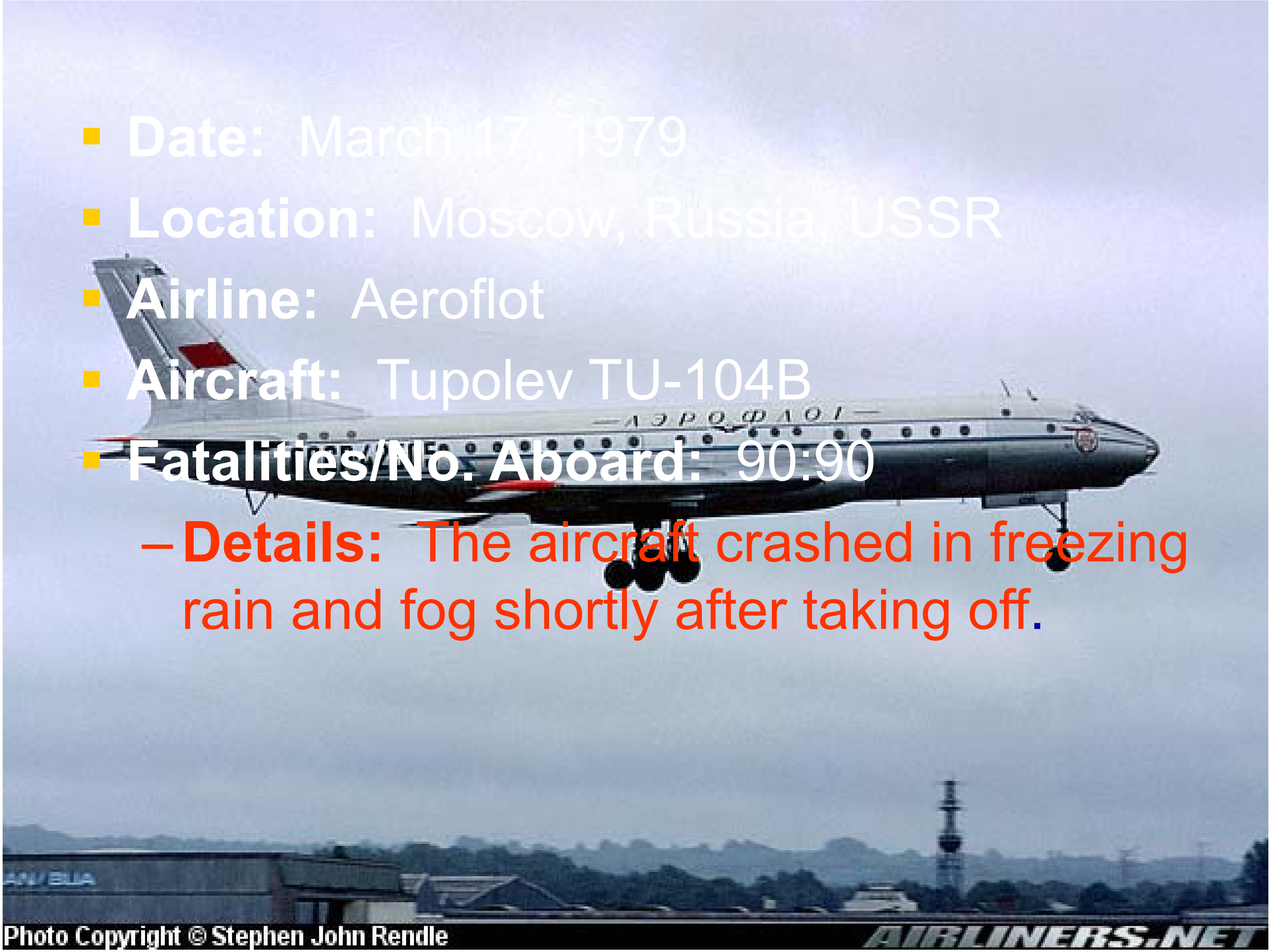
Aircraft Surface Contamination Training

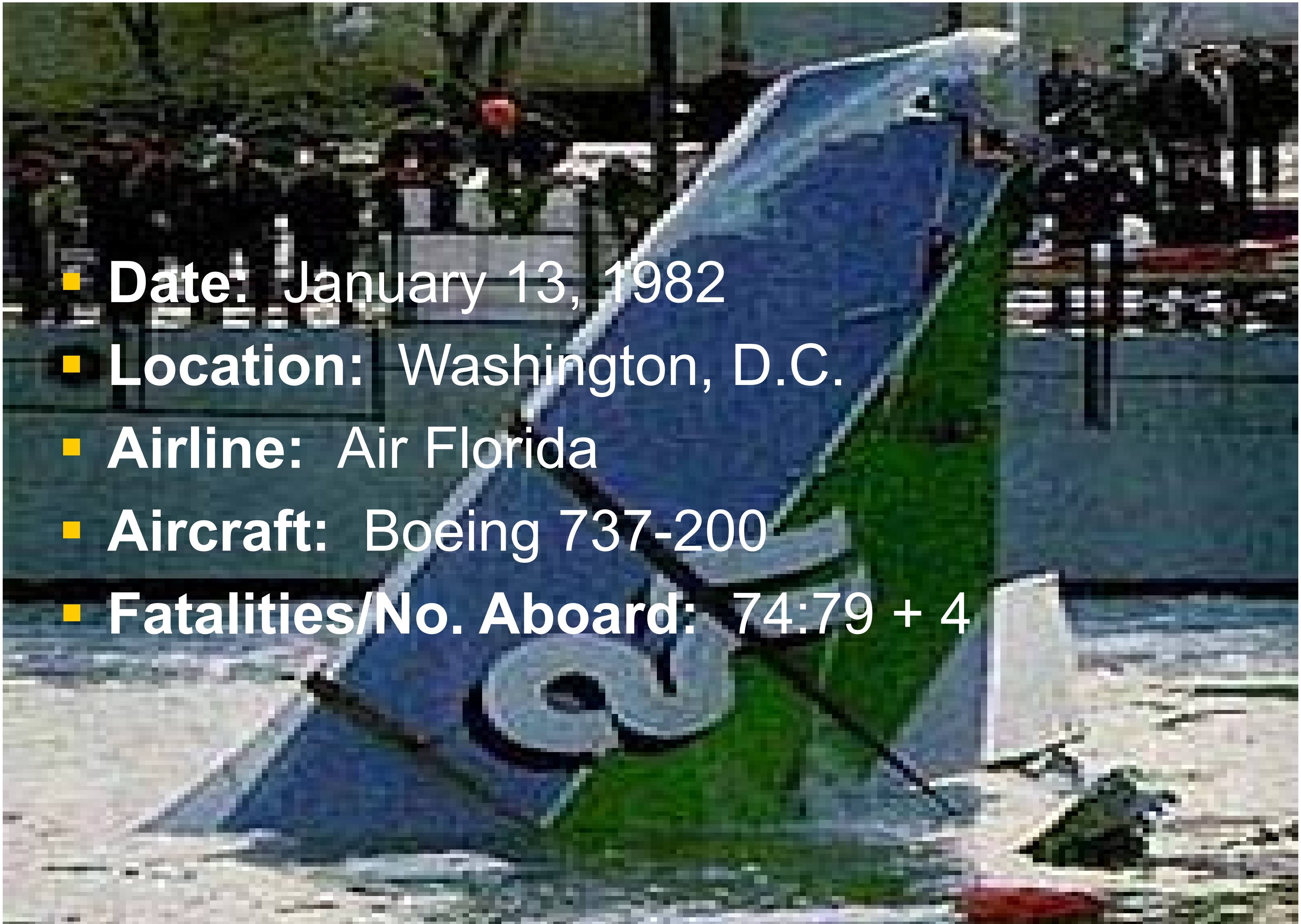
Effects of Ground Icing

Course Outline

- Hazards related to critical surface contamination of ice, frost and snow
- Regulations related to operations in icing condition
- Responsibility of pilot-in-command and other operations personnel
- Weather conducive to ice, frost and snow contamination
- Inspection before flight and removal of contamination
- In-flight icing recognition (video)

