TP 10643E
(12/2004)

When in Doubt...

Small and Large Aircraft

Aircraft Critical Surface Contamination Training For Aircrew and Groundcrew

Seventh Edition
December 2004

Transport Canada Transports Canada

How to Use This Manual

This manual has been organized and written in chapter and summary format. Each chapter deals with certain topics that are reviewed in a summary at the end of the chapter.

The manual is divided into two parts: Part 1-for aircrew and groundcrew; Part 2-additional information for ground crew. The final chapter contains questions that any operator may utilize for their ground icing program examination. The references for each question are listed to assist with answers. The Holdover Tables (HOT) included in the appendix are solely for the use with the examination questions and **must** **not** be used for operations. Contact Transport Canada from the addresses located later in this document for the latest HOT.

Warnings
These are used throughout this manual and are items, which **will** result in: damage to equipment, personal injury and/or loss of life if not carefully followed.

Cautions
These are used throughout this manual and are items, which **may** result in: damage to equipment, personal injury or loss of life if not carefully followed.

Notes
These are items that are intended to further explain details and clarify by amplifying important information.

Should
Implies that it is advisable to follow the suggested activity, process or practice.

Must
Implies that the suggested activity, process or practice needs to be followed because there are significant safety implications.

Comments or suggestions with respect to this publication should be referred to:

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Record of Revisions

REVISION	DATE	DESCRIPTION OF CHANGES	AFFECTED PAGES	INITIALS

Part 1: Aircrew and Groundcrew Training

Table of Contents

CAUTION:
This book contains information that may be at variance with, or deviate from, individual carrier or aircraft standards, policies, orders or recommendations. Canadian Aviation Regulations (CARs), your company operations and maintenance control manuals and the manufacturers' aircraft flight and maintenance manuals must be considered the final authorities.

Published by Transport Canada

List of Tables and Figures

Foreword

There is no such thing as a little ice. In airline operations where large numbers of aircraft are dispatched, the process of assuring that each flight will be safe must be a team effort. In smaller commercial and in private operations, the pilot may have to perform all the functions. **In all cases, the pilot-in-command is ultimately responsible for ensuring that the aircraft is in a condition for safe flight. If the pilot cannot confirm that the aircraft critical surfaces are free of contamination, take-off must not be attempted.**

The reasons for the regulations are straightforward. The degradation in aircraft performance and changes in flight characteristics when frozen contaminants are present are wide-ranging and unpredictable. Contamination makes no distinction between large aircraft, small aircraft or helicopters, the performance penalties and dangers are just as real.

To assist air operators in establishing Surface Contamination Training, Transport Canada has made available this training package concerning the adverse effect of critical surface contamination on aircraft performance. This package consists of three video's and this accompanying Training Manual (TP 10643 E) plus sample examination questions. This information is intended to reach all pilots and other personnel who are involved in aircraft operations.

This publication is to be used with reference to the Canadian Aviation Regulations (CARs) Parts VI and VII, Ground Icing Operations Update TP-14052E, the Aeronautical Information Publication (A.I.P.) - Canada, and industry publications.

The videos When in Doubt... for Small Aircraft, Large Aircraft, and Ground Crew, and this package, as well as the copies of the Ground Icing Operations Update TP-14052E may be obtained from the Civil Aviation Communication Center Toll Free: 1-800-305-2059
In the National Capital Area: (613) 993-7284

And from the following websites:

http://www.tc.gc.ca/aviation

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

Merlin Preuss
Director General
Civil Aviation

Chapter 1- Air Law, The Clean Aircraft Concept

History

- 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: **February 01 1985**
  Location: **Minsk, Belarus, USSR**
  Airline: **Aeroflot**
  Aircraft: **Tupolev TU-134A**
  Fatalities/No. Aboard: **58:80**
  Details: **The aircraft crashed during takeoff. Icing. Double engine failure.**

- Date: **December 12 1985**
  Location: **Gander, Newfoundland, Canada**
  Airline: **Arrow Airways**
  Aircraft: **Douglas DC-8-63PF**
  Fatalities/No. Aboard: **256:256**
  Details: **The aircraft stalled and crashed during takeoff. There is controversy surrounding this crash. The majority opinion of the Safety Board was that the cause of the sequence leading up to the stall and crash could not be determined, with icing a possibility.**

- 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, Canada**
  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.**

- Date: **12/27/1991**
  Location: **Stockholm, Sweden**
  Airline: **Scandinavian Airlines (SAS)**
  Aircraft: **McDonnell Douglas MD-80 (MD-81)**
  Fatalities/No. Aboard: **0:129**
  Details: **The aircraft reached an altitude of 3,000 feet and then made an emergency descent, clipping trees and crash landing in a field. Failure of both engines due to improper deicing of the aircraft led to chunks of ice breaking off and being ingested into both engines, leading to engine failure.**

- 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.**

- Date: **4 Jan 2002**
  Location: **Birmingham, England**
  Airline: **Corporate**
  Aircraft: **Canadair Challenger CL-600-2B16**
  Fatalities/ No Aboard: **5/5**
  Details: **The aircraft was parked overnight on the Western Apron. There was no precipitation while the aircraft was at Birmingham. The air temperature remained below zero with a minimum temperature of minus 9°C at 0550 hrs. Initially, the sky was clear but the amount of cloud increased to give variable cloud cover after midnight. The surface wind remained southeasterly at less than 5 kt. The next morning, one of the crew, together with one of the passengers, arrived at the aircraft at approximately 1040 hrs. The commander arrived at approximately 1100 hrs. At different times, each crewmember was seen to carry out an independent external inspection of the aircraft. Aircraft refueling commenced at about 1105 hrs and the aircraft fuel tanks were reported full (20,000 lb) at about 1140 hrs. During the morning, other witnesses stated that they had seen frost or ice on the wing surfaces of N90AG prior to departure. Other aircraft, which had been parked overnight, were de-iced during the morning, with associated reports of moderate to severe ice or frost accumulations. Neither crewmember requested deicing, so N90AG was not de-iced prior to departure. The aircraft crashed just after takeoff due to icing on the aircraft's critical surfaces.**

When in Doubt………ASK, INVESTIGATE, CHECK !

Air Law, The Clean Aircraft Concept

1. As demonstrated in the above examples, the degradation in aircraft performance and changes to the flight characteristics when frozen contaminants are present are wide-ranging and unpredictable. Contamination makes no distinction between large aircraft, small aircraft or helicopters, the performance penalties and dangers are just as real.

2. 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.

3. On March 10, 1989 at Dryden, Ontario an Air Ontario Fokker F –28 MK 1000 crashed off the end of the runway on departure. Twenty-one of the 65 passengers and three of the four crew members (including the Captain, First Officer and one Flight Attendant) on board died as a result of the crash. The aircraft was destroyed in the post crash fire.

