*RESIDUE FROM DEICING/ANTI-ICING FLUID IS AN INDUSTRY-WIDE ISSUE THAT AFFECTS A VARIETY OF AIRPLANE MODELS.*

# *Deicing and Anti-icing* Fluid Residues

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Airplane deicing and anti-icing fluids can leave residue in critical areas in the wings and stabilizers. This residue can rehydrate and expand into a gel-like material that can freeze during flight and cause restrictions in the flight control systems. Therefore, attention to this residue should be part of a regularly scheduled inspection and cleaning process. Additionally, industry experience has shown that using a two-step deicing/anti-icing process helps to reduce the amount of fluid residue that forms in the wings and stabilizers.

Operating airplanes during winter conditions can be very challenging. Removing ice, frost, or snow is obviously a requirement for safe airplane operations. But the use of thickened deicing/anti-icing fluids to allow takeoff during active snowfall adds another dimension to winter operations: Although these fluids have undoubtedly made winter operations safer, they have also been known to cause problems that may degrade the airworthiness of an airplane. This article provides insight into these problems and how to resolve them. It includes:

- Overview of deicing and anti-icing fluids and fluid residues.
- Differences in deicing and anti-icing practices between Europe and North America.
- Interaction of airplane fluids and runway fluids.
- Inspection and cleaning recommendations.
- Industry actions.

## Overview of Deicing and Anti-icing Fluids and Fluid Residues

One of the most significant consequences of winter operations is the need for ground application of deicing and anti-icing fluids to protect against performance degradation due to snow, ice, or frost in critical locations on the airplane. When these fluids are properly used and applied, they will maintain the airplane in the approved configuration for takeoff and safe flight. However, events in recent years have shown that residue from thickened deicing/anti-icing fluids (Types II, III, or IV) can remain in aerodynamically quiet areas and accumulate over time.

During suitable weather conditions, this residue can rehydrate and form into a gel-like substance that swells to many times the original size. The residue gel can freeze during flight, and if located in areas of flight control components and linkages, control surface movement may be restricted, which could result in airplane controllability issues on one or more of the flight axes (see figs. 1–3). Accordingly, airplanes exposed to deicing/anti-icing fluids should be subjected to periodic inspections for fluid residue, and any residue found should be removed. Failure to do so may degrade the airworthiness of the airplane.

During the last two winter seasons there have been reports of impaired flight controls on airplanes operating throughout the European region. These reports have involved regional and commuter airplanes as well as small commercial jetliners. The events have occurred on both types of airplanes — those that have hydraulically powered flight control systems and those that have nonhydraulically powered flight control systems. The events are more common on smaller airplanes because, during severe winter weather, small- and medium-sized airplanes may receive many fluid treatments every day, increasing the possibility of anti-icing fluid residue accumulation.

*Figure 1*

*Anti-icing residue gels can freeze during flight, causing interference with flight control linkages and surfaces, such as these MD-90 elevator tab control rods.*

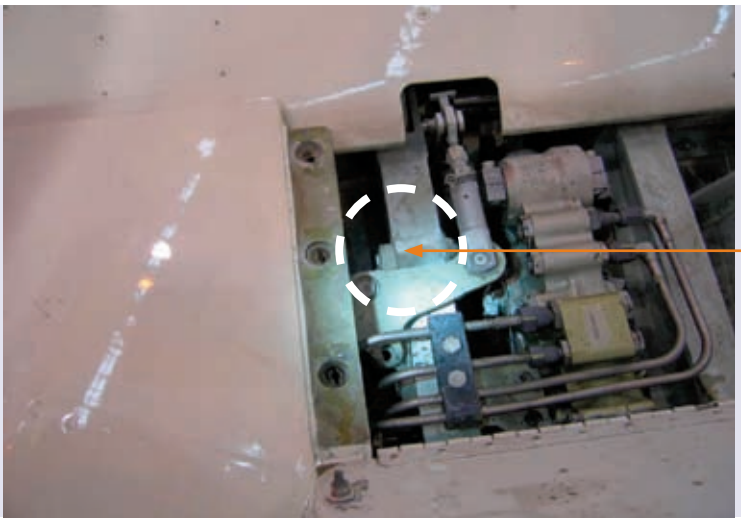



*Figure 2*

*Residue gel under the input arm of the MD-90 elevator power control unit interfered with the pilot input, making the restriction evident to the pilot through the control column feel forces.*

