BOMBARDIER CUSTOMER SERVICES BUSINESS AIRCRAFT

INFO SERVICE

BOMBARDIER GLOBAL

INSIDE

Global Series
2010 – 2011 Cold Weather Operations

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Icing Precautions and Procedures

The following precautions and procedures regarding use of ANTI-ICING/DE-ICING fluids and ICING PRECAUTIONS in general are drawn from, but do not supersede the relevant aircraft manuals.

Classification and Use of Type I / II / III / IV Fluids

Type I de-icing fluids provide minimal anti-icing capability, leading to very short holdover times. Type I fluids are normally supplied in concentrated form, but should be used diluted with hot water between ambient and the freezing temperature.

Type II anti-icing fluids provide longer holdover times. Type II fluids may be used in the concentration supplied or be diluted with water depending on the outside air temperature.

Type III has a longer holdover time than Type I but a lower viscosity than Type II or Type IV. The application procedure for Type III fluid is the same as the application procedure for Type II and Type IV fluids.

Type IV anti-icing fluids provide greater protection than Type II in most cases.

- **DE-ICING** is a procedure by which ice, snow and/or frost is removed from the aircraft by applying hot water or a hot mixture of water and de-icing fluid. De-icing may also be used to mean the removal of snow and contaminants by mechanical means.
- **ANTI-ICING** consists of the application of an anti-icing fluid at recommended concentration levels to the aircraft surfaces to protect against the accumulation and adherence of ice, snow and/or frost after de-icing. Prior to application of anti-icing fluids the surfaces must be free of any accumulation of ice, snow and/or frost.
- **ONE-STEP DE-ICING/ANTI-ICING** consists of the application of a mixture of fluid and hot water at the recommended concentration level necessary to provide a freezing point 10°C (18°F) below ambient temperature. This application takes into account the prevailing weather conditions, and removes ice, snow, and/or frost from the aircraft's surfaces and protects those surfaces from further contaminant accumulation but has very limited time duration.

- **TWO STEP DE-ICING/ANTI-ICING** consists of de-icing with hot water only or a mixture of hot water and de-icing fluid, followed closely by an application of anti-icing fluid. Care must be taken not to allow the aircraft surfaces to re-freeze between the de-icing and anti-icing processes. To delay re-freezing, the de-icing fluid concentration should provide a freezing point not more than 10°C (50°F) above ambient temperature. If hot water alone is used the ambient temperature must be not less than 3°C (37.4°F) and particular care must be taken against the possibility of refreezing on cold aircraft surfaces. The final objective of de-icing and anti-icing procedures is to provide and maintain clean aerodynamic surfaces free from adhesive ice, frost or snow.
- **HOLDOVER TIME** is the estimated time a de-icing/anti-icing fluid will prevent ice, snow, and/or frost from forming or accumulating on the treated surfaces of an aircraft. The protection time is dependent upon the ambient and surface temperature, the type and intensity of precipitation and the type and concentration of fluid. Refer to Chapter 12, of the Aircraft Maintenance Manual (AMM) for instructions and approximate holdover times. Reference to the cold weather operations can also be found in the Flight Crew Operating Manual (FCOM) / Operating Manual (OM), Volume 1, Operating Limitations and the Supplementary chapter. The Holdover Time (HOT) obtained from the tables is only a guide to the expected safe period. Flight crews should be aware of other factors, such as wind speed and direction, which can adversely affect anti-icing fluid performance.

Infrared De-Icing Systems

- Bombardier Aerospace accepts the use of the Infrared Energy De-icing System as a de-icing method. However, since the Infrared Energy System can support only the de-icing process, aircraft requiring anti-icing protection will still need the application of an appropriate anti-icing Freezing Point Depressant (FPD) fluid.
- Infra-red de-icing, is acceptable for use on our Global Express, Global 5000, Global Express XRS type aircraft when it follows the acceptable industry standard, such as SAE ARP 4737, and conforms to the applicable FAA documents, such as FAA Advisory Circular No: 150/5300-14 Appendix A, and Advisory Circular No: 120-89 .
- When de-icing the aircraft using the Infrared Energy System, make sure to obey to all safety precautions as stated in SAE ARP 4737.
- The Aircraft Maintenance Manual (AMM) Chapter 12-31-09 has been revised to include instructions for Infra-red Energy De-icing. These instructions are included into the Flight Crew Operating Manual (FCOM) for Global Express and Global Express XRS and the Global 5000.