4. The Commission of Inquiry into this accident, concluded that information regarding the operation of aircraft on a wet and contaminated runway must be made available to persons at all levels of flight operations.

5. The significance of these effects are such that 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. The Canadian Aviation Regulations (CARs) prohibit persons from conducting or attempting to conduct a take-off in an aircraft that has frost, ice or snow adhering to any of its critical surfaces such as wings and propellers. Therefore, 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 is called the **"Clean Aircraft Concept."**

6. Where frost, ice or snow may reasonably be expected to adhere to the aircraft, the CARs require that an inspection or inspections shall be made before take-off or attempted take-off. The type and minimum number of inspections indicated by the regulations, depends on whether or not the operator has an approved **Ground Icing Operations Program** using the **Ground Icing Operations Standards** as specified in the General Operating and Flight Rules, 622.11 (GOFR 622.11)

7. There are strict regulations in Canada governing the removal of ice, frost and snow (deicing) and preventing their accumulation on aircraft (anti-icing) prior to departure. Air operators are responsible for having deicing and anti-icing procedures in place to comply with Canadian Aviation Regulations. An inspection by delegated company personnel or the Pilot-in-Command (PIC) must be conducted immediately prior to take-off to make sure that no frost, ice or snow is present. Transport Canada enforces its deicing and anti-icing

regulations through a number of means, including a comprehensive monitoring, inspections and audits program.

8. The Clean Aircraft Concept is essential to the maintenance of flight safety. In all aviation operations, the PIC has the ultimate responsibility to determine if the aircraft is in a condition for safe flight. However, flight crewmembers, ground or maintenance personnel, or any other operational personnel shall report frozen contamination adhering to the aircraft, to the PIC.

9. It is imperative that take-off not be attempted on any aircraft unless the PIC has determined that all critical surfaces of the aircraft are free of frost, ice or snow contamination. This requirement may be met if the PIC obtains verification from properly trained and qualified personnel that the aircraft is ready for flight. Aircraft without rear-mounted engines are permitted to take-off with “Hoar frost” (see glossary) adhering to the fuselage only, provided this is approved in the aircraft manufacturers instructions.

10. However, a Notice of Proposed Amendment (NPA) to the pertinent sections of CAR 602.11 and GOFR 622.11 has been submitted which, under specified conditions, would permit Canadian Air Operators and Foreign Air Operators in Canada operating aircraft with rear-mounted engines to conduct a takeoff with hoar-frost on the fuselage. At the time of printing, this NPA had not been approved.

11. In the meantime, an exemption to CARs 602.11 (1) and (2) has been issued. The purpose of this exemption is to permit Canadian Air Operators and Foreign Air Operators in Canada utilizing aircraft with engines mounted on the rear of the fuselage to conduct a takeoff with hoar-frost on the **fuselage only,** after it has been determined that no other contamination is adhering to the fuselage.

12 The exemption is subject to the following conditions:

- Hoar-frost shall be the only acceptable contaminant on the fuselage, of aircraft with engines mounted on the rear fuselage.
- Prior to conducting a takeoff, the operator shall ensure that the hoar-frost is not mixed with other contaminants such as ice or snow. If any other contaminant or contaminants are on the fuselage, the operator shall de-ice the entire fuselage.
- A copy of this exemption shall be attached to the Aircraft Deicing/Anti-icing Procedures in the Operator’s Manual.

13. The CAR’s require that all personnel involved in aircraft operations shall have initial and annual recurrent critical surface contamination training to continue performing their duties. This includes all ground personnel directly participating in aircraft operations such as, deicing crews and baggage handlers. **Any person observing frozen contamination on the aircraft critical surfaces shall report this immediately to the PIC.**

14. This combination of reduced lift and increased weight can have crucial safety consequences even with small amounts of ice or snow. Test data indicates that 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%. Even small amounts of contamination such as this have caused and continue to cause aircraft accidents, which result in substantial damage and loss of life. 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. Thicker or rougher frozen contaminants can have increasing effects on lift, drag, stall speed, stability and control.

15. The removal of the contaminants prior to flight operations is accomplished through the application of a heated deicing fluid that melts the ice and removes it from the aircraft. In addition, an ice-preventive agent (anti-icing fluid) may be applied to critical surfaces prior to take-off, to prevent the accumulation of ice on critical surfaces. Aircraft that are approved for flight into known icing conditions are equipped with devices that, while the aircraft is in flight, either break up and remove ice on critical surfaces (de-ice boots) or prevent the accumulation of ice on critical surfaces (heated wing leading edge devices).

16. Also, a phenomenon, called “cold soaking” (discussed later), can form clear ice or frost on the wings. Under these circumstances, take-off is permitted only with the aircraft manufacturers approved instructions. In most cases, these approved instructions will specify a maximum allowable thickness for the contamination and usually limit its presence to the underside of the wing.

17. There is no such thing as a little ice. **When in Doubt…Ask, Investigate, Check!**

Summary-Chapter 1

- History has shown that numerous aircraft accidents have occurred due to contaminated critical surfaces from frost, ice or snow.
- Aircraft performance degradation is wide-ranging and unpredictable.
- Frozen contamination has two affects on aircraft by increasing the all-up-weight and reducing aircraft performance.
- The significance of these conditions led to the “Clean Aircraft Concept.”
- The Clean Aircraft Concept is essential to the maintenance of flight safety and the PIC has the ultimate responsibility to determine if the aircraft is in a condition for safe flight.
- Canadian and Foreign Operators in Canada may take-off with hoar frost on the fuselage if the following conditions are met:
    I. Hoar-frost shall be the only acceptable contaminant on the fuselage only, of aircraft with engines mounted on the rear fuselage.
    II. Prior to conducting a takeoff, the operator shall ensure that the hoar-frost is not mixed with other contaminants such as ice or snow. If any other contaminant or contaminants are on the fuselage, the operator shall deice the entire fuselage.
    III. A copy of this exemption shall be attached to the Aircraft Deicing/Anti-icing Procedures in the Operator’s Manual.
- Aircraft may be permitted to take-off with hoar frost on the fuselage of rear mounted engines or when cold soaked ice exists on the underside of the wing, if approved in the aircraft manufacturers instructions.
- It is everyone’s responsibility to report contamination issues to the PIC immediately.
- The removal of the contaminants prior to flight operations is accomplished through the application of a heated deicing fluid that melts the ice and removes it from the aircraft. In addition, an ice-preventive agent (anti-icing fluid) may be applied to critical surfaces prior to take-off, to prevent the accumulation of ice on critical surfaces.
- **WHEN IN DOUBT… ASK, INVESTIGATE, CHECK!**

Chapter 2-Theory and Aircraft Performance

1. As discussed in Chapter 1, 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. The consequence 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 or add significantly to aircraft weight as well as block critical aircraft sensors. There is no such thing as an insignificant amount of ice.

