

***Flight Control Restrictions
Due to Deicing/Anti-icing
Fluid Residues***

**A Large Aircraft Manufacturer's
Perspective**

De/anti-icing Fluid Residues

- De/anti-icing fluid residues have caused flight control restriction events on many different airplane models
 - Including Boeing 737, MD-80 and MD-90 models
 - Airplanes with and without powered flight controls
- Type II, III or IV thickened de/anti-icing fluids can remain inside structural and aerodynamically quiet areas
 - Over time, the glycol evaporates, leaving a residue of additives - including the polymer thickeners
 - Dry residue is almost invisible, but when it absorbs moisture it grows dramatically into a gel mass

De/anti-icing Fluid Residues

- The residue may remain for years through deicing seasons, depending on its location
 - More residue may accumulate from additional applications
- The dry residue is typically a very thin coating on hardware surfaces
 - This coating can be difficult to see

De/anti-icing Fluid Residues

- Boeing has reports of thickened fluid residues from several operators in two different areas of the world
 - Operators report multiple occurrences of control anomalies attributed to Type II and IV Fluid residues
 - One operator states that their policy is to always apply Type I Fluid/Hot Water between each Type IV application
 - Another operator says that their policy is a maximum of three Type IV applications before cleaning with Type I Fluid/Hot Water

De/anti-icing Fluid Residues

- Sufficient residue mass in control surface balance bays, or inside control surfaces, can affect control response, especially on aircraft with unpowered control surfaces
- Type II, III or IV fluid that has dried and re-hydrated forms a gel mass that can freeze at normal operating temperatures
- Frozen residue on control linkages can degrade system response, even on aircraft with powered controls
- Degraded control response has the potential for creating operational problems for flight crews

