ASOS Research Brief

Research Request:

Information on Takeoff Performance Degradation Using Type IV Anti-Icing Fluids

Research Response:

A search was conducted of the NTSB, NASA, and FAA databases for adverse events related to Type IV anti-icing fluid and aircraft performance. Six events were discovered that specifically pertained: two on takeoff, two on climbout, two in-flight. The reports are listed below by phase of flight.

Takeoff

Event 1- A DORNIER 328 ON TKOF TO 110 FT HAD A MOMENTARY LOSS OF ELEVATOR CTL SUSPECTED CAUSE STABILIZER SNOW AND ICE SLIDING BACK INTO ELEVATOR GAP.

THE ACFT SHORTLY THEREAFTER WAS COVERED WITH SNOW AS A SQUALL PASSED OVER THE ARPT WITH HVY SNOW FOR APPROX 20 MINS. THE CREW PLANNED FOR DEICING IN ZZZ1. AT APPROX XB41 THE ACFT WAS PUSHED BACK FROM THE GATE, BOTH ENGS WERE STARTED AND THE ACFT WAS TAXIED TO A REMOTE DEICING OP. TYPE I DEICING WAS APPLIED TO THE ENTIRE ACFT, FOLLOWED BY **TYPE IV** ON THE WINGS AND TAIL. THIS PROCESS TOOK APPROX 5 MINS. THE CREW TAXIED THE AIRPLANE ONTO THE RWY PERFORMING A PRE-CONTAMINATION TKOF CHK (NO CONTAMINATION OF THE REPRESENTATIVE SURFACES NOTED) AND ALL TKOF CHKLIST ITEMS APPROPRIATE TO THE CLRNC. ZZZ1 TWR CLRED THE AIRPLANE FOR TKOF, FINAL CHKLIST ITEMS WERE COMPLETED AND THE TKOF ROLL BEGUN. CONDITIONS AT THE TIME OF TKOF WERE LIGHT SNOW, VERT VISIBILITY RPTED 500 FT AND VISIBILITY GREATER THAN 1 MI. V-SPDS FOR THE TKOF REFLECTED WET CONTAMINATED TKOF DATA. AS THE ACFT ACCELERATED, THE PNF (THE FO) MADE APPROPRIATE CALLS OF 80 KTS, V1, ROTATE. AFTER RECEIVING THE ROTATE COMMAND, I (THE CAPT) APPLIED BACK PRESSURE TO THE CTL COLUMN AND NOTED THAT THERE WAS AN OPPOSING FORCE. I QUICKLY ENSURED THE GUST LOCK WAS SEATED IN THE APPROPRIATE DOWN POS AND CONTINUED TO APPLY ABNORMAL BACK PRESSURE TO THE ELEVATOR. AFTER APPROX 2-3 SECONDS, THE COLUMN SEEMED TO BE RELIEVED OF ALL ABNORMAL FORCES AND THE ACFT PITCHED NORMALLY. THE ACFT WAS HAND FLOWN TO APPROX 4000 FT MSL WHILE TRYING TO NOTE ANY ABNORMAL CTL FORCES. THE AUTOPLT WAS THEN ENGAGED AND THE ACFT CONTINUED TO CLB TO A CRUISE ALT OF FL230. THE CREW DISCUSSED THE PROB NOTING THAT THERE WAS NO QRC OR QRH FOR THE UNEXPLAINED CONDITION UPON ROTATION.