2. Ice can form even when the outside air temperature (OAT) is well above 0°C (32°F). An aircraft equipped with 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. This phenomenon is known as cold-soaking. Liquid water coming in contact with a wing, which is at a below freezing temperature, will freeze to the wing surfaces.

3. Cold-soaking can be caused by fueling an aircraft with cold fuel. Where fuel tanks are located in the wings of aircraft, the temperature of the fuel greatly affects the temperature of the wing surface above and below these tanks. If there is rain or high humidity, ice can 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. Cold soaking can cause frost to form on the upper and lower wing under conditions of high relative humidity. This is one type of contamination that can occur in above freezing weather at airports where there is normally no need for deicing equipment, or where the equipment is deactivated for the summer. This contamination typically occurs where the fuel in the wing tanks becomes cold-soaked to below freezing temperatures because of low temperature fuel uplifted during the previous stop or cruise at altitude where low temperatures are encountered, or both, and a normal descent is made into a region of high humidity. In such instances, frost will form on the under and upper sides of the fuel tank region during the ground turn-around time, and tends to reform quickly even when removed.

4. After a flight, the temperature of an aircraft and the fuel carried in the wing tanks may be considerably colder than the ambient temperature. An aircraft's cold-soaked wings conduct heat away from precipitation so that, depending on a number of factors, clear ice may form on some aircraft, particularly on wing areas above the fuel tanks. As well, cold soaking can cause ice to form due to humidity in the air when there is no precipitation, even when the temperature is above freezing. Such ice is difficult to see and in many instances cannot be detected other than by touch with the bare hand or by means of a special purpose ice detector such as a Ground Ice Detection System (GIDS). 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.

5. Sheets of clear ice can dislodge from the wing or fuselage during takeoff or climb and can be ingested by aft fuselage mounted engines, thereby damaging or stopping them and can also cause impact damage to critical surfaces such as, the horizontal stabilizer.

6. The formation of 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;

- a large amount of cold fuel remaining in the wing tanks causing fuel to come in contact with the wing upper surface panels, especially in the wing root area;

- 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.

7. 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.

8. In any case, 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**.

9. Aircraft certified for flight in known icing condition have been designed and have demonstrated system capability of providing some protection against the adverse effects of airframe icing in flight only. In addition, stall warning systems only give an effective warning under clean wing conditions.

10. 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

Freezing Rain Conditions

11. 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.

CAUTION:

Operation of an aircraft during freezing rain conditions should be avoided whenever possible.

Freezing Drizzle

12. 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

13. These are 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. Now internationally recognized, ice pellets include two fundamentally different types of precipitation, which are known in the United States as (a) sleet, and (b) small hail. Thus a two-part definition is given:

- 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. Note that the term "sleet" in British terminology and in some parts of the U.S. refers to a mixture of rain and snow and therefore should not be used.

- 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

14. 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

15. 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.

CAUTION:

Heavy freezing rain, heavy snow conditions and ice pellets.

- **Aircraft anti-icing fluid Hold Over Times have not been evaluated under moderate and heavy freezing rain conditions.**
- **The capability of anti-icing fluid to tolerate a heavy snowfall rate has not been evaluated; therefore holdover times for heavy snow conditions have not been generated.**
- **The holdover time performance of an anti-icing fluid in the presence of ice pellets has not been evaluated, but is expected to be extremely short.**

Frost

16. 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

17. 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.

Frost on the Fuselage

18. Despite the requirement to clean contamination from critical surfaces, it is acceptable for aircraft with aft fuselage mounted engines to take-off when hoarfrost is adhering to the **upper surface of the fuselage** if it is the only remaining contaminant, provided all vents and ports are clear. Also, aircraft with wing mounted engines can take-off in such conditions however, for both types this can only be conducted in accordance with the aircraft manufacturer's instructions.

Snow

19. The meteorological approach to estimating snow rate has always been based on visibility alone. Scientific research has indicated that the use of visibility in snow as the sole criteria for establishing snowfall rate/intensity is invalid. The evidence indicates that a visibility and temperature pair needs to be used for establishing more accurate snowfall rates. The highest snowfall rates occur near 0° C. The Visibility in Snow versus Snowfall Intensity Chart contained in the Transport Canada HOT Guidelines document is based on Research sponsored by Transportation Development Centre (TDC) Transport Canada.

20. For example, based upon the 2003 Transport Canada Visibility in Snow vs. Snowfall Intensity Chart, assume that the daytime visibility in snowfall is 1 statute mile and that the temperature is –7° C. Using the "Visibility in Snow vs. Snowfall Intensity Chart" (Table 1), for

this example, we conclude that the snowfall rate is light. This snowfall rate will be used to determine which HOT Guideline value will be appropriate for the fluid in use.

21. 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.**

TABLE 1 VISIBILITY IN SNOW VS. SNOWFALL INTENSITY CHART[1]

Lighting	Temperature Range		Visibility in Snow (Statute Miles)			
	ºC	ºF	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

1 Based on: *Relationship between Visibility and Snowfall Intensity* (TP 14151E), Transportation Development Centre, Transport Canada, to be published in November 2003; and *Theoretical Considerations in the Estimation of Snowfall Rate Using Visibility* (TP 12893E), Transportation Development Centre, Transport Canada, November 1998.

HOW TO READ THE TABLE

Assume that the daytime visibility in snowfall is 1 statute mile and the temperature is -7°C. Based on these conditions, the snowfall intensity is light. This snowfall intensity is used to determine which holdover time guideline value is appropriate for the fluid in use.

Holdover Time Guidelines – General

22. 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.

23. Holdover time guidelines provide an estimate of the length of time anti-icing fluids will be effective. 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. 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.

24. 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.

25. 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.

26. Transport Canada has, for a number of years, published Holdover Time Guidelines that were the same as those published by the Society of Automotive Engineers (SAE) for generic fluids and were based upon the recommendations of the SAE G-12 Holdover Time Subcommittee. The SAE has chosen to cease publishing generic HOT Guidelines, as of 2002.

27. The Federal Aviation Administration (FAA) and Transport Canada (TC) jointly support the testing of anti-icing fluids and, with the assistance of the members of the SAE Holdover Time Subcommittee, evaluate the test results and publish the recommended HOT guidelines for the manufacturer specific fluids. The generic table for Type II, III and IV fluids are based on these. This procedure will continue with both the FAA and Transport Canada publishing the HOT Guidelines.