De/anti-icing Fluid Residues

- MD-90 Elevator PCU Input Linkage



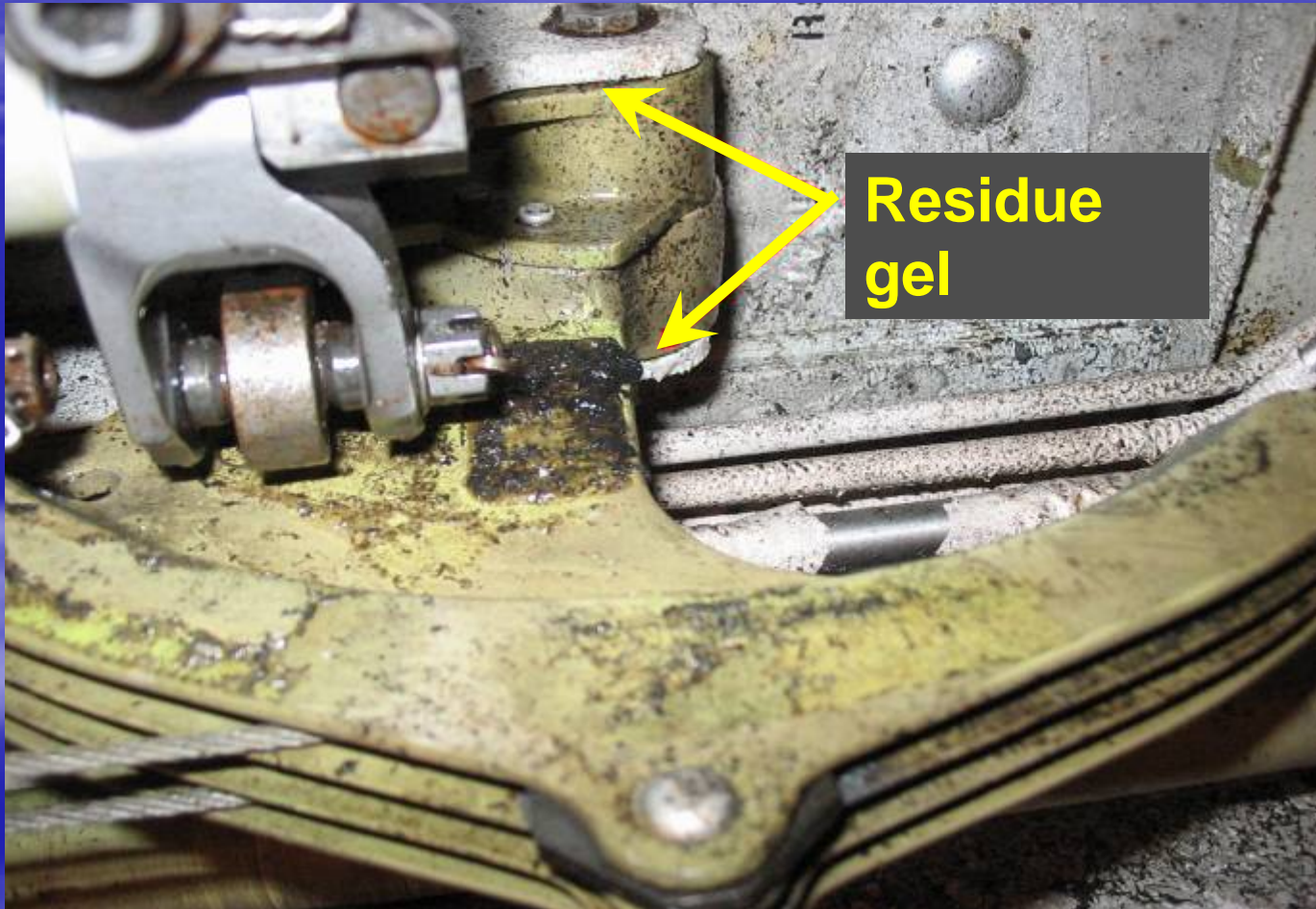
De/anti-icing Fluid Residues

- MD-90 Elevator Tab Control Rods



De/anti-icing Fluid Residues

- 737-300 Flight Spoiler PCU Input Quadrant



De/anti-icing Fluid Residues

- 737-400 “Inside” Elevator Control Surface



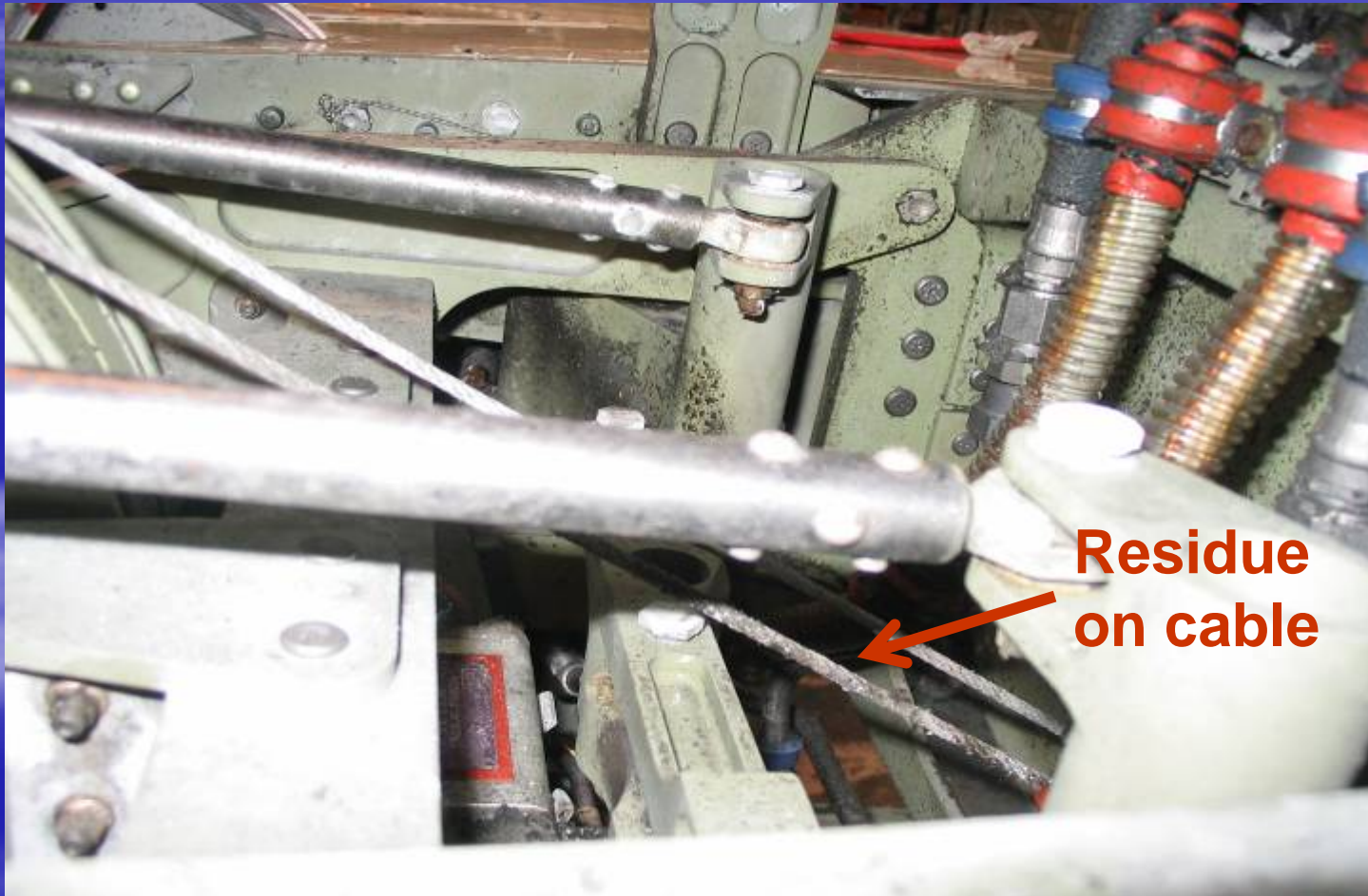
De/anti-icing Fluid Residues

- 737-600 Elevator Balance Panel



De/anti-icing Fluid Residues

- MD-90 Junction of Vertical & Horizontal Stab



De/anti-icing Fluid Residues

- MD-90 Junction of Vertical & Horizontal Stab



De/anti-icing Fluid Residues

- Large volumes of fluid can be used during severe weather



De/anti-icing Fluid Residues

- Boeing and Operators would like to see fluid manufacturers develop Type II, III and IV fluids with benign residue characteristics
- Boeing recommends that the SAE G-12 Fluids Sub-Committee add requirements for benign residue characteristics to the AMS1424 and AMS1428 specifications