*Figure 3*

*Residue in gel form on the elevator balance panel of a 737-800 airplane.*

It is important for all operators to realize that keeping airplanes safe for winter operations now involves more than inspecting for snow or ice on the wings and stabilizers and treating the airplane with deicing/anti-icing fluids. It also involves inspecting for and removing deicing/anti-icing fluid residues in hidden places in the wings and stabilizers.

The wide variety of airplanes that have been affected makes it clear that deicing/anti-icing fluid residues are an industrywide issue. Airplanes from several different manufacturers have experienced in-flight control issues that have resulted from the presence of residue gel. In several cases, it was determined that the residue had been generated from fluids that were applied during previous winter seasons. Although Type III fluids have not been specifically linked to any events involving flight controls, the composition of these fluids makes them equally susceptible to residue problems as the Type II and Type IV fluids. It is important to note that Type III fluids have only been commercially available for a short time, and on a limited basis, which is likely the reason they have not caused any known residue problems so far.

It is also important for operators and/or their service providers to take steps to ensure that all deicing/anti-icing fluids are being stored and handled properly in accordance with the fluid manufacturers' recommendations. Improper storage and use could result in degraded fluid performance or the use of greater volumes of fluid, which could contribute to the formation of more residue. For example, spraying fluid from the rear of the wing rather than from the front, which is the correct method, might result in more fluid entering the flight control areas through the control surface vent gaps.

As a result, it is important for all operators to realize that keeping airplanes safe for winter operations now involves more than inspecting for snow or ice on the wings and stabilizers and treating the airplane with deicing/anti-icing fluids. It also involves inspecting for and removing deicing/anti-icing fluid residues in hidden places in the wings and stabilizers.

## DIFFERENCES IN DEICING AND ANTI-ICING PRACTICES BETWEEN EUROPE AND NORTH AMERICA

A larger number of deicing/anti-icing fluid residue problems have occurred in Europe compared to North America and Asia. Industry experts agree that one of the reasons for this is the difference in deicing and anti-icing practices between the continents.

In Europe, a one-step deicing/anti-icing process is commonly used. This process involves the application of deicing/anti-icing fluids in a single application, using a heated mixture of Type II fluid and water, usually in a ratio of 75/25.

In North America, a two-step process is commonly used. This process involves deicing with heated Type I fluid, or a heated mixture of Type I fluid and water, which is followed by an application of Type IV anti-icing fluid. Experience and testing has shown that deicing with heated Type I fluid will help clear away residue from previous anti-icing fluid treatments.

## INTERACTION OF AIRPLANE FLUIDS AND RUNWAY FLUIDS

Early research also indicates that the interaction between airplane deicing/anti-icing fluids and runway deicing fluids may contribute to the formation of residue gels.

Airplane deicing/anti-icing fluids typically comprise glycols with thickening agents (polymers). Runway deicing fluids contain potassium acetate- or potassium formate-based fluids (deionizing salts). When these fluids combine, the separation of the anti-icing fluid thickeners may be enhanced, leading to a more rapid formation of the residue.

The fluids can be mixed together in two different ways — when the airplane fluid flows off the wing during the takeoff roll and goes onto a runway that has been treated with deicers, or when the engine thrust reversers send runway fluids up onto the wing during the landing roll and they flow into the rear spar areas through the control surface vent gaps. These situations make it possible for residue gel to form on the external wing surfaces as well as the internal quiet areas of the rear spar and the balance bays.