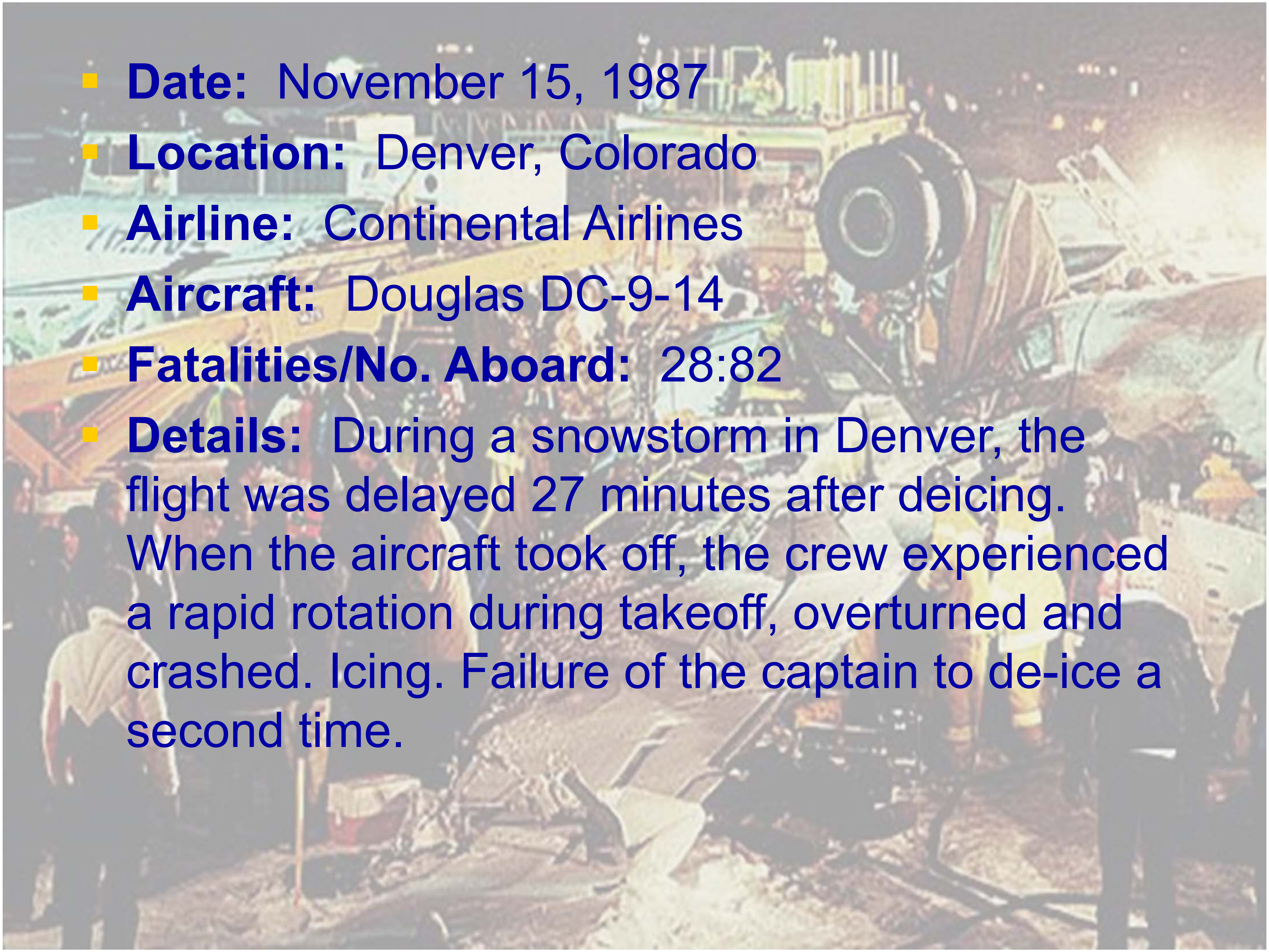
- **Date:** March 17, 1979
- **Location:** Moscow, Russia, USSR
- **Airline:** Aeroflot
- **Aircraft:** Tupolev TU-104B
- **Fatalities/No. Aboard:** 90:90
  - **Details:** The aircraft crashed in freezing rain and fog shortly after taking off.