Ramp Maintenance Precautions

- Be sure to use equipment designated for the fluids being applied. Equipment suitable for the application of Type I fluids may not be suitable for the application of Type II, III or Type IV fluids. The protective properties of Type II, III and Type IV fluids can be seriously degraded by mechanical shearing that is inherent in the design of some dispensing equipment. Mechanical or equipment shearing of Type II fluids may reduce their viscosity and therefore, the estimated holdover time. Since Type I fluids are not similarly affected, be sure to refer to the fluid manufacturer's guidelines for the specific fluid being used.
- Since a corrosive vapor develops above the fluid, Type II, III and Type IV fluids require storage tanks to be made of materials not susceptible to corrosion. For this reason, carbon steel tanks, which are commonly used for storage of Type I fluids, would not generally be recommended for the storage of Type II, III or Type IV fluids. Stainless steel or fiberglass tanks are generally recommended for storage of Type II, III and Type IV fluids. Carbon steel tanks can be used if lined with an appropriate material.
- Check de-icing/anti-icing fluid concentration before application to aircraft. To determine the mixture percentage of de-icing/anti-icing fluid to water that should be used at a given temperature, refer to the manufacturer's specifications for the particular fluid.
- When using Type II, III & IV anti-icing fluid, in aerodynamically quiet areas, cavities and gaps, any fluid that collects will not be sheared and may stick to the aircraft. This fluid, if not cleaned off, will gel, dry out, and eventually become a powder. There have been cases of this gel or powder re-hydrating during subsequent anti-ice

procedures or in rain/snow conditions and swelling to greater than its original size. This substance can freeze and possibly interfere with flight controls.

- The flight controls on the Global are hydraulically powered; the mechanical portion (cables, pulleys, quadrants etc.) could be affected by re-hydrated fluids, so care should be taken during periods of repeated use of Type IV fluids. During these periods of repeated use of Type IV fluid, periodically wash the aircraft with hot water or a diluted Type I fluid to rinse off any residual Type IV fluid. Both the top and bottom surfaces of wings, stabilizers and flight controls must be cleaned, with particular attention paid to flight control hinge points. This can be part of a two-step de-icing/anti-icing procedure when using hot water or diluted Type I fluid to de-ice.

Ramp De-Icing/Anti-icing Procedures

- Do not operate APU while de-icing/anti-icing
- If possible, avoid operating engines while de-icing/anti-icing.
- Select bleed air off if engines are running while de-icing/anti-icing.
- Do not spray de-icing/anti-icing fluid directly into engine or APU inlets, exhausts, brakes, probe inlets, scoops, vents, and drains.
- Do not direct a solid stream of fluid perpendicular to aircraft surfaces. A high-pressure stream of fluid can damage aircraft surfaces.
- Application of fluids should follow the sequence below:
  - Horizontal stabilizer
  - Vertical stabilizer
  - Top of fuselage
  - Sides of fuselage
  - Wings

  Note: On wings and stabilizers, application should always be from leading edge to trailing edge and from outer panels to inner panels.
- De-icing should be continued until the surface is clean. Anti-icing should be applied in a thick even coat.
- Both the left and right wings and the left and right horizontal stabilizers must receive EQUAL and complete de-icing and anti-icing treatment.
- Apply de-icing fluid to the fuselage from the forward to the aft section. Spray the fuselage from the top center and then outboard.
- Do not spray fluid directly on cockpit or cabin windows especially if they are cold.
- During ice and snow removal procedures; ensure no ice or snow are directed into the openings around flight control surfaces, and air inlets of APU or engines.
- Clear ice, which is difficult to detect, may be present below the layer of snow and slush. Visually check to ensure removal of all ice after de-icing/anti-icing procedures. Inspection by touch is recommended.
- Know what type and concentration level of de-icing/anti-icing fluid has been applied so that you can estimate a holdover time.
- Snow should be removed from parked aircraft at regular intervals to prevent a large build-up, and possible freezing to the aircraft surfaces.

