuels, oils, greases and similar substances are regulated and generally conform to specifications agreed with the relevant Airworthiness Authority. Such substances are usually approved for use following test and evaluation by the manufacturer to ensure, firstly, that they perform as intended and, secondly, that they pose no short or long term risk to flight safety. In addition, their 'shelf life', usage and/or manner of storage and are usually specified. At present, no such regulation applies to the manufacture, quality or application of de/anti-icing fluids.

The Joint Airworthiness Requirements Section JAR-OPS 1.345 'Ice and other contaminants - ground procedures' states:

> *'a) An operator shall establish procedures to be followed when ground de-icing and anti-icing and related inspections of the aeroplane(s) are necessary.'*

To the AAIB's knowledge, there are no further requirements beyond this relating to either the procedures for de-/anti-icing or the properties required of the fluids. However, advisory material is provided in the supporting document ACJ OPS 1.345: Paragraph 3d) states:

> *'Fluids used for de-icing and anti-icing should be acceptable to the operator and the aeroplane manufacturer. These fluids normally conform to specifications such as SAE AMS 1424, 1428 or equivalent. Use of non-conforming fluids is not recommended due to their properties not being known.'*

Section 8 *'Special Maintenance Considerations'*, states:

> *a) General*
>
> *The operator should take proper account of the possible side-effects of fluid use. Such effects may include, but are not limited to, dried and/or re-hydrated residues, corrosion and the removal of lubricants.*
>
> *b) Special Considerations due to residues of dried fluids*
>
> *The operator should establish procedures to prevent or detect and remove residues of dried fluid. If necessary the operator should establish appropriate inspection intervals based on the recommendations of the airframe manufacturers and/or own experience.*
>
> *ii) Operators are strongly recommended to request information about the fluid dry-out and re-hydration characteristics from the fluid manufacturers and select products with optimised characteristics.'*

On 15 September 2005, the JAA issued a Safety Information Communication the subject of which is '*Information on precautions and measures to be taken to counteract the presence, and also the formation of ice and other contaminants prior to flight*'. In this document, the phenomenon and hazards of the drying out and re-hydration of certain anti-icing fluids are highlighted. Reference guidance material is also provided.

The Association of European Airlines (AEA) document entitled '*Recommendations for De-Icing/Anti-Icing of Aircraft on the Ground*' is generally accepted by European airlines to be the definitive guidance document on ground de/anti-icing practices, but it is not compulsory to follow these recommendations.

Airframe manufacturer's advice to operators

The information provided by the regulatory authority implies that the aircraft manufacturer will recommend inspection intervals for the detection and removal of de/anti-icing fluid residues. The aircraft manufacturers have issued a considerable amount of advice to warn operators of the problems posed by thickened de/anti-icing fluid residues and the importance of inspecting for residues and removing them by regular cleaning of the affected areas, however, with some exceptions, these documents generally do not go as far as to recommend inspection intervals, leaving this to the operator to determine, based on their own service experience.

Given the problems on Avro 146/RJ aircraft in the winter 2004/2005 period caused by de-icing fluid residues, the aircraft manufacturer, BAE Systems, issued Technical Operational Response (TOR) Serial Number 2845, containing a draft revision to Chapter 12-30-31 of the Aircraft Maintenance Manual. This contains comprehensive instructions on how and where to inspect for residues and how they should be removed. The instruction also recommends the frequency of inspection, as follows:

> *'It is recommended that where thickened (Type II, Type III or Type IV) anti-icing fluids are used, the aircraft should be inspected for residues daily. Operators should develop an inspection and cleaning schedule taking into account their own operational environment and procedures, as well as the factors affecting build-up as stated above. If any residues are found they must be removed from the aircraft before the next flight.'*

BAE Systems has also issued a reference card to operators which provides advice on the application of de/anti-icing fluid. This contains a caution that fluid should not be applied to the aircraft in a forward direction, in order to prevent it entering the structure through various aerodynamic fairings. The manufacturer has also re-issued Service Information Letter (SIL) 27/80 to include the latest 'winterisation' advice.

Information gathered by the AAIB suggests that operators who inspect for de/anti-icing fluid residues more frequently, scheduled either on a short time interval, or after a specified number of applications of thickened de-icing fluids, tend not to suffer from flight control restriction problems. Operators' experience suggests that an inspection interval of 30 days may not be frequent enough. Whilst frequent inspection and cleaning of the flight controls places a large burden on an operator's resources, and requires the availability of suitable facilities and equipment (eg, hangars and access hoists), such inspections are unavoidable if thickened de/anti-icing fluids are used on aircraft with non-powered flight controls.