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THERE WERE NO CAS MESSAGES NOTED ON THE EICAS SCREEN OR FLT CTL PAGE. THE CREW CONTACTED DISPATCH AND MAINT CTL THROUGH ZZZ2 RADIO TO DISCUSS THE CURRENT SIT. IT WAS AGREED UPON THAT THE CREW WOULD PERFORM AN INFLT CONTROLLABILITY AND CONFIGN CHK. AN EMER WAS ALSO DECLARED AS A PRECAUTION TO A POSSIBLE FLT CTL FAILURE. THE FLT ATTENDANT WAS TOLD TO PREPARE THE CABIN FOR A POSSIBLE EVAC SHOULD THE CTL PROB REOCCUR. THE CREW PUT PERSONAL LIMITATIONS OF 5 DEGS NOSE UP AND DOWN, AND 10 DEGS BANK L AND R ON THE ACFT FOR THE DURATION OF THE FLT. AFTER PERFORMING A CONTROLLABILITY CHK OF ALL CTLS (PRIMARY AND SECONDARY TO INCLUDE TRIM) AND A CONFIGN CHK, THE CREW FOUND NO ABNORMALITIES IN THE RESPONSE OF THE AIRPLANE TO CTL INPUTS. THE AIRPLANE WAS GIVEN RADAR VECTORS TO RWY 22L AT ZZZ, WHERE IT WOULD BE MET BY CRASH AND FIRE RESCUE VEHICLES AND PERSONNEL. THE ACFT LANDED UNEVENTFUL AND TAXIED TO GATE X WHERE IT WAS IMMEDIATELY DOWNED FOR MAINT. THE FACT THAT THE GUST LOCK WAS FOUND TO BE SEATED AND NO FURTHER MECHANICAL ABNORMALITIES WERE EXPERIENCED, LEADS ME TO BELIEVE THAT THERE WAS POSSIBLE ICE THAT MAY HAVE INHIBITED MOVEMENT OF THE ELEVATOR, BUT BROKE FREE AS APPLIED PRESSURE CONTINUED TO INCREASE. SINCE THE CTLS ARE CHKED FREE PRIOR TO TKOF, IF ICE WAS PRESENT, IT MUST HAVE BEEN FORWARD OF THE CTL SURFACE AND MOVED AS AIRSPD/AIRFLOW INCREASED. TO PREVENT FURTHER OCCURRENCES, IF ICE WAS THE CAUSE THEN DE-ICE PROCS MUST BE ESPECIALLY THOROUGH AROUND HINGE POINTS OF FLT CTLS.

Event 2- ON TKOF AFTER DE-ICING, A B737-700 LOST ALL FLT INSTRUMENTS REQUIRING A PITOT STATIC INPUT. AN EMER WAS DECLARED AND FLT DIVERTED TO A VMC ARPT.

ON TKOF FROM ZZZ AT APPROX 400 FT WE LOST ALL AIRSPD/ALT AND VVI READOUTS INCLUDING STANDBY INSTRUMENTS. WE ALSO HAD A WINDSHEAR WARNING. WE USED EMER THRUST AND 12-15 DEGS PITCH ATTITUDE TO ENSURE CLBOUT. PNF CALLED ALTS OFF OF RADAR ALTIMETER. AIRSPD WAS FLUCTUATING BETWEEN 60-180 KTS AND THE STALL WARNING STICK SHAKER KEPT ACTIVATING WHEN THE AIRSPD GAUGE DROPPED BELOW 100 KTS. BOTH ALTIMETERS WERE STUCK AT 200 FT MSL AND THE VVI WAS FLUCTUATING UP AND DOWN. PNF ADVISED PF TO CONTINUE 12-15 DEGS PITCH WITH EMER POWER TO ENSURE CLB EVEN WITH WHAT APPEARED TO BE ERRONEOUS STALL WARNINGS. TWR WAS TOLD OF THE EMER AND SWITCHED US TO APCH CTL FOR CLB AND VECTORS. RMI'S APPEARED TO BE WORKING SO WE WERE VECTORED SW INITIALLY FOR ZZZ1. WE INFORMED APCH CTL THAT WE DID NOT WANT TO DSND THROUGH THE CLOUDS WITHOUT PITOT STATIC INSTRUMENTS. ZZZ1 WAS RPTING 7000 FT BROKEN SO WE REQUESTED AN AIRFIELD THAT WAS CAVU. ZZZ2 WAS RPTED TO BE CAVU. WE ASKED FOR A VECTOR TO ZZZ2. WE ALSO HAD A LEADING EDGE SLAT TRANSIT LIGHT AND OUR LEADING EDGES WERE STUCK DOWN WITH THE TRAILING EDGE FLAPS UP. WE REQUESTED AT LEAST A 10000 FT RWY DUE TO FLAPS 15 APCH. WE ARRIVED OVER ZZZ2 AT WHAT APPEARED TO BE 10000 FT OF ALT. WE HAD ZZZ3 VISUAL BY THEN AND ASKED FOR A STRAIGHT IN ILS TO RWY 27L. WE THEN RAN THE CHKLIST FOR LEADING EDGE FLAP TRANSIT LIGHT AND CHKED OPC DATA TO ENSURE WE COULD LAND FLAPS 15. WE THEN PROCEEDED TO AN UNEVENTFUL LNDG AT ZZZ3. AFTER ROLLOUT, WE TAXIED OFF THE RWY AND TOLD GND CTL THAT WE WERE SECURE AND WOULD NOT REQUIRE EMER SVCS ANY