Pre-Taxi Precautions

- Determine/verify existence of icing conditions.
- Preflight the aircraft to see that the aircraft is free of snow, ice, and frost. Ensure that all control surfaces are clean; that all protective covers are removed; that engine inlets are clear of snow or ice; that pitot heads, static ports, fuel tank vents, air conditioning inlets/exits, and landing gear doors are clear of snow, ice and slush.
- In addition to the visual check, a tactile check of the wing leading edge and wing rear upper surface is done during the external walk around inspection to determine that the wing is free of frost, ice, snow or slush when:
  - The outside air temperature is 5°C (41°F) or less, or
  - It cannot be determined that the wing fuel temperature is above 0°C (32°F) and there is visible moisture (rain, drizzle, sleet, snow, fog, or water) is present on the wing, or
  - The atmospheric conditions have been conducive to frost formation.
- It should be noted that ice and frost might continue to adhere to wing surfaces for some time even at outside air temperatures above 5°C (41°F).
- If any doubt remains as to the aerodynamic cleanliness of your aircraft, request de-icing/anti-icing or proceed to a de-icing/anti-icing facility. NEVER assume that snow will blow off, there could be a layer of ice under it. DO NOT underestimate the effect of even a thin layer of ice on wing surfaces. Data from available literature suggests that ice roughness as small as 0.004 - 0.010 inches (0.1 to 0.25 mm) may negate takeoff stall margins.

Taxi Precautions

- Ignition should be “OFF” for taxi, and as required by the AFM Limitations section for take-off. Igniters “ON” during taxi may mask an engine problem.
- During taxi, do not use high thrust or high taxi speed in order to avoid displacement of applied de-icing/anti-icing fluids.
- During taxi, avoid using high thrust on snow or slush-covered runways, taxiways or ramps unless absolutely necessary. Using reverse thrust on snow/slush-covered ground can cause slush and water to become airborne, to be drawn into the engine intakes and to adhere to wings and other critical surfaces.
- Maintain greater than normal distances between aircraft while taxiing to aid in stopping, turning and to reduce the possibility of anti-icing fluid being blown from the critical surfaces or snow/slush being sprayed onto your aircraft.
- If taxi route will be through slush or standing water in low temperatures, taxi with flaps up. Do not accomplish take-off checklist until flaps are extended to take-off setting.
- In all freezing or near freezing precipitation conditions, up to 10°C (50°F) or below, operate engines with cowl anti-ice “ON”.
- When Type II, III and IV fluids are used, the wing anti-icing must only be switched “ON” just prior to increasing thrust for takeoff. Operation of the system during taxi may cause the Type II, III or IV fluid to change its viscosity/properties and therefore, alter the protection it is designed for.

Takeoff Precautions

- Verify using established reference areas that the aircraft is free of ice, snow and/or frost before moving into position for takeoff. If there is any doubt as to the cleanliness of the aircraft, an external inspection and/or repeat de-icing/anti-icing (if required) must be conducted.

- Engine intake cowl anti-icing should always be on during engine operation in freezing or near freezing precipitation conditions up to 10°C (50°F). Accelerating the engines for a short period before the takeoff can better ensure engine fan de-icing.
- When Type II, III & IV fluids are used, the wing anti-icing MUST ONLY be switched “ON” just prior to increasing thrust for takeoff. Operation of the system during taxi may cause the Type II, III or IV fluid to dry and leave deposits on the wing surfaces.
- Before brake release, check for stable engine operation. After setting take-off power check to see that cockpit indications are normal.
- Re-check full and free movement of the flight controls to ensure that no contaminates have impeded the movement of any control surfaces.

In-Flight Precautions

- Know and understand the icing procedures in the AFM.
- Do not use engine or wing anti-ice in a de-icing mode (i.e. don't wait until ice has accumulated before selecting the anti-ice system “ON”).
- Monitor flight instruments as there is the potential for significant performance loss in icing conditions.
- Do not hold in icing conditions with the slats extended.
- Verify that the aircraft is free of ice accumulation.
- In icing conditions use landing and taxi lights, where practical, to minimize ice accumulation on that portion of the wing leading edge.
- Remember that a very small area of rough ice near the wing leading edge can change stall characteristics, stall speeds or stall warning margins, and if not cleaned could ultimately negate stall warning.
- Be aware that even light icing can be hazardous.
- Anticipate the need for engine/nacelle anti-ice at all times, especially during low speed hold or approach in instrument meteorological conditions (IMC) or during flight through precipitation.