Use of Holdover Time as a Decision Making Criterion

28. GOFR 622.11 states in part: "When holdover timetables are used as decision-making criteria, only high confidence level times shall be used and the procedures to be followed after holdover time has expired must be clearly documented".

Establishing the HOT Range

29. 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:
  i. Fluid Type; and
  ii. 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.

Summary-Chapter 2

- A very small amount of frozen contamination as low as 0.40 mm (1/64 in.) disrupts the airflow over the lift and control surfaces of an aircraft and can result in severe lift loss, increased drag and impaired maneuverability.
- The adverse effect of frost, ice or snow on an aircraft decreases thrust and lift, increases drag and stall speed while altering handling qualities.
- Cold soaking can cause frost to form on the upper and lower wing under conditions of high relative humidity.
- Fueling an aircraft with cold fuel can cause cold-soaking. Ice can form even when the outside air temperature (OAT) is well above 0°C (32°F).
- Cold soaking can cause ice to form due to humidity in the air when there is no precipitation.
- Such ice is difficult to see and in many instances cannot be detected other than by touch with the bare hand or by means of a special purpose ice detector such as a Ground Ice Detection System (GIDS).
- 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.
- Sheets of clear ice dislodged from the wing or fuselage during takeoff or climb and can be ingested by aft fuselage mounted engines.
- 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**.
- Aircraft anti-icing fluid Hold Over Times have not been evaluated under moderate and heavy freezing rain conditions or a heavy snowfall rate; therefore, these holdover times have not been generated.
- The holdover time performance of an anti-icing fluid in the presence of ice pellets has not been evaluated, but is expected to be extremely short.
- Evidence indicates that a visibility and temperature pair needs to be used for establishing more accurate snowfall rates.

- Holdover Time Guidelines represents their function in providing guidance to flight crew and the need for the flight crew to use judgment in their interpretation.
- GOFR 622.11 states in part: “When holdover timetables are used as decision-making criteria, only high confidence level times shall be used and the procedures to be followed after holdover time has expired must be clearly documented”.

Chapter 3-Deicing /Anti-icing Fluids

1. 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. There are a number of FPD fluids available for use on commercial aircraft and, to a lesser extent, on general aviation aircraft. Deicing and anti-icing fluids should not be used unless approved by the aircraft manufacturer.

2. Although FPD fluids are highly soluble in water, they absorb or melt slowly. 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.

3. 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.

Note: It is the heat contained by the Type I (de-ice) fluid and the hydraulic force that removes the frozen contaminants. The glycol provides some protection during precipitation conditions until Type II, III or IV fluid is applied.

Deicing and Anti-icing of Aircraft

De/Anti-Icing

4. 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.

5. During flight operations under icy conditions, any frost, snow or ice on a critical surface of an aircraft must be removed prior to departure. Large aircraft operating from major airports such as Toronto, Montreal, Vancouver, Calgary and Halifax are de-iced and anti-iced immediately prior to take-off at a central deicing facility (CDF) located on the airport. Deicing Operators normally operates these facilities.

6. Aircraft operating from smaller regional airports are generally de-iced by company personnel, or in some cases directly by the pilot of the aircraft, using a pressure sprayer containing an approved deicing fluid. Aircraft must be deiced shortly prior to take-off. When operating under icing conditions from sites not equipped with a CDF, 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.

7. Transport Canada has an extensive research program dealing with a wide range of projects including deicing and in-flight icing hazards. Transport Canada also participates actively in several Canadian and international committees working to further improve deicing and anti-icing products and procedures.

8. For instance, Transport Canada is one of many partners in the Alliance Icing Research Study project led by the National Research Council Institute for Aerospace Research, Environment Canada's Meteorological Service of Canada and NASA's Glenn Research Centre. The project is examining technology designed to detect aircraft icing on the ground and in the air.

9. Transport Canada continues to raise awareness within the civil aviation community on the hazards of flying with ice and snow adhering to aircraft wings and on flying into icy conditions. Awareness is raised through products such as videos, safety seminars and articles in aviation safety publications.

10. As stated before, CARs 602.11 (1) and (2) prohibit take-off when frost, ice or snow is adhering to any critical surface of the aircraft. This “Clean Aircraft Concept” is essential to the maintenance of flight safety. **In all aviation operations, the PIC has the ultimate responsibility to determine if the aircraft is in a condition for safe flight.**

11. The requirement for the PIC to determine that all critical surfaces of the aircraft are free of frost, ice or snow contamination may be met if, the PIC obtains verification from properly trained and qualified personnel that the aircraft is ready for flight.

Fluid Properties

Fluid Description

12. 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.

13. 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.

14. 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.

Industry Fluid Specifications

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

Note: The status of ISO ground icing related documents has become uncertain. Therefore only current SAE Specifications and documents are recognized by Transport Canada.

16. The SAE specifications are SAE Aerospace Material Specification (AMS) 1424, entitled: "Aircraft Deicing/Anti-icing Fluid SAE Type I"; and, SAE AMS 1428, entitled: "Deicing/Anti-icing Fluid SAE Type II, III and IV".

Note: Users should request certificates of conformance to these SAE specifications from the fluid manufacturers.

Qualified Fluids

17. 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. They have also been subjected to chemical property tests. **The operator is ultimately responsible for ensuring that only qualified fluids are used.**

Freezing Characteristics of FPD Fluids

18. Before a fluid is used on an aircraft, it is crucial that the user knows and understands its freezing characteristics. These characteristics can be determined through understanding of the fluid procurement specifications and tolerances and through quality control inspections. 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.

FPD Fluid Strength When Applied

19. 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. The reasons for this caution are explained below:

- 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%.

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

Recommended Practices

21. 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 (ARP) 4737.

22. The FPDs used to de-ice aircraft in North America are usually composed of ethylene glycol or propylene glycol combined with water and other ingredients. The exact formulations of commercial fluids are proprietary; some contain wetting agents or corrosion inhibitors for specialized applications. Users can purchase FPD fluid in a concentrated form or pre-mixed, depending on customer requests.

23. 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

24. 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:

1. Type I fluids: Orange colour.
2. Type II fluids: Colourless or a pale Straw colour.
3. Type III fluids: TBA
4. Type IV fluids: Emerald Green colour.

<u>CAUTION:</u>

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)

25. 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.

<u>WARNING:</u>

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)

26. SAE Type II fluids were introduced in North America in 1985 with widespread use, which began in 1990. Similar fluids, but with slight differences in characteristics, have been developed, introduced, and used in Canada.

27. 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.