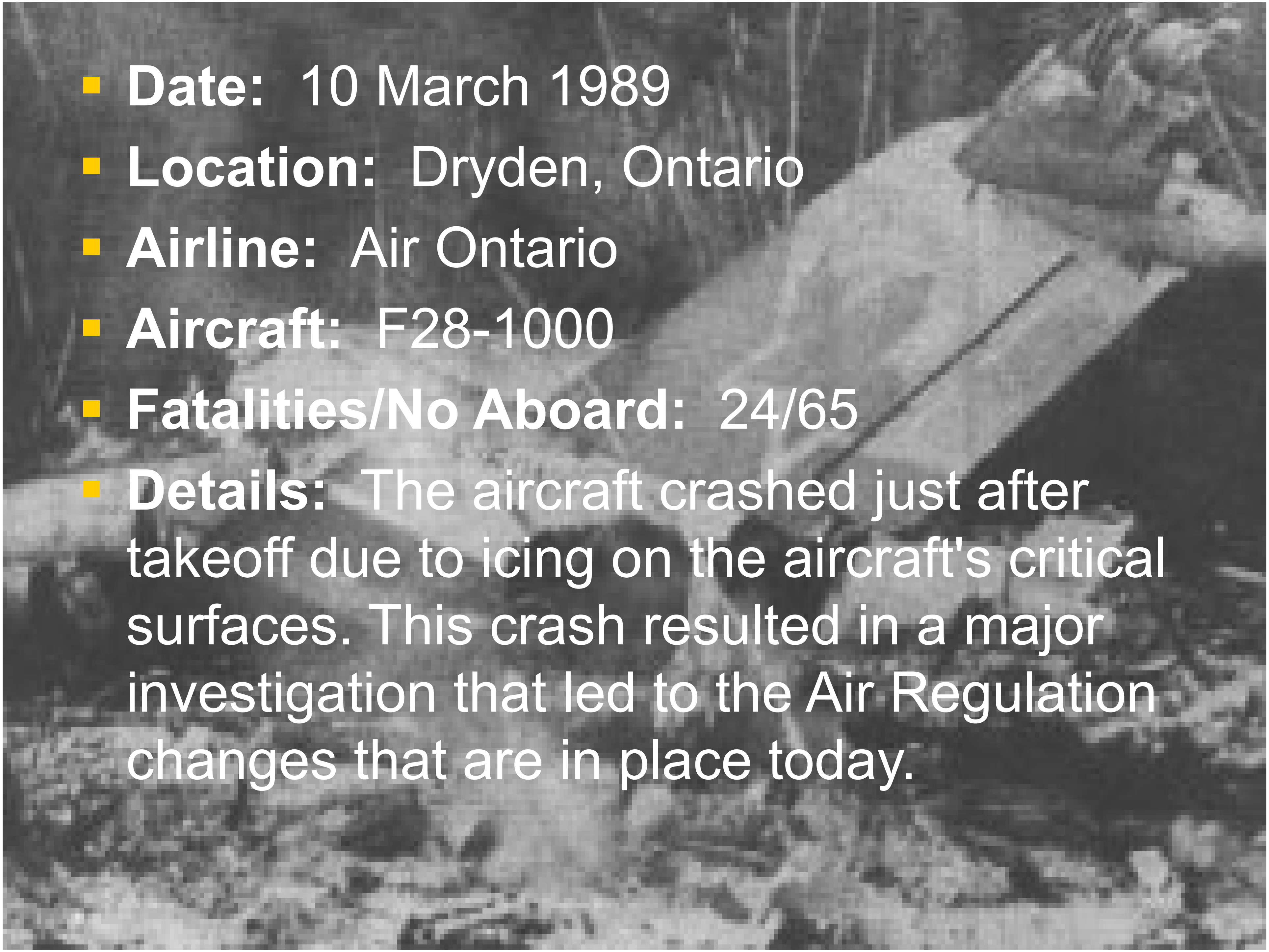


- **Date:** January 13, 1982
- **Location:** Washington, D.C.
- **Airline:** Air Florida
- **Aircraft:** Boeing 737-200
- **Fatalities/No. Aboard:** 74:79 + 4

- **Details:** The aircraft crashed into the 14th St. bridge and the Potomac River and sank shortly after taking off from Washington National Airport. The aircraft reached a peak altitude of 300 ft. The causes were the crew's failure to use the engine anti-icing system during takeoff and failure to de-ice the plane a second time before takeoff with snow/ice on the critical surfaces of the aircraft. Ice that accumulated on the engine pressure probes resulted in erroneously high Engine Pressure Ratio (EPR) readings. When the throttles were set to takeoff EPR, the engines were actually developing significantly less than takeoff thrust. The crew's inexperience in icing conditions was a contributing factor.



- **Date:** November 15, 1987
- **Location:** Denver, Colorado
- **Airline:** Continental Airlines
- **Aircraft:** Douglas DC-9-14
- **Fatalities/No. Aboard:** 28:82
- **Details:** During a snowstorm in Denver, the flight was delayed 27 minutes after deicing. When the aircraft took off, the crew experienced a rapid rotation during takeoff, overturned and crashed. Icing. Failure of the captain to de-ice a second time.



- **Date:** 10 March 1989
- **Location:** Dryden, Ontario
- **Airline:** Air Ontario
- **Aircraft:** F28-1000
- **Fatalities/No Aboard:** 24/65
- **Details:** The aircraft crashed just after takeoff due to icing on the aircraft's critical surfaces. This crash resulted in a major investigation that led to the Air Regulation changes that are in place today.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- **Date:** 22 March 1992
- **Location:** New York, NY
- **Airline:** USAir
- **Aircraft:** F28-4000
- **Fatalities/No Aboard:** 27/51
- **Details:** The aircraft crashed just after takeoff due to icing on the aircraft's wings. The aircraft was departing from La Guardia airport in snowy conditions

Air Law/Clean Aircraft Concept

- the degradation in aircraft performance when frozen contaminants are present are wide-ranging and unpredictable. Contamination makes no distinction between large aircraft, small aircraft

- Frost, ice or snow on critical surfaces of an aircraft such as wings, propellers and stabilizers can have a significant impact on the operation of an aircraft. The aircraft can be affected in two ways.

- The additional weight of the ice or snow adds to the total weight of the aircraft, increasing the lift required for the aircraft to take off.

- The formation of frost, ice or snow also changes the airflow over the wing, reducing the overall lift a wing can produce.

Clean Aircraft Concept

- **Aircraft Icing**
- **602.11 (1)** In this section, "critical surfaces" means the wings, control surfaces, rotors, propellers, horizontal stabilizers, vertical stabilizers or any other stabilizing surface of an aircraft and, in the case of an aircraft that has rear-mounted engines, includes the upper surface of its fuselage.
- **(2)** No person shall conduct or attempt to conduct a take-off in an aircraft that has frost, ice or snow adhering to any of its critical surfaces.
- **(3)** Notwithstanding subsection (2), a person may conduct a take-off in an aircraft that has frost adhering to the underside of its wings that is caused by cold-soaked fuel, if the take-off is conducted in accordance with the aircraft manufacturer's instructions for take-off under those conditions.
- **(4)** Where conditions are such that frost, ice or snow may reasonably be expected to adhere to the aircraft, no person shall conduct or attempt to conduct a take-off in an aircraft unless
- *(a)* for aircraft that are not operated under Subpart 5 of Part VII,
- (i) the aircraft has been inspected immediately prior to take-off to determine whether any frost, ice or snow is adhering to any of its critical surfaces, or
- (ii) the operator has established an aircraft inspection program in accordance with the *Operating and Flight Rules Standards*, and the dispatch and take-off of the aircraft are in accordance with that program; and

- **(5)** The inspection referred to in subparagraph (4)(a)(i) shall be performed by
- *(a)* the pilot-in-command;
- *(b)* a flight crew member of the aircraft who is designated by the pilot-in-command; or
- *(c)* a person, other than a person referred to in paragraph (a) or (b), who
- (i) is designated by the operator of the aircraft, and
- (ii) has successfully completed an aircraft surface contamination training program pursuant to Subpart 4 or Part VII.
- **(6)** Where, before commencing take-off, a crew member of an aircraft observes that there is frost, ice or snow adhering to the wings of the aircraft, the crew member shall immediately report that observation to the pilot-in-command, and the pilot-in-command or a flight crew member designated by the pilot-in-command shall inspect the wings of the aircraft before take-off.
- **(7)** Before an aircraft is de-iced or anti-iced, the pilot-in-command of the aircraft shall ensure that the crew members and passengers are informed of the decision to do so.

Clean Aircraft Concept

- If the Pilot-in-Command (PIC) cannot confirm that the aircraft is “clean”, takeoff must not be attempted until confirmation is obtained that the aircraft is free of frozen contaminants
- This requirement may be met if the PIC obtains verification from properly trained and qualified personnel that the aircraft is ready for flight

Clean Aircraft Concept

- The Clean Aircraft Concept is essential in maintaining flight safety
- PIC has the ultimate responsibility to determine if the aircraft is in a condition for safe flight.
- Flight crewmembers, ground or maintenance personnel, or any other operational personnel shall report frozen contamination adhering to the aircraft, to the PIC.

- Combination of reduced lift and increased weight have crucial safety consequences even with small amounts of ice or snow.
- During takeoff, frost, ice or snow formations having a thickness and surface roughness similar to medium or coarse sandpaper, on the leading edge and upper surface of a wing, can reduce wing lift by as much as 30% and increase drag by 40%.
- A significant part of the loss of lift can be attributed to leading edge contamination. The changes in lift and drag significantly increase stall speed, reduce controllability and alter aircraft flight characteristics.

- There is no such thing as a little ice.

Theory and Aircraft Performance

Theory and Aircraft Performance

- a very small amount of roughness, in thickness as low as 0.40 mm (1/64 in.), caused by ice, snow or frost, disrupts the air flow over the lift and control surfaces of an aircraft
- consequences of this roughness is severe lift loss, increased drag and impaired maneuverability, particularly during the take off and initial climb phases of flight
- Ice can also interfere with the movement of control surfaces and add significantly to aircraft weight as well as block critical aircraft sensors

Cold Soaking Phenomenon

- Ice can form even when the outside air temperature (OAT) is well above 0°C (32°F).
- Wing fuel tanks may have fuel that is at a sufficiently low temperature such that it lowers the wing skin temperature to below the freezing point
- Liquid water coming in contact with a wing, which is at a below freezing temperature, will freeze to the wing surfaces.