Landing Precautions

- The aircraft should be flown to a firm touchdown at the aiming point.
- Immediately after main wheel touchdown, lower the nosewheel to the runway to enhance directional control.
- Let the anti-skid system do its work. Do not pump brake pedals. The anti-skid system will monitor the onset of tire skidding and modulate brake pressures to achieve maximum braking.
- If reverse thrust is used in a crosswind, be prepared for a possible down-wind drift on slippery runways. To correct back to the runway centerline, advance power levers to flight idle and reduce braking. After regaining directional control, increase braking.
- Do not attempt to turn off the runway until speed has been reduced to a manageable level.
- To prevent possible damage to flaps and wing trailing edges, if landing in heavy slush, do not retract flaps until after-landing inspection and removal of any slush has been carried out.

References

Please refer to and be familiar with the information contained in the AFM, FCOM/OM, and in the Chapter 12 of the AMM/SMM.

During winter, flight crew and maintenance personnel must pay particular attention to the hazards imposed by the season. The following information packages are available on the password-protected CIC website (http://www.cic.bombardier.com).

- Information Guide

  Guidelines for fluid application titled Deicing/Anti-icing Fluid Application Information Guide. This information is available within Technical Library > Quick Reference Cards > Global Express, Global 5000 or Global Express XRS.

- Winter Operations Awareness - Takeoff Safety Enhancement Winter 2010-2011

In addition to our annual newsletter, Bombardier is pleased to offer a website dedicated to supporting our customers in continuing to operate safely in winter conditions. Please visit the following web addresses to obtain details on a range of training and awareness materials being made available free-of-charge.

http://www.batraining.com/blog/index.php/2010/09/21/winter-operations-awareness-takeoff-operational-safety-enhancement/

http://www.batraining.com/eLearning/Free%20Courses/icingawareness.asp

Further reference information can be obtained from:

Transport Canada

Winter 2010-2011 Holdover Time (HOT) Guidelines

AC 0072R (Advisory Circular) Ground De-icing/Anti-icing With Engines Running

To obtain copies:

http://www.tc.gc.ca/CivilAviation/commerce/HoldoverTime/menu.htm and

http://www.tc.gc.ca/CivilAviation/commerce/circulars/menu.htm

For any other information contact:
Email: questions@tc.gc.ca Phone: 613-990-2309 TTY: 1-888-675-6863
Fax: 613-954-4731 / 613-998-8620

Mailing Address: Transport Canada
330 Sparks Street
Ottawa, ON K1A 0N5
Attention: Commercial and Business Aviation Issues Officer

U.K. Civil Aviation Authority (CAA)

A winter operations reference page can be found at the following link:
http://www.caa.co.uk/default.aspx?catid=720&pagetype=90&pageid=6930

CAA focal points for winter operations and icing:

Flight Operations

Phone 01934 529852

Fax 01934 529850

Design and continued airworthiness

Phone 01293 573309

Fax 01293 573976

Continuing airworthiness (including maintenance)

Phone 01293 573766

Fax 01293 573984

Research

Phone 01293 573462

Fax 01293 57398

Federal Aviation Administration (FAA)

A winter operations reference page can be found at the following link.
http://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/safo/all_safos/media/2006/safo06002.pdf

http://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/safo/all_safos/media/2009/SAFO09004.pdf

Windshield Precautions

- Even though the windshields and side windows are required to endure extreme cold as part of the certification process, the winter traditionally signals an increase in transparency removal rates.
- While we have no definitive data to indicate why, it is clear that the prolonged exposure to cold, freezing precipitation and de-icing fluids can cause more removals in the winter months. To minimize the risks of a premature removal, operators are reminded of the following cold weather maintenance practices. Snow and ice should be removed from the transparencies as much as possible with a soft broom or brush. Do not use sharp objects when removing snow and ice and, when cleaning, never use a dry cloth on a dry windshield surface. The windshield/side window heat systems should not be used to melt large amounts of snow and ice. Windshield heat should be selected to low during initial power up only if the windshield is devoid of snow and ice. De-icing fluid should not be sprayed directly onto the transparencies.
- For complete details on snow removal and de-icing procedures refer to the Ground Handling and Servicing Manual Section 4. Operators are also reminded to be diligent in ensuring the windshield and side window aerodynamic seals are inspected regularly. Look for lifting, cracking or separation from the outer ply. Precipitation or de-icing fluids can migrate under the seal and cause a heat failure or delamination. Aerodynamic seal repairs are available in the AMM chapter 56. Windows .