De/anti-icing Fluid Residues

- Possible Solutions for Residue Problems
 1. Reformulate thickened fluids so they will not leave residues
 2. Do not allow the use of thickened fluids
 3. Redesign aircraft to prevent the problem
 4. Use Type I fluid between each use of thickened fluid
 5. Frequent inspection and cleaning

De/anti-icing Fluid Residues

- **Solution 1 - Comments**
 - Reformulate thickened fluids so they will still provide protection but will not leave residues that can affect flight controls
 - Fluid manufacturers are working toward this, but an immediate change is not likely
 - If new formulation possible, new fluid likely to not enter service for years due to the required testing and approval process

De/anti-icing Fluid Residues

- **Solution 2 - Comments**
 - **Do not allow the use of thickened fluids**
 - **Not a practical solution for today's economic operating environment**
 - **Significant impact to operators in cold climates**
 - **More frequent applications of Type I deicing would be required**
 - **Has potential environmental impacts**
 - **Costly**
 - **Greater exposure to icing hazards**

De/anti-icing Fluid Residues

- **Solution 3 - Comments**
 - **Redesign aircraft to prevent residues from affecting flight controls – if possible**
 - **Not practical for existing aircraft**
 - **Long lead time for design changes**
 - **Add airplane weight and affect maintenance access**
 - **Increased cost for all operators**

De/anti-icing Fluid Residues

- **Solution 4 - Comments**
 - Use a two-step process with heated Type I between each application of Type II or IV
 - Appears to significantly reduce fluid residues – common practice in North America
 - No guarantee of residue elimination
 - Type I fluid not available at many airports, especially in Europe
 - Costly investment to add Type I equipment

De/anti-icing Fluid Residues

■ Solution 5 - Comments

- Regular and systematic inspection and cleaning to prevent residue accumulation in critical areas
 - Inspection and cleaning consumes time and labor, and requires training
 - Many variables for each operator:
 - Different types of fluid used at different stations
 - Different volumes being applied (training)
 - Different processes (two-step or one-step process)
 - Weather pattern changes
 - Airplane routing

De/anti-icing Fluid Residues

■ Boeing Conclusions

- The issue is significant and cannot wait for a long-term solution such as changes to fluids, or aircraft design changes
- Use of Type I between applications of thickened fluid improves safety, but problems have still occurred where this process is used
- *Inspection and Cleaning* is the most effective and practical solution for the near-term and intermediate-term

De/anti-icing Fluid Residues

- Inspection and Cleaning
 - Can be implemented immediately
 - Can be adjusted based upon experience
 - More certain than just using Type I between each use of thickened fluid
 - Critical work is done on a schedule, not during bad weather just before take-off

De/anti-icing Fluid Residues

- **Boeing Actions:**
 - Conducted reviews to identify locations where frozen residue could create problems
 - Revised Airplane Maintenance Manuals
 - Added instructions on inspecting for, and cleaning of, residues
 - Issued new multi-model service letters
 - Issued Fleet Team Digest articles
 - Boeing Aero Magazine article, 1st Quarter 07

De/anti-icing Fluid Residues

- **Two Boeing multi-model Service Letters**

- **Boeing Seattle models**

- 707-SL-12-016-A
- 727-SL-12-016-A
- 737-SL-12-019-A
- 747-SL-12-016-A
- 757-SL-12-015-A
- 767-SL-12-019-A
- 777-SL-12-007-A

- **Boeing Long Beach models**

- 717-SL-12-104
- DC-8-SL-12-104
- DC-9-SL-12-104
- DC-10-SL-12-104
- MD-10-SL-12-102
- MD-11-SL-12-104
- MD-80-SL-12-104
- MD-90-SL-12-104

De/anti-icing Fluid Residues

- **How frequently to inspect & clean?**
 - Too many variables
 - Operators must decide based on their own operating experience.
 - Boeing encourages operators to inspect as frequently as practical until sufficient data has been collected to accurately define their inspection period.

De/anti-icing Fluid Residues

- Be aware of how frequently your airplanes are being deiced/anti-iced during winter operations.
- Be aware of what de/anti-icing fluids are being applied to your airplanes.
 - Are they 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 your personnel or your service provider.
 - Are the fluids being stored and handled properly?
 - Are they being applied properly?
 - Is more fluid than necessary being applied?
- Establish an inspection and cleaning schedule for de/anti-icing fluid residues to ensure no flight control restrictions will occur.