Cold Soaking Phenomenon

- rain or high humidity can cause ice to form on the cold-soaked wing and accumulate over time
- This ice can be invisible to the eye and is often referred to as clear ice.
- frost can form on the upper and lower wing under conditions of high relative humidity

- Note - A layer of slush on the wing cannot be assumed to flow off the wing on takeoff and must be removed. This layer can also hide a dangerous sheet of ice beneath.

Contamination Formation

- Contamination on the wing is dependent on the type, depth and liquid content of precipitation, ambient air temperature and wing surface temperature.

- The following factors contribute to the formation intensity and the final thickness of the ice layer:

- low temperature of the fuel uplifted by the aircraft during a ground stop and/or the long airborne time of the previous flight resulting in a situation that the remaining fuel in the wing tanks is subzero. Fuel temperature drops of up to 18°C have been recorded after a flight of two hours;

- weather conditions at the ground stop, wet snow, drizzle or rain with the ambient temperature around 0°C is very critical. Heavy freezing has been reported during drizzle or rain even in a temperature range between +8°C to +14°C.

- Skin temperature should be increased to preclude formation of ice or frost prior to take-off. This is often possible by refueling with warm fuel or using hot Freezing Point Depressant (FPD) fluids, or both

- Ice or frost formations on upper or lower wing surfaces must be removed prior to take-off
- The exception is that take-off may be made with frost adhering to the underside of the wings provided it is conducted in accordance with the **aircraft manufacturer's instructions**
- In the case of our company, we may NOT take off with frost adhering to the underside of the wings.

- Frost, ice or snow formations on an aircraft may decrease the lift and alter the stall and handling characteristics. Aircraft may become airborne in ground effect but be unable to climb.

Frozen Contaminants and Holdover Time Guidelines

Freezing Rain

- Hold Over Times for aircraft anti-icing fluids have not been evaluated under moderate and heavy freezing rain conditions and aircraft have not been certified to fly in freezing rain conditions.
- The ability of an aircraft to continue to fly safely in these conditions is questionable

Freezing Drizzle

- Aircraft anti-icing fluids provide greater protection for freezing drizzle than for freezing rain, but similar caution should be exercised as high winds or high taxi speeds can increase the effective precipitation rate for freezing drizzle.
- Freezing drizzle can also be so light that it is almost imperceptible

Ice Pellets

- These is a type of precipitation consisting of transparent or translucent pellets of ice, 5 mm or less in diameter. They may be spherical, irregular, or (rarely) conical in shape. Ice pellets usually bounce when hitting hard ground, and make a sound upon impact
- Ice pellets include two fundamentally different types of precipitation, which are known in the United States as (a) sleet, and (b) small hail.

Sleet

- Sleet or grains of ice: Generally transparent, globular, solid grains of ice which have formed from the freezing of raindrops or the refreezing of largely melted snowflakes when falling through a below-freezing layer of air near the earth’s surface.

Small Hail

- Small hail: Generally translucent particles, consisting of snow pellets encased in a thin layer of ice. The ice layer may form either by the accretion of droplets upon the snow pellet, or by the melting and refreezing of the surface of the snow pellet. It is believed that the ice pellets are capable of penetrating the fluid and have enough momentum to contact the aircraft's surface beneath the fluid. Additionally, the ice pellets are of significant mass and therefore local dilution of the fluid by the ice pellet would result in the very rapid failure of the fluid

Snow Pellets

- These are a kind of precipitation, which consists of white and opaque grains of ice. These grains are spherical or sometimes conical; their diameter is about 2-5 mm. Grains are brittle, easily crushed. They do bounce and break on hard ground

Hail

- Precipitation of small balls or pieces of ice with a diameter ranging from 5 mm to greater than 50 mm falling either separately or agglomerated

Frost

- CAR 602.11(3) states: Notwithstanding subsection (2), a person may conduct a take-off in an aircraft that has frost adhering to the **underside** of its wings that is caused by cold-soaked fuel, if the take-off is conducted in accordance with the aircraft manufacturer's instructions for take-off under those conditions.

Hoarfrost

- Is a uniform thin white deposit of fine crystalline texture, which forms on exposed surfaces during below-freezing, calm, cloudless nights with the air at the surface close to saturation but with no precipitation. The deposit is thin enough for surface features underneath, such as paint lines, markings and lettering, to be distinguished

Snow

- The meteorological approach to estimating snow rate has always been based on visibility alone.
- Use of visibility in snow as the sole criteria for establishing snowfall rate/intensity is invalid.
- Visibility and temperature pair needs to be used for establishing more accurate snowfall rates.
- The highest snowfall rates occur near 0°C.

Lighting	Temperature Range		Visibility in Snow (Statute Miles)			
	°C	°F	Heavy	Moderate	Light	Very Light
Darkness	-1 and above	30 and above	≤ 1	> 1 to 2½	> 2½ to 4	> 4
	Below -1	Below 30	≤ 3/4	> 3/4 to 1½	> 1½ to 3	> 3
Daylight	-1 and above	30 and above	≤ ½	> ½ to 1½	> 1½ to 3	> 3
	Below -1	Below 30	≤ 3/8	> 3/8 to 7/8	> 7/8 to 2	> 2

- Snowfall rate will be used to determine which HOT Guideline value will be appropriate for the fluid in use

HOT Tables

- The snow column in the HOT tables indicates the range of holdover times for light to moderate snowfall rates. **The maximum snowfall rate covered by the HOT guidelines is moderate**

Holdover Time Guidelines

- Holdover Time tables are referred to as holdover time guidelines because this term more appropriately represents their function in providing guidance to flight crew and the need for the flight crew to use judgment in their interpretation

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- Holdover time guidelines provide an estimate of the length of time anti-icing fluids will be effective in preventing frost, ice, slush or snow from adhering to treated surfaces . Because holdover time is influenced by a number of factors, established times may be adjusted by the pilot-in-command according to the weather or other conditions
- Holdover time is calculated as the beginning of the final application of the anti-icing fluid, and as expiring when the fluid is no longer effective

Hold Over Times

- Air Operators' manuals must describe the procedures to be followed for using holdover time guidelines. When the guidelines are used as decision-making criteria, the procedures to be followed by the pilot-in-command for varying the established values must also be specified.