While research is ongoing as fluid manufacturers continue to conduct tests on the interaction between airplane deicing/anti-icing fluids and runway deicing fluids, it is prudent to remove as much of all types of residue as possible.

# INSPECTION > CLEANING > RELUBRICATION > FOLLOW-UP

## INSPECTION AND CLEANING RECOMMENDATIONS

Boeing issued a multi-model service letter (No. 737-SL-12-014) in January 2000 that advised operators about the potential for deicing/anti-icing fluid residue problems. At that time, the service letter quoted a new caution note that had been added to the Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 4737 Methods Document. The note was also added to the Airplane Maintenance Manual (AMM) Cold Weather sections at that time.

New multi-model service letters (Nos. 737-SL-12-019 and MD80-SL-12-104) have been issued that include information about where to inspect for residue and updated procedures for cleaning residue. The service letters also advise of AMM revisions that include more information about where to look for fluid residue.

The service letters and AMM revisions recommend that the inspection and cleaning processes outlined below be followed for all airplanes that are exposed to deicing/anti-icing fluids during winter operations. The frequency of the inspections should be based on each operator's experience during winter operations. Boeing recommends that all airplanes that have been exposed to deicing/anti-icing fluids should be subjected to the inspection and cleaning procedures both prior to and at the end of the winter season. Boeing also recommends that during the winter season, each airplane should be inspected and cleaned no less than once per month.

This frequency is based upon information from operators that have experienced multiple occurrences of flight control issues due to deicing/anti-icing fluid residues. Some operators perform inspections much more frequently than once per month, and Boeing encourages operators to inspect as frequently as practical until sufficient data has been accumulated to more accurately define the inspection period.

Boeing recommends that the inspection and cleaning be performed as follows:

## INSPECTION

1. Gain access to the following areas where flight controls and other systems components are located:

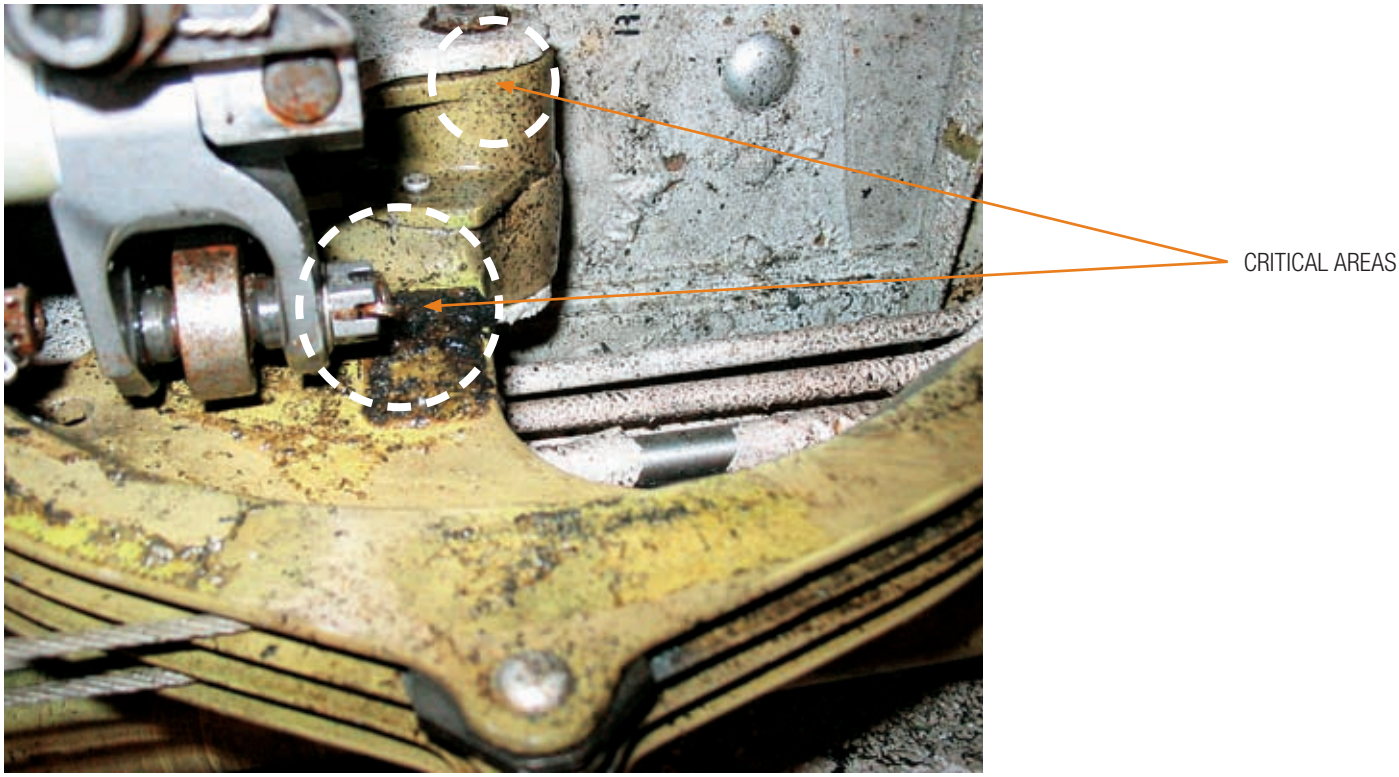
- Wing rear spar area, including the actuating components for the spoilers, ailerons, flaps, flaperons (if applicable), and the control surface hinges and balance bays.
- Wing leading edge devices, including the actuating components.
- The horizontal stabilizer rear spar, including the actuating components for the elevators, elevator tabs (if applicable), and the control surface hinges and balance bays.
- Vertical stabilizer, including actuating components for the rudder, and the control surface hinges.
- The auxiliary-power-unit bay and the bilge area of the tailcone.