Landing Gear, Wheels and Brakes

The following is being reprinted to serve as a reminder that winter operations may require additional diligence. Additional note(s) have been included for your consideration.

The ensuing references serve as the basis for the following points. Referring to the FCOM/OM manuals is recommended, as they will provide additional information; for Operating from Wet, Snow-Covered or Slush-Covered Surfaces and Cold Weather Operations.

Nose wheel and Main Landing Gear Areas

- Check clear of frost, ice and snow.
- Latching and operating mechanisms are free and clear of any accumulation (uplocks/downlocks).
- Check electrical components (connector, cables and micro switches) for evidence of moisture ingress.
- Gear doors are free from accumulations of ice or snow.
- Tire pressure is acceptable and wheels are not frozen to the ground
  - Note: Refer also to "Adjusting for Temperature" (which you will find later in this article).
  - Gear shock struts , check for evidence of leakage and proper level of chrome showing .

Nose wheel steering (Taxi Out)

- Nose wheel steering should be exercised in both directions during taxi.
- Avoid large steering inputs .

Brakes (Taxi Out)

- Application of brakes should be kept to a minimum during turns or not at all if possible.
- Be aware of increased stopping distances.
- During taxi, use light brake applications to warm brakes to 4 units BTMS before takeoff. Monitor brake temperature monitoring system (BTMS) during taxi.

  Note: See also "Brakes - Procedures for Wet/Freezing Conditions".

Brakes (Landing)

- When operating from wet, snow covered or slush covered runways or taxiways, the following steps are applicable in order to prevent freezing of the wheel brakes;
  - When landing, carry out a positive landing to ensure initial wheel spin up and breakout of frozen brakes if icing has occurred
  - During the landing roll and subsequent taxi, use the brakes to prevent progressive build-up of ice on the wheels and brakes. Monitor BTMS during taxi.
- Lower the nosewheel immediately and hold light forward control column pressure.

  CAUTION: Use of thrust reversers on snow covered surfaces can create a white-out situation which can preclude the safety of the airplane and the passengers.
- Use maximum reverse thrust as soon as possible after touchdown. Thrust reversers are most effective at high speed. At low speed, minimize the intensity and duration of reverse thrust, however, maximum reverse thrust may be used to a complete stop in case of an emergency situation.

- DO NOT pump the brakes as this will only diminish braking effectiveness. Apply brakes normally with steadily increasing pressure, allowing the anti-skid system to modulate brake pressures to obtain maximum braking.
- Maintain directional control with the rudder as long as possible and use nosewheel steering with extreme care.

  CAUTION: If a skid develops, reduce reverse thrust to idle reverse and if necessary, return the engines to forward idle thrust to return to centerline. Regain the centerline with rudder and/or differential braking. Use nosewheel steering with caution.

Procedures to Prevent Freezing of Wheel Brakes

- If operating from runways and taxiways with standing or puddle water, to preclude the chance of water saturated brakes freezing at altitude and being locked for landing touchdown, use sufficient brake applications during taxi to warm the brakes to approximately 4 units BTMS prior to takeoff.
- When operating from wet, snow covered or slush-covered runways or taxiways, or following overnight parking in known icing conditions, the following steps are applicable in order to prevent freezing of the wheel brakes:
  - During taxi, use firm brake applications to warm brakes before takeoff. Monitor BTMS during taxi.
  - When landing, carry out a positive landing to ensure initial wheel spin-up and breakout of frozen brakes if icing has occurred.
  - During the landing roll and subsequent taxi, use the brakes to prevent progressive build-up of ice on the wheels and brakes. Monitor BTMS during taxi.
- Following takeoff or landing on wet, snow or slush-covered runways and taxiways, tires should be inspected for flat spotting prior to the next flight.