LONGER. WE TAXIED TO THE GATE AND SHUT DOWN THE ACFT. DUE TO RWY LENGTH AT ZZZ, WE HAD USED A BLEEDS OFF TKOF WITH THE APU POWERING THE LEFT AIR CONDITIONING PACK. WE FORGOT TO RECONFIGURE DURING THE CLBOUT AND WE GOT A CABIN ALT WARNING HORN AT 10000 FT CABIN ALT. WE THEN RECONFIGURED THE PACKS AND BLEEDS AND RESET

THE CABIN ALT WARNING SWITCH. THE PITOT STATIC EMER TOOK ALL OUR ATTENTION AND WE MISSED THE CABIN ALT AND LEADING EDGE SLAT PROBLEM INITIALLY. I AM NOT SURE WHAT CAUSED THIS EVENT BUT IT WAS VERY COLD WITH BLOWING SNOW. WE HAD TO DEICE WITH HEATED TYPE I FLUID THEN **TYPE IV** FLUID WAS APPLIED FOR ANTI-ICE PROTECTION. THE WHOLE AIRPLANE WAS COVERED WITH BOTH FLUIDS INCLUDING BOTH WINDSCREENS. WE WERE AIRBORNE WITHIN 10-12 MINUTES OF INITIAL ANTI-ICE APPLICATION. THE PUBLISHED HOLDOVER TIME WAS 30-50 MINUTES. A PIREP FROM AN ACFT ON APCH CALLED FOR GUSTY WINDS AND MODERATE ICING BELOW 1000 FT. DURING THE EMER WE USED PITCH/POWER AMD RADAR ALTIMETER READINGS TO ENSURE ADEQUATE CLB WAS MAINTAINED. GND SPD WAS ALSO AVAILABLE BUT NEITHER OF US THOUGHT TO USE IT TIL WE HAD ATTAINED VFR ON TOP. DURING THE DSCNT FOR LNDG, WE STARTED TO GET WHAT APPEARED TO BE AIRSPD AND ALT READOUTS BUT WE WERE NOT SURE OF THE ACCURACY SO WE USED RADAR ALTIMETER ALTS AND GND SPD VERSUS TWR WIND READOUTS FOR OUR AIRSPD ONCE WE WERE ON THE GLIDESLOPE. WE WALKED AWAY FROM THIS INCIDENT BECAUSE WE WERE ABLE TO SEPARATE OURSELVES FROM OUR TRAINING ON STALLS AND TRUST THAT 12-15 DEGS OF PITCH ATTITUDE WITH EMER THRUST WOULD SUSTAIN OUR CLBOUT EVEN THOUGH WE HAD INTERMITTENT STICK SHAKER AND AT ONE TIME A DON'T SINK WARNING DUE TO ERRONEOUS VVI READOUTS. HAD WE CHASED THE STICK SHAKER, WE COULD HAVE DSNDED WITH DISASTROUS CONSEQUENCES. CALLBACK CONVERSATION WITH RPTR ACN 684037 REVEALED THE FOLLOWING INFO: RPTR SAID THAT AN EXTENSIVE INVESTIGATION BY HIS ACR HAS NOT YET PRODUCED A DEFINITIVE CAUSE OF THE PITOT STATIC SYSTEM'S BEHAVIOR, ADDING MAINT DISCOVERED A SMALL AMOUNT OF LIQUID IN THE STATIC TUBES BUT IT IS UNKNOWN IF THAT CAUSED A BLOCKAGE. THE RPTR INDICATED THE GND CREW SPRAYED TYPE I AND **TYPE IV** FLUID ON THE FRONT PART OF THE ACFT DURING PRE-DEP DE-ICING. IT IS POSSIBLE THAT FLUID ENTERED THE PITOT STATIC SYSTEM. THE RPTR INDICATED THE ACCEPTED PROC IS TO DE-ICE/ANTI-ICE ONLY FROM THE FORWARD PART OF THE WINGS AFT. THIS CREW SAID THE FORWARD PART OF THE ACFT, INCLUDING THE COCKPIT, WAS SPRAYED. REPORTEDLY, AT THE END OF THE FLT, WHEN THE ACFT DSNDED OUT OF 5400 FT, THE CAPT'S INSTRUMENTS RETURNED WHILE THE FO'S INSTRUMENTS RETURNED AT 4000 FT, BUT NEITHER WERE COMPLETELY STABLE AND THEREFORE WERE NOT RELIED UPON AS PRIMARY FLT INSTRUMENTS.