2. Visually inspect for the presence of dry or rehydrated residue anywhere in these areas. The residue may be very hard to see, especially if dry. Dry residue will normally be a thin film that may be partially covered with dirt or grease (see fig. 4). Rehydrated residue will often be a gel-like substance of more visible thickness.

3. Spray the area with a fine mist of warm water to rehydrate any residue that may be present and to make it easier to identify. In some cases, rehydration may occur quickly, but the process often may be slow, especially if residue has accumulated from multiple applications over a long period of time. Wait at least 15 minutes to allow rehydration to take place.

*Figure 4*

*Deicing/anti-icing residues gel on a 737-300 flight spoiler power control unit input quadrant.*

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*Large volumes of deicing/anti-icing fluids are commonly used during severe winter weather, especially on small- and medium-sized airplanes.*

4. If no rehydrated residue is visible, repeat this step at least three more times, if practical, including the wait time of 15 minutes to allow rehydration to take place. This recommendation to perform repetitive spraying and wait for rehydration to occur is based on the experience of several operators during the previous two winter seasons.

Do not spray the controls with water when the ambient temperature is below freezing unless the airplane is in a heated hangar. Doing so may result in ice that impairs the flight controls.

## CLEANING

1. Once identified, the residue should be removed by using warm water with rags and/or soft brushes to hand clean the gel-like substances away. You may also use a low-pressure stream of water or compressed air to rinse away the residue. Make sure the water or compressed air do not cause the residue to enter crevice areas that are not accessible.

Research and experience have shown that the use of Type I deicing fluid, or a mixture of water and Type I fluid, is also a good cleaning agent for removal of residue. Test data indicates that use of a detergent additive with water may actually reduce the cleaning effectiveness.

2. This cleaning process has the potential of removing grease from control system bearings and fittings, and removing corrosion inhibiters from control cables. Care should be taken to avoid spraying cleaning fluids onto bearings, fittings, control cables, and electrical connectors.

The cleaning process also has the potential to wash the residue into other areas, where it may deposit and create a future problem. Attention should be paid to the runoff from the cleaning process into other areas of the airplane, and these areas should also be flushed until the operator is confident that any deicing/anti-icing fluid residues have completely left the airplane.