Tires

When extreme drops in temperature are experienced, these precautionary tips can help provide safe, trouble-free operation:

1. Follow manufacturer's recommendations on mounting as described on the new tire label.
2. Use only new, wheel manufacturer approved, o-ring seals with proper cold weather properties, properly lubricated and installed.
3. Use only an accurate calibrated pressure gauge.
4. Be sure that wheel bolts are properly torqued per wheel manufacturer's instructions.
5. Aircraft parked and exposed to cold temperature for a period of 1 hour or more, should have tire pressure checked and adjusted accordingly.
6. High-speed taxi and sharp turns should be avoided to prevent excessive side loading.
7. An important fact to remember is that every 3°C (5°F) change in temperature will result in a corresponding 1% change in tire pressure (see “Adjusting for Temperature” below.)
8. Do not reduce the inflation pressure of a cold tire that is subjected to frequent changes of ambient temperature.

Adjusting for Temperature

When tires will be subjected to ground temperature changes in excess of 27°C (48°F) because of flight to a different climate, inflation pressures should be adjusted for the worst case prior to takeoff. The minimum required inflation pressure must be maintained for the cooler climate; pressure can be readjusted in the warmer climate. Before returning to the cooler climate, adjust inflation pressure for the lower temperature. An ambient temperature change of 3°C (5°F) produces approximately one percent (1%) pressure change. Excessive inflation pressure should never be bled off from hot tires - all adjustments to inflation pressure should be performed on tires cooled to ambient temperature.

* The following information was originally taken from the Goodyear Tire Care and Maintenance guide. Similar guidelines can be found in the “Flight Safety Foundation – Aviation Mechanics Bulletin, March – April 1999 ... Monitoring Aircraft Tire Pressure Helps Prevent Hazardous Failures”.

An excerpt from the bulletin states...

> “The rubber manufacturers association (RMA) recommends that when a difference in ambient temperature greater than 50 degrees F (28 degrees C) causes a lower tire pressure than the specified operating pressure, the cold tire pressure should be adjusted to the specified operating pressure. The relationship between pressure and temperature is that a temperature change of 5 degrees F (3 degrees C) is equivalent to a change in tire pressure of approximately 1 percent.”

If a 50-degree F temperature change is the industry’s agreed-upon trigger point, (a 50-degree F temp drop would result in a tire pressure change of –10%) then the equivalent trigger point in Celsius is 27 - 30 degrees (depending upon source data). A 30-degree Celsius temp drop results in the same –10% tire pressure change.

Rounding up or down by the various sources seems to be implicated for the various values.

Effects of Environmentally Friendly De-Icing Fluids on the Landing Gear and Brakes

In recent years, new environmentally friendly RDI (Runway De-Icing) fluids which contain potassium formate, acetate and other alkalis have been introduced at airports in certain parts of the world. These ingredients work as a carbon oxidation catalyst which can lead to carbon disk deterioration and failure.

The presence of the alkalis in the RDI creates a catalytic condition, which lowers the temperature of oxidation and softens the carbon. This condition can cause the brake to flake and crumble over time, reducing the life and long-term efficiency. Goodrich Corporation has released a service letter (SL 2095, Rev 1, 2009-10-22) with instructions for inspecting the brakes for evidence of catalytic oxidation and procedures if catalytic oxidation is found. The Aircraft Maintenance Manual (AMM) has been revised in accordance with this service letter. It contains instructions on how to inspect the brakes for catalytic oxidation at every wheel change (REF AMM TASK 32-41-01-000-801 & 32-43-13-220-801).

For the landing gear, Messier-Dowty Inc. have also released a service letter (MD-T SL700-32-010, Rev 2, 2010-07-15) with information pertaining to the effects of environmentally friendly RDI fluids on the cadmium protected components. They recommend cleaning and lubrication of the landing gears at the earliest convenience after operation in such an environment.

Finally, operators should be aware of the EASA (Information Bulletin No. 2008-19R1), FAA (SAIB NM-08-27R1) and TC (Service Difficulty Advisory AV2009-03) publications pertaining to the effects of environmentally friendly RDI fluids. As already contained in the AMM, these publications suggest performing a visual inspection of the brake unit at each tire change for obvious damage, distortion, missing elements or corrosion, on aircraft operated to/from airports using RDI fluids.

Slush on the Runway and What it does to Aircraft Performance

By Gerard van Es, Senior Research Engineer, Flight Testing & Safety Department, National Aerospace Laboratory NLR, The Netherlands, April 2003.

Analysis of accidents that occurred in the last 20 years has shown that the risk of overrunning the end of a slush- or water-covered runway is about eight times higher than on a dry runway. The hazardous effect of slush on aircraft field performance was first brought into prominence after an accident involving a BEA Airspeed Ambassador aircraft, in which 23 people were killed, in Munich in 1958. The introduction of tricycle under carriages and higher operating speeds of modern aircraft in the late 1950's were associated with this new hazard to aircraft operations. In the early 1960's, investigations on the effects of slush were carried out in the United States, the United Kingdom and France. Tests were conducted using catapult-driven test carriages as well as full-scale aircraft. These early tests gave a clear picture of what slush does to an aircraft that takes off or lands. It was found that the acceleration during takeoff was reduced due to an increase in total drag acting on the aircraft. This increase in drag was caused by the tires displacing the slush and the impingement (interference, intrusion) of the spray of slush on the airframe thrown up by the tires. It was shown that the additional drag increased with increasing slush depth. It was also discovered that there was a considerable possibility of loss of engine power, system malfunctions and structural damage due to spray ingestion or impingement. Furthermore, the problem of very low braking friction between the tires and surface was identified in which aquaplaning of the tires plays an important role. The problem of slush is more acute for aircraft with turbine engines than for aircraft with piston engines because of the higher operating speeds and increased susceptibility to ingestion and impingement due to geometrical characteristics of aircraft with turbine engines.

Let us have a look at some typical numbers with respect to the effect of slush on takeoff performance. Just 13 mm (0.5 in.) of slush can subject a large jumbo jet to a drag that is equal to approximately 35% of the thrust of all its four engines. This number increases to 65% for 25 mm (1 in.) of slush, making it impossible to take off. In general, for a multi-engine transport aircraft, just 13 mm (0.5 in.) of slush can increase the take-off distance by some 30-70%.

Slush can have an adverse effect on the landing performance. Braking friction can be low because aquaplaning is likely to occur on slush-covered runways. This will increase the landing distance compared to a dry runway. Although it sounds strange, a thicker layer of slush can be better than a thin layer because the drag from the slush helps stop the aircraft. The more slush you have on the runway, the higher the drag on the aircraft. This also applies to rejected takeoffs and can lead to strange performance restrictions when taking off from slush-covered runways. For instance, more slush can give lower take-off weight penalties.

What about regulations for operating on slush-covered runways? In 1992, the Moshansky Commission of Inquiry into the Air Ontario Crash at Dryden, made several recommendations regarding operations on contaminated runways. The commission recommended that Transport Canada should require that Aircraft Flight Manuals (AFMs) contain guidance material for operating on wet and contaminated runways and that operators provide adequate training to their crews with respect to the effects of contaminated runways on aircraft performance. At the present time, Canadian Operational Regulations do not provide for a Canadian operator of turbo-jet aircraft to have any information in the manuals for operating on contaminated runways. But on the other hand, effective August 1992, an AFM associated with a new type approval must have performance advisory material that deals with operations on contaminated runways.

What is this situation elsewhere in world? In Europe, any commercial operator whose principal place of business is in a Joint Aviation Authorities (JAA) Member State must comply with the operational regulations, JAR-OPS 1, which formalizes requirements for operational performance information. JAR-OPS 1 requires that an operator account for the effect of contaminated runways on take-off and landing performance. Several non-European countries have adopted JAR-OPS 1. At present the regulations in the United States do not address performance on contaminated runways. The Flight Test Harmonization Working Group will address harmonization of this issue with the JAA in the future. However, this is awaiting harmonization of the associated operating rules by the Airplane Performance Harmonization Working Group. Transport Canada and Canadian operators are some of the members of this last working group.

There are more problems caused by slush than described here. For instance loss of directional control when operating in crosswind and the accumulation of slush in the main landing gear bay areas that could freeze and interfere with the landing gear, just to name a few.

Remember that slush on the runway today is as big a risk to aircraft operations as it was 40 years ago. Fly safely in the remainder of this and all upcoming winters!

You can read about some real-life occurrences in which slush was a factor in Transportation Safety Board of Canada (TSB) accident reports with numbers A98O0034, A96A0047 A96A0050, A96C0232 (see www.tsb.gc.ca).

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