SUPPLEMENTAL INFO FROM RPTR ACN 684030: DURING TKOF, LOST ALL ALT, IAS, VVI, AND STBY IAS, ALT, BOTH CAPT AND FO SIDES. ONLY HAD FMC GND SPD INDICATOR AND ATTITUDE FLT INFO. ALSO HAD WINDSHEAR WARNING AND BOTH L AND R LE SLATS FULLY EXTEND. USED POWER SETTINGS AND ACFT PITCH TO CLB TO VMC CONDITION. ABOUT 5 TO 8 MINUTES IN THE WX UNTIL BREAKING OUT ABOUT 8000 TO 9000 FT. THE HUD INFO WAS ALSO BAD. DECLARED AN EMER WITH APCH CTL. STAYED APPROX 10000 TO 11000 FT AND USED FMC GND SPEED TO DIVERT TO ZZZ3 WHICH WAS VMC. FLEW A FLAPS 15 APCH TO RWY 27L. WX DURING TKOF WAS WINDS 330/25 G40, BLOWING SNOW, -7 DEGS CELSIUS AND

29.42, VIS 3/4. CALLBACK CONVERSATION WITH RPTR ACN 684030 REVEALED THE FOLLOWING INFO: THE RPTR STATED RIGHT AFTER LIFTOFF LOST BOTH CAPT'S AND FO'S IAS, ALT, VVI, AND STBY ALT AND IAS. DECLARED AN EMER BUT COULD NOT RETURN TO THE DEP ARPT DUE TO WX. ALSO HAD WINDSHEAR WARNING AND LEADING EDGE DEVICES DEPLOYED. DID HAVE FMC GND SPD AND ATTITUDE INDICATIONS. USED POWER SETTINGS AND ACFT PITCH TO CLB OUT TO VMC CONDITIONS. THIS AIRPLANE WAS DEICED PRIOR TO DEP WITH **TYPE IV** DEICING FLUID AND THE FORWARDED PART OF THE FUSELAGE WAS COVERED WITH THE 'GREEN GOO' DRIPPING AND RUNNING OFF THE SIDES. THE RPTR NOTED THAT THE STATIC PORTS ON THE B737-700 ARE NOT LOCATED IN THE PITOT PROBE BUT ON THE SIDES OF THE FORWARD FUSELAGE JUST FORWARD OF THE #1 L AND #1 R ENTRANCE DOOR AND ARE NOT HEATED. THESE PORTS WERE COVERED WITH THE DEICING FLUID AND MAY HAVE PLUGGED THE SMALL HOLES. THE ACFT WAS DEICED BY COMPANY GND PERSONNEL.

Climbout

Event 3- CL65 TOOK OFF WITH SEVERE ICE RPTED BY A LARGE ACR. THE TRAILING EDGE FLAPS FAILED BEFORE THE FLAPS WERE RETRACTED.

