WINTER OPERATIONS REVIEW

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INTRODUCTION

Regulations were established by the Civil Aeronautics Board (CAB) in 1950 prohibiting takeoff of aircraft when frost, snow, or ice is adhering to wings, propellers, or control surfaces of the aircraft. These regulations remain in effect as cited under FAR **135.629, 91.209** and 121.629. The basis of these regulations, which are commonly referred to as the clean aircraft concept, is known degradation of aircraft performance and changes of aircraft flight characteristics when ice formations of any type are present. These effects are wide ranging, unpredictable, and dependent upon individual aircraft design. The magnitude of these changes is dependent upon many variables and is thus unpredictable, but these changes can be significant. Wind tunnel and flight tests indicate that ice, frost, or snow formations on the leading edge and upper surface of a wing, having a thickness and surface roughness similar to medium or coarse sandpaper, can **reduce wing lift by as much as 30 percent and increase drag by 40 percent.** These changes in lift and drag will significantly increase stall speed, reduce controllability and alter aircraft flight characteristics. Thicker or rougher ice accumulations in the form of frost, snow, or ice deposits influence is surface roughness relative to critical portions of an aerodynamic surface. It is therefore imperative that take off not be attempted unless it has been ascertained, as required by regulation, that all critical components of the aircraft are free of the aircraft are free of adhering snow, frost, or other ice formations.

Most transport aircraft used in commercial transportation as well as some other aircraft types are certificated for flight in icing conditions. Aircraft so certificated have been designed and demonstrated to have the capability of penetrating supercooled cloud icing conditions in the forward flight regime. This capability is provided either by ice protection equipment installed on the critical surfaces (usually the leading edge) or demonstration that ice formed, under supercooled cloud icing conditions, on certain unprotected components will not significantly affect aircraft performance, stability and control. Ice, frost, or snow formed on these surfaces **on the ground** can have a totally different effect on aircraft flight characteristics than ice formed in flight. Exposure to weather conditions on the ground that are conducive to ice formation can also cause accumulation of frost, snow, or ice on ice protected areas of the aircraft that are designed for inflight use only and that are not designed for use during ground operation. In addition, aircraft are considered airworthy and are certificated by the FAA only after extensive analyses and testing have been accomplished. With the exception of analyses and testing to ascertain the flight characteristics of an aircraft during flight in icing conditions, all analyses and certification testing are conducted with a clean aircraft flying in a clean environment. If ice formations are present, other than those considered in the certification process, the airworthiness of the aircraft may be invalid and no attempt should be made to fly the aircraft until it has been restored to the clean configuration. **The ultimate responsibility for this determination rests with the pilot in command of the aircraft.**

Common practice developed by the North American and European aviation community over many years of operational experience is to **deice an aircraft prior to takeoff**. Various techniques of ground deicing were also developed. The most modern of these techniques is use of **Freezing Point Depressant (FPD)** fluids to aid the ground deicing process and to provide a protective film of FPD (anti-icing) to delay formations of frost, snow, or other ice. The practice developed and accepted by the North American air carrier industry using traditional North American fluids is to ensure that the remaining film has **a freeze point of at least 20ºF below ambient temperature.**

In the Fractional industry, we have a large number aircraft being dispatched many different airports all around the world. Our points of dispatch are rarely the same. Assuring airworthiness must be a team effort where each member of the team has specific duties and responsibilities. In all cases, **the PIC has the ultimate responsibility of ascertaining that the aircraft is in a condition for safe flight.**

Effect of Icing on Aircraft Control

It is important that a pilot understand the conditions that are conducive to icing. An understanding of these conditions allows the pilot to evaluate the available weather data and make an educated decision as to whether an intended flight should be made. One of the best sources of available weather data is pilot reports. The Federal Aviation Administration encourages all pilots to report their flight conditions when warranted.

For ice to form, there must be moisture present in the air and the air must be cooled to a temperature of 0ºC (32ºF) or less. Aerodynamic cooling can lower the temperature of an airfoil to 0ºC even though the ambient temperature is a few degrees warmer. **Generally speaking, anytime the OAT is 50ºF (10ºC) or less and there is visible moisture present, or when there is standing water, ice, snow or slush on the airport surfaces, the pilot should be alert to icing.** However, when the temperature reaches –40ºC (-40ºF) or less, it is generally too cold for ice to form. Ice is identified as clear, rime, or mixed.

Rime ice forms if the droplets are small and freezes immediately when contacting the aircraft surface. This type of ice usually forms on areas such as the leading edges of wings or struts. It has a somewhat rough looking appearance and is a milky white color.

Clear Ice is usually formed from larger water droplets of freezing rain that can spread over a surface. **This is the most dangerous type of ice** since it is clear, hard to see, and can change the shape of the airfoil. **Mixed ice** is a mixture of clear ice and rime ice. It has the bad characteristics of both types and can form rapidly. Ice particles become imbedded in clear ice, building a very rough accumulation.

The following table lists the temperature at which the various types of ice will form.

0º to -10ºC	CLEAR
-10ºC to -15ºC	CLEAR and RIME mix
-15ºC to –20ºC	RIME

There are two kinds of icing that are significant to aviation: **structural icing and induction icing**. Structural icing refers to the accumulation of ice on the exterior of the aircraft; induction icing affects the powerplant operation. Significant structural icing on an aircraft can cause aircraft control and performance problems. The formation of structural icing could create a situation from which the pilot might have difficulty recovering and, in some instances, may not be able to recover at all. To reduce the probability of ice buildup on the unprotected areas of the aircraft, a pilot should maintain at least the minimum airspeed for flight in sustained icing conditions. This airspeed will be listed in the airplane flight manual (AFM)

Structural icing can block the pilot tube and static ports and can cause the breakage of antennas on the aircraft. This can cause a pilot to lose or receive erroneous indications from various instruments such as the airspeed indicator and altimeter and can cause a loss of communications and radio navigation capabilities.

The **most hazardous aspect of structural icing is its aerodynamic effects.** Ice can alter the shape of an airfoil. This can cause control problems, change the angle of attack at which the aircraft stalls, and cause the aircraft to stall at a significantly higher airspeed. The stall warning may give erroneous indications. Ice can reduce the amount of lift that an airfoil will produce and increase drag several fold. Additionally, ice can partially block or limit control surfaces which will limit or make control movements ineffective. Also, if the extra weight caused by ice accumulation is too great, the aircraft may not be able to become airborne and, if in flight, the aircraft may not be able to maintain altitude.

For this reason, **Title 14 of the Code of Federal Regulations (14 CFR) prohibits takeoff when snow, ice, or frost is adhering to wings, propellers, or control surfaces of an aircraft. This clean aircraft concept is essential to safe flight operations.**

Another hazard of structural icing is the possible uncommanded and uncontrolled roll phenomenon referred to as **roll upset** that is associated with severe in-flight-icing. Pilots flying airplanes certificated for flight in known icing conditions should be aware that **severe icing is a condition that is outside of the airplane's certification icing envelope.** Roll upset may be caused by airflow separation (aerodynamic stall) inducing self-deflection of the ailerons and loss of or degraded roll handling characteristics. These phenomena can result from severe icing conditions without the usual symptoms of ice accumulation or a perceived aerodynamic stall.

The term **sever icing** is associated with the rapid growth rate of visible ice shapes most often produced in conditions of high liquid water content and combinations of other environmental and flight conditions. Severe icing is often accompanied by aerodynamic performance degradation such as high drag, aerodynamic buffet, and premature stall. Sever icing can be recognized in flight by freezing precipitation beyond the heated section of the wing.

In addition, **ice associated with freezing rain or freezing drizzle can accumulate on and beyond the limits of an ice protection system.** This kind of ice may not produce the familiar performance degradation; however, it may be potentially hazardous. Freezing rain and freezing drizzle contain droplets larger than the criteria specified by certification requirements. Temperatures near freezing can produce severe icing.