- The estimated time is expressed as a range in the guidelines and is based upon the type and concentration of the specific fluid, the outside air temperature, and the kind and intensity of precipitation involved. The HOT guidelines are applicable to an aircraft experiencing ground icing conditions and are not applicable to airborne icing conditions

- The time that the fluid remains effective in ensuring a safe take-off is the time from **first application** of anti-icing fluid on a clean wing until such time as ice crystals form or remain in the fluid creating a surface roughness for take-off that deteriorates the performance or controllability of the aircraft

- Holdover time cannot be precisely determined because it depends on many variables. Some of the variables include: prevailing environmental conditions, variation in precipitation intensity, temperature, wind effects and the humidity, aircraft type and its configuration, effectiveness of the treatment on surfaces, taxiing direction relative to the wind and jet blast from other aircraft. The effects of these variables need to be taken into account by the pilot when establishing the HOT value. There is no simple solution to this complex issue

Establishing the HOT Range

- Establishing the appropriate HOT time range will require the acquisition of at least the following information:
  - Choose the precipitation type
  - Determine the precipitation rate; (for snow use the visibility table)
  - Note the fluid in use, including:
    - Fluid Type; and
    - Fluid manufacturer
  - The fluid dilution must be determined; and
  - OAT must be noted.
- Using this information, enter the appropriate HOT guideline and identify the HOT cell containing the full range of times available

Deicing/Anti-icing Fluids

- The most common techniques for removing frozen precipitation from aircraft critical surfaces and protecting the aircraft against re-contamination are accomplished with aircraft deicing and anti-icing fluids called Freezing Point Depressant (FPD) fluids.
- Deicing and anti-icing fluids should not be used unless approved by the aircraft manufacturer

- If frost, ice or snow is adhering to an aircraft surface, the accumulation can be melted by repeated application of proper quantities of heated FPD fluid.
- As the ice melts, the FPD mixes with the water, thereby diluting the FPD. As dilution occurs, the resulting mixture may begin to run off the aircraft.
- If all the ice is not melted, additional application of FPD becomes necessary until the fluid penetrates to the aircraft surface.
- When all the ice has melted, the remaining liquid residue is a mixture of FPD and water at an unknown concentration.
- The resulting film could freeze (begin to crystallize) rapidly with only a slight temperature decrease.
- If the freezing point of the film is found to be insufficient, the deicing procedure must be repeated until the freezing point of the remaining film is sufficient to ensure safe operation.

- The deicing process can be sped up considerably by using the physical energy of high-pressure spray equipment and heat, as is the common practice.

- Deicing is a procedure by which frost, ice, snow or slush (i.e. the frozen contamination) is removed from an aircraft by use of a heated aircraft deicing fluid (ADF), to provide clean surfaces
- Anti-icing is a procedure in which an aircraft anti-icing fluid (AAF) is applied to a surface free of frozen contaminants in order to protect the surface from the accumulation of frozen contaminants for a limited period of time

- Aircraft must be deiced shortly prior to take-off. When operating under icing conditions from sites not equipped with a deicing facility, aircraft operators are responsible for carrying the appropriate anti-icing and deicing equipment on board the aircraft or store the equipment at the airport. If conditions are too severe, pilots are required not to attempt a take-off.

Fluid Description

- Aircraft deicing/anti-icing fluids consist of four types. They are Type I, II, III, and IV. The various types all have different physical and chemical properties and their use is aircraft specific.

- Deicing fluids are typically ethylene glycol, diethylene glycol or propylene glycol based fluids containing water, corrosion inhibitors, wetting agents and dye. These fluids are formulated to assist in removing ice, snow and frost from the exterior surfaces of aircraft. They also provide a short period of anti-icing protection.

- Anti-icing fluids are similar in composition except that they also contain polymeric thickeners. They are formulated to prevent formation of unabsorbed frozen contamination for a longer period of time than deicing fluids; however, the protection is still for a limited period of time

- The Society of Automotive Engineers (SAE) and the International Standards Organization (ISO) have specifications for ADFs and AAFs
- Transport Canada recognizes only the most up-to-date SAE specifications, and all fluids applied to aircraft must meet these specifications.

- Qualified fluids have undergone laboratory testing to meet performance specifications and to confirm their aerodynamic acceptability. They have also been subjected to endurance time tests from which the holdover guidelines have been developed
- **The operator is ultimately responsible for ensuring that only qualified fluids are used.**

- FPD fluids are either pre-mixed (diluted with water) by the manufacturer or mixed by the user from bulk supplies. To ensure known freezing characteristics, samples of the final mixture should be analyzed before use. FPD fluid manufacturers can supply methodology and suggest equipment needed for quality control examinations

- The ratio of FPD fluid to water, or fluid strength, is a significant factor in the deicing fluid properties. HOT tables present guidelines for holdover times achieved by SAE Type I, SAE Type II, Type III and Type IV fluids as a function of fluid strength, weather conditions and outside air temperature (OAT).
- **Caution:**
- ***Do not* use pure (100%) ethylene glycol or pure propylene glycol fluids in non-precipitation conditions.**

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- Pure ethylene glycol or pure propylene glycol have a much higher freezing point than ethylene glycol diluted with water. Slight temperature decreases can be induced by factors such as cold-soaked fuel in wing tanks, reduction of solar radiation by clouds obscuring the sun, wind effects, and lowered temperature during development of wing lift;

- Undiluted propylene glycol, having a strength of about 88% glycol at temperatures less than -10°C (+14°F), is quite viscous. In this form, propylene glycol based fluids have been found to cause lift reductions of about 20%.

- Propylene glycol FPD fluids are not intended to be used in the undiluted state unless specifically recommended by the aircraft manufacturer

Recommended Practices

- The fluids must be used in accordance with the Approved Ground Icing Program. Application should respect the fluid manufacturers instructions and be applied in accordance with the most recent version of the SAE Aerospace Recommended Practice
- The basic philosophy of using FPD fluids for aircraft deicing is to decrease the freezing point of water in the liquid or crystal (ice) phase

Colour

- Colours are used as a visual aid in the application of fluids to aircraft surfaces. SAE fluid specifications indicate the appropriate colour for each of the Types of fluids, as follows:
- Type I fluids: Orange colour.
- Type II fluids: Colourless or a pale Straw colour.
- Type III fluids: TBA.
- Type IV fluids: Emerald Green colour.

- **If the colour of the fluid being applied to the aircraft is NOT the colour anticipated, the procedure should be stopped and the situation investigated**

SAE Type I Fluids (Orange)

- These fluids in the concentrated form contain a minimum of 80% glycol and are considered "unthickened" because of their relatively low viscosity. These fluids are used for deicing or anti-icing, but provide **very** limited anti-icing protection.
- **Note: It is the heat contained by the Type I (de-ice) fluid and the hydraulic forces that removes the frozen contaminants. The glycol provides some protection during precipitation conditions until Type II, III or IV fluid is applied**

- Warning:
- Extra vigilance is required by Flight Crews when conducting operations after spraying with Type I fluids only. Flash freeze over (fluid failure) can occur in a very short period of time after the HOT expires, even in very light precipitation conditions. This results in a contaminated critical surface and an unsafe condition for flight.

SAE Type II Fluids (Clear or Pale Straw)

- Fluids such as those identified as SAE Type II will last longer in conditions of precipitation and afford greater margins of safety if they are used in accordance with aircraft manufactures' recommendations.
- SAE Type II fluids should be used on aircraft with rotation speeds (Vr) above 100 knots

- SAE Type II fluids should not be applied unless the aircraft manufacturer has approved their use, regardless of rotation speed
- SAE Type II fluids are considered "thickened" because of added thickening agents that enable the fluid to be deposited in a thicker film and to remain on the aircraft surfaces until the time of take-off

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- Type II fluids provide greater protection (holdover time) than do Type I fluids against frost, ice or snow formation in conditions conducive to aircraft icing on the ground
- effective anti-icers because of their high viscosity and pseudo-plastic behavior. They are designed to remain on the wings of an aircraft during ground operations, thereby providing anti-icing protection

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- during a take-off run, their viscosity decreases drastically, allowing the fluids to flow off the wings and causing little adverse effect on the aircraft's aerodynamic performance.
- SAE Type II fluids, if applied with improper equipment, may lose 20 to 60% of their anti-icing performance

- All Type II fluids are not necessarily compatible with all Type I fluids. Therefore, refer to the fluid manufacturer or supplier for compatibility information. As well, the use of Type II fluid over badly contaminated Type I fluid will reduce the effectiveness of Type II fluid.