Similar to the inspection phase, do not spray the controls with water when the ambient temperature is below freezing unless the airplane is in a heated hangar. Doing so may result in ice that impairs the flight controls.

## RELUBRICATION

1. If residue has been found and removed by cleaning, Boeing recommends that all bearings, fittings, and control cables in the area that was cleaned should be relubricated in accordance with appropriate AMM instructions.

2. Any areas from which corrosion-inhibiting compound has been removed or depleted by the residue-cleaning process should be retreated in accordance with the appropriate standard overhaul practice manual procedures.

## FOLLOW-UP ACTIONS

Operators have reported that it can be very difficult to remove all residue with a single cleaning, and that residue may slowly migrate out of crevices after it is removed from open areas by cleaning. If practical, Boeing recommends reinspection within three days of any areas from which residue has been cleaned, following the inspection instructions above.

If residue is found, additional cleaning is recommended. These inspections and cleanings should be continued on a frequent basis until no additional residue is found. These recommendations are based upon the experience of several operators during previous winter seasons. However, the recommendations are also dependent on the specific schedules for each airplane and the amount of deicing/anti-icing treatments being encountered. Some operators have developed their own maintenance programs to remove existing deicing/anti-icing fluid residue based on their own data.

Service experience by many operators using several different airplane models has shown that use of thickened deicing/anti-icing fluids can result in the accumulation of residue that may rehydrate and expand into a gel-like substance which can interfere with airplane flight control systems. Failure to regularly remove this residue may degrade the performance of the airplane.

## INDUSTRY ACTIONS

Numerous reports of problems due to deicing/anti-icing fluid residues prompted the formation of a Residues Working Group as part of the SAE G-12 Aircraft Ground Deicing Fluids Subcommittee. Among the group's responsibilities is the development of improved fluid dryout and residue tests for the SAE Aerospace Material Specification (AMS) 1428.

Also, the SAE G-12 Aircraft Ground Deicing Methods Subcommittee is making new revisions to the caution note regarding residue in the Methods Document, SAE ARP 4737, section 6.3.1.2.

The subject of deicing/anti-icing fluid residues is also under discussion by the European Regions Airline Association.

In the United Kingdom (UK), the Air Accidents Investigation Branch (AAIB) issued four safety recommendations in early 2006 regarding the subject of deicing/anti-icing fluid residues. In response to the AAIB recommendations, the UK Civil Aviation Authority has recently issued Flight Operations Division Communication number 15/2006, which recommends specific procedures for the use of deicing/anti-icing fluids, and for cleaning of fluid residue, on airplanes with nonpowered flying controls. In addition, the European Aviation Safety Agency (EASA) has released Safety Information Notice (SIN) No. 2006-09. This notice includes information and recommendations regarding deicing/anti-icing fluid residue in section 8, Special Operation Considerations, and section 9, Special Maintenance Considerations. Please note that the SIN is only an advisory document, and further regulatory action may be expected by EASA.

## SUMMARY

Service experience by many operators using several different airplane models has shown that use of thickened deicing/anti-icing fluids can result in the accumulation of residue that may rehydrate and expand into a gel-like substance which can interfere with airplane flight control systems. Failure to regularly remove this residue may degrade the performance of the airplane. As a result, these considerations should be part of an airline's winter operations:

- Be aware of how frequently your airplanes are being deiced/anti-iced.
- Be aware of what deicing/anti-icing fluids are being applied to the fleet. Is the fleet undergoing a one-step or two-step process? Is the process the same at all airports?
- Make sure that proper procedures are being followed by airline personnel or a third-party service provider. Are the fluids being stored and handled properly, and are they being applied properly?
- Establish an inspection and cleaning schedule for deicing/anti-icing fluid residue to ensure no flight control restrictions will occur.
- Include the application of lubricants and corrosion inhibitors as necessary to the areas where residue cleaning occurs.

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