During the winter of 2005/2006, one operator reported three incidents of elevator trim circuit restrictions on an Avro RJ aircraft. A significant amount of anti-icing fluid residue was found to have accumulated under fairings on both elevators. These fairings covered the two trim circuit control rods where the trim tab drive passed in to the trim tab itself. As a result of this finding, on 20 January 2006, the manufacturer issued an All Operators Message (AOM), 06/001V, to highlight this finding and recommend rectification action. A copy of this AOM is appended to this report (see page 20).

BAE Systems Anti-icing Residue Focus Group

On 10-11 May 2005 the manufacturer of the Avro 146/RJ series aircraft, BAE Systems PLC, held a forum for operators of the aircraft type to discuss the subject of fluid residues. This meeting was also attended by representatives from the UK CAA and the AAIB. This provided an open forum for operators to share their experiences of the problem and the measures taken to combat the effects of the residues of thickened fluids.

At the forum, the aircraft manufacturer committed to issuing further information to operators on maintenance practices for the inspection and removal of the residues. The forum highlighted some initiatives which, if implemented, would help address the problem of fluid residues. These included:

- 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 solutions/solvents and the use of residue identification dye.

Discussion

The numerous recent incidents in the UK and elsewhere in Europe, of flight control restrictions attributable to the freezing of residues of thickened de/anti-icing fluids, show that this problem has still not been addressed effectively. This is a matter of concern, given that the potential dangers posed by such residues were publicised both in a recent AAIB bulletin and in advisory material issued by the aircraft manufacturers and the JAA. Experience has shown that the currently available thickened de-icing fluids, with their rehydratable residues, are not practically suited for use on aircraft with non-powered flight controls. They pose a potential hazard to flight safety through their ability to cause flight control restrictions, unless strict procedures are invoked to inspect for, and remove, the residues on a frequent basis.

Industry experience suggests that the problems can be largely eliminated by frequent controlled inspections and removal of the accumulated residues. Despite operators having adopted such a process, a small number have continued to experience problems. Evidence suggests that operators who perform the inspection and cleaning task at a short time interval, or who schedule the task based on the number of applications of thickened fluid, are generally more successful in managing the problem than an operator who inspects for residues at an interval of 30 days, for example. Most aircraft manufacturers do not specify to operators a suitable frequency for the task, leaving it to the operators to decide, based on their own, possibly limited, experience. Given that the task to inspect and remove the de/anti-icing fluid residues is very labour intensive and places a heavy burden on an operator's resources, it can at best be considered a short

term solution which addresses the symptoms, rather than the cause of the problem.

The JAR OPS requirements state:

> *'Fluids used for de-icing and anti-icing should be acceptable to the operator and the aeroplane manufacturer.'*

For aircraft with non-powered flight controls, the thickened de/anti-icing fluids currently available are neither acceptable to the operator nor to the aircraft manufacturer. However, as long as market forces continue to drive for de/anti-icing fluids with longer holdover times, thickened fluids will continue to be supplied in preference to Type I fluids. It is therefore considered that a regulation is necessary to ensure that only suitable fluids are used on aircraft with non-powered flight controls.

A potential solution would be for operators of aircraft with non-powered flight controls to avoid using the thickened fluids where possible and to de-ice using Type I fluids. Even though some operators would prefer to do this, the de-icing service providers seem reluctant to hold stocks of Type I fluid, given the limited demand from the relatively small number of operators of such aircraft. As there is a general desire within the industry to use thickened fluids which provide anti-icing protection for long holdover times, if a 'thickened' fluid could be developed whose residues are not rehydratable, the potential for such a fluid to cause flight control restrictions on aircraft with non-powered flight controls would be much reduced.

Conclusions

The hazards posed by the re-hydrated residues of thickened de/anti-icing fluids in causing flight control restrictions on aircraft with non-powered flying controls have been well publicised by both the aircraft manufacturer's and the JAA's advice to operators, and also in a recent AAIB bulletin. Despite this, recent events in the UK and elsewhere in Europe in the winter of 2004/2005 have shown that the problem is still prevalent, suggesting that more effective action is required.

The options available to operators of non-powered flight control type aircraft for de-icing are few, given the limited availability of Type I fluids and the use of currently available thickened fluids which impose a large penalty in increased maintenance costs. Therefore, the AAIB believes that regulation is necessary to effect the changes necessary to resolve this situation.