28. Flight tests performed by manufacturers of transport category aircraft have shown that SAE Type II fluids flow off lifting surfaces by rotation speed (V_r), although some large aircraft do experience performance degradation and may require weight or other take-off compensation. Therefore, SAE Type II fluids should be used on aircraft with rotation speeds (V_r) above 100 knots. Degradation could be significant on aeroplanes with rotation speeds below this figure.

29. As with any deicing or anti-icing fluid, SAE Type II fluids should not be applied unless the aircraft manufacturer has approved their use, regardless of rotation speed. Aircraft manufacturers' manual may give further guidance on the acceptability SAE Type II fluids for specific aircraft.

30. 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. These fluids are used for deicing when heated, and anti-icing. 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.

31. These fluids are 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. However, when these fluids are subjected to shear stress, such as that experienced 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.

32. **The pseudo-plastic behavior of SAE Type II fluids can be altered by improper deicing/anti-icing equipment or handling.** Therefore, some North American airlines have updated deicing and anti-icing equipment, fluid storage facilities, deicing and anti-icing procedures, quality control procedures, and training programs to accommodate these distinct characteristics. Testing indicates that SAE Type II fluids, if applied with improper equipment, may lose 20 to 60% of their anti-icing performance.

33. 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)

34. 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 V_r exceeding 60 knots.

35. The SAE has approved a specification in AMS 1428A 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)

36. 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 (V_r) above 100 knots. In recognition of the above, holdover time guidelines are available for Type IV fluids.

37. The product is dyed emerald green as it is believed that the green product will provide for application of a more consistent layer of fluid to the aircraft and will reduce the

likelihood that fluid will be mistaken for ice. **However, as these fluids do not flow as readily as conventional Type II fluid, caution should be exercised to ensure that enough fluid is used to give uniform coverage.**

38. Research indicates that the effectiveness of a Type IV fluid can be seriously diminished if proper procedures are not followed when applying it over Type I fluid.

Aerodynamics

39. 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.

40. There are two separate aerodynamic acceptance tests, one for faster aircraft and one for slower aircraft. The objective of the tests is to determine the coldest temperature at which the deicing/anti-icing fluids have acceptable aerodynamic characteristics as they flow off lifting and control surfaces during the take off ground acceleration and climb. The aircraft manufacturer should be consulted to establish which fluids could be safely used on their models of aircraft.

High Speed Test

41. The High Speed Aerodynamic test establishes the aerodynamic flow off requirements for fluids used to deice or anti-ice large transport jet aircraft with rotation speeds generally exceeding 100 to 110 knots and with ground acceleration to lift of times exceeding 23 seconds. Some slow take off speed aircraft manufacturers have allowed the use of fluids designed for high speed aircraft on their models. There are often changes required to take off procedures, to take off configuration or to both. The aircraft manufacturer must be consulted.

Low Speed Test

42. The Low Speed Aerodynamic test establishes the aerodynamic flow off requirements for fluids used to deice or anti-ice slower aircraft whose takeoff rotation speeds generally exceed 60 knots and with ground acceleration to rotation time exceeding 16 seconds. As stated before, some slow take off speed aircraft manufacturers have allowed the use of fluids designed for high speed aircraft on their models. The aircraft manufacturer must be consulted.

Freezing Point

43. The freezing points are determined by the American Society for Testing Materials (ASTM) D 1177 method, which measure the temperature of the first ice crystal formation.

44. Frequent determinations of the freezing point of fluids are required to ensure that the desired freezing point is maintained.

45. 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

46. 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. The qualified fluids have undergone laboratory testing to quantify their protection and to confirm aerodynamic acceptability.

CAUTION:

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.

47. It is expected that additional fluids will be qualified from time to time. Operators are encouraged to contact suppliers or manufacturers to determine the qualification status of any deicing or anti-icing fluid that do not currently appear in the Transport Canada HOT guidelines. However, the operator will be required to prove that fluids not on the qualified list have been properly tested.

FPD Temperature Buffer

48. The freezing point of a fluid is normally a function of the glycol concentration. An assessment of the fluid concentration can be performed in the field by measuring the refractive index of the fluid. The magnitude of refraction (how much light bends) is related to the concentration of glycol in the solution and hence the freezing point. Fluid manufacturers provide fluid specification charts that correlate refraction index, also called BRIX, versus fluid freezing point. Since there could be some error in reading the BRIX, or the skin temperature could be lower than the outside air temperature, it was decided to add a safety buffer to all the calculations, and a value of 10°C was agreed for Type I fluids, by the SAE G-12 Fluids sub-committee, and 7°C for Types II, III and IV fluids.

This buffer allows for absorption of precipitation.

Lowest Operational Use Temperature of Types I, II, III, & IV fluids

49. 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.

50. The qualification of de/anti-icing fluids, also called freezing point depressants (FPD), is a complex and thorough process, which evaluates a multitude of fluid properties and characteristics. The one of particular interest in this case is the lowest operational use temperature (LOUT). The LOUT is fluid concentration specific. The fluid concentration may change if the fluid is subjected to sustained heating.

51. The LOUT for a given fluid is the <u>higher</u> 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.

<u>Note</u>: Manufacturers state that a fluid must not be used when the outside air temperature or skin temperature is below the LOUT of the fluid.

52. An example of establishing an 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 <u>higher</u> 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, <u>this fluid as is, can't be used.</u>

Type II and Type IV Fluid Dryout

53. 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.

54. 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.

55. 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. The fluids do not flow out of these areas during normal take off conditions. These residues have been known to re-hydrate and expand under certain atmospheric conditions, such as during high humidity or rain. Subsequent to re-hydration, the residues may freeze, typically during flight at higher altitudes. The re-hydrated fluid gels have been found in and around gaps between stabilizers, elevators, tabs and hinge areas. The problem can be exacerbated for aircraft without powered controls. Pilots have reported that they have had to reduce their altitude until the frozen residue melted, which restored full flight control movement.

56. A number of European Air Operators have reported this condition when they have used a diluted Type II or Type IV fluid as a first step and then a concentrated Type II or Type IV as a second step, in their de/anti-icing procedure. North American Air Operators, to date, have not reported this situation. It is suggested that the use of heated Type I fluid/water high pressure washing may alleviate the occurrence of fluid dryout. Such routine procedures may result in the requirement for more frequent lubrication of components. Special attention should be paid the aerodynamically quiet areas such as: gaps between stabilizers, elevators, tabs, and hinge areas.