I WAS ACTING AS THE FO ON FLT FROM ZZZ TO ZZZ2. WE LEFT THE GATE AND PROCEEDED OVER TO THE RAMP, WHERE WE WERE DEICED WITH TYPE I AND **TYPE IV** DEICING FLUID. I THEN CALLED FOR TAXI CLRNC. WE WERE INSTRUCTED TO TAXI TO RWY 36L. WHILE WAITING FOR OUR TKOF CLRNC, TWR RPTED THAT AN MD11 HAD RPTED MODERATE TO SEVERE ICING ON FINAL APCH. I LOOKED AT MY CAPT AND STATED SEVERE ICING. SHE SAID 'DISREGARD,' AND WE WERE CLRED ONTO THE RWY FOR TKOF. DURING OUR CLBOUT, WE ENCOUNTERED NO ICE, BUT MODERATE TURB. DURING OUR NORMAL CALLOUTS OF ACCELERATION ALT, AND V2 +12 KTS, THE CAPT ASKED FOR FLAPS 8 DEGS, WHICH I RESPONDED WITH FLAPS 8 DEGS. I THEN CALLED OUT V2 +20 KTS. SHE THEN ASKED FOR 'FLAPS UP, SET CLB THRUST.' I RESPONDED BY SELECTING THE FLAPS TO ZERO AND SETTING CLB THRUST. WHEN WE RECEIVED A MASTER CAUTION, I CANCELLED AND IDENTED THAT THE FLAPS HAD FAILED. WE NOTIFIED ATC AND REQUESTED TO LEVEL OFF AT 16000 FT, WHERE WE RAN CHKLISTS AND NOTIFIED COMPANY OF THE SIT. WE WERE INSTRUCTED TO DIVERT TO ZZZ3, WHERE WE DECLARED AN EMER AND EXECUTED A NO-FLAP LNDG, WHERE WE LANDED WITHOUT INCIDENT AND DEPLANED THE PAX. I BELIEVE THE SIT WAS DUE TO THE WX CONDITIONS AT THE ARPT AT THE TIME OF DEP.

Event 4- ACCIDENT AND INCIDENT DATABASE (Aircraft Model DC-9) Aircraft elevator froze while climbing to altitude.

THE AIRCRAFT OVER NIGHTED IN CYYZ WHERE A HARD RAIN DRIVEN BY GUSTY WINDS HITTING THE AIRCRAFT FROM THE REAR FOR QUITE A PERIOD OF TIME. UPON DEPARTURE FROM CYYZ AND WHILE CLIMBING TO ALTITUDE THE AIRCRAFT ELEVATOR FROZE AND WAS UNCONTROABLE. AN EMERGENCY WAS DECLARED INTO MKE AND AS THE AIRCRAFT CAME DOWN INTO WARMER AIR THE ELEVATOR CONTROL WAS REGAINED BY THE FLIGHT CREW. AN INSPECTION OF THE AIRCRAFT BY MWEA AT MKE DID NOT FIND ANY DEFINITIVE

CAUSE FOR THIS PROBLEM. THIS IS THE 4TH TIME MWEA HAS HAD THIS CONDITION HAPPEN TO ONE OF THIER AIRCRAFT. THEY ALL EXPERIENCED THE SAME PREFLIGHT CONDITIONS;IE, DRIVING WIND 30MPH AND HARD RAIN. HORIZONTAL STABILIZER RUB SEALS WERE REPLACED AS PRECAUTIONARY BUT THERE WAS NO EVIDENCE SHOWING THAT THIS WOULD CORRECT THE PROBLEM. IN THE INVESTIGATION, TYPE 4 **ANTI**-ICE FLUID WAS NOTED AS A PROBLEM SINCE IT WILL GET INTO PULLEY AREAS AND BECAME DRY THEN AS WATER HITS IS PLACED ON TOP OF THE DRIED TYPE 4 IT BECAME PARTICALLEY REACTIVE BUT THEN FREEZES AT ALTITUDE. MWEA IS PUTTING IN PLACE DURING THEIR "A" CHECK INSPECTIONS A HOT TYPE 1 DEICING FLUID WASH TO CLEAN OUT ANY REMAINING DRIED TYPE 4 FLUID. THIS TYPE 4 FLUID HAS BEEN IDENTIFIED AS PART OF THE PROBLEM.

In Flight (at altitude)

Event 5- DC9 CREW HAD THE ACFT ELEVATOR BECOME JAMMED INFLT.