Ice detection is very important in dealing with icing in a timely manner. A careful preflight of the aircraft should be conducted to ensure that all ice or frost is removed before takeoff. This is especially true in larger aircraft where ice is difficult to see in some locations. Also, it is more difficult to detect ice during flight on such areas as the tail, which may be impossible to see. At night, aircraft can be equipped with ice detection lights that will assist in detecting ice. Being familiar with the airplane's performance and flight characteristics will also help in recognizing the possibility of ice. Ice buildup will require more power to maintain cruise airspeed. Ice on the tailplane can cause diminished nose up pitch control and heavy elevator forces, and the aircraft may buffet if flaps are applied. Ice on the rudder or ailerons can cause control oscillations or vibrations.

Airplane Deice and Anti-Ice Systems

When operating in icing conditions on the ground or in flight, a pilot must have knowledge of aircraft deicing and anti-icing procedures. **Deicing** is a procedure in which frost, ice, or snow is removed from the aircraft in order to provide clean surfaces.

Anti-icing is a process that provides some protection against the formation of frost or ice for a limited period of time. There are various methods and systems that are used for deicing and anti-icing. A pilot must be knowledgeable regarding the systems and the procedures to be used on the specific aircraft before operating in icing conditions.

There are numerous methods that are capable of removing ice from the aircraft surface. One method is pneumatic boots. This system is commonly used on smaller aircraft and usually provides ice removal for the wing and/or tail section by inflating a rubber boot. Ice can also be removed by a heat system or by a chemical fluid. Deicing the propeller is usually done by electrical heat, but it can also be done with a chemical fluid.

Anti-icing can be accomplished by using chemical fluid or a heat source. Anti-ice systems are activated before entering icing conditions to help prevent the ice from adhering to the surface. These methods provide protection for the wings, tail, propeller, windshield, and other sections of the aircraft that need protection

ICING ACCUMULATION TABLE

Icing Intensity	Accumulation	Pilot Action
Trace	Ice becomes perceptible. Rate of accumulation of ice is slightly greater than the rate of loss due to sublimation	Unless encountered for one hour or more, deicing/anti-icing equipment and/or heading or altitude change not required
Light	The rate of accumulation may create a problem if flight in this environment for one hour.	Deicing/anti-icing required occasionally to remove/prevent accumulation or heading or altitude change required
Moderate	The rate of accumulation is such that even short encounters become potentially hazardous	Deicing/anti-icing required or heading or altitude change required
Severe	The rate of accumulation is such that deicing/anti-icing equipment fails to reduce or control the hazard.	Immediate heading or altitude change required.

For an airplane to be approved for flight into icing conditions, the airplane must be equipped with systems that will adequately protect various components. There are two regulatory references to ice protection: the application to airplane type certification in 14 CFR parts 23 and 25 and the operating rules contained in 14 CFR parts 91 and 135.

Atmospheric Conditions and Icing

Supercooled clouds	Clouds that contain very small (5-100 microns) water droplets that have remained in liquid form yet the ambient temperature is below 32ºF (to as cold as -40ºF)
Ice crystal clouds	These clouds exist at very cold temperatures where the moisture has already frozen to the solid/crystal state.
Mixed conditions	Ambient temperatures below 32ºF and containing a mixture of ice crystals and supercooled water droplets.
Freezing rain and drizzle	Precipitation that exists within or below clouds at an ambient temperature below 32ºF. Freezing rain remains in the supercooled state. Freezing drizzle is different from freezing rain only in size of the water droplets.

Ice Accretion Information in METAR/SPECI

Currently, ASOS reports the occurrence of freezing precipitation but provides no information on the rate of accumulation (accretion). The National Weather Service (NWS) has developed a new algorithm, to be applied to the existing freezing rain sensor on ASOS, that can accurately measure the report the amount of surface ice accretion at a specific point over a given time period. The NWS plans to implement the new ice accretion algorithm for public forecast and warning purposes starting this year.

However, since the amount of ice accretion can vary widely from none to significant amounts over relatively small distances on and around an airport, the utility of this ice accretion information for tactical aviation decision making is highly uncertain. Therefore, the FAA provides this guidance to aviation users through operations inspectors regarding the application of this information to their operations.

As currently planned by the NWS, the ASOS Freezing Sensor and the newly developed ice accretion algorithm will generate information that will be included in the remarks section of an METAR or SPECI. This icing information will only be included on a METAR/SPECI when icing is detected.

The remarks section of a METAR/SPECI is prefaced by "RMK" and is located at the end of the report. A typical METAR/SPECI includes sections for Location, Date/Time, Wind, Visibility, Significant Weather, Clouds, Temperature/Dewpoint, Altimeter, and Remarks (RMK). There can be any number of items in the remarks section, such as peak wind, variable ceiling or visibility, funnel clouds, etc.

The icing information may appear before or after other information in the remarks section, depending on the priority of the information.

The icing information will appear in the **remarks section** of the METAR/SPECI in three segments:

1. The first segment will provide the ice accretion amount during the preceding hour
2. The second segment is the 3-hour ice accretion report, which presents the amount of ice accretion during the last 3 hours.
3. The third segment is the 6-hour ice accretion report, which presents the ice accretion amount during the last 6 hours.

All ice accretion amounts will be reported to the nearest one-hundredth of an inch (0.001 in.). An example of a 1, 3, 6-hour ice accretion remark would be: "I1010 I3015 I6022." This translates to 0.01 inches of ice in the last our, 0.15 inches of ice in the last 3 hours, and 0.22 inches of ice in the last 6 hours.

This information will be useful to NWS forecasters in producing public weather warnings as well as public and aviation weather forecasts. It can also be useful to aviation users by providing general awareness of possible icing conditions at the airport. However, this ice accretion information is from a single sensor at a single location and **cannot be considered representative of the overall icing potential for the airport surface as a whole.** Because icing can be highly localized, icing occurring at the ASOS sensor may not be occurring at the same rate or at all on the ramp. The localized variability in icing is due to such factors as differences in ground temperatures, winds, sheltering, and precipitation rates over short distances at airports. Therefore, **aviation users must recognize that ice accretion reports are useful for general awareness but should not be used as the basis for tactical decision making.**

Ice accretion remarks reported by ASOS should ***NOT*** be used as the basis for airplane deicing decisions. Carriers shall not be required to make any changes to anti-icing or de-icing procedures as a result of ice accretion information available from the ASOS.

SUMMARY

It is extremely important that pilots understand the dangers of aircraft icing. Even if an airplane is equipped and certificated to operate in known icing conditions, there are limitations, effects and appropriate training and experience in use of deice and anti-ice systems should be avoided. It is important to know both the pilot's and the airplane's limitations. Pilots should become familiar with the types of weather associated with and conducive to icing and understand aircraft systems, control, and performance. They should also know how to respond to the situation if accidentally caught in icing conditions. A knowledgeable pilot is better prepared to make timely decisions and promptly recognize the factors that can contribute to aircraft icing accidents.

ROLL UPSET

The following is a summary of the cues that a pilot should recognize and corrective actions that can be taken if the aircraft encounters an uncommanded or uncontrolled roll upset due to severe in-flight icing. It is based on the FAA's investigation of airplane accidents and incidents during or after flight in freezing rain or freezing drizzle conditions causing severe in-flight icing. The term **"supercooled large droplets" (SLD)** includes freezing rain or freezing drizzle.

The most effective means to identify severe icing are cues that can be seen, felt, or heard. The general information provided in this appendix is intended to assist pilots in identifying inadvertent encounters with SDL conditions. The suggestions below are not intended to be used to prolong flight in conditions that may be hazardous. Because of the broad range of environmental conditions, limited data available, and various airplane configurations, pilots must use the manufacturer's airplane flight manual (AFM) for specific guidance on individual types of aircraft.

<u>Detecting SLD</u>

1. Ice visible on the upper or lower surface of the wing aft of the heated leading edges. It may be helpful to look for irregular or jagged lines or pieces of ice that are self-shedding. All areas to be observed need adequate illumination for night operation

2. Granular dispersed ice crystals or total translucent or opaque coverage of the unheated portions of the front or side windows. This may be accompanied by other ice patterns on the windows such as ridges. These patterns may occur within a few seconds to one-half minute after exposure to SLD conditions.