Summary Chapter 3

- Frozen contaminants are most often removed in commercial operations by using Freezing Point Depressant (FPD) fluids.
- It is the heat contained by the Type I (deice) fluid and hydraulic forces (high pressure spray equipment) that removes the frozen contaminants.
- It is imperative that take-off not be attempted on any aircraft unless the PIC has determined that all critical surfaces of the aircraft are free of frost, ice or snow contamination.
- Aircraft deicing/anti-icing fluids consist of four types. They are Type I, II, III, and IV.
- Deicing fluids are typically ethylene glycol, diethylene glycol or propylene glycol based fluids containing water, corrosion inhibitors, wetting agents and dye.
- 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 operator is ultimately responsible for ensuring that only qualified fluids are used.
- 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.
- Type I fluids are used for deicing or anti-icing, but provide **very** limited anti-icing protection.
- Type II fluids are designed to remain on the wings of an aircraft during ground operations, thereby providing anti-icing protection. This fluid should be used on aircraft with rotation speeds (V_r) above 100 knots, unless otherwise specified by the aircraft manufacturer.
- Type III fluids are designed for aircraft that have a shorter time to rotation and this should make it acceptable for some aircraft that have a V_r of less than 100 knots unless otherwise specified by the aircraft manufacturer.
- Type IV anti-icing fluids meet the same fluid specifications as the Type II fluids and have a significantly longer HOT.
- The LOUT for a given fluid is the <u>higher</u> of:

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

- Some Type II or IV fluid residue may remain throughout the flight and this residue should be cleaned periodically. It is suggested that the use of heated Type I fluid/water high pressure washing may alleviate the occurrence of fluid dryout.

Chapter 4-Preventative Measures and Deicing Procedures

Hangars

1. 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. Availability of space, particularly for larger aircraft is a major obstacle with respect to the use of hangars on a routine basis.

2. 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. This, of course, will impact the users of the hanger. Depending on the facility, it may be possible to apply anti-icing fluids prior to departing the hanger.

3. 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. When the fuel is in contact with the upper surface of the wing, the wing surface will assume the temperature of the fuel; so cooling the wing surface by opening the hangar doors is less effective. This 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. Possibly, under these circumstances, the aircraft should not be hangared with significant volumes of fuel in wing tanks.

4. Once an aircraft is contaminated, if a heated hanger is available, the heat and shelter from the elements will help the removal of contamination. Unfortunately, this takes time but will reduce the amount of deicing fluid required.

Wing Covers

5. Many operators of smaller aircraft have found wing covers to 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. One other drawback of wing covers is the 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.

6. In some circumstances, when the Aircraft Manufacturer recommends it, dry, powdery snow can be removed by blowing cold air or compressed nitrogen gas across the aircraft surface. In other circumstances, a shop broom could be employed to clean certain areas accessible from the ground. Heavy, wet snow or ice can be removed by placing the aircraft

in a heated hangar, by using solutions of heated FPD fluids and water, by mechanical means such as brooms or squeegees, or a combination of all three methods. 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.

7. Conditions may be encountered whereby cold dry snow is falling onto the cold wing of an aircraft. The wind often causes the snow to swirl and move across the surface of the wing and it is evident that the snow is not adhering to the wing surface. Under these circumstances the application of de/anti-icing fluid to the wing of the aircraft would result in the snow sticking to the fluid. Under such operational conditions it may not be prudent to apply fluids to the wing.
However, if snow has accumulated at any location on the wing surface it must be removed prior to take-off. It cannot be assumed that an accumulation of snow on a wing will "blow off" during the take-off.

8. A frost that forms overnight must be removed from the critical surfaces before take-off. Frost can be removed by placing the aircraft in a heated hangar or by other deicing procedures. A recent accident in Birmingham England is a prime example of such an occurrence.

Manual Methods

9. Reducing the amount of deicing fluid used can have a positive impact on both the cost and the environmental. 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.

10. 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.

11. Some of the more common devices are:

- Brooms
- Brushes
- Ropes
- Scrapers

Note: Extreme care must be taken anytime manual methods are used to protect the highly sensitive and often fragile sensors and navigation antennas. Also very vulnerable to damage are: pitot tubes, static ports, angle of attack sensors, and vortex generators. When sweeping or “pulling” contamination off an aircraft, care must be taken to use motions which pull contamination away from any openings, in order to avoid forcing the contamination into any openings on the wings or stabilizers.

Brooms

12. Probably the most commonly used and most readily available deicing manual tool is the broom. Although a common household broom could be used, a larger, sturdier commercial variety is usually chosen. 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.

13. Brooms are very useful in cleaning windows and other sensitive areas (e.g. a radome) where the application of hot liquid is best avoided or prohibited.

14. Aircraft height requires that extra attention be paid to safety, especially when combined with the tendency to stretch the reach with a broom. If a ladder or other such device is used, personnel must be certain that it is well steadied. Slippery surfaces can make climbing somewhat dangerous.

15. Personnel have attempted to sweep snow from wing and tail surfaces while standing on these surfaces. This is an extremely unsafe practice with a very high risk of a slip and fall accident. As well, many surfaces are not stressed to support the weight of a person. The broom should be used in a pulling motion from leading edge to trailing edge

Scrapers

16. The most common type of scraper used is the commercial variety used to remove accumulation from building roofs. Because the 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. Normally best with wet heavy snow, the scraper should be used in a pulling motion from leading edge to trailing edge (i.e. lay the scraper high on the aircraft surface and pull towards you).

17. Also available commercially, and of similar benefit to the scraper, is the squeegee. Squeegees are generally available in a variety of sizes and have foam or a similarly soft material on one side and a rubber blade on the other side.

Ropes

18. Ropes are another method of removing contamination (usually light frost) from wings and horizontal tailplanes. The method requires two personnel and a seesaw motion back and forth across the surface to remove the contaminants. This method tends to polish thicker layers of frost and under such conditions, is not considered an acceptable method of preparing an aircraft for flight. This method would leave frost contamination on the critical surfaces prior to take off, which would not comply with CAR 602.11 or GOFR 622.11, and therefore, would not fulfill the “clean wing concept”.

Portable Forced Air Heaters

19. Heat from a portable forced air heater can effectively remove frost and ice from critical surfaces. These heaters are commonly found in remote and Northern Canadian locations and are normally used to heat aircraft interiors and to pre-heat aircraft engines.

20. 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.

21. 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. The operator must keep moving the duct to avoid overheating any spot as these heaters generate enough heat to cause damage to de-ice boots and other equipment if directed at a single spot for too long. Any water tends to refreeze quickly as no FPD fluids are used.

Hand Sprayers

22. Extreme operational conditions often require specific solutions. Winter operations in the Canadian North pose their own problems due to the extremes in both weather and temperature. It has been noted that a number of Air Operators carry Type I fluids with them in the aircraft from station to station so that it is available. The containers in which the fluid is kept resemble the common garden insecticide sprayer. The fluid in this circumstance would appear to be kept at a room temperature.