Type III Fluids (TBA)

- Type III is a thickened FPD fluid that has properties that lie between Types I and II. Therefore, it provides a longer holdover time than Type I but less than Type II. Its shearing and flow off characteristics are designed for aircraft that have a shorter time to rotation making it acceptable for some aircraft that have a Vr exceeding 60 knots

- The SAE has approved a specification for Type III anti-icing fluids that can be used on those aircraft with rotation speed significantly lower than the large jet rotation speeds, which are 100 knots or greater. Type III may be used for anti-icing purposes on low rotation speed aircraft, but only in accordance with aircraft and fluid manufacturer's instructions

SAE Type IV Fluids (Emerald Green)

- Type IV anti-icing fluids meet the same fluid specifications as the Type II fluids and have a significantly longer HOT. Therefore, SAE Type IV fluids should be used on aircraft with rotation speeds (Vr) above 100 knots

- Deicing and/or anti-icing fluid remaining on the aircraft following the deicing and/or anti-icing operation have an affect on the aerodynamic performance of any aircraft.
- As the temperature decreases, fluids generally become more viscous and have an increased negative effect on the aerodynamics.
- As an aircraft gains speed on its take off run the aerodynamic shear forces cause the fluids to flow off the aircraft's surfaces.
- The amount of fluid that is sheared off the aircraft depends upon the speeds reached during the take off run and the time it took to reach those speeds.

Freezing Point

- As the concentration of the fluid is increased from 0% upwards, by volume, the freezing point decreases. At some point as the concentration is increased towards 100%, the freezing point starts to increase
- The reason for this tendency is that a solution has a lower freezing point than a pure solvent. Research has indicated that if the fluid is not applied correctly, the HOT guideline values are not achievable.

Qualified Fluids

- A list of qualified deicing and anti-icing fluids is included on the TC website in the Transport Canada HOT guidelines. If reliable holdover times are to be achieved, only qualified fluids, stored, dispensed and applied in accordance with the manufacturers' instructions are acceptable.

- When HOT guidelines are used in determining safe take-off criteria the operator of the aircraft is ultimately responsible for ensuring that only qualified fluids are used

Lowest Operational Use Temperature (LOUT)

- Just as an aircraft has a specific operating envelope within which it is approved to be operated, de/anti-icing fluids are also tested and qualified for operation within a specific temperature envelope

- The LOUT for a given fluid is the *higher* of:

- The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type, or

  The actual freezing point of the fluid plus its freezing point buffer of 10°C, for a Type I fluid, and 7°C for a Type II or IV fluid.

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- **Manufacturers state that a fluid must not be used when the outside air temperature or skin temperature is below the LOUT of the fluid.**

- An example of establishing a LOUT. Lets take as an example a Type I fluid that has met the aerodynamics acceptance test down to -45°C.
- The reported freezing point of the fluid (as measured by the Deicing Operator) is -43°C. The OAT is -39°C.
- Can this fluid be used to de-ice the aircraft under these conditions?

- The LOUT for a given fluid is the *higher* of:

- The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type, in this case -45°C; or

  The actual freezing point of the fluid plus a freezing point buffer of 10°C, in this case -43°C + 10°C = -33°C.
- **The LOUT is -33°C and since the OAT is -39°C, *this fluid as is, can't be used*.**

Type II and Type IV Fluid Dryout

- Dryout may occur with repeated use of Type II and Type IV fluids without prior application of hot water or without a heated Type I fluid mixture. The result can be that fluid will collect in aerodynamically quiet areas or crevices
- There have been reported incidents of restricted movement of flight controls surfaces, while in flight, which has been attributed to fluid dryout. Further testing has shown that diluted Type II and Type IV fluids can produce more of a gel residue than neat fluids

Preventative Measures and Deicing Procedures

Hangars

- The best method of ensuring that an aircraft is clean of contamination is by preventing the contamination from collecting in the first place; that is, park the aircraft in a hanger

- If precipitation is present, care must be taken to reduce the skin temperature to below freezing prior to taking the aircraft from the hanger.
- This can be accomplished by opening the hanger doors prior to rolling the aircraft out.
- Depending on the facility, it may be possible to apply anti-icing fluids prior to departing the hangar.

- Parking a fully or partially fuelled aircraft in a heated hangar presents special considerations
- The temperature of the fuel will gradually rise towards the ambient temperature of the hangar
- wing surface will assume the temperature of the fuel

- temperature effect will be present for an extended time period while the fuel cools once the aircraft is exposed to the outside temperature
- When precipitation is present, the warm surface can cause snow and sleet to warm and stick to the wing or to melt
- In this instance the application of deicing/anti-icing fluids may be the only effective solution

- Should the aircraft be placed in a heated hangar ensure it is completely dry when moved outside, otherwise, pooled water may refreeze in critical areas or on critical surfaces.

Wing Covers

- Wing covers can be an effective way to prevent the build up of contamination on wings.
- Wing covers, although effective, have some drawbacks.
- Extreme care is required in both installation and removal of the covers in order to avoid damage to the aircraft.
- Depending on the aircraft type, ladders or a similar device are required during installation and removal of covers; and in inclement weather safety is a concern when climbing ladders due to the possibility of slipping.

- Installing covers on wings that are already contaminated often leads to problems.
- Requirement for a large area to store the covers and allow them to dry (i.e. a place to hang them).
- There have also been problems of wings “sweating” while covered, and then having the covers freeze to the wings.

Manual Methods

- Manual methods of snow removal should be used whenever possible, as long as safety is not compromised. There are a wide variety of devices available to assist in the removal of frozen contaminants from aircraft. Factors such as temperature, amount of contamination, wind conditions, and contaminant location must be taken into account when choosing the method.

- Under extremely low temperatures, the use of glycol based fluids is limited (refer to the fluid manufacturers' specifications for details). In these circumstances, manual methods may be the only option.
- Some of the more common devices are:

  Brooms

  Brushes

  Ropes

  Scrapers

Brooms

- Care must be taken to ensure the bristles are sturdy enough to be effective, yet not so stiff as to do damage to the skin of the aircraft.
- The broom that is to be used to sweep snow from the aircraft should not be used to sweep floors as this can introduce unwanted foreign contaminants and chemicals to the aircraft surfaces.
- The broom should be used in a pulling motion from leading edge to trailing edge

Scrapers

- handles of this type of scraper will often make contact with the wing, care must be taken to protect the wing.
- This can be accomplished by covering the handle with a foam wrap.
- scraper should be used in a pulling motion from leading edge to trailing edge

Ropes

- Ropes are another method of removing contamination (usually light frost) from wings and horizontal tailplanes.
- The method requires a seesaw motion back and forth across the surface to remove the contaminants.

Portable Forced Air Heaters

- Heat from a portable forced air heater can effectively remove frost and ice from critical surfaces
- The operator directs the airflow from a flexible duct onto the contaminated surface and the combined effect of the heated air and low velocity airflow melts and evaporates contaminants

- This technique has the effect of briefly warming the wing surface and can cause snow or other contaminants to stick to the surface when precipitation is present.
- Any water tends to refreeze quickly as no FPD fluids are used.
- Ensure aircraft is completely dry when moved outside, otherwise, pooled water may refreeze in critical areas or on critical surfaces.

Hand Sprayers

- Deicing fluid is mixed with hot water to remove contamination from the aircraft.
- This is done from the top of the aircraft down and in a symmetrical fashion.
- Follow all guidance material listed in the flight manual for normal procedures.