3. Unusually extensive coverage of ice, visible ice fingers, or ice feathers on parts of the airframe not normally covered by ice.

Additional Cues Significant at Temperatures near Freezing:

1. Visible rain (consisting of very large water droplets). In reduced visibility conditions, select taxi/landing lights “ON” occasionally. Rain may also be detected by the sound of droplets impacting the aircraft.

2. Droplets splashing or splattering on impact with the windshield. Droplets covered by icing certification envelopes are so small that they are usually below the threshold of detectability. The largest size of the drizzle droplets covered is about the diameter of a 0.5mm pencil lead.

3. Water droplets or rivulets streaming on heated or unheated windows. The droplets or rivulets are an indication of high liquid water content HLWC of any sized droplet.

4. Weather radar returns showing precipitation. Returns showing precipitation suggest that increased vigilance for all of the cues is warranted. Evaluation of the radar may provide alternative routing possibilities.

Roll Upset Prevention/Correction

Before Takeoff:

1. Know the pilot weather reports (PIREP) and the forecast.

2. Know where the potential icing conditions are located in relation to the planned route and which altitudes and directions are likely to be warmer or colder. About 25% of the cases of SLD are found in stratiform clouds colder than 0ºC at all levels with a layer of wind shear at the cloud top. There need not be a warm melting layer above.

In Flight:

1. Maintain awareness of the outside temperature. Know where the freezing level static air temperature (SAT) is located. Be especially alert for severe ice formation at total air temperature (TAT) near 0º C or warmer (when the SAT is 0º C or colder) many icing events have been reported at these temperatures.
   a. SAT is what would be measured from a balloon and is the temperatures given in a forecast.
   b. TAT is measured by a probe having velocity with respect to the air. Because of heating due to compression upstream of the probe, the total temperature will be warmer than the SAT. The difference is kinetic heating or the so-called “ramrise”. There is less kinetic heating in saturated air than in dry air because it takes less heat to raise the same unit mass by one degree. TAT and SAT are normally associated with air data systems.

2. Avoid exposure to SLD icing conditions, usually at temperatures warmer than -10º C (+14ºF) SAT but possible at temperatures down to -18º C (-1º F) SAT. Be alert for cues and symptoms of SLD at temperatures down to -15º C (+5 º F) SAT. Normally, temperature decreases between approximately 1.5ºC (2.7º F) for saturated air to 2.75ºC (5ºF) for dry air with each 1,000 foot increase in altitude. In an inversion, temperature may actually increase with altitude.

Actions when Exposed to SLD Conditions:

1. Disengage the autopilot. Hand-fly the airplane. The autopilot may mask important cues or may self disconnect and present unusual attitudes or control conditions.

2. Advise air traffic control and promptly exit the condition, using control inputs that are as smooth and small as possible.

3. Change heading, altitude, or both to find an area that is warmer than freezing, substantially colder than the current ambient temperature, or clear of clouds. In colder temperatures, there may still be ice that has not completely shed adhering to the airfoil. It may be hazardous to make rapid descents close to the ground to avoid severe icing conditions.

4. When severe icing conditions exist, reporting may assist other crews in maintaining vigilance. Submit a PIREP of the observed icing conditions. It is important not to understate the conditions or effects of the icing observed.

Roll Control Anomaly:

1. Reduce the angle of attack (AOA) by increasing airspeed or extending wing flaps to the first setting if at or below the flaps extend speed (VFE). If in a turn, roll wings level.

2. Set appropriate power and monitor the airspeed/AOA. A controlled descent is a vastly better alternative than an uncontrolled descent.

3. If Flaps are extended, do not retract them unless it can be determined that the upper surface of the airfoil is clear of ice because retracting the flaps will increase the AOA at a given airspeed.

4. Verify that wing ice protection is functioning normally and symmetrically by visual observation of the left and right wing. If not, follow manufacturer's instructions.

Roll Upset Summary

Roll upset may occur as a consequence of, or prior to, a wing stall due to anomalous forces that cause the ailerons to deflect or because the ailerons have lost effectiveness. Deflection of ailerons or loss of aileron effectiveness may be caused by ice accumulating in a sensitive area of the wing aft of the protected area under unusual conditions associated with SLD and, rarely, normal cloud droplets in a very narrow temperature range near freezing.

Pilots can minimize the chance of a roll upset by being sensitive to cues that identify severe icing conditions and promptly exiting the severe icing conditions before control or handling characteristics of the airplane are degraded to a hazardous level.

It is important to review the AFM for aircraft type-specific information. Also, pilots should check any available icing related bulletins from the airplane manufacturer.

Warning: This document describes two types of upset: roll upset and tailplane stall (pitch upset). The procedures for recovery from one are nearly opposite those for recovery from the other. Application of the incorrect procedure during an event can seriously compound the event. Correct identification and application of the proper procedure is imperative.

PITCH UPSET (Tailplane Stall)

Introduction

On some airplane designs, if the horizontal tailplane is inadequately cleared of ice, either by anti-ice/deice system failure, failure to operate the system properly, or by ice, snow, or frost left on critical sections of the airfoil, a tailplane stall could occur.

Accident records have shown that ice-induced tailplane stall have been reported with as little as 3/16" –1" ice on the tail surfaces. And yet, other pilots have landed safely in the same type airplane with 3-6" of ice on the leading edges! The type and texture of the ice, its location, approach speed, flap settings, and pilot technique are all variables.

The airfoil on the horizontal stabilizer is generally better at collecting ice than the main wing because it has a smaller leading edge radius. There have been reports of ice tail buildup 3-6 times that of the wing! Even if the ice was building up at the same rate, its effect on the tail is magnified because of the shorter chord.

What's Happening?

The normal flow of air over the wings creates a downwash over the horizontal stabilizer. This gives the tail "lift", but since the horizontal stabilizer airfoil is upside down, the lift generated is downward. This is normal and gives the airplane its stability. The addition of flaps will normally increase the downwash and create a nose pitch up tendency. However, when there's ice on the horizontal stabilizer it may cause the tail to stall!

As the airflow over the horizontal stabilizer is disrupted by ice, flow separation occurs on the bottom of the airfoil. The downforce or "lift" that normally would be produced is actually reduced due to the stall of the airfoil. Without this downforce, the aircraft nose now has a tendency to pitch down.

A tailplane stalls when the maximum negative AOA for the tailplane is exceeded. You'll know this has happened because you'll see or feel a nose down trim change and it will probably occur after the addition of flaps. This may require a very large nose up force of anywhere from 100-400 lbs. And if you're at a low enough altitude you may not have sufficient time or room to recover. Not all airplanes have the same susceptibility to tailplane stall. The worst designs for icing have aerodynamically balanced/assisted elevators, small leading edge radii, highly effective flaps, and an airfoil design that is sensitive to contamination (highly efficient airfoils).

Generally, **tailplane stall would be encountered** immediately after extension of the trailing edge flaps to an intermediate position or, more commonly, **after extension from an intermediate position to the full down position.** Usually, tailplane stall (or impending stall) can be identified by one or more of the symptoms listed below occurring during or after flap extension. The symptom(s) may occur immediately or after nose down pitch, airspeed changes, or power increases following flap extension.

Tailplane Stall Symptoms

1. Elevator control pulsing, oscillations, or vibrations*
2. Abnormal nose down trim change*
3. Any other unusual or abnormal pitch anomalies (possibly resulting in pilot-induced oscillations) *
4. Reduction or loss of elevator effectiveness*
5. Sudden change in elevator force (control would move nose down if unrestrained)
6. Sudden uncommanded nose down pitch

*May not be detected by the pilot if the autopilot is engaged.

Tailplane Stall Corrective Actions

1. Immediately retract the flaps to the previous setting and apply appropriate nose up elevator pressure.
2. Increase airspeed appropriately for the reduced flap extension setting.
3. Apply sufficient power for aircraft configuration and conditions. (High engine power may adversely impact response to tailplane stall conditions at high airspeed in some aircraft designs. Observe the manufacturer's recommendations regarding power settings.)
4. Make nose down pitch changes slowly, even in gusting conditions, if circumstances allow.