DURING CLB TO AND LEVELOFF AT ALT, IT WAS DETERMINED THE ELEVATOR HAD FROZEN/BECOME JAMMED. FLEW ACFT USING PRIMARY AND ALTERNATE TRIM. STARTED AIRFOIL ANTI-ICE/TAIL CYCLING. CHKED ARPTS FOR XWIND, TEMP AT SURFACE, FREEZING LEVELS, LENGTHS OF RWYS. INCLUDED MKE, ORD, STL, DSM, MCI, OMA. FLT ORIGINATED IN MKE. BEST ARPT BASED ON ABOVE OMA. DSNDED TO LOWER ALT. STARTED APU. AT FL200 FREEZING LEVEL WITH TEMP INVERSION LOWER. AT 16000 FT TEMP +20 DEGS C, LEVELED AT OMA. ELEVATOR CTL REGAINED AFTER 10 MINS AT 16000 FT. LANDED OMA WITHOUT INCIDENT. NOTE: MKE WX HAD HVY RAIN ALL NIGHT. ACFT WAS PARKED THERE TAIL N THAT DAY. WX AT DEP TIME: XA56Z, 050 DEGS AT 21 KTS GUSTING TO 27 KTS. VIS 2 1/2, RAIN, 9 BROKEN, 15 OVCST, TEMP/DEW PT 3/3, ALTIMETER 29.52, ILS RWY 7R. THIS HAS OCCURRED BEFORE. MAY OR MAY NOT BE A RELATED PROB. CALLBACK CONVERSATION WITH RPTR REVEALED THE FOLLOWING INFO: RPTR INDICATED HIS AIRLINE HAS HAD MANY FROZEN ELEVATORS THIS YR. THE FAA, NTSB, AND THE MANUFACTURER ARE CURRENTLY INVOLVED IN THE INVESTIGATION. IT SEEMS THAT A NEW **TYPE IV** ACFT ANTI-ICING FLUID IS PLUGGING UP WATER DRAIN HOLES IN THE TAIL AREA. WHEN THE ACFT IS POSITIONED SO THAT THE RAIN AND WIND BLOW AT A 50 DEG ANGLE FROM THE NOSE ON THE L SIDE, WATER ACCUMULATES IN THE TAIL. WHEN THE WATER FREEZES, AS THE ACFT CLBS TO ALT, THE CABLES THAT ACTIVATE THE ELEVATOR CTL TABS FREEZE. THEY ARE IMMOBILIZED UNTIL THE ICE IN THE TAIL AREA MELTS, AS THE ACFT DSNDS.

Event 6- FLT CREW OF B757-200 ENCOUNTER FAILED AIR DATA INSTRUMENTATION INCLUDING BOTH AIRSPD INDICATORS AND ENG INSTRUMENTATION.

WX CONDITIONS WERE IFR WITH LIGHT TO MODERATE SNOW. DEICED ACFT WITH 100% **TYPE IV** FLUID. HOLDOVER TIME BEGAN AT XA07Z. DEPARTED ZZZ1 WITHIN HOLDOVER TIME AT XA27Z. UNEVENTFUL CLBOUT. AT APPROX FL300, CAPT LOST HIS AIRSPD INDICATOR (FLUCTUATING WILDLY) AND ASKED ME TO TAKE CTL OF THE ACFT. SHORTLY THEREAFTER, I LOST MY AIRSPD INDICATOR AS

WELL. IN ADDITION, EPR, N1, AND N2 INDICATORS WENT BLANK. WX WAS IFR WITH MODERATE TURB. EMER WAS DECLARED. ELECTED TO LAND AT NEAREST SUITABLE VFR ARPT THAT DID NOT REQUIRE US TO RE-ENTER ICING CONDITIONS.CONSULTED WITH DISPATCHER AND WITH ATC. WE ALL AGREED ZZZ2 WAS THE CLOSEST SUITABLE VFR ARPT. LNDG WAS UNEVENTFUL. ACFT WAS IN COMPLETE CTL AT ALL TIMES.

Synopsis

The above events support published information referring to the potential effects of Type IV anti-ice fluid build-up in control surface areas resulting in restricted surface movement. No events were located citing aerodynamic performance degradation after use of Type IV fluid. There is currently research being conducted by NRC Aerospace (Canada) to estimate the "aerodynamic performance penalties produced by de-icing and anti-icing fluids."