- Caution:
- Proper fluid coverage is absolutely essential for proper fluid performance. It is imperative that the personnel applying the fluid are properly trained and that a consistent fluid application technique is utilized.

- Common practice over many years of experience is to deice and, if necessary, anti-ice an aircraft as close to the time of take-off as possible
- Deicing process is intended to restore the aircraft to a clean configuration so neither degradation of aerodynamic characteristics nor mechanical interference from contaminants will occur.

Deicing and Anti-Icing the Airframe

- Heating FPD fluids increases their deicing effectiveness; however, in the anti-icing process unheated fluids are more effective because the thickness of the fluids is greater.

- Deicing and anti-icing with FPD fluids may be performed as a one-step or two-step process, depending on predetermined practices, prevailing weather conditions, concentration of the FPD used and available deicing and anti-icing equipment and facilities.

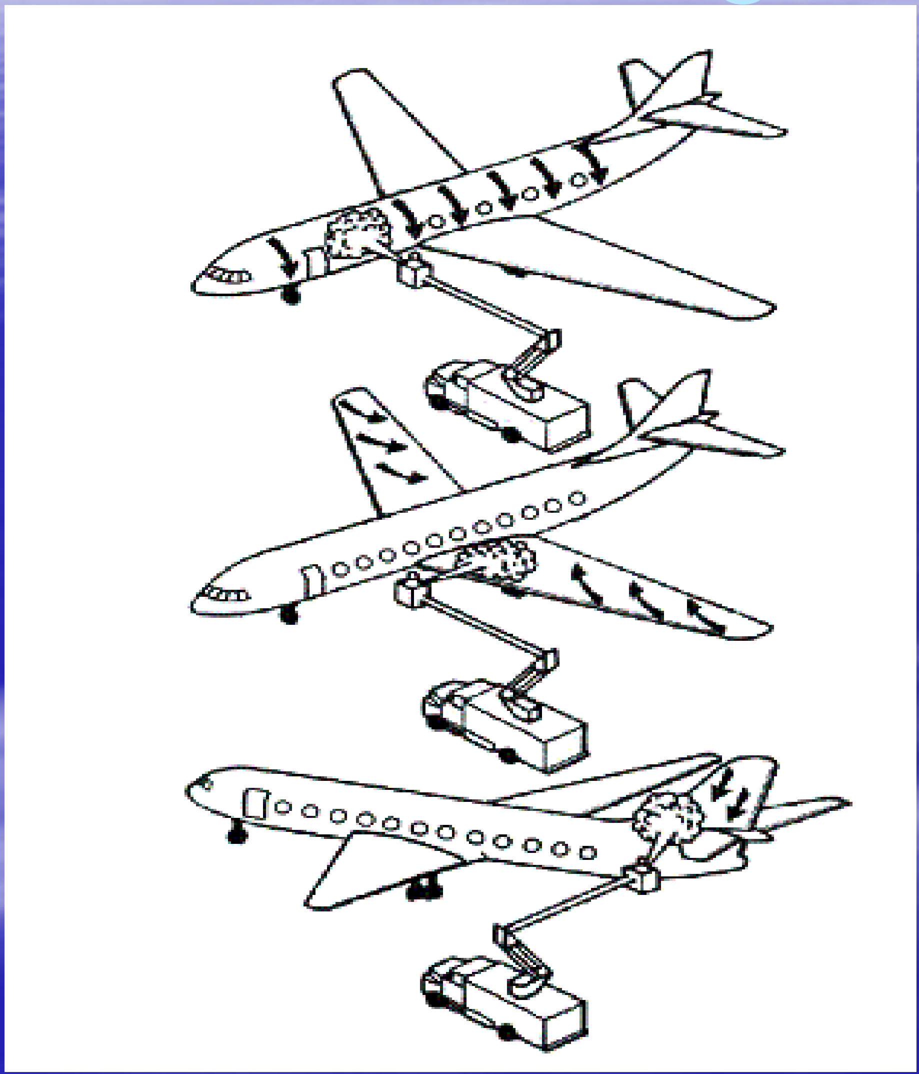
- The **one-step method** is accomplished using a heated FPD mixture. In this process, the residual FPD fluid film provides a very limited anti-icing protection.

- The **two-step procedure** involves both deicing and anti-icing.
- Deicing is accomplished with hot water or a hot mixture of FPD and water. The ambient weather conditions and the type of accumulation to be removed from the aircraft must be considered when determining which deicing fluid to use.
- The second (anti-icing) step involves applying a mixture of SAE Type II, III or IV and water to the critical surfaces of the aircraft.

- Anti-icing fluid should typically be applied within 3 minutes of deicing with a heated deicing fluid.
- The effectiveness of Types II, III and IV fluids can be seriously diminished if proper procedures are not followed when applying it over Type I fluid.

- Under no circumstances should SAE Type II, III or IV fluids, be applied directly to the following areas of an aircraft:
- Pitot heads, static ports and angle-of-attack sensors;
- Control surface cavities;
- Cockpit windows and the nose of fuselage;
- Lower side of the radome underneath the nose;
- Air inlets and intakes; and
- Engines.

Deicing Technique



- Generally, the fuselage should be de-iced and anti-iced from the top down.
- Spraying the upper section with heated FPD fluid first allows the fluid to flow down, warming the sides of fuselage and removing accumulations.
- This is also effective when deicing the windows and cockpit windshield of the aircraft. Direct spraying of these surfaces can cause thermal shock, resulting in cracking

- On many aircraft, deicing of the wing begins at the leading edge wing tip, sweeping in the aft and inboard direction.
- For aerodynamic reasons, ensure that the deicing and anti-icing procedures are conducted in a symmetrical fashion
- If ice accumulation is present in areas such as flap tracks and control cavities, it may be necessary to spray from the trailing edge forward. Also, under some weather or ramp conditions, it is necessary to spray from trailing edge. Consult the aircraft manufacturer for specific details

- Taxiing in wet/slush conditions, even after de/anti icing, may contaminate flap/slat and landing gear door/sensor surfaces and may cause takeoff and/or after takeoff problems. Most Manufacturers recommend that flap/slat devices be deployed just prior to takeoff and taxi speed reduced to minimize splashed contaminants from freezing to landing gear door/sensor surfaces

- The tail surfaces require the same caution afforded the wing during the deicing procedure. It is important that both sides of the vertical stabilizer and rudder be de-iced because it is possible for directional control problems to develop on certain aeroplanes if the contamination is removed from one side only.

- The following list are some of the major variables that can influence the effectiveness of FPD fluids, especially when the fluids are being diluted by precipitation:
- Aircraft component inclination angle, contour, and surface roughness;
- Ambient temperature;
- Aircraft surface (skin) temperature;
- FPD fluid application procedure;
- FPD fluid aqueous solution (strength);
- FPD fluid film thickness;
- FPD fluid temperature;
- FPD fluid type;
- Operation in close proximity to aircraft, equipment or structures;
- Operation on snow, slush or wet ramps, taxiways or runways;
- Precipitation type and rate;
- Presence of FPD fluids;
- Radiation cooling;
- Residual moisture on the aircraft surface;
- Relative humidity;
- Solar radiation; and
- Wind speed and direction.

- A PIC of an aircraft holds the ultimate responsibility for ensuring that his aircraft takes off in a safe manner; and in the case of ground icing conditions, the PIC must ensure that his aircraft’s critical surfaces are free of frozen contaminants.
- It is important therefore that the Deicing Operator understand what specific requirements a pilot has in the pursuit of his duties during ground icing conditions.