23. 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. Don't forget the undercarriage and the assistance of other personnel.

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.

24. Most aircraft ground icing related accidents have occurred when the aircraft was not de-iced prior to take-off. The 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.

25. 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. Pilots may call ATC and request information about anticipated delays before deicing and anti-icing is commenced. Controllers can assist pilots by giving them the best available information about delays, so the pilot may arrange to have the aircraft de-iced and anti-iced as closely as possible to the actual departure time.

26. Various techniques of aircraft ground deicing and anti-icing have been developed. The most common technique is to use FPD fluids in the ground deicing process and to anti-

ice with a protective film of FPD fluid to delay formations of frost, ice or snow. See SAE ARP4737A recommended deicing and anti-icing procedures.

Deicing and Anti-Icing the Airframe

27. Operational procedures employed in aircraft ground deicing and anti-icing vary, depending on the type of accumulation on the surface of the aircraft and the type of aircraft. The general procedures used by aircraft operators are similar and are based on the procedures recommended by the aircraft manufacturer, which, in turn, may be based upon procedures recommended by the fluid manufacturer, engine manufacturer, and the SAE HOT guidelines provide guidance based upon SAE recommendations for the application of SAE Types I, II, III and IV fluids as a function of outside air temperature (OAT).

28. An aircraft may be deiced by any suitable manual method. Parking the aircraft in a heated hangar for an appropriate amount of time to melt all contamination is a common deicing procedure for a smaller aircraft. Using wing covers or other temporary shelters will often reduce the amount of contamination and the time required for deicing and anti-icing aircraft, especially when the aircraft must be stored outside. Some types of contamination such as light, dry snow can be removed with a shop broom, or very light frost can be rubbed off using a rope sawed across the contaminated area.

29. Deicing is normally accomplished using heated water or solutions of heated water and FPD fluids, often followed by anti-icing using cold, Type II, III, or IV that have a longer HOT. Each fluid has very unique characteristics and handling requirements.

30. One of the more common deicing procedures in commercial operations involves using water, FPD fluids, or solutions of FPD fluids and water. High pressure spraying equipment is often used in large operations to add physical energy to the thermal energy of deicing fluids. Heating these fluids increases their deicing effectiveness; however, in the anti-icing process unheated fluids are more effective because the thickness of the fluids is greater.

31. 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.

32. 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.

33. 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.

CAUTION:

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. Consult the fluid manufacturer for further information.

Ensure Type IV fluids are applied evenly and thoroughly and that an adequate thickness has been applied in accordance with the fluid manufacturer's recommendations.

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.**

34. Figure 1 demonstrates how an aircraft must be systematically and symmetrically de-iced and anti-iced in weather conditions conducive to icing. Each aircraft surface requires a specific cleaning technique.

35. Generally, the fuselage should be de-iced and anti-iced from the top down. Clearing the top of the fuselage manually instead of by spraying requires that personnel use caution not to damage protruding equipment (e.g., antennae) while deicing. 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 or crazing of the windows. Deicing the top of the fuselage is especially important on aircraft with an aft-mounted centreline engines. The ingestion of ice or snow can result in compressor stalls or engine damage.

36. The radome or nose of the aircraft should be de-iced to eliminate snow or ice accumulations from being projected into the crew's field of vision during take-off. The nose also contains navigation and guidance equipment; therefore, it must be cleared of accumulations to ensure proper operation of the sensors.

37. The cargo and passenger doors must also be de-iced and anti-iced to ensure proper operation. All hinges and tracks should be inspected to ensure that they are free of accumulation. Although accumulation may not impair operation on the ground, it may freeze at flight altitude and prevent normal operation at the aircraft's destination. Frozen accumulation may also cause damage and leakage on cargo and passenger door latches and seals.

38. Sensor orifices and probes along the fuselage (e.g., static ports, pitot tubes, air intakes or temperature sensors) require caution during the application of FPD fluid. Direct spraying into these openings can damage the equipment, or residues could result in faulty readings.

39. The wings are the main lifting surfaces of the aircraft and must be free of contamination to operate efficiently. An accumulation of frost, ice or snow on the wing changes the airflow characteristics, reducing its lifting capabilities, increasing drag, increasing stall speed and changing pitching moments. The weight increase is slight and its effects are secondary to those caused by surface roughness.

40. On many aircraft, deicing of the wing begins at the leading edge wing tip, sweeping in the aft and inboard direction. This procedure avoids increasing the snow load on outboard wing sections, which under some very heavy snow conditions could produce excessive wing stresses. This method also reduces the possibility of flushing ice or snow deposits into the balance bays and cavities.

41. For aerodynamic reasons, ensure that the deicing and anti-icing procedures are conducted in a symmetrical fashion.

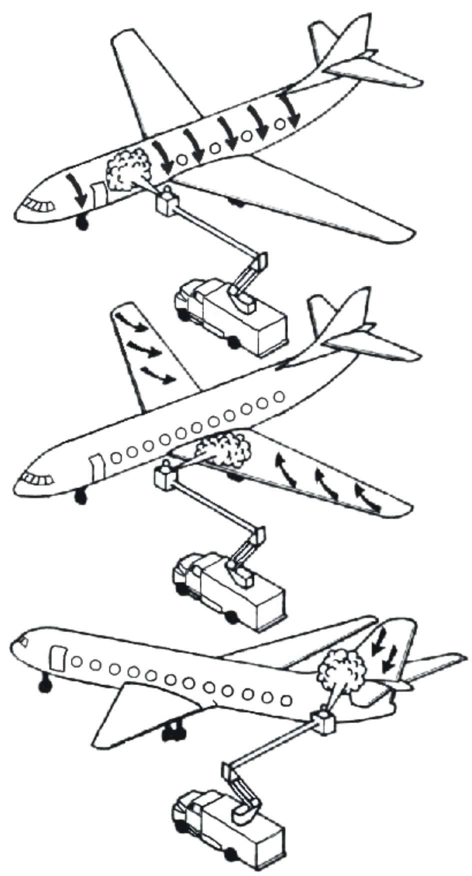

FIGURE 1. SYSTEMATIC AND SYMMETRICAL DEICING OF AIRCRAFT

42. 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.