Warning: Once a tailplane stall is encountered, the stall condition tends to worsen with increased airspeed and possibly may worsen with increased power settings at the same flap setting. Airspeed, at any flap setting, in excess of the airplane manufacturer's recommendations, accompanied by uncleared ice contaminating the tailplane, may result in a tailplane stall and uncommanded pitch down from which recovery may not be possible. A tailplane stall may occur at speeds less than Vfe

Tailplane Stall Summary

Ice can form on the aircraft's tail at a greater rate than on the wing and can exist on the tail when no ice is visible on the wing. If ice is permitted to gather on the stabilizer

Warning: Freezing rain, freezing drizzle, and mixed conditions (snow and/or ice particles and liquid droplets) may result in extreme ice buildp on and aft of protected surfaces, possibly exceeding the capability of the ice protection system. Freezing rain, freezing drizzle, mixed conditions, and descent into icing conditions in clouds from above freezing temperatures may result in runback ice forming beyond protected surfaces where it cannot be shed and may seriously degrade airplane performance and control.

leading edge, the maximum lift capacity may be reduced as much as 50% and the tail

may stall at normal approach speeds. If a complete tail stall is obtained, the aircraft may go into a near vertical dive.

When ice is visible, do not allow ice thickness to exceed the operating limits for deicing system operation or the system may not shed the tail ice. If the control symptoms listed above are detected or ice accumulations on the tail are suspected, land with a lesser flap extension setting and increase airspeed commensurate with the lesser flap setting. Avoid uncoordinated flight (side or forward slips) and, to the extent possible, restrict crosswind landings because of the possible adverse effect on pitch control and the possibility of reduced directional control. Avoid landing with a tailwind component because of the possibility of more abrupt nose down control inputs. Increased landing distances must also be considered because of increased airspeed at reduced flap settings.

Anti-ice/De-ice FPD Fluid Types and Characteristics

The application of deicing/anti-icing fluid is the most common means of effecting ground deicing and anti-icing protection. These fluids are water/glycol mixtures and classified as Type I (deice), and Type II, Type III, Type IV, (all anti-ice). Type III is not currently used on any of our aircraft.

The FAA and the International Standards Organization (ISO) issue specifications that define the composition and characteristics of these fluids. For all practical purposes they are identical. General information about these fluids is shown below.

Type	Color	Viscosity	Solution	Comments
I	Red	Low	50%/50% Glycol/water	Heated, usually de-ice only. VERY limited holdover times
II	Clear	Medium	50%, 75% or 100%	Most common
IV	Emerald Green	High	50%, 75% or 100%	50% to 100% greater holdover times than Type II, depending on solution strength.
IV Ultra+ ®	Emerald Green	High	100% only	

Additionally:

- Most icing related accidents have occurred when the aircraft was not de-iced before takeoff attempt. A pretakeoff check may be required before takeoff roll is initiated.
- Heated solutions of FPD, water, or both are more effective in the deicing process than unheated solutions because thermal energy is used to melt the ice, snow, or frost formations. Unheated FPD fluids or aqueous solutions, especially SAE and ISO Type II, are more effective in the anti-icing process because the thickness of the final residue is greater.
- Ice, frost, or snow on top of de-icing or anti-icing fluids must be considered as adhering to the aircraft. Takeoff should not be attempted

- FPD fluids used during ground deicing or are not intended for, and do not provide, ice protection during flight.

- Flight tests performed by manufacturers of transport category aircraft have shown that most SAE and ISO Type II fluid flows off lifting surfaces by rotation speeds (Vr). Some large aircraft experience performance degradation and may require weight or other takeoff compensation. Degradation is significant on small airplanes. Some fluid residue may remain throughout the flight. The aircraft manufacturer should have determined that this residue will have little or no effect on aircraft performance or handling qualities in aerodynamically quiet areas. However, this residue should be cleaned periodically.

<u>Use of Holdover Tables</u>

Use of Holdover Tables in the AFM are based on several conditions:

1. ambient temperature
2. surface temperature
3. wind
4. precipitation type
5. precipitation intensity
6. Fluid type
7. Fluid concentration and temperature
8. Solar radiation
9. Radiational cooling

It's important to remember that the use of the tables is highly subjective and the final determination of the "correct" holdover time rests with the Captain. The HOT's can also let you know the right kind of fluid. If at any time there is an uncertainty as to whether or not the holdover time has been exceeded, the Captain should return to the de-ice area to get de-iced/anti-iced again. The time used to figure the appropriate holdover time begins at the first application of the anti-ice fluid. Holdover tables should be used in conjunction with a pre-takeoff or pre-takeoff contamination check.

A range is always given for each set of conditions. This allows for the varying intensities of the precipitation. For simplicity, try dividing the time frame into "threes". The beginning time is meant for heavy precipitation, the ending time is for light precipitation, and the middle, for moderate precipitation. Use the following table as a guide for falling **snow** intensities.

SNOWFALL INTENSITIES AS A FUNCTION OF VISIBILITY

Time of Day	Temp.		Visibility (Statute Mile)					
	(°C)	(°F)	≥1 1/4	1	3/4	1/2	≤1/4	
Day	≤ -1	≤ 30	Light	Light	Light	Moderate	**Heavy**	**Snowfall Intensity**
	> -1	> 30	Light	Light	Moderate	**Heavy**	**Heavy**	
Night	≤ -1	≤ 30	Light	Light	Moderate	**Heavy**	**Heavy**	
	> -1	> 30	Light	Moderate	**Heavy**	**Heavy**	**Heavy**	
NOTE: Based upon technical report, "The Estimation of Snowfall Rate Using Visibility," Rasmussen, et al., Journal of Applied Meteorology, October 1999.								

However, the chart is only a guide. Please consider the following reprint from the *USA today* when comparing visibility.

"Dangerous Ice Can Form in "light" Snow"

Researchers at the National Center for Atmospheric Research (NCAR) have found that **snow that appears light can sometimes create dangerous ground icing for aircraft.**

Roy Rasmussen, Jeffrey Cole, and Kevin Knight of NCAR's Research Applications Program, along with R. K. Moore and Murray Kuperman of United Airlines conducted a study of five takeoff accidents involving large jets, which showed how snow that appears light can be dangerous.

They found that the amount of water in the snow and the temperature were key to how much ice formed on aircraft. One of their most important findings was the visibility is not a good indication of how much water, and therefore how much icing danger; snow contains.

While the study involved commercial jet accidents, the same conditions would be potentially dangerous to any aircraft.

In the cases studied, dangerous ice formed when temperatures were between 25º-31ºF and snow was falling at the liquid-equivalent rate of 0.08 inches to .10 inch an hour. In other words, an hour's worth of snow would melt down to 0.08 to .10 inches of water.

The researchers also uncovered a secondary problem caused by the geometry of aircraft wings when winds were blowing between 9 and 15 mph. Planes typically taxi downwind – with the wind coming from behind them- to the takeoff runway in order to take off into the wind. When rain or snow is falling, any wind during the taxi to takeoff will blow the particles more directly onto the upper surface of the wing, which is typically angled at about 10 degrees from true horizontal.

"For the wind speeds observed during the aircraft accidents studied, the enhancement factor ranges from 1.75 to 2.0." says Rasmussen. In other words, a wind from behind the airplane can pack from 1.75 to 2 times as much snow on its wings than if the wind were calm. Thus, the **accumulation rate of snow on a wing can nearly double if a plane is pointed in the same direction as a 10-15 mph wind while taxiing to the takeoff runway.**

The researchers began by looking at 10 large jet-aircraft accidents in which ice on the wings was considered a contributing factor. In seven of the cases, weighing snow gauge data was available, which meant the researchers had data on water content. Of these, five were snow events and two were freezing drizzle events.

Freezing rain or freezing drizzle – liquid precipitation that turns to ice when it hits – can quickly build up thick accumulations of ice. But, in these cases the danger is more obvious than when snow is falling because ice tends to form on everything. Dry snow, typical of colder weather, isn't as dangerous as wet snow because the flakes blow off before sticking to anything, such as an airplane's wings.

The researchers studied these accidents:

* New York's LaGuardia Airport on March 23, 1992	F-28	snow
* Denver's Stapleton International Airport on Nov. 15, 1987	DC-9	snow
* Washington (D.C.) National Airport on Jan. 13, 1982	B-737	snow
* Boston's Logan International Airport on Feb. 18, 1980	Bristol 253	light snow fog
* Newark International Airport on Now. 27, 1978	DC-9	snow; fog

Four of the five crashes resulted in fatalities, ranging from 7 to 69 killed.

In all five cases, temperatures were between 25 and 31 degrees Fahrenheit, winds were between 10 and 15 miles per hour, and snow was falling at a liquid-equivalent rate of between 0.08 and 0.10 inches per hour, as measured in the hour preceding each crash. But visibility varied from ¼ mile in the Washington case to 2 miles in the Boston case.

Because weather stations report snowfall intensity based entirely on visibility, the snowfall in the five cases was reported as anywhere from "light" to "heavy", even though roughly the same amount of water equivalent was being deposited in each case.

A fluffy snowflake can obscure visibility up to ten times more than a small, dense flake holding the same amount of water. Thus, the different visibility in the five cases can be explained largely by the type of snow falling in each case.

The nearly identical liquid equivalent precipitation rate suggests that **accidents may be avoided if snowstorm periods with precipitation rate equal to or greater than this value are avoided**. This would require a real-time estimate of liquid equivalent snowfall rate to be available to ground operations coordinators and airline station control centers.[1]

Pilots and air traffic controllers may be misled by relatively good visibility when snowfall consists of dense, compact flakes that are actually depositing substantial amounts of frozen water onto aircraft, according to Rasmussen. It is this deposition that can cause ice accumulation on wings after deicing but prior to takeoff.

"**An accumulation of as little as 0.03 inch of ice on the upper wing surface can result in a 25% loss of lift** and increase in drag during takeoff rotation," says Rasmussen. The fluids used in de-icing can only protect aircraft from re-icing for a limited time, and delays caused by poor weather can prolong the time planes must wait before takeoff.

The study points out the high visibility immediately before the accident at New York's LaGuardia Airport was noted by the first officer of the aircraft. He described the snowfall as "not heavy, no large flakes." Since he did not have access to any real-time liquid equivalent precipitation rate, the only way he could make a judgment that the snow fall rate was not heavy was by visibility; and he even notes that there were no large flakes.

The LaGuardia weather observer characterized the snow as wet, which is consistent with the snowflakes having a high density, leading to the high precipitation rates observed. Rasmussen and colleagues have relayed their findings to major airlines. USAir and United Airlines were among the first to implement these results into their training materials for winter weather operations.

This research was sponsored by the National Science Foundation through an Interagency Agreement with the FAA's Aviation Weather Development Program.

FAA Approved Deicing Program Updates, Winter 2002-2003

This bulletin provides revised Types I, II, and IV fluid holdover time (HOT) guidelines that meet the Society of Automotive Engineers (SAE) qualifications and associated guidelines for the application of these deicing/anti-icing fluid mixtures. The FAA has revised HOT guidelines to reflect new test results for heated Type I fluids and to accommodate new Type II fluids. There are no changes to the Type IV HOT guidelines.

A listing of qualified Types I, II, and IV deicing/anti-icing fluids for the 2002-2003 winter icing season, including updated information.

NOTE: The SAE no longer publishes HOT guidelines. However, the FAA remains active in activities of the SAE G-12 Aircraft Ground Deicing HOT Sub-Committee to preclude any interruption in updated information or services that this committee provides.

HOT Guidelines

Included in Appendix 1 are revised FAA-approved HOT guidelines for SAE Types I, II, and IV fluids, as well as FAA-approved SAE guidelines for the application of these fluids. Because of the difference in performance of specific Types II and IV deicing/anti-icing fluids available for this winter season, the FAA also included twelve (four Type II and eight Type IV) manufacturers' specific HOT guidelines. The manufacturer specific Types II and IV HOT guidelines are as follows:

MANUFACTURER SPECIFIC TYPE II FLUIDS	MANUFACTURER SPECIFIC TYPE IV FLUIDS
KILFROST ABC 2000	KILFROST® ABC-S
KILFROST ABC II Plus	UNION CARBIDE® ULTRA+
OCTAGON E-MAX	OCTAGON® MAX-FLIGHT
SPCA ECOWING 26 Type II	SPCA AD-480 Type IV
	CLARIANT SAFEWING MP IV 1957
	CLARIANT SAFEWING MP IV 2001
	CLARIANT MP IV 2012 PROTECT
	CLARIANT SAFEWING FOUR

The FAA Types II (Table 2) and IV (Table 4) HOT guidelines comprise the **generic HOT values** and encompass the minimum (worst-case) HOT values for all fluids for a specific precipitation condition, temperature range, and fluid mixture concentration. Air carriers may only use the manufacturer specific HOT guidelines (Tables 2A-2D and Tables 4A-4H) when these specific fluids are used during the anti-icing process. If a carrier can not positively determine which specific Type II or IV fluid was used, it must use the HOTs from Table 2 or 4, as appropriate.

A new addition is Table 7, which is a visibility table relating various snowfall intensities. It presents critical information on the variability of snowfall intensities as a function of prevailing visibilities.

Type I HOT Guidelines

The FAA revised the format for Type I HOT guidelines (Table 1) for the 2002-2003 winter icing season.

The new HOT values of the guidelines are primarily based upon SAE revised test methodologies to accommodate the effects of applying heated Type I fluids in determining their time of effectiveness for the various freezing precipitation conditions. In prior years, Type I HOT values had been determined based upon the application of unheated fluids.

The revised Type I HOT Guideline includes two separate SNOW columns representing both light snow and moderate snow conditions.

Several changes have been made to the temperature ranges/bands. These revisions are based upon recently completed tests, sponsored by the FAA, Transport Canada (TC) and fluid manufacturers, in which heated Type I fluids were used in acquiring test data from which the HOT values were derived.

Recent findings indicated that the time of protection provided by Type I fluid, unlike Types II and IV, is directly related to the heat input to aircraft surfaces. Type I fluid dilutes rapidly under precipitation conditions. Therefore, the heat that the aircraft surface absorbs will tend to keep the temperature of the fluid above its freeze point. Values in the Moderate and Light Snow columns are based upon extensive tests conducted by APS Aviation of Montreal, Canada and the Anti-Icing Materials Laboratory of Chicoutimi, Quebec, Canada during the 2001-2002 winter icing season. Previously, SNOW HOT guideline values were based upon the current Moderate Snow conditions and a liquid equivalent snowfall rate of 1.0 to 2.54 mm/hr (.04 to .10 inch of liquid equivalent snow fall per hour.) The SAE G-12 committee has defined Light Snow as snow conditions less than 1.0 mm/hr (<.04 inches of liquid equivalent snowfall per hour). In the current FAA Type I HOT guideline, HOT values for snowfall intensities between 0.5 and 1.0 mm/hr (.02 to .04 in/hr) were selected for the Light Snow column.

This selection was based upon a number of factors, including:

- Snow intensity reporting and measurement inaccuracies for light conditions of <0.5mm/hr
- Potential wind effects
- Light snow variability
- Possible safety concerns associated with pretakeoff checks

Note that, in Table 1, there is a double diamond (Light Snow◆◆ and Moderate Snow◆◆)in the light and moderate snow columns with an accompanying note. The note states, **"TO USE THESE TIMES, THE FLUID MUST BE HEATED TO A MINIMUM TEMPERATURE OF 60 °C (140 °F) AT THE NOZZLE AND AT LEAST 1 LITER/M^2 (≈ 2 GALS/100FT^2) MUST BE APPLIED TO DEICED SURFACES."** When establishing compliance with the temperature requirement of 60 °C (140 °F) at the nozzle, the FAA does not intend for air carriers or deicing operators to continually measure the fluid temperature at the nozzle. The FAA deems establishing the temperature drop (at nominal flow rates) between the last temperature monitored point in the plumbing chain and the nozzle sufficient.

The FAA revised the temperature bands in Table 1. In prior Type I tables, the guidelines indicated temperature bands of above 0 °C, 0 to –10 °C, and below –10 °C. The revised Type I table (Table 1) incorporates temperature bands of –3 °C and above, below -3 to –6 °C, -7 to –10 °C, and below –10 °C.

The FAA eliminated the temperature range of "above 0 °C" because most of the Type I HOT values (except for snow) are determined in laboratory-climatic test facilities.

As such, conditions of Frost, Freezing Fog, and Freezing Drizzle could not be readily produced at temperatures above 0 °C in laboratory facilities. The FAA deemed that the elimination of the range of above 0 °C did not affect the HOT values of 2-5 minutes for the conditions of Light Freezing Rain and Rain on Cold-soaked Wing.
Dividing the 0 to –10 °C temperature range into temperature bands of –3 °C and above , below -3 to –6 °C, and –7 to –10 °C makes the longer HOT values in the below -3 to –6 °C temperature range available to the user. In prior Type I tables, the values used in the range of 0 to –10 °C were those at –10 °C. In most cases, this range produced shorter HOT values than at the warmer temperatures in the below -3 to –6 °C range. This is especially true for Freezing Drizzle, Snow, and Freezing Fog conditions. This did not affect the Frost and Light Freezing Rain HOT value. Overall, the user obtains more utility and flexibility from the addition of the other temperature ranges.

The FAA intends for HOT guidelines to provide an indication of the approximate length of time that a freezing point depressant (FPD) fluid will protect aircraft surfaces during icing conditions and while on the ground. The guidelines do not imply icing protection while airborne. **SAE II and SAE IV** have been termed **generic** or **worst-case tables**. Of all fluids tested for each type, the FAA has entered the lowest HOT value in each cell for each precipitation condition.
Therefore, for any brand of fluid, its HOT will be as good or better than the value in the appropriate worst-case chart. This can be important if the brand of fluid is not known.

The HOT of a FPD fluid is primarily a function of the OAT, precipitation type and intensity, and percent FPD fluid concentration applied. The icing precipitation condition (i.e., frost, freezing fog, snow, freezing drizzle, light freezing rain, and rain on a cold-soaked wing) implies that these meteorological conditions are active.

NOTE: All HOT values (except for snow) are determined in the lab under no-wind conditions. Generally, wind reduces HOT. Snow testing is conducted outdoors and may or may not involve varying winds. This can have varying effects on the test results.

For Types II and Type IV fluids, the percent mix is the amount of **neat fluid** (as marketed by the manufacturer) in water. A 75/25 mix is, therefore, 75 percent FPD fluid and 25 percent water.

NOTE: The FAA does not approve takeoff in conditions of moderate and heavy freezing rain.

The FAA also emphasizes that air carriers should read and understand all notes and cautions (such as the reference to the 10 °C (18 °F) buffer) in the guidelines to preclude improper usage of the fluid. The caution notes are important to manufacturers' specific tables because unique characteristics of a particular brand of fluid may warrant cautions not found in the generic or worst-case guidelines.

Tables 2() and 4() have a caution note (**) that states, "No holdover time guidelines exist for this condition below -10 °C (14 °F)." This statement informs the user that, although the temperature range is below "27 °F to 7 °F," the FAA does not consider HOT values valid below -10 °C (14 °F) for freezing drizzle and light freezing rain. These conditions usually do not occur at temperatures below –10 °C. On rare occasions when these conditions do occur at temperatures below –10 °C, you should use caution regarding HOT value usage.

There is only one HOT value entered under the FROST column for a given temperature band. Frost intensities or accumulations are low in comparison to other precipitation conditions and decrease at the colder temperatures. This usually results in HOTs for frost being considerably longer in comparison to HOTs for other precipitation conditions. The longer HOT should accommodate most aircraft ground operational requirements. Furthermore, when testing in the laboratory for frost, only one precipitation condition is considered rather than a range. Thus, there is no HOT range for frost. You should only use the single time, as with all the times in the tables, as a guide.

NOTE: HOTs for frost are for *active* frost conditions.

Unique HOT Guidelines

In the manufacturers specific Type IV HOT guidelines for MAXFLIGHT there is an increase of protection with a reduction in fluid concentration. In some cells under the SNOW, FREEZING DRIZZLE, and LIGHT FREEZING RAIN columns, the 75/25 concentration provides a moderate increase in protection over the 100/0 concentration. The addition of certain quantities of water to some neat fluids can enhance their performance up to a certain point. For example, when water is added to Octagon MAXFLIGHT. It allows the fluid to build up thicker on a surface. In this instance, thicker does not mean a higher viscosity. Without knowing about this particular fluid mix phenomenon, an air carrier may think that the data presented in the tables is an error.

Similar performance contradictions were observed (i.e., the 75/25 concentrations exceeded those of 100/0 concentrations) for the following fluids at FREEZING FOG conditions:

- Kilfrost ABC-II Plus
- Kilfrost ABC-2000 Type II
- Clariant Safewing MP IV 1957 Type IV fluids

Another unique fluid is Ultra+® Type IV (Table 4A). There are no HOT values for this fluid in the 72/25 and 50/50 concentrations (i.e., no dilutions.)

Snowfall Intensity - Visibility Table - Table 7. This table presents critical information on the variability of snowfall intensities as a function of prevailing visibilities. The HOT of any anti-icing fluid is directly related to the amount of moisture it can absorb before freezing. Currently, snow intensities reported by the National Weather Service are the best means of providing flight crews with information relating to the moisture content of precipitation. However, these snow intensities are typically based upon the prevailing visibility.

Snowflake density is a key factor in determining the moisture content of snow. Wet snow, which generally occurs at temperatures above –1 °C, has a greater density than dry snow. Also, being heavier, it will fall at a higher velocity than dry snow. Thus for a given visibility these two factor will cause wet snow to deposit more moisture than dry snow. Table 7 presents temperature correlation information, which more accurately relates wet snow and dry snow intensities to visibilities.

During night snowfall conditions for the same snowfall rate, visibility is about twice as good as it is during the day. This occurs because snow reflects light at a high rate and, during the day, light comes from all directions, which makes the reflections worse. At night there is less light and light rays are more directed toward you with a reduced glare and reflections. Therefore, Table 7 also presents a differentiation between day and night conditions to make visibility a more accurate indicator of moisture content for a given snowfall intensity and temperature. Therefore, you must consult Table 7 for an accurate estimation of snowfall intensity moisture content, which is based upon prevailing visibilities.

HOT Changes

The HOTs for Type I fluids have been changed significantly for the 2002-2003 winter icing season. These changes were presented earlier in this document.

Although there were three new Type II fluids, their performance did not lower the generic Type II HOT values that the FAA published in prior years.

The manufacturer specific HOT guideline for Clariant Safewing MP II 1951 was withdrawn by manufacturers' request because it was no longer produced at the higher viscosities (8,700cP) required to meet all HOT values in the manufacturer's specific table (Table 2B, published in last years FSAT 01-09). However, Clariant Safewing MP II 1951 is still being produced at a lower viscosity and meets all requirements for application of the FAA Type II HOT guideline (Table 2). Also, the FAA continues to list it in the list of qualified fluids (Table 6).

The FAA changes the application table for Type I fluid mixtures (Table 1A) to reflect the requirement for applying **heated** Type I fluid to the one and two step deicing/anti-icing procedures. The revised notes state:

> "**Mix of fluid and water heated to 60°C (140 °F) minimum at the nozzle, with a freeze point of at least 10°C (18 °F) below OAT."**

The caution note added for the 2000-2001 deicing season to Table 5, Guidelines for the Application of SAE Type II and Type IV Fluid Mixtures, is retained. This note reads:

> **"CAUTION: As fluid freezing may occur, 50/50 mixes of Type II or IV fluid shall not be used for the anti-icing step of a cold-soaked wing as indicated by frost or ice on the lower surface of the wing in the area of the fuel tank."**

This note cautions the user that cold-soaked fuel may render the use of a 50/50 mix ineffective. This condition may manifest itself by the formation of frost or ice on the under portion of the wing. If such a condition exists, you should apply a mix more concentrated than 50/50.

> **NOTE:** Fluid failure is complex. It is dependent on OAT, percent mix, type and rate of precipitation, and other variables. Keep in mind that the phenomenon exhibited by mixing water with MAXFLIGHT Type IV fluid is not consistent with all variables or for other neat fluids

Fluid Dry-Out

There have been reported incidents of restricted movement of flight control surfaces, while in-flight, attributed to fluid dry-out. Testing has shown that diluted Types II and IV fluids can produce more gel than neat fluids.

NOTE: Changing from Type IV to II will not necessarily result in an improvement.

Such events may occur with repeated use of Types II and IV fluids without prior application of hot water or Type I fluid mixtures. This can result in fluid collecting in aerodynamically quiet areas or crevices, which do not flow off the wing during the take-off ground roll. These accumulations can dry to a gel-like or powdery substance. Such residues have been known to rehydrate and expand under certain atmospheric conditions, such as high humidity or rain. Subsequently, the residues freeze, typically during flight at higher altitudes. Rehydrated fluid gels have been found in and around gaps between stabilizers, elevators, tabs, and hinge areas. This can especially be a problem with non-powered controls. Some pilots reported that they have reduced altitude until the frozen residue melted, which restored flight control movement.

The FAA has suggested that high-pressure washing with a hot Type I fluid/water mix in areas where fluid could accumulate may alleviate the problem. Such a procedure may require subsequent lubrication. If not successful, fluid dry-out may become a maintenance issue, in which case-appropriate procedures are necessary to address the problem. Increasing the frequency of inspection may be a necessity if fluid dry-out with consequent restricted flight control movement becomes a recurring problem.

You should check aircraft surfaces, quiet areas, and crevices for abnormal fluid thickening, appearance, or failure before flight dispatch, especially if Type II or IV fluids are used exclusively. If you suspect residue as a result of fluid dry-out, spray with water from a spray bottle and wait 10 minutes. Residue will rehydrate in a few minutes and be easier to identify. This residue may require removal.

Frost

In the past several inquiries have been raised relative to active frost. Active frost is a frost condition that is actively growing crystals and gaining in mass and thickness and is considered a precipitation condition. It typically forms at night under clear skies and calm winds when the OAT is below 0ºC/32ºF. As an example, if an aircraft is parked outdoors on a cold clear night, heat can radiate from its surface at a rate greater than is absorbed from its surroundings. The net effect is that the aircraft surface temperature drops below the OAT. If this temperature is below the frost point temperature of the air, moisture will deposit in the form of hoarfrost.

As a guide, if there is frost on any object in the deicing area (including the aircraft) and the OAT and dew point are 3ºC apart and narrowing there is likely to be active frost. If the OAT and dew point are 3ºC apart and expanding, it is not clear if there is active frost.

Therefore, if there is doubt, the condition should be treated as active frost. Weather forecasts and METARs usually do not provide information on frost conditions.

Fluid Application

During previous seasons, surveillance of deicing/anti-icing operations has indicated several problems in the fluid application area. These findings include:

- Instances when the application of fluid was applied in the reverse order of company-approved procedures, (e.g., approved procedure being wing-tip to wing-root)
- Insufficient fluid temperature buffers
- Incomplete removal of contamination

Ground testing of Types II and IV fluids indicates that the effectiveness of these fluids are highly dependent on the training and skill of the individual applying the fluids. When these fluids are used, ground personnel should ensure that they are evenly applied so that all critical surfaces, especially the leading edge of the wings, are covered with fluid. In addition, an insufficient amount of anti-icing fluid, especially in the second-step of a two-step procedure, may cause reduced HOT due to the uneven application of the second step fluid. The effects of trace icing on aircraft performance vary according to the type of aircraft. Many aircraft experience little or no noticeable effect. Other types may experience significant loss of performance or controllability. Do not disregard a report of trace icing. Consider all reports of in-flight icing as potentially hazardous.

Communication

Communication between all personnel involved in the air carrier's approved program is critical to ensuring that the pilot has the information needed to make the final determination that the aircraft is free of contamination before flight. Approved programs should emphasize that all personnel (e.g., management personnel, dispatchers, ground personnel, and flight crewmembers) who perform duties, as outlined in the approved program, clearly and concisely communicate essential information needed to ensure that no frozen contaminants are adhering to any critical surfaces of the aircraft. In Canada, the use of electronic signs at a centralized deicing facility has been introduced to aid in the transmission of critical information to the flightcrews. This includes aircraft ground control information at the deicing pad and information on the ongoing deicing/anti-icing procedure and fluid application. Long-range plans are underway to employ aircrafts' Airborne Communications Addressing and Reporting System (ACARS) datalink systems to relay deicing information to the flightcrews.

Specifically, review approved programs to determine whether the ground personnel accomplishing the deicing/anti-icing procedure **communicate the following information to the pilot**:

- The Type fluid used (for Types II and IV fluids, the specific manufacturer name and type fluid or
  SAE Type II or SAE Type IV)

- The percentage of fluid within the fluid/water mixture (for Types II and IV fluids)
- The local time the final deicing/anti-icing began
- The results of the post-deicing/anti-icing check, unless the approved program has other procedures for ensuring this information is conveyed to the pilot

Although reporting the results of the post-deicing/anti-icing check may be redundant in some cases, it confirms to the pilot that all contamination has been removed from the aircraft.

Representative Surfaces/Where Fluids Tend to Fail First

Preliminary aircraft testing indicates that the first fluid failures on test aircraft appear to occur on the leading or trailing edges of the wing's surface rather than the mid-chord section of the wing. Tests also indicate that fluid failures may be difficult to identify. Where possible, representative surfaces should:

- At least include a portion of the wing leading edge
- Be visible by the pilot from within the aircraft

Winter Operations – General

Preflight

1. Underwing sublimation frost may occur in the fuel tank areas. It's common when the temperatures are above freezing coupled with high humidity. MUST BE REMOVED PRIOR TO TAKEOFF
2. Make sure that the tires are not frozen to the surface.
3. The following areas must be clear of contaminates or they must be deiced.

a. all control surfaces
b. all lifting surfaces
c. engine inlet areas
d. control surface actuators
e. radome and windshields
f. probes, ports, tubes, vanes
g. gear doors, actuators, and steering components
h. APU inlet

Taxi

1. Flaps should be retracted during taxi.
2. Give yourself more space between the aircraft in front of you.
3. Use brakes sparingly and carefully and avoid large steering inputs.
4. Be alert to other aircraft blowing snow/slush onto our aircraft.
5. Avoid reverse thrust if possible. If used during taxi make sure you don't blow contaminants onto our own plane.

6. Expect that more thrust will be needed to start the aircraft moving and possibly more thrust to keep it moving, but be careful of too much thrust.
7. Watch for obstruction of taxiway/runway markings and/or snow-covered lights.
8. Watch out for snow banks.
9. Consider use of APU for backup electrical in icing conditions.

Pre-Takeoff Check

1. This will be accomplished if the holdover time, as determined by the PIC, has **not** been exceeded. A pre-takeoff check will be accomplished by the PIC during taxi-out any time the ground icing conditions exist, the aircraft has been deiced/anti-iced, or a HOT is established. The following should be accomplished prior to takeoff to satisfy this check.

    a. Ensure that engine anti-ice is on and appropriate procedures complied with.

    b. Visually check for contamination by looking at: windshields and frames, aircraft surfaces visible from the cockpit. Ascertain that the current weather conditions are consistent with those conditions existing or forecast at time of anti-icing. Adjust as necessary the planned HOT to the actual weather conditions experienced since the HOT began.

    c. Based on this check, make a judgment as to whether or not contamination exists on the airframe critical surfaces.

    d. Review HOT to ensure that time to takeoff does not exceed determined limit.

    e. Assess runway surface conditions (slush, snow covered, etc) and appropriate performance corrections for takeoff. Because of the variables involved in the determination of HOT, it is necessary for the cockpit crew to conduct a visual inspection of the aircraft. Do not rely on the HOT as the sole determinate that the aircraft is free of contaminates.

Pre-Takeoff Contamination Check

1. If the PIC determines that the holdover time has been exceeded or if there is any doubt about whether or not is has been exceeded, a pre-takeoff contamination check or a new deicing/anti-icing procedure must me accomplished. Takeoff should not be made until a pre-takeoff contamination check of the aircraft is accomplished. If it has been determined from the check that the anti-ice fluid is still providing protection, takeoff must be accomplished within five minutes. If it is determined from the check that the anti-icing has lost its effectiveness, the aircraft must either return to the ramp or proceed to a remote site where deicing/anti-icing can be performed. Communication with the certified deicing personnel is required to ensure the cockpit crew is aware of the airworthiness of the aircraft.

Takeoff

1. Use takeoff power
2. DO NOT takeoff when the runway contamination limits exceed those listed in the AFM.
3. Directional control can be enhanced by applying forward pressure on the control column.
4. Run the engine up to max, and check for stable readings before brake release.
5. Cross-check all engine instruments for proper readings when icing conditions exist.
6. Hydroplaning

    a. Normal (or dynamic) hydroplaning – when any standing water on the runway is not displaced fast enough by the tires. In essence, there is water between the tire and the runway pavement. The approximate speed at which this occurs is about 9 X ☆tire pressure . This works 102 knots. Parti~~al hydroplaning~~ (where some of the tire is touching the pavement) occurs at lower speeds.

    b. Viscous Hydroplaning – any hydroplaning that's a result of a substance thicker than water, i.e., slush. Because of its increased viscosity, the ability of the tire to displace it has diminished. Consequently, this type of hydroplaning occurs at much lower speeds.

Cruise

1. Clear Air Turbulence (CAT) is most prevalent during the winter months. The eastern part of the U.S. is one of the "hotspots" for this; especially on the north side of the jetstreams. If you inadvertently encounter CAT, a climb/descent will normally get you out a lot faster than moving laterally. That's because jetstreams can vary in width from 100-400 miles, but only vary in thickness by 3000-7000 feet.

Descent and Landing

1. If you're in and out of the clouds and/or visibility is 1 mile or less, YOU ARE IN VISIBLE MOISTURE – ANTI-ICE ON.

2. Observe minimum N_1 limits on the descent.

3. Deploy speedbrakes and/or spoilers upon ground contact. Touchdown firmly.

4. Keep abreast of the latest braking reports and give a PIREP if the braking action is different than that previously reported.

5. Keep forward pressure on the control wheel to minimize hydroplaning and increase nosewheel steering effectiveness.

6. Be alert to the aircraft drifting when there is a crosswind.

7. Restrict use of reverse thrust when in the lower speed requiems to avoid possible “whiteout”.

8. No high speed turns. Slow more than usual before making any turns.

Aircraft Limitations in Cold Weather for the Excel

1. The aircraft should not be operated when the OAT is below `30° C on the ground.

2. The boots should not be operated below `40°C RAT.

3. Engine Anti Ice must be on any time the <u>outside</u> air temperature is 10°C or lower in visible moisture on the ground or in the air. The Engine Anti Ice should be selected **before** entering icing conditions. When air is sucked into the engines there is a venturi effect that will decrease temperature. So, it is possible to get ice build up on the engine lip at +10° C. When using the engine anti ice on the ground you must bring the power up to 65% N1 every 10 min.

4. Wing Anti Ice must also be selected on any time the OAT is 10° C or lower in visible moisture. When using wing anti-ice on the ground it is at your discretion.

   NOTE: if you have been anti-iced with type II or IV, you should leave the wing anti-ice off. The heat will reduce the effectiveness of the fluid.

5. Pitot Heat is limited to two minutes on the ground except when needed for icing conditions.

6. The Excel is prohibited to <u>operated</u> in ½ inch of slush.

7. If the aircraft has been cold soaked below `10° C then the battery has to be warmed to at least `10° C. Check the battery temperature with the bat temp gauge. If you know the aircraft is going to be cold soaked, remove the battery and the O2 masks. Store them in a place that will be at least `10° C or warmer.

8. When being deiced the APU must be shut down.

9. The use of engine preheat should not be required at temperatures down to `25° C. However, it should be verified after engine start and before flight that there are no visible oil leaks.

10. If the avionics have been cold soaked, they may require a warm up. The warm up may take up to 30 minutes. You must insure that the following instruments are operating properly:

- RAT indications are stable and correct.
- Standby Flight Display (meggitt) aligned and indicating correctly
- PFDs and MFD including air data displays indicating correctly.
- FMS CDUs an Radio Management Units (RMUs) indicating and operating correctly with no visible waviness or distortion.
- Audio reception is available on all applicable avionics.

11. The cockpit should be warmed to at least 50º F. The APU will accomplish this task more rapidly then the engines on the ground. If the APU is inoperative then the engines will need to be approximately 60% N2.

12. To get the maximum cabin heat, switch the temperature control selector to MANUAL and select HOT for 10 seconds, this ensures that the mixing valve is in the full hot position. Use of the CKPT RECIRC fan to HI will increase air circulation. If the APU is inoperative, then maximum heat is achieved by using the right engine and make sure the PRESS SOURCE SELECT is in NORM.

13. The use of MANUAL mode of the AUTO TEMP SELECT should be restricted to below 31,000 ft. to prevent possible overheating of the air cycle machine.

14. If the cabin is cold soaked, the W/S TEMP annunciator may not test. If this happens, warm the cockpit and do the test again. The test must be completed prior to flight.

15. If the engines need to be preheated, put the covers on and use the oil filler access door for the heated air.

16. If the battery voltage is below 11 volts after the start button is pressed indicates a potential for an unsuccessful start.
17. When operating in extremely cold temperatures the fuel solubility is reduced and will super cool any water in the fuel. The tank and fuel filter drains should be drained frequently. If the drain becomes blocked, it is probably because of ice formation. You will need to apply heat until the fuel flows freely. Maintain heat after flow begins to ensure that all particles have melted and collect the drainage in a clear, clean container to inspect for water globules.
18. Do not set the parking brake if anticipated cold soak temperature is -15ºC (+5ºF) or below

Based on past operating experience

1. Remove liquid stock items from aircraft and have FBO store them in a warm place.
2. Arrange for aircraft to be hangared (if available). If unable to obtain hangar space and winter precipitation is expected overnight, inform the PM on duty.
3. If you anticipate that aircraft deicing may be required, you should inquire of the FBO on its availability. If lack of deicing equipment could impact your next morning's departure you must inform a Crew Services Flight Manager.
4. Engine inlet and exhaust covers, and pitot tube covers, shall be installed on ALL overnight stops regardless of forecast weather conditions and weather aircraft will be hangared or not. Previous verbal guidance that covers were not required if aircraft

would be hangared is hereby rescinded. This is not strictly a "cold weather" requirement.

5. During pre-flight, ensure the engine fan turns freely. A small amount of frozen water is sufficient to prevent fan rotation during engine start and may precipitate engine over-temp occurrence.

6. If the MEGGITT standby flight display fails to initialize, indicated by annunciation of "ATTITUDE" on the display within 30 seconds of power on, leave the unit powered on with the display full bright for a minimum of 15 minutes. At end of this "warm-up" period, turn the "STBY PWR" OFF for five(5) seconds, then turn back ON. The unit should initialize normally. This procedure may be repeated twice more if unit does not initialize after first "warm-up" period.

SNOWFALL INTENSITIES AS A FUNCTION OF VISIBILITY

Time of Day	Temp.		Visibility (Statute Mile)					
	(°C)	(°F)	≥1 1/4	1	3/4	1/2	≤1/4	
Day	≤ -1	≤ 30	Light	Light	Light	Moderate	**Heavy**	**Snowfall Intensity**
	> -1	> 30	Light	Light	Moderate	**Heavy**	**Heavy**	
Night	≤ -1	≤ 30	Light	Light	Moderate	**Heavy**	**Heavy**	
	> -1	> 30	Light	Moderate	**Heavy**	**Heavy**	**Heavy**	

NOTE: Based upon technical report, "The Estimation of Snowfall Rate Using Visibility," Rasmussen, et al., Journal of Applied Meteorology, October 1999.