Sufficient Lead Time

- Communication between the pilot and the Deicing Operator, as soon as possible in advance of the aircraft arriving at the deicing location, ensures that the deicing operation will be accomplished in the safest and most efficient manner, for both the flight crew and the ground crew.

Exchange of Vital Information Prior to the Deicing/Anti-Icing Fluid Application

- Prior to commencement of the deicing/anti-icing operation, certain vital information will need to be shared and acknowledged between the Deicing Operator and the PIC, to ensure that the aircraft is treated correctly, in a safe manner, and with a safe result.
- In order to ensure that these basic criteria are met, the following items, dealing with the exchange of information between the pilot and the deicing crew, should be accomplished prior to commencing the operation:

- Communication established between deicing crew and pilot.
- Confirmation that brakes are set and aircraft correctly configured for the type of deicing being accomplished (e.g. engines at idle, propellers feathered, bleed systems correct, etc.).
- Confirmation of the deicing/anti-icing methodology being used.
- Confirmation of type of fluid(s) to be applied to aircraft.
- Confirmation of fluid mixture ratio, if applicable.
- Communication of any last minute cautionary or advisory information deemed pertinent to the impending deicing/anti-icing operation.
- Confirmation from the Deicing Operator to the PIC that deicing/anti-icing operations are about to commence.
- Time noted at the start of anti-icing fluid application. This is required by the PIC for the commencement of HOT timing. The Deicing Operator should note the time and advise the PIC

Pre De/Anti-icing

- Prior to commencing deicing activities the PIC must advise the passengers.
  CAR 602.11(7) states: "before an aircraft is de-iced or anti-iced, the pilot-in-command of the aircraft shall ensure that the crew members and passengers are informed of the decision to do so".

- The start time of the final application of anti-icing fluid to the aircraft must be relayed in a clear and concise manner to the PIC. The PIC will use this time to establish the beginning of the holdover time (HOT).

Communicating Problems to the PIC

- The Deicing Operator must routinely provide information to the PIC, which typically includes: the final anti-icing fluid application start time, the type of fluid used, and information on the contamination status of the critical surface (i.e. clean or contaminated).

- However, the following are examples of other times when information of a critical nature needs to be relayed to the pilot. The ground icing training program needs to address circumstances such as these and describe the correct response.
- Damage or potential damage to the aircraft.
- The inadvertently spraying of sensitive aircraft parts.
- Notice of risk or injury to the Deicing Operator personnel

Post De/Anti-icing

- Under ground icing conditions, this inspection is mandatory. This inspection must be accomplished upon completion of the deicing/anti-icing operation. A report shall be made to the PIC of the aircraft. The ground icing program must describe how this inspection will be accomplished

Departure Notification for the Flight Crew

- Following a deicing/anti-icing treatment of the aircraft and confirmation that the Critical Surface Inspection has been completed, and that the aircraft is free of frozen contaminants, the pilot will need the following information from the deicing crew:
- Confirmation that all staff and equipment are clear of the aircraft.
- Authorization to start engines (if applicable).
- Authorization to unfeather propellers (if applicable).
- Notification to switch to hand signals (if applicable

Critical Surface Inspections

- Critical surface inspections should be performed immediately after final application of the anti-icing fluid to verify that the aircraft critical surfaces are free of contamination.
- Areas to be inspected depend on the aircraft design and should be identified in a critical surface inspection checklist.
- The checklist should include, at a minimum, all items recommended by the aircraft manufacturer.
- While some items may not be critical surfaces their proper operation is required and must be clean of contaminants.
- Generally, a checklist of this type includes the following items:

- Wing leading edges, upper surfaces, and lower surfaces;
- Vertical and horizontal stabilizing devices, leading edges, upper surfaces, lower surfaces, and side panels;
- High lift devices such as leading edge slats and leading or trailing edge flaps;
- All control surfaces and control balance bays;
- Propellers;
- Engine inlets, particle separators, and screens;
- Windshields and other windows necessary for visibility;
- Antennae;
- Fuselage;
- Exposed instrumentation devices such as angle of attack vanes, pitot-static pressure probes and static ports;
- Fuel tanks and fuel cap vents;
- Cooling air intakes, inlets, and exhausts; and
- Landing gear

- Once it has been determined through the critical surface inspection that the aircraft is clean and adequately protected, the aircraft should be released for take-off as soon as possible.
- This procedure is especially important in conditions of precipitation or high relative humidity.
- Pilot must be informed when contamination of the aircraft critical surfaces still exists and that further deicing is required.
- Pilot's decision to terminate the flight may be based solely upon information obtained from the Deicing Operator.

Pre-Take-off Contamination Inspection

- As required by regulations, immediately prior to take-off, a pre-take-off inspection shall be made to determine whether frost, ice or snow is adhering to any of the aircraft critical surfaces
- The pilot may need the assistance of qualified personnel to perform this inspection
- **If, under any circumstances, the PIC cannot ascertain that the critical surfaces are free of any adhering frost, ice or snow, take-off must not be attempted.**

- If any aircraft surfaces have not been treated with FPD fluid, the PIC or another crew member should look for and examine any evidence of melting snow and possible refreezing. In addition, any evidence of ice formation that may have been induced by taxi operations should be removed
- If the aircraft has been treated with FPD fluid, aircraft surfaces should appear glossy, smooth, and wet.
- Frost, ice or snow on top of deicing or anti-icing fluids must be considered as adhering to the aircraft and take-off must not be attempted. In this case, the aircraft should be returned for additional deicing and, where appropriate, anti-icing.

Take-off After Holdover Times Have Been Exceeded

- In accordance with the operator's program, take-off may occur after holdover time has been exceeded only if a pre-take-off contamination inspection is conducted and it is determined that critical surfaces are not contaminated.
- Subparagraph 602.11(4)(a)(i) of the **Canadian Aviation Regulations (CARs)** states: "The aircraft has been inspected immediately prior to take-off to determine whether any frost, ice or snow is adhering to any of its critical surfaces".

- Transport Canada's interpretation of the phrase "inspected immediately prior to take-off", in the ground icing context, is that the inspection must be conducted within **five minutes prior to beginning of the take-off roll**.
- Fluid testing has indicated that this procedure must not be applied to Type I fluids. Type I fluids have very short HOT performance and fluid failure occurs suddenly.

- The procedure should only be applied to Types II, III and IV anti-icing fluids and then only when the pertinent minimum holdover time equals or exceeds 20 minutes.
- **This practice is not intended to be used continuously every 5 minutes but as a one time only condition after hold over times have been exceeded.**
- **If, after conducting the contamination inspection, it is not possible to take-off within five minutes, the aircraft must return for deicing/anti-icing.**

Failed Fluid Recognition

- A fluid is considered failed when it is no longer able to absorb frozen precipitation. Under these circumstances it must be assumed that the contamination is adhering to the critical surfaces
- Upon recognition of a failed fluid the aircraft must return for further de/anti-icing or take-off delayed until the weather improves and the contamination melts.

- Failed fluids can be difficult to recognize in that a layer of clear ice may have formed under the fluid. This clear ice can usually only be detected by a tactile inspection. A failed fluid will usually lose all its glossiness and resemble a dulled crystalline appearance. While snow fall on a wing may be readily apparent, the clear ice that may have formed underneath is not. Snow that has accumulated on a wing on top of de/anti-ice fluids means the fluid has failed and will not “blow off” on the takeoff roll. Similarly, Type I fluid when used alone, can refreeze in a matter of a few minutes after the holdover time has expired under certain precipitation conditions (especially freezing drizzle and freezing rain). The appearance is of a dulled rough coating of frost

Wake Up