43. It is important for operators to consider the configuration of their aircraft during deicing. Manufacturers may indicate that their aircraft need to be in a specific configuration during the deicing and anti-icing process. However, if an aircraft is in a clean configuration, that is with all high lift devices retracted, during deicing the operator needs to consider what untreated areas of the wing are subsequently exposed to freezing precipitation once the devices are extended/deployed. The areas under a leading edge flap or slat, if not protected by anti-icing fluids, have the potential of becoming a contaminated critical surface prior to take-off. Air operators need to consider this scenario and may need to develop additional procedures to ensure that the aircraft is taking off in an uncontaminated condition.
Two possible options include: delaying slat/flap deployment until just prior to take-off; and deploying the devices prior to de/anti-icing so that the surfaces under these devices are treated.

CAUTION:

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.

44. 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 balance bay area between moveable and stationary tail surfaces should be closely inspected. For some aircraft, positioning the horizontal stabilizer in leading-edge-down position allows the FPD fluid and contaminants to run off rather than accumulate in balance bays, while others may require the horizontal stabilizer in the leading-edge-up position. Consult your aircraft manuals for complete information.

45. Balance bays, control cavities and gap seals should be inspected to ensure cleanliness and proper drainage. When contaminants do collect in the surface juncture, they must be removed to prevent the seals from freezing and impeding the movement of the control surface.

Deicing the Engine Area

46. Minimal amounts of FPD fluid should be used to de-ice the engine area and auxiliary power unit (APU). FPD fluids ingested in the APU can cause smoke and vapours to enter the cabin. Engine intake areas should be inspected for the presence of ice immediately after shutdown. Accumulations should be removed while the engine is cooling and before installation of plugs and covers. Any accumulation of water must be removed to prevent the compressor from freezing.

47. For turbo-jet engines, FPD fluids should not be used for deicing internal components. Fluid residue on the engine fan or compressor blades can reduce engine performance or cause stall or surge. In addition, this could increase the possibility of glycol vapours entering the aircraft through the engine bleed air system.

48. Most turbo-jet and turbo-prop engine manufacturers recommend that thrust levers be advanced periodically to an N1 rpm of 70 to 80% while the aircraft is in ground operations to prevent ice accumulation that can result in reduced thrust, dynamic imbalance of the fan or compressor or excessive induction of shed ice. Pilots must be aware of these operating procedures and should comply with the manufacturers recommended procedures established for their aircraft.

Ground Deicing/Anti-Icing With Main Engines and/or APU Running

49. A number of aircraft and engine manufacturers have published information on the advisability of deicing/anti-icing with the main engines running, and when permitted, there are procedures to be followed in order to protect the engines.

50. Experience shows that problems can be minimized if precautions are taken to limit the ingestion of deicing/anti-icing fluid by the engines. The following procedures, which must be adapted to the specific aircraft type, were developed to protect the aircraft during deicing/anti-icing with the main engines running:

- Operate as few engines as possible during the deicing process;
- Operate at the lowest practicable power setting;
- If possible select air conditioning 'OFF';
- Avoid spraying fluid directly into the engine, APU, and air conditioning system intakes;
- Avoid a large run-off of fluid from adjacent surfaces into the intakes, e.g., from a vertical stabilizer into a tail-mounted engine or APU;
- Minimize the generation of spray in the vicinity of the intakes.
- Configure the aircraft in accordance with Manufacturers specifications

51. Particular care should be exercised for the APU inlet because fluid ingestion could cause an APU runaway condition, flameout or, in an extreme case, an APU rotor burst which often results in a fire.

52. More information can be found in the current CBAAC: “Ground Deicing/Anti-Icing Of Aircraft With The Main Engines Running” from the following website: http://tcinfo/CivilAviation/commerce/circulars/AC0072r.htm

Central and Remote Deicing

53. Some facilities employ remote deicing that is conducted near the end of the active runway. This practice has diminished in the last few years in favour of central facilities that can capture and recycle spent fluid, for environmental reasons.

54. Certain large airports have created highly automated and efficient Central Deicing Facilities (CDF) that can accommodate many aircraft at one time. They employ the latest

technology to expedite and control the flow of aircraft from the gate area to the deice pads which in turn minimizes takeoff delay time after the de/anti-ice procedure.

55. State of the art deice vehicles along with highly trained crews ensure that deicing operations are conducted efficiently and safely. The facilities have underground storage tanks that house fluid reserves and capture the runoff fluid from the aircraft for recycling purposes. They have the ability to adjust the amount of FPD in deicing fluid, called ”Proportional Mixing” or “Variable Blend”, for the given conditions. This process utilizes the automation of these facilities to adjust the fluid concentrations for the given weather conditions, which in turn become a cost savings for the operators. One operator has developed a program where all “Remain Over Night” (RON) aircraft are deiced with forced air, when dry snow conditions exist, during quiet hours. This minimizes the amount of deicing operations the next day as well as reducing the amount of deicing fluid utilized.

56. Voice and data transmission are conducted via set procedures and controlled by centralized operations centers. Controllers here can view each aircraft in the deice bay and its current stage of deicing, as well as maintain contact with each aircraft and the individual deice vehicles. Computer displays installed in the control centers and the deicing vehicles display updated information on aircraft status throughout the entire deicing process. Electronic message boards advise Air Crews of their status in the deice pads such as, the type of fluid being utilized, posting the time when final application of fluid commenced, the completion of spraying operations, and radio frequencies to contact ATS when deicing operations has ceased and all deicing crews are clear.

Variables That Can Influence Holdover Time

57. 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.

58. Holdover time guidelines are given in standard tables for different types of fluids, as a function of precipitation type and rate, and temperature to assist pilots.

Pilot Issues

59. 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

60. An efficient and reliable method of communication, appropriate to the site, allows pilots to communicate their intentions to the Deicing Operator at the earliest possible time. This may include details on aircraft type, on the estimated time of arrival (ETA) at the de-ice pad (if off gate deicing operations are in effect), on the possible requirement for a ground power unit (GPU), on the possible requirement for engine shutdown and treatment of the propellers (if so equipped), on the pertinent type of treatment required, on the type of any fluid(s) which may be required, or on any anomalies specific to the impending operation.

61. This early exchange of information allows the flight crew to adapt to problems that may come to light as a result of feedback received through early communication with the Deicing Operator. For example, if a specific fluid type was found to be unavailable, the pilot would be in a better position to review options and proceed with alternate arrangements if necessary and thereby reduce confusion and delay during ground deicing operations. This scenario will always be preferable to a situation where an aircraft arrives at the deicing location and then, due to a problem unknown to the pilot, is unable to undergo deicing with the likely result in the aircraft returning to the gate. This causes a delay and will inconvenience everyone involved; including the passengers and crews of other aircraft waiting in turn to enter the deicing facility or to use the deicing equipment.

62. On the other hand, if a flight crew receives an early warning of problems such as other aircraft experiencing unusually long delays, the aircraft PIC might elect to alter his plans. The change of plans may include adjusting fuel uplift, making additional communