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PART TWO — COPING

Winter of Discontent

Anti-icing fluid issue challenges European stakeholders to look beyond competing interests.

BY WAYNE ROSENKRANS

Reformulations of problematic anti-icing fluids may not be available for five years, or possibly much longer, so European aircraft ground deicing/anti-icing reformers this winter are urging everyone concerned to make a concerted effort to reduce the risk that gels will form from water-soaked residues of anti-icing fluids, then freeze in flight. At stake are rare, but serious, airplane flight control restrictions (*ASW*, 10/08, p. 26) — for example, gel immobilizing control rods and bearings under aerodynamic fairings or filling the area between the elevator and elevator control tabs. Adequate progress also requires reconciling competing interests — including the preference of the majority of European airlines for certain fluids while regional airlines in the minority cope with unpredictable incidents, operational difficulties, and costly inspections and cleaning regimes that these fluids necessitate.

"The industry finds itself in a challenging position, and our main ambition is to influence those with the responsibility and authority to do the right thing," said Alistair Scott, chief airworthiness engineer and head of flight safety, BAE Systems Regional Aircraft, which has introduced design modifications to aid in aircraft deicing/anti-icing and maintenance, and has conducted a continual program of operator awareness. "Our TC holder responsibilities are somewhat limited in the ability to influence the safety of winter operations because the residue issue covers the operation of aircraft, the manufacture of fluid, and the regulation and approvals of companies that may or may not apply the fluid, and how [their services] are controlled."

A primary impediment to reform has been the innate drive by airlines to minimize the cost of winter operations and to maximize holdover capability, adds Kirsten Dyer, chairwoman of the SAE G12 Committee's Residue Workgroup and senior materials engineer for BAE Systems Regional Aircraft. "The big operators of the larger aircraft types are not having any problems with residues, and they like the one-step

fluid application process as it is the cheapest method of giving them sufficient holdover to anti-ice all of their aircraft once in the morning. Large operators represent 80 percent of the fluid purchasing power, so they make the decisions."

Countermeasures generally have been effective. But in winter 2007-2008, one unidentified European regional airline that provides deicing/anti-icing services to other airlines experienced further incidents. "This operator was actually one of those more aware of this issue than others from purchasing and applying these fluids to aircraft — yet was still caught unawares," Dyer said. "[Despite a] cleaning and inspection regime that had been effective before, they had incidents between the cleaning and when the inspection regime kicked in. From what we understand, a new fluid adopted by this operator dried out faster than the previous fluid. That is a big danger — that a manufacturer could bring a new fluid onto the market that maybe has some property that causes an incident or worse."

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Type certificate holders typically cannot prescribe a universal, detailed cleaning and inspection program because of differences in operational environments and seasonal conditions, so a significant share of safety responsibility falls to operators. "The operator has to establish a frequency of inspection and check it periodically, depending on the types of fluids they have been using, the fluid-application process and the frequency of fluid use," Scott said. "If they don't want to clean the aircraft after every application, then they have to put a plan in place, and that requires some assessment. The flight safety people in airlines understand the issues, but [some] don't feel empowered to make decisions about the type of fluid used … the people who have that responsibility are elsewhere in the organization."[1]

EASA Response

The European Aviation Safety Agency (EASA) responded in September 2008 to 139 comments on its proposed tactics to address potential safety hazards related to anti-icing fluid residues. This evaluation of industry sentiment yielded insights into the difficulty of persuading affected organizations to update winter operations. Commenters included seven airlines, three deicing/anti-icing service providers, four professional associations, one standards organization, one airport, four aircraft manufacturers and five civil aviation authorities.[2]

For aircraft with non-hydraulically powered flight controls, the agency has called for type certificate holders to publish — in time for winter 2008-2009 — technical instructions recommending that operators use Type I deicing fluids rather than Type II anti-icing fluids and that they implement procedures for identifying and eliminating anti-icing fluid residues if Type II is used; that deicing/anti-icing service providers be licensed or certificated; and that residue-free anti-icing fluids be developed and certificated.

EASA agreed with some commenters who argued that the residue risk also should be addressed for aircraft with hydraulically powered flight controls. The agency proposed that all type certificate holders provide or improve instructions for operators and service providers, participate in work groups to revise fluid standards to include gel-formation potential, and review EASA's airplane certification specifications on this issue.

Boeing Commercial Airplanes considers deicing/anti-icing fluid residues to be an industrywide issue.[3] Airbus reminded EASA that the residue problem has not affected all airplane manufacturers/types. "Some aircraft have experienced many serious incidents due to residues, others have experienced very few or none," Airbus said. "This is the case with the Airbus fly-by-wire aircraft fitted with powered flight controls. Airbus aircraft fitted with powered flight controls have no adverse safety records related to the frozen rehydrated residues problem (e.g., control surface stiffness, control surface jamming, etc.)."

Unresolved issues in Europe include whether to institute regulatory approval of service providers; how to introduce standardization to diverse ground services provided by regulated airport operators and unregulated service providers, possibly by indirect regulation through airport operators; and whether

airplane design modifications can compensate — without significant economic burden or added weight — for unpredictable factors such as service providers ignoring technical instructions by spraying anti-icing fluids from the rear of the aircraft into openings in the wing or other areas where flight control, hydraulic and electrical systems are located. Some civil aviation authorities argued that airworthiness directives — not revision of certification specifications — are the appropriate method of addressing residue effects on specific aircraft rather than investigating the susceptibility of all types of commercial transport aircraft.

Lack of choice of fluids at airports often was cited as a problem. "Most [commenters] would wish that [EASA] find ways so that an appropriate range and stock of thickened and unthickened fluids to anti-ice aircraft (i.e., each type of fluid should be available) is maintained and offered at each aerodrome receiving commercial air transport aircraft; deice/anti-ice service providers be approved; and fluids to deice and anti-ice aircraft [be] certified," EASA said, noting its current lack of jurisdiction in these areas.

The agency focused earlier this year on amending existing regulations to require operators to implement residue countermeasures via maintenance programs. If industry response is unsatisfactory or there is insufficient time to adequately address the issue by amending maintenance regulations, EASA may issue airworthiness directives for specific aircraft types before the end of 2008.

In the long term, EASA will monitor the issue and participate in industry working groups; consider the feasibility of amending aircraft certification standards to address flight control sensitivity to frozen gels; investigate and recommend methods for civil aviation authorities to deal with industry demands for service providers to be certified; include provisions in pending airport regulations to promote safer deicing/anti-icing practices, making available the types of fluids that operators need to manage their risk; consider amending pending air operations regulations to address the issue; and take steps toward rule making to extend jurisdiction from aircraft "parts and appliances" to fluids and materials.

Service Provider Issues

One service provider's comment to EASA summarized a perspective that other service providers have expressed to BAE Systems Regional Aircraft. "For an airline operating, say, three, four or maybe even five types of aircraft, the type-specific [deicing/anti-icing] training would not be a problem," Airline Services said. "For a service provider

Aircraft type certificate holders urge service providers to spray anti-icing fluid from the front toward the rear to reduce fluid penetration into aerodynamically quiet areas.

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deicing in excess of 100 different types of aircraft, perhaps for 120 different operators — all with differing interpretations of the same requirement — this would be a problem of major proportions. A standard training program for each aspect of deicing is essential, with anything type-specific being covered in a training section titled 'Type Specific.' My company currently deices at 10 different airports. None of these have dictated or even suggested the fluids that we supply. Just so long as we comply with current health and safety and spillage regulations, then we are acceptable to them."

While such service providers say they are trying to reduce variation at any given airport, type certificate holders, operators and civil aviation authorities remain concerned about inconsistencies among airports in deicing/anti-icing. "Poor training in the application of the [anti-icing] fluids can significantly increase the amount of residues if the fluids are sprayed directly into aerodynamic fairings, or more fluid is applied than necessary," Dyer said. "Holdover and residues are connected — the more holdover expected [by the large aircraft operators], the more thickeners within the fluid and the more residue."

From the type certificate holder's viewpoint, best practices might be ignored by service providers. "There needs to be additional awareness of the importance of spraying the aircraft from the front, and knowing the areas where not to spray," Scott said. "They must not ever deice from the back of the aircraft, which forces fluid into all the gaps and aerodynamically quiet areas where it is just going to stay. Flying around Europe, I see deicing from the back time and time again." He cited the U.K. Civil Aviation Authority (CAA) as one of the European authorities pushing for better training this year to eliminate unsafe practices by service providers.[4]

Scott says flight crews depend on service providers' documentation, but sometimes it shows no record of anti-icing fluid being applied although airline personnel saw fluid applied. "The accuracy of recording the type of fluid applied, indeed the actual brand of fluid, and the processes is valuable when it comes to troubleshooting," Scott said. "After a few applications of different fluids, however, it becomes very hard to ascertain which particular fluid caused the [residue] problem. … To really get to the bottom of the problem, aircraft operators should review their quality management system to see if or how it records this information."

Futuristic Fluids

Reformers and EASA encourage fluid manufacturers to reformulate today's anti-icing fluid as soon as possible. The best the operators can do for now, the reformers say, is to consider independent research alongside technical information obtained directly from the fluid manufacturers and operators' own winter experience.

"The residue workgroup's consensus is that all of the [anti-icing] fluids use a similar chemistry and have the potential to form residues," Dyer said. "However, some aircraft types appear to be more susceptible to the issue and some fluids are thought to have 'worse' residue properties. I obtained agreement in the workgroup this year in terms of future required testing, but there is unlikely to be consensus on whether the results can be used to classify the fluids for performance — which is the desired outcome — due to commercial interests." The work group includes some of the fluid manufacturers.

The latest independent research was conducted by the Anti-icing Materials International Laboratory (AMIL) at the University of Quebec at Chicoutimi in Canada with sponsorship of some work by the U.K. CAA.[5] AMIL's December 2007 report was designed to help operators understand, in general terms, the significant differences when specific brands of Type II, Type III and Type IV anti-icing fluids were applied to a vertical aluminum plate representing an external vertical panel on an aircraft.[6]

Eight fluid manufacturers and 21 of their fluid brand names are deidentified on the published AMIL chart, but a separate list makes it possible for the participating manufacturers to be contacted about gel-formation potential. "Posting the results on the AMIL site with the fluids unnamed and such a complex document is a first step … the best that we could do," Dyer said.

Airworthiness authorities, including EASA, cannot compel publication of trade secrets by the fluid manufacturers, and they prefer other approaches. "The process, to be effective, must recognize and accommodate the confidentiality of proprietary information," the agency said, calling safety information notices by regulators the preferred solution.

The AMIL report notes that its data alone are insufficient for selecting fluids or predicting residue effects. "If the characteristics are known to airlines/deicing providers, it would allow them to buy the 'best' fluids and would therefore encourage fluid manufacturers to develop better fluids," Airbus said in comments to EASA. "The simplistic SAE G12 [Committee–AMIL] test for fluid residue formation is known to be imperfect, but the results are useful nevertheless."

Dyer hopes that fluid manufacturers' research and development programs soon will yield the first residue-free anti-icing fluids — candidate fluids that also would help SAE International to revise existing standards. "Some manufacturers

whose fluids do not have an acceptable residue performance may develop new fluids with a better residue performance," she told EASA. "It has to be remembered, though, that this has to be balanced with the holdover performance, environmental impact, cost and ease of application."

New environmental regulations that are sure to force fluid reformulations are expected within the next year or two — resulting from a U.S. Environmental Protection Agency initiative on waste water at airports and the Airport Cooperative Research Program — so no new fluids will be introduced until these guidelines are issued, Dyer said. Given this context, she is concerned that eliminating residue may not end up among the fluid manufacturers' main priorities.

The conundrum for fluid dynamicists, however, is that ingredients responsible for desirable properties of anti-icing fluids — especially safe aerodynamic flow-off during takeoff — are linked to residues. "This is a long-term solution," Dyer said. "The tests in the current SAE Aerospace Materials Specification (AMS) 1428 [Aircraft Deicing/Anti-icing Fluids] prevent the use of different thickener technologies that do not form residues. Current fluids either have a low residue formation but then a higher gel formation, so they rehydrate quickly and form heavy gels that can fall off [external areas]; or they rehydrate slowly but then don't have sufficient weight to help the gels fall off.

"If researchers develop a new fluid that doesn't cause residue, then because of the chemistry of the fluids, chances are that it won't meet at least some of the parts of AMS 1428. The specification and approval of the new fluid for use on aircraft basically then would become a new SAE G12 Committee task — probably developing a new specification, which is potentially longwinded and not easy."

By mid-2008, some fluid manufacturers had expressed to the residue workgroup willingness to disclose proprietary information about residues, Dyer said. The workgroup has proposed to reduce from 13 to five the number of residue-related factors to be tested in a new standard. "The intention is for fluid manufacturers to agree that new AMIL tests will be used as the objective comparison, possibly allowing the fluids to be classified without keeping any of the fluids from being available on the market," she said. An airframe manufacturer/type certificate holder in turn would be able to tell operators that a specific brand/type of anti-icing fluid is not acceptable on its aircraft.

Despite its limitations, AMIL testing is helping to replace industry myths with facts. For example, the research has shown that gels can form and freeze in aerodynamically quiet areas regardless of whether anti-icing fluids are applied undiluted or diluted, and regardless of whether Type II or Type IV anti-icing fluids are applied.

Notes

1. Association of European Airlines. *Training Recommendations and Background Information for De-Icing/Anti-Icing of Aircraft on the Ground, 5th Edition.* September 2008.
2. 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.
3. Hille, Joel. "Deicing and Anti-icing Fluid Residues." *Aero,* p. 15. <boeing.com/commercial/aeromagazine>. First quarter, 2007. "[During winter 2005-2006] in Europe, restricted elevator movement interrupted the flight of two MD-80 airplanes," Boeing said. "In both cases, frozen contamination, a gel with a high freezing point, caused the restricted movement. The gel was Type IV fluid residue that rehydrated during takeoff or climbout in rain."
4. U.K. CAA Safety Regulation Group. "Training for Ground Deicing and Anti-icing of Aircraft." Flight Operations Division Communication no. 31/2008. Aug. 18, 2008.
5. AMIL. "Anti-icing Fluids Gel Residue Testing Results." Dec. 12, 2007. <www.uqac.ca/amil/en/gel-residues/web-gel-residues-type.pdf>
6. According to the AMIL report, its charts "depict the weight of [rehydrated] gel residue remaining on a clean, non-coated, vertical aluminum plate that has been dipped in anti-icing fluid and subjected to successive dry-out and hydration cycles." Fluid manufacturers were ABAX Industries-SPCA, Aviation Xi'an High-Tech Physical Chemical Co., Clariant Produkte (Deutscheland), Dow Chemical Co., Kilfrost, Lyondell Chemical Co, Newave Aerochemical Technology and Octagon Process.