Following are extracts from several sources presenting the possible side effects of anti-ice fluid on aircraft performance, as well as the caution associated with fluid build-up and drying.

FAA Advisory Circular 135-16 (Ground Deicing and Anti-Icing Training and Checking)

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(3) De-icing/Anti-icing Fluids Handling/Performance Implications. The type fluid used and how completely the fluid flows off the wing during takeoff determines the effects of the following handling/performance factors. The aircraft manufacturer may also provide performance information regarding the use of the different de-icing/anti-icing fluids.

(i) Increased rotation speeds/increased field length.
(ii) Increased control (elevator) pressures on takeoff.
(iii) Increased stall speeds/reduced stall margins.
(iv) Lift loss at climbout/increased pitch attitude.
(v) increased drag during acceleration/increased field length.
(vi) Increased drag during climb.

CAA United Kingdom Flight Operations Department Communication 30/2005

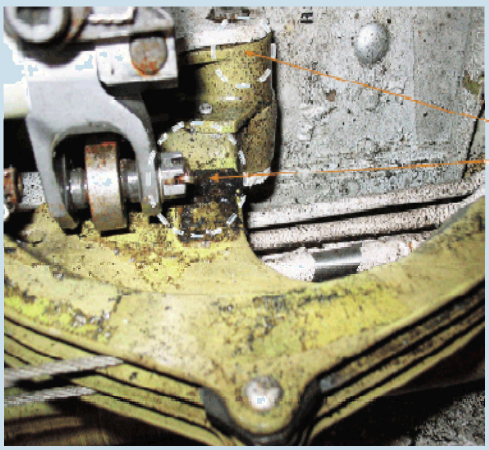
4 REHYDRATION OF TYPE II AND TYPE IV DE-ICING/ANTI-ICING FLUID RESIDUES

4.1 Type II and Type IV Anti-Icing Fluids

4.1.1 The repeated application of Type II and Type IV anti-icing fluid may cause residues to collect in aerodynamic quiet areas, cavities and gaps. These residues may rehydrate and freeze under certain temperature changes, in high humidity and/or rain conditions. In addition, they may block or impede critical flight control systems and should be removed.
4.1.2 In order to limit these problems, the repetitive use of Type II or Type IV anti-ice fluid should be avoided as far as possible.
4.1.3 When Type II and Type IV anti-icing fluid residue has been detected, no take-off should be authorised until the residues have been removed.

4.2 Recommendations

4.2.1 Operators should obtain guidance and instructions from the aeroplane manufacturer as to how to establish satisfactory procedures to detect and remove residues of dried fluid.
4.2.2 Operators should review their anti-icing procedures when using Type II or Type IV fluid. Their Operations Manual should be amended, where necessary, to ensure that the airframe is clear of residue, which could rehydrate and adversely affect the operation of the aeroplane. Procedures relating to a specific aeroplane type or operation should be promulgated in detail to all staff involved in de-icing/anti-icing operations.



Dow Briefing: UCAR Endurance EG106 (2007)

Aerodynamics

Deicing and/or anti-icing fluid remaining on the aircraft following the deicing and/or anti-icing operation can affect the aerodynamic performance of any aircraft. As temperature decreases, UCARTM Endurance EG106 ADF/AAF viscosity generally becomes more viscous and can have an increased effect on aerodynamics. The objective of aerodynamic acceptance tests is to determine the coldest temperature at which the deicing or anti-icing fluid has acceptable characteristics as it flows off during takeoff ground acceleration and climb.

There are two separate aerodynamic acceptance tests for aircraft deicing and anti-icing fluids: one for faster aircraft (high-speed ramp test) and one for slower aircraft (low-speed ramp test). The high-speed ramp aerodynamic test establishes flow-off requirements for fluids used to deice or anti-ice large transport jet aircraft with rotation speeds generally exceeding approximately 100 knots and with time from brake release to rotation speed greater than 20 seconds. The other test, known as the low-speed ramp test, establishes flow-off requirements for commuter type aircraft with takeoff rotation speeds exceeding approximately 60 knots and with time from brake release to rotation speed greater than 15 seconds. Both tests are fully described in SAE AS 5900.