Safety Recommendations

Previous safety recommendations made by the AAIB were addressed to the UK Civil Aviation Authority. However, it is apparent that this problem also affects operators throughout Europe. Within European aviation, the JAA has oversight of operational matters, whilst EASA has responsibility for certification standards and the airworthiness of aircraft and their components. In order to effectively address the safety issue of the accumulation of rehydrated residues of 'thickened' de-icing fluids, which can freeze in flight and cause flight control restrictions, the following safety recommendations are made:

Safety Recommendation 2005-135

It is recommended, that the Joint Aviation Authorities, in consultation with the European Aviation Safety Agency, issue safety documentation to strongly encourage operators of aircraft with non-powered flight controls to use Type I de/anti-icing fluids, in preference to 'thickened' fluids, for de-icing.

Safety Recommendation 2005-136

It is recommended that where the use of 'thickened' de/anti-icing fluids is unavoidable, the Joint Aviation Authorities, in consultation with the European Aviation Safety Agency, ensure that operators of aircraft with non-powered flight controls who use such fluids, invoke controlled maintenance procedures for the frequent inspection for accumulations of fluid residues and their removal.

Safety Recommendation 2005-137

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.

Safety Recommendation 2005-148

It is recommended that prior to the European Aviation Safety Agency assuming responsibility for operational matters within Europe, they consider the future need for the training and licencing of companies who provide a de/anti-icing service, so that anti-icing fluids are applied in an appropriate manner on all aircraft types, but specifically to ensure that the entry of such fluids into flight control mechanisms and control surfaces is minimised.

	DATE	AC Reg	INCIDENT DETAILS	FINDINGS
Avro 146/RJ				
1	18-Mar-05	G-CFAC	With AP engaged @ FL22 abnormal variation in ROC/ROD. On disconnecting AP only minimal movement of elevator and ailerons possible. Normal control regained at FL070. Conditions: VMC, Rain. AAIB File ref: EW/G2005/03/09	Re-hydrated de-icing fluid residues found under aileron panels 511BB, 611BB, 533CB, 633CB, 533BB and 633BB & elevator panels 347BB, 348BB, 333BB & 334BB. Areas washed & cleaned w/ warm water, then lubricated.
2	18-Mar-05	G-CFAC	A/P failed to follow FD turn cmd at FL130 w/ flight control restrictions in pitch & roll after A/P disengaged. PAN & air-turnback. Pitch restriction remained until start of final approach. A/c descended to lower altitude & restriction reduced as OAT increased. AAIB File ref: EW/G2005/03/11	Further contamination found under elevator panels 333AB, 334AB 348AB, 347AB, 336MB & 335MB & heavy contamination under panels 336CT & 335CT. When rehydrated significant residue build up around servo/ trim tab bearings & rod ends. Areas cleaned and re-hydrated several times before all traces of contamination cleared. Signs of re-hydrated fluid under aileron panels 511FB, 611FB, 331BB, 631BB, 533AB, 633AB, 581AAB, 681AAB, 581ABB & 681ABB. Significant contamination found esp. in the shrouds around the servo/trim tab rods after re-hydration. Areas cleaned & re-hydrated several times before all traces of contamination had cleared. Items lubricated & op chk of flying controls performed.
3	19-Mar-05	G-CFAA	At FL280 in clear air, a/c failed to follow AP commands. When AP disconnected, pitch & roll controls restricted & trim wheels jammed. PAN declared & descended to FL200. Pitch problem moderated during descent. Full roll authority not regained until FL080. Light/mod. rain during previous turnround at SZG. Departure climb flown thru mod. icing until around FL140. AAIB File ref: EW/G2005/03/18	De-icing fluid residue contamination reported on ailerons and elevators but no specific locations recorded. A/c returned to service - further report of flight control restriction on 30/3/05 at FRA.
4	22-Mar-05	G-CFAB	Just prior to reaching cleared level FL250 with AP engaged, pitch difficulties experienced with V/S fluctuations of of up to +/- 600 fpm, which persisted after level off. When AP disconnected, pitch/roll forces were heavy. Normal control regained by 5000 ft. Conditions: Day VMC. Wx on departure moderate rain with surface temp +12 degrees. AAIB File ref: EW/G2005/03/14	De-icing fluid residue found in ailerons & elevators. Residue removed IAW company procedure and the aircraft returned to service. Further reports made under ASR 283/05/146 & 290/05/146 where further residues were noted to have been found in the same locations as previously.
5	22-Mar-05	G-CFAD	At FL250 in day VMC, just before TOD, a/c failed to track LNAV properly. When AP disconnected, ailerons found frozen. Directional control available with rudder. PAN called & descent made, on passing FL120 controls freed & PAN cancelled. No record in Tech Log of de-icing for 12 days. Moderate rain for 30+ mins on ground prior to departure. AAIB File ref: EW/G2005/03/13.	Contamination from de-ice fluid residue found on operating rods under panels 531/631AB, 533/633BB, 533/633AB (LH/RH ailerons) & under panels 347BB, 347AB, 336AB (LH/RH elevators). Residue cleaned out.
6	23-Mar-05	G-CFAH	In level flight @FL220 w/ AP engaged, a/c failed to follow FD heading change. On disconnecting AP aileron controls found to be restricted. Full control regained later regained on passing FL100 @OAT +2 C. AAIB File ref: EW/G2005/03/20.	On engineering inspection contamination found around panels 581/681AB (input to left & right aileron torsion bar). Contamination cleaned off

TABLE 1: Control Restriction Events on UK-Registered Aircraft - Avro 146/RJ

	DATE	AC Reg	INCIDENT DETAILS	FINDINGS
7	25-Mar-05	G-OINV	Level @ FL270 in day VMC, aileron trim warning occurred. AP disconnected. Roll control available but no spoiler movement in R/H turns. Full roll spoiler not available until just before landing. A/c last de-iced on 13-3-05, no rain overnight. A/c flown through a layer of cloud 500 ft thick after take off. Possible defect w/ spoiler system. AAIB File ref: EW/G2005/03/21.	Full inspection of roll spoiler system carried. Captain confirmed system had come good when OAT had risen. No sign of water ingress to the components Nor any hydraulics problems. Both system contents correct. Autopilot functioned-NFF. Spoilers deployed & indication good. Full range of aileron movement achieved. A/c considered serviceable. Crew asked to monitor on return to Inverness.
8	26-Mar-05	G-OINV	Aileron trim warning during right turn, controls stiff during right turns. OK in left turns. A/c flown manually to ILS approach LGW R/W 08R. Controls returned to normal at temps above 0 deg C. See item above. AAIB File ref: EW/G2005/03/22.	Inspection of roll spoiler and aileron linkages carried out. Operation found to be very smooth. System checked with & w/out auto pilot. A/c considered serviceable for retum flight to Inverness pls report any further problems. Suggest lubrication of various bearing & rod ends.
9	27-Mar-05	G-CFAB	In cruise a/c not tracking LNAV properly. When A/P disconnected, ailerons found to be frozen with virtually no control available from them. Airframe & engine a/ice selected on and a/c descended after PAN call. Normal control restored by FL120, PAN canx. On approach to FRA on prev sector a/c flew thru rain for several minutes. AAIB File ref: EW/G2005/03/23.	On inspecting aircraft no contamination found on the aileron controls. Minor contamination found on the elevators at panels 347AB/BB. Area washed and a/c returned to service.
10	29-Mar-05	G-CFAB	A/c failed did not follow AP turn cmd properly. A/c felt to jerk and failed to apply enough bank. On disconnecting AP ailerons found very stiff to operate. Diversion to GLA where visibility better. Controls became normal on descending thru' 5000 ft where OAT +2 deg C. Drizzle on turnound and rain during climb this sector. VMC in cruise. AAIB File ref: EW/G2005/03/17.	Reported failure to follow steering command from FD. Inspection revealed de-ice residue contamination at the LH/RH aileron inputs under panels 581AB/AAB & ABB & 681AB/AAB & ABB. Residues cleaned off and aircraft returned to service.
11	30-Mar-05	G-OINV	During cruise aileron trim caption came on. When AP disconnected ailerons v. stiff & no movement of R/H roll spoiler. AP reengaged when light went out. When giving hdg changes trim light came on again & AP unable to follow FD. OAT -30 deg C in thin cirrus (=icing) on descent. Ailerons still stiff @ FL150. At FL070 (0 deg C isotherm) controls unfroze to give full & free movement. See item above. AAIB File ref: EW/G2005/03/28.	Initial inspections found no de-ice residue on the aileron controls & emphasis moved to the roll spoiler mechanism. The cam box on the RH wing was replaced. A/c operated a number of sectors with similar reports of OAT levels without further report. On 5/4/05 the aircraft was reported with minor restriction again in RH turns with an aileron trim warning. A/c had stood overnight in heavy rain. On arrival back at INV the input connectors (behind panels 581-681AAB/ABB) on the LE of the LH & RH ailerons were checked and found to have a minor level of de-ice fluid residue contamination. The residue was removed. RH roll spoiler also replaced as a precaution.
12	30-Mar-05	G-BZAY	In descent passing FL 270 w/ AP in, a/c made uncommanded LH turn. AP disconnected & ailerons found frozen. (Roll spoilers appeared OK on gauges). A/c difficult to control in roll. Further descent initiated promptly. Controls began to return to normal at FL130 but did not fully recover until passing 3000 ft where OAT 0 deg C. A/c not de-iced in previous 2 weeks. AAIB File ref: EW/G2005/03/25.	Minor contamination of the aileron servo actuator found. Extensive cleaning carried out and a/c released to service. Refer to 289/05/146 for further report on next flight where the aircraft diverted to MAN during positioning flight EDI to BHX

TABLE 1 (cont.): Control Restriction Events on UK-Registered Aircraft - Avro 146/RJ

	DATE	AC Reg	INCIDENT DETAILS	FINDINGS
13	30-Mar-05	G-BZAY	In cruise heading control poor on AP. When AP disconnected, aileron controls very stiff to the right & almost non-existent to the left. PAN & diversion due poor weather at planned destination. Controls freed up at around 6000 ft during descent. 0 deg C level at 6000 ft. AAIB File ref: EW/G2005/03/30.	Second report on the same day. After this report further contamination was noted on under the final drive panels on the LH & RH ailerons (581/681AAB & ABB) & on the left and right elevators under panels 348AB/ BB & 347AB/BB. Contamination removed & areas thoroughly cleaned. Aircraft returned to service.
14	30-Mar-05	G-MABR	During cruise, AIL warning occurred. QRH actioned & warning extinguished. A/c stiff in roll with AP disconnected. Roll normal at lower altitudes in warmer temperatures. AAIB File ref: EW/G2005/03/29.	Found aircraft contaminated with residue of de-icing fluid. ETR TS5845R4 carried out. Contamination removed.
15	30-Mar-05	G-CFAC	In cruise at FL300 after 44 mins flying, a/c failed to respond to FD commands in roll. When AP disconnected, although responding in pitch, a/c was difficult to roll left or right. Roll control improved in the descent. Occasional showers whilst parked outside overnight at Stuttgart. Minor de-icing fluid rehydrated residues found on RH aileron. AAIB File ref: EW/G2005/03/24.	On engineering inspection at BHX minor contamination reportedly found on the RH aileron's final drive. Residue removed and the aircraft returned to service.
16	30-Mar-05	G-BZAZ	In climb at about 16,000 ft with AP in V/S mode a/c oscillated in pitch at =/- 400 fpm. Same response with AP in Speed Mode. When AP disconnected controls heavier than normal, esp pitch. Controls freed up fully by 6,000 ft in the descent. A/c parked overnight in heavy rain. On taxi out elevator water drain procedure performed. AAIB File ref: EW/G2005/03/26.	During subsequent inspections contamination was noted at the LH & RH aileron final drive locations at panels 533/633AB & on the LH and RH elevators at panels 335/336AB, 347/348AB & 347/348BB. All areas cleaned & the aicraft was retuned to service.
17	30-Mar-05	G-CFAA	During initial climb AP disconnected with 'ELEC TRIM' & 'FTC' captions lit. QRH actioned to no avail. In hand flown descent, higher than normal forces required to roll a/c to left. Roll control became normal after selection of Flap 18. AAIB File ref: EW/G2005/03/27.	On engineering inspection heavy contamination reported on ailerons & elevators but no specific locations were recorded. A/c cleaned at these locations and returned to service.
18	30-Mar-05	G-CFAC	In cruise a/c failed to follow FD roll demand. AP disconnected to manually correct. Aileron controls found very stiff. PAN call issued & a/c continued to destination. Aileron control became easier passing FL070 but was not fully free until vectors to the ILS were given.	No contamination found on the ailerons & only minor contamination found on elevators. Contamination was cleaned and the aircraft RTS.
19	30-Mar-05	G-BXAR	Overspeed occurrence as a/c descended from cruise. A/c passed thru tailwind into headwind. AP slow to compensate. When AP disconnected controls had limited travel & were very heavy. AAIB File ref: EW/G2005/03/32.	No contamination found during the subsequent inspection. Possible that this event not related to de-ice residue. Flight Ops: Crew debiefed - inital overspeed possible due to atmospheric conditions / failure of GNSX to compute windspeed /direction. Overspeed should have been controlled using automatics, suspected that crew are not familiar with manual flight control forces experienced at higher speeds.

TABLE 1 (cont.): Control Restriction Events on UK-Registered Aircraft - Avro 146/RJ

	DATE	AC Reg	INCIDENT DETAILS	FINDINGS
20	30-Mar-05	G-CFAH	Passing FL200 in AP level change climb, vertical speed variation of +/-1500. When AP disconnected control foces in pitch & roll heavier than normal. Control forces normal again by latter stages of approach. AAIB File ref: EW/G2005/03/33.	On engineering inspection heavy contamination found under panel 581ABB (LH aileron) and light contamination under panel 681ABB (RH aileron). Both LH and RH elevator controls were contaminated but no locations specified. Contamination cleaned & aircraft returned to service.
21	06-Apr-05	G-MANS	A/C climbed to FL260 with no indication of any problem, but experienced problems maintaining cleared FL AP disconnected at 26200 and LH control column was found locked solid. (calvary charge heard on deselection of auto pilot)! Unable to overpower the LH control column, "pitch jam" called and elevator disconnect pulled. LH column still locked. First officer had control. Card 32A actioned & 32B actioned. Autopilot disengaged on later attempts. Card 34B actioned before an uneventful landing.	Heavy contamination by de-ice residue of elevators found during inspection. Elevator interior cleaned.
22	07-Apr-05	G-BZAX	In descent AP reluctant to follow heading. When AP disengaged control restriction felt in ailerons. Much more noticeable with right roll. Restriction continued until approach, by landing no apparent restriction. Rain prior to departure at Zurich & a/c in moist cloud until FL300. AAIB File ref: EW/G2005/04/10.	Aircraft was found contaminated with de-ice residue when inspected. Internals of flight controls cleaned as required by ETR TS6779.
23	08-Apr-05	G-BZAV	A/c observed to be oscillating in pitch whilst maintaining FL300. AP disconnected, elevator found to be frozen. Descent initiated - restriction also noted in roll. A/c flown manually, full control recovery at 2000 ft. AAIB File ref: EW/G2005/04/11.	De-ice fluid residue contamination found in elevator & aileron controls. Interior of the controls were washed and aircraft returned to service on 9/4/05.
24	19-Apr-05	G-CFAC	During descent a/c did not follow heading commands on AP. When AP disconnected, roll control found to be almost totally jammed to left and extremely stiff to right. A/c descended immediately & roll control became easier in warmer air. Full roll control regained at approx 4000 ft at OAT +10 deg C. Freezing level at FL070. Rain at Frankfurt on departure with temp +11 deg C. Elevator drained for 30 sec prior to departure. Engine & airframe anti-ice on for whole flight. AAIB File ref: EW/G2005/04/13.	When panels 581/681AAB and 581/681ABB on L/E of L/H & R/H ailerons removed, "considerable" contamination found at the LH aileron (under panels 581AAB/ABB) & area cleaned to remove contaminant. The RH aileron satisfactory.
25	22-Jun-05	G-CFAA	Approaching cleared level w/ AP engaged, abnormal pitch & roll response occurred. When AP disconnected at FL140, abnormal 'jolts' evident in pax cabin. Subsequently during manual flight, pitch & roll controls reportedly v. stiff. AAIB File ref: EW/G2005/06/31.	De-icing fluid rehydration checks carried out on AP, elevators, ailerons & elevator tab rod. No anomalies found & a/c returned to service.

TABLE 1 (cont.): Control Restriction Events on UK-Registered Aircraft - Avro 146/RJ

	DATE	AC Reg	INCIDENT DETAILS	FINDINGS
Embraer 145				
1	30-Mar-05	G-ERJF	On initiating descent with autopilot engaged. A/C began to oscillate in pitch. Autopilot disconnected & retrimmed. Elevator found seized. A/C decended through 0 deg C isothern using trimmer & thrust. Elevator effective on passing 0 deg isothern. Normal approach and landing.	Heavy de/anti ice fluid contamination found in & around elevator & tabs. De/anti ice fluid residue rehydrated & multiple flush/ cleans c/out to removed contamination range of movement checks c/out satis
2	06-Apr-05	G-EMBL	On levelling @ FL260 on descent from FL360 AP had difficulty in maintaining level. AP disconnected & found to be very stiff. A/C elevators - pan call initiated - flown manually in descent through freezing level where control returned to normal. Normal approach & landing.	
Bombardier DHC-8				
1	15-Mar-05	G-NVSA	A/c was flown with an ADD for pitch oscillations in cruise w/ AP2. In cruise, AP1 also found similarly affected. A/c oscillated around + - 200' from captured ALT with vertical speeds of approx +/- 1200 FPM. On disconnecting AP the force required to maintain the a/c level was very high. A/c also v. difficult to trim. As OAT increased above 0 deg C pitch forces returned to normal. AAIB File ref: EW/G2005/03/10.	Elevator inspection C/O I.A.W. ETR TS5900R4. Heavy contamination apparent @ elevator surfaces, control rods, servo tabs, trim tabs & quiet areas. Amount of re-hydrated de-icing fluid considered sufficient to cause control movement restrictions.
2	05-Jul-05	G-BRYX	Passing FL150 in day VMC, 'NOSE DN PITCH MISTRIM' annuniciation occurred. AP was disconnected & 'nose down' pitch trim could not be moved, although 'nose up' trim available. When QRH actioned, standby nose down trim also failed. Flight completed manually. Pitch trim normal after arrival at destination. This flight & previous 3 were flown in wet & icy conditions. AAIB File ref:EW/G2005/07/13.	Engineering inspections unable to replicate fault. During subsequent inspection & lubrication of elevator trim jacks, some moisture contamination of RH screw-jack was found.
3	27-Sep-05	G-NVSA	Following top of descent, AP 'pulsated' as AP attempted to trim down. When AP disconnected, 'pitch-up' felt. Trim restricted until FL080. AAIB File ref: EW/G2005/09/13.	

TABLE 1 (cont.): Control Restriction Events on UK-Registered Aircraft - Embraer 145 & Bombardier DHC-8

	DATE	AC Reg	INCIDENT DETAILS	FINDINGS
Avro 146/RJ				
1	12-Mar-03	D-AEWA (146-300)	Between FL80 & FL100 with AP engaged, unusual behaviour of AP observed, starting w/ slight pitch oscillations, increasing to around 3,500-4,500 ft/min (or 18 deg pitch up). A/c behaved the same after disconnecting AP. Flight conditions: IMC & icing. Engine & airframe anti & de-ice on and working normally. A/c control regained only slightly with manual elevator trim. Reaching VMC and non-icing conditions out of FL130, no improvement of a/c handling. The only way to control the a/c was by using manual elevator trim. Emergency declared & flapless ILS approach to STR flown w/ 60 NM final.	Based on German AAIB (BFU) preliminary findings: When a/c inspected in hangar ca 1-1.5 hrs after landing, ice found bewtween fin and rudder & small amount of ice found in gap between elevator and horizontal stabiliser. Evidence of de-icing fluid residues found on fin & rudder. BFU Investigation ongoing.
2	22-Mar-05	HB-IXQ	On short final after switching off autopilot, F/O reported 'sticky' elevator controls as if the AP had not disconnected after AP cut. After 5 seconds control feel was back to normal. Mod icing reported bu ZRH ATC below FL150 but no visible ice on a/c.	Visual inspection of elevator revealed a jelly like substance & dirt between horizontal stabiliser, elevator and control tabs. A lot of gaps covered with jelly-like substance. Washed down elevator & cleaned all surfaces.
3	23-Mar-05	HB-IXK	In climb out from FL220 a/c unstable in pitch. When VS mode set to 1500 ft/min, AP not able to hold 1500 ft/min climb. ROC varied between 1800 ft/min & 200 ft/min. A/c controllable with high force input on elevator. At approx. 8,000 ft normal ops again.	Entire elevator moving surfaces clean & free from jelly-like material. All drain holes free. Opened all hinge inspection covers on LH & RH elevators. Found small traces of jelly-like material. Cleaned by hand. Both elevator servos replaced (suspect one clutch was engaged).
4	24-Mar-05	HB-IXH	During climb above FL200 we observed big pitch changes in 'LVL CHG MODE' with FGC2. Changed to VS but AP was not able to maintain steady VS. AP disconnected & elevator found almost impossible to move, control was only possible with trim. Airframe & tail anti-ice were selected on 10 mins earlier. IMC conditions with icing. Control over elevator regained below FL100 & out of icing conditions. Successful landing with Flaps 24 (for more aerodynamic control).	Visual inspection of LH & RH elevator moving surfaces - found small amount of jelly-like material along the hinges of moving surfaces & in front of leading edge of moving surface. Opened all inspection panels on hinges of moving surfaces. Found small amount of jelly-like residue on LH & RH most inboard hinge. Cleaned affected area. LH & RH elevators washed.
5	25-Mar-05	HB-IXQ	FL215 IAS MODE 280 kt, OAT -20 deg C, light to mod. Pitch changes with VS varying between +2,800 & -300 ft/min. Wind change from 8-19 kt, suspected waves. To stabilise, pitch change mode changed from IAS to VS. Pitch changes increased. Suspected frozen elevator. AP disconnected & found elevator blocked. Unable to maintain present FL. Vertical control achieved by means of EI pitch control. Informed ATC for descent & return to ZRH. Full control achieved below 5,000 ft, OAT + 2 deg C.	Not known.
6	25-Mar-05	HB-IXH	During climb in VMC, passing FL 210, speed 250 kt, experienced moderate pitch changes in 'LVL CHG MODE' with FGC1 & AP on. AP was disconnected & pitch changes reduced. At that time pitch oscillation started & reduced when speed decreased towards 210 kt.	Not known.
7	30-Mar-05	D-AVRG (Avro 146 RJ85)	During climb, low freq. pitch oscillation (AP in 'V/S mode', vertical speed fluctuating significantly). During level flight same behavior in 'altitude hold' mode. Crew disconnected AP & noticed in manual flight that unusually heavy control inputs necessary for pitch & roll control. Crew decided to divert to Cologne but situation deteriorated. Priority landing in Frankfurt requested & emergency declared. During descent, situation improved slightly, followed by 'normal' approach & landing.	Reported to German AAIB (BFU) - File ref: BF 17/05. Currently under investigation.

TABLE 2: Control Restriction Events - Other European-Registered Aircraft

All Operator Message: Ref 06/001V

All Operator Messages Contain Safety Related Information

Recommended Distribution

- [X] **Engineering**
- [X] **All Maintenance Staff**
- [X] **All Ground Staff**

Aircraft Type : Bae 146 / Avro RJ

- [X] **Flight Operations**
- [X] **All Flight Crew**
- [ ] **All Cabin/Operations Staff**

SUBJECT: Flight Controls – Icing Restrictions ATA: 27

Reason

Recent reports of elevator trim circuit restrictions.

Description

An operator has reported three incidents of elevator trim circuit restrictions, the controls were inspected and cleaned on the aircraft following the incidents. The elevators were then removed from the aircraft for further investigation. This revealed a significant amount of anti-icing fluid residue under fairings on both elevators. On re-hydration this residue impinged on the control rods. The fairings, part number HC552H0341, cover the two trim circuit control rods where the trim tab drive passes into the trim tab itself.
De-icing/Anti-icing the aircraft from the rear increases the probability of fluid entering this area.

Recommendations

Operators are advised to remove the fairings when inspecting the aircraft for fluid residue accumulations. If residues are found ensure they are removed before further flight. The fairing is retained by tri-wing screws, part number NAS4403-4 and -5.These fasteners have proved difficult to remove on occasion, particularly when the slots become filled with paint. It is permissible to replace them with NAS7403-4 and -5 screws if required. BAE Systems will supply necessary approvals if required.
Operators are recommended to ensure their service providers are following the guidelines of BAe146/AvroRJ De-icing/Anti-icing Application Guide as issued by BAE Systems, in particular with the respect to direction of de-icing.

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Issue: 1 - Date: 20 JAN 06 Form ref PD103/1 Page 1/2

Additional Information

There have been a few reports of restrictions of flying controls recently. This fits the weather pattern which was seen last year, and which has been described previously. A period of cold weather, giving repeated applications of anti-icing fluid, followed by warmer weather gives the fluid time to dry out and form residues. This has been followed by warmer wetter weather, which re-hydrates the residues, and leads to ice formation in critical areas. Operators are reminded of this phenomenon.

Early indications are that this weather pattern is about to repeat itself. Operators are reminded that their inspection/cleaning regime should take this into account

CUSTOMER TECHNICAL SUPPORT

AOM 06/001V
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