Winter of Discontent

PART ONE

Ten years ago, reports about control problems caused by the freezing of water-soaked residues left by anti-icing fluids came to the attention of winter operations planners at airlines worldwide. The phenomenon had caused elevator control tab restrictions and pitch oscillations during two BAe 146 flights operated by Crossair. The parent company, Swiss Airlines, consequently abandoned the common European practice of spraying regional/commuter airplanes — up to five times a day — with heated, water-diluted SAE International Type II or Type IV fluids, which are formulated primarily for anti-icing, keeping airplane surfaces free of frozen contaminants before takeoff, and also are approved for deicing.[1,2]

Fast-forwarding to winter 2008–2009, the same basic one-step deicing/anti-icing method — usually with Type II fluid — is still favored by most European deicing/anti-icing service providers and some airlines because it involves a simple application of various mixtures, holdover times well suited to diverse airport environments with frost more prevalent than ice/snow contaminants, and a relatively low cost.

A number of European companies and organizations exposed to this risk of flight control restriction continue pressing for faster government intervention (*ASW*, 9/06, p. 26), however. They argue that commercially driven decision making, inadequate voluntary compliance with safety advice and a weak regulatory environment on this issue have not fully addressed far-reaching safety recommendations by the U.K. Air Accidents Investigation Branch (AAIB) and the German Federal Bureau of Aircraft Accidents Investigation (BFU), or the risk factors identified in dozens of incidents after the Crossair experience.

The European Regions Airline Association (ERA), the Association of European Airlines, airframe manufacturers and other organizations advocate the regulation of deicing/anti-icing service providers, which are not covered by civil aviation regulations because of their legal status as contractual partners of the operators.[3]

Risks from anti-icing fluid residues remain troublesome for European airlines despite a wealth of safety advice.

BY WAYNE ROSENKRANS

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Paste-like gels form when anti-icing fluid residue absorbs water in aerodynamically quiet areas.

"Regulatory action is needed in some areas before a major incident occurs that will subsequently expose inactivity on these known serious issues," said Mike Ambrose, director general of ERA. "There is a strong argument for requiring the regulation of agencies undertaking deicing and anti-icing, thereby ensuring that these agencies maintain proper training and qualification of staff carrying out ground deicing/anti-icing activities. Operations can be safely undertaken when these problems are addressed by appropriate procedures, however, although the associated costs of aircraft checking and cleaning of critical areas are high."

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The current situation is seen as a consequence of the gradual shift of regulatory oversight from national civil aviation authorities to the European Aviation Safety Agency (EASA), and it has dissatisfied the advocates of deicing/anti-icing reforms. "Type certificate holders have been extremely frustrated in Europe — there is no single accountable regulatory authority that we can go to and speak to about the whole breadth of the residue issues, such as aircraft design information, providing deicing/anti-icing service, maintenance instructions, fluid specifications and operation of aircraft," said Alistair Scott, chief airworthiness engineer and head of flight safety for BAE Systems Regional Aircraft, the type certificate holder for the BAe 146/Avro RJ. "Due to the evolving regulatory environment, people don't feel the need to take action on all these issues."

In September 2008, EASA published an update of its general policy and action plan covering short-term and long-term solutions, including responses to public comments about which of several proposed countermeasures should be pursued.[4]

"Dried fluid residue could occur when surfaces have been treated but the aircraft has not subsequently been flown and not been subject to precipitation," says EASA's latest advisory information. "Repetitive application of thickened deicing/anti-icing fluids may lead to the subsequent formation/buildup of a dried residue in aerodynamically quiet areas, such as cavities and gaps. This residue may rehydrate [absorb water] if exposed to high humidity conditions, precipitation, washing, etc., and increase to many times its original size/volume [often described as a wallpaper paste–like gel].

"This residue will freeze if exposed to conditions at or below 0 degrees C [32 degrees F]. This may cause moving parts such as elevators, ailerons and flap actuating mechanisms to stiffen or jam in flight. Rehydrated residues may also form on exterior surfaces, which can reduce lift, and increase drag and stall speed. Rehydrated residues may also collect inside control surface structures and cause clogging of drain holes or imbalances to flight controls. Residues may also collect in hidden areas around flight control hinges, pulleys, and grommets, on cables and in gaps."[5]

EASA recommends consideration of the two-step deicing/anti-icing method — in which deicing with Type I fluid helps to remove residue — if thickened fluids are to be used, residue inspection/cleaning procedures under operator policies that define safe intervals, situations necessitating supplementary training, and operators obtaining information from fluid manufacturers to be able to specify, to the extent possible, brand name fluids with the lowest gel-formation potential from residues.

For the short term, EASA will focus on requiring type certificate holders/manufacturers to inform operators about preventive actions and provide instructions to operators on detecting and removing dried residues and rehydrated gel, and requiring operators to implement these instructions.

Regional safety officials eventually will be empowered to take actions they deem necessary on more of the residue issues raised by the deicing/anti-icing reform advocates. "In the meantime, responsibilities remain with the appropriate bodies within the member states, who, according to the agency's preliminary research, generally do not regulate this area," EASA said.

"The greatest risk to flight safety is still a control restriction that can't be cleared in flight," said Scott. "We were pleasantly surprised in winter 2007–2008 by the majority of BAe 146 operators following current safety advice. They ended up with a very small number of incidents — a handful compared with two or three years ago — albeit at significant cost due to their cleaning and inspection routines. The four main countermeasures are cleaning and inspections, training, better fluids and use of Type I fluids when possible. The only way we are ever going to fix this situation is by putting in place a new generation of fluids. All these factors are being tackled concurrently, but progress is slow. Some European operators have learned nothing and, in fact, have taken a step backward."

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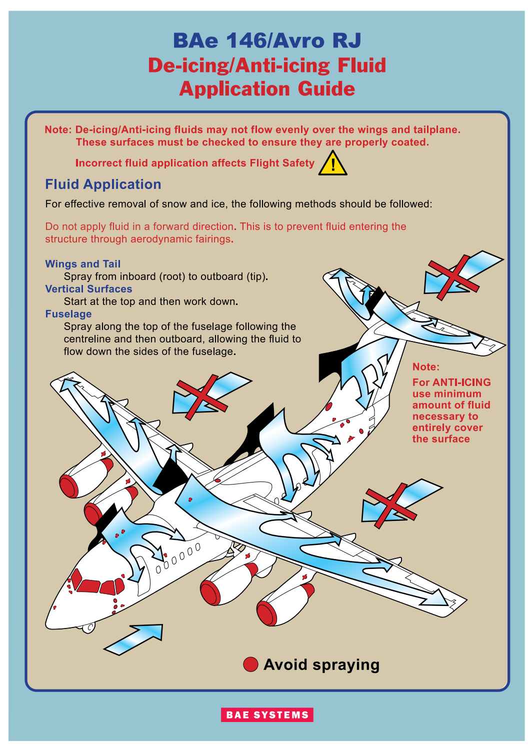
Serious Incidents

In early incident reports involving the 146/RJ, the McDonnell Douglas DC-9/MD-80 and the de Havilland Canada DHC-8, the common denominators were non-hydraulically powered flight control systems, for which flight crews may lack sufficient physical force to break out frozen deposits; high T-tails difficult to inspect for residues; and short-haul operations with multiple fluid applications per day, said Kirsten Dyer, chairwoman of the SAE G12 Committee's Residue Workgroup and senior materials engineer for BAE Systems Regional Aircraft. Civil aviation authorities initially responded by advising operators not to use the Type IV fluids on aircraft with non-powered flight controls.

Often-cited cases of control restrictions (*ASW*, 2/07, p. 58) include one in March 2003 near Edinburgh, Scotland. The flight crew of a DHC-8 saw that the autopilot had failed to level the airplane at the selected altitude of Flight Level 170. The combined efforts of both pilots to stop the climb were ineffective. They conducted memorized actions for an elevator jam condition and, by selecting the pitch disconnect handle, were able to regain elevator control with reduced elevator authority. After conducting quick reference handbook procedures, they landed the airplane without further incident. The cause was restriction of the right elevator spring tab by frozen rehydrated residues of anti-icing fluids from previous fluid applications.[6]

"Between January and April 2005, and mainly over a four-day period, 48 incidents were reported on RJ/146, Embraer 145 and DHC-8 aircraft, directly related to anti-icing fluid residues," Dyer said. Although the AAIB and BFU have



published tables of apparent incidents, a reasonably consistent and up-to-date count of all European incidents has yet to be published by any authority to the knowledge of Dyer and Scott.

A review of winter 2007–2008 operator data by the residue workgroup has been inconclusive regarding any new causal factors. "There doesn't seem to be any pattern, rhyme or reason as to why an incident occurs on one aircraft and doesn't on another of the same type," Dyer said. "For instance, cleaning programs of some operators allow only so many applications of any anti-icing fluid before calling for a residue inspection. But one had an incident about two or three fluid applications before reaching its interval limit. This operator's other airplanes of the same type, with the same fluids applied in the same conditions, did not show any residue on inspection when they reached the same limit."

Dried residue in the form of light powder or rubbery skin remains after the evaporation of glycol and water from the Type II, Type III and Type IV fluids but, by itself, is relatively harmless until unusual sequences of weather conditions occur, Scott said. During internal residue inspections, maintenance technicians usually can see the gel, but residues are difficult to detect except by intentionally spraying water onto suspected areas in a heated hangar, then waiting 15 minutes to see if the gel forms.[7]

"As the fluids dry out in layers, incidents have occurred after the top layers of the residue have been rehydrated and cleaned off, and the aircraft has then been returned to service, with the inner layers still rehydrating from contact with the cleaning water, which are then freezing in flight," Dyer said.[8] "A danger in relying on inspection and cleaning programs is that they are open to errors and changes in fluid. For instance, one European operator's program worked through the worst recent conditions — winter 2004–2005 — but after changing to a new product the next season, the operator had a series of incidents."

Some manufacturers of commercial transport airplanes with hydraulically powered flight control systems, such as Boeing Commercial Airplanes, say that any airplane type could be susceptible to adverse effects from frozen residues; Boeing provides type-specific safety advice to operators.[9]

Any time they apply anti-icing fluid, airlines actually are using one contaminant to remove another, the frozen contaminant, Scott said. "Effectively, they then take on the commitment that they subsequently will remove this fluid, including the residues, at safe intervals to keep the aircraft airworthy," he said. "The whole winter operation is a balance of risks and defenses; getting the balance right keeps the operators on the safe side."

Dyer says that significant reduction of the known residue-related risks ultimately will require "airframe manufacturers to modify their current and future aircraft types if possible [such as by improved seals to prevent fluids from penetrating aerodynamically quiet areas]; service providers and airlines to ensure the widespread availability and use of Type I fluids and the two-step process; fluid manufacturers to develop fluids that have acceptable residue properties; SAE International to [update] the SAE AMS 1428 specification such that only fluids demonstrating suitable residue properties can be approved in the future, as well as giving proper guidance on their application; and in particular, regulatory authorities to put the correct measures in place to ensure that the above processes are implemented."[10]

Part Two will cover industry attempts to study the gel-formation potential of anti-icing fluids in the laboratory and report test results; overcome barriers of proprietary information; require practices that lead to consistent results; and seek new fluids that meet goals for safety, effectiveness, the environment and cost.

Notes

1. Beisswenger, Arlene; Perron, Jean. "Laboratory Testing of Aircraft Anti-Icing Fluid Rehydrated Gel Residues." Paper presented to the SAE Aircraft and Engine Icing International Conference, Seville, Spain, Sept. 24–27, 2007.
2. EASA. "Ground De-/Anti-Icing of Aeroplanes: Intake/Fan-blade Icing and Effects of Fluid Residues on Flight Controls." Safety Information Notice (SIN) no. 2008-29, April 4, 2008. EASA said, "Type II and Type IV [anti-icing] fluids contain thickeners which enable the fluid to form a thicker liquid-wetting film on surfaces to which it is applied. Generally, this fluid provides a longer holdover time than Type I [deicing] fluids in similar conditions. … Type III [is a] thickened [anti-icing] fluid intended especially for use on airplanes with low rotation speeds."
3. BFU. "British Aerospace BAE-146 – De-icing Fluid." Report no. 5X007-0/05.
4. EASA. "Comment Response Document to Advance Notice of Proposed Amendment (NPA) 200711 on Possible Course of Action for EASA to Address the Residues That Can Result From Application of Deicing/Anti-icing Fluids." Sept. 2, 2008.
5. EASA. SIN 2008-29.
6. AAIB. "De Havilland Canada DHC-8-311, G-BRYJ." March 2, 2003. Bulletin no. 12/2003.
7. Scott, Alistair. "Aircraft Icing Fluids — How Can We Resolve the Problems?" Presentation to the ERA Regional Airline Conference, Malta. April 10, 2008.
8. Dyer, Kirsten P. "Anti-Icing Fluid Residues." Paper presented to the SAE Aircraft and Engine Icing International Conference, 2007.
9. Hille, Joel. "Deicing and Anti-icing Residues." *Aero,* First Quarter 2007, p. 15. <boeing.com/commercial/aeromagazine>.
10. Dyer.