UCARTM Endurance EG106 ADF/AAF was evaluated and qualified to AS 5900 using the high-speed ramp aerodynamic acceptance test at temperatures above -25°C (-13° F). Since the geometry of the wing and control surfaces, takeoff speed and ground roll time are the responsibility of the airframe manufacturer, Dow recommends the use of UCARTM Endurance EG106 ADF/AAF only if the airframe manufacturer has approved the use of Type IV fluids (or specifically UCARTM Endurance EG106 ADF/AAF) for use on its aircraft.

Successive Dryout and Rehydration

The industry has become aware of the potential for thickened SAE Type II, Type III, and Type IV fluids, especially when used in a one-step process, to form gels and residues upon dryout. Several airlines, mostly those in Europe, have reported incidents in which residues of thickened fluids in aerodynamically quiet areas rehydrated and froze at altitude, thereby restricting the movement of or blocking control surfaces. The use of a two-step deicing/anti-icing process, where the first step is a Type I fluid, reportedly reduces the propensity for residue formation (see Application, pages 22-25). A test procedure has been developed to evaluate fluid performance under simulated dryout and rehydration conditions and is described in Appendix A of SAE AMS 1428. Within SAE, work is ongoing to further define test requirements for fluids as well as to understand the impact of application techniques to eliminate or control such residues. Users should inspect aircraft as recommended in SAE ARP 4737. If residues are present, users should evaluate their application practices and establish an appropriate inspection and cleaning program.

EASA Safety Information Notice No 2008-29 (04 April 2008)

8. Special operational considerations

a. When using thickened de-icing / anti-icing fluids, the operator should consider a two step de-icing/anti-icing procedure, the first step preferably with hot water and / or non thickened fluids.

b. The use of de-icing / anti-icing fluids has to be in accordance with the aeroplane manufacturer's documentation. This is particular true for thickened fluids to assure sufficient flow-off during take-off.

c. The operator should comply with any type-specific operational requirement(s) such as an aeroplane mass decrease and/or a take-off speed increase associated with a fluid application.

d. The operator should take into account any flight handling procedures (stick force, rotation speed and rate, take-off speed, aeroplane attitude etc.) laid down by the aeroplane manufacturer when associated with a fluid application.

e. The limitations or handling procedures resulting from c and / or d above should be part of the flight crew pre take-off briefing.

9. Special maintenance considerations

a. General

The operator should take proper account of the possible side-effects of fluid use. Such effects may include, but are not necessarily 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 or engine manufacturers and / or own experience:

(i) Dried fluid residues.

Dried fluid residue could occur when surfaces have been treated but the aircraft has not subsequently been flown and not been subject to precipitation. The fluid may then have dried on the surfaces;

(ii) Re-hydrated fluid residues.

Repetitive application of thickened de-icing / anti-icing fluids may lead to the subsequent formation / build up of a dried residue in aerodynamically quiet areas, such as cavities and gaps. This residue may re-hydrate if exposed to high humidity conditions, precipitation, washing, etc., and increase to many times its original size / volume. This residue will freeze if exposed to conditions at or below 0° C. This may cause moving parts such as elevators, ailerons, and flap actuating mechanisms to stiffen or jam in flight.

Re-hydrated residues may also form on exterior surfaces, which can reduce lift, increase drag and stall speed.

Re-hydrated 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, grommets, on cables and in gaps;

(iii) Operators are strongly recommended to request information about the fluid dry-out and re-hydration characteristics from the fluid manufacturers and to select products with optimised characteristics;

(iv) Additional information should be obtained from fluid manufacturers for handling, storage, application and testing of their products;

(v) Special attention, if necessary, should be paid during the pre-flight, especially when performed by ground handling organisation on behalf of the crew.
(vi) Inspections should be addressed in the maintenance programme (Part M.A.302) in order to describe what and when to inspect;

(vii) Maintenance organisations should have the proper documentation: how to inspect, tolerances or acceptable residue development, how to remove and to clean, tools to be used etc.

(viii) The Safety and Quality policy, Maintenance procedures and Quality system should include considerations for icing. Special procedures and audits / organisational reviews should be performed by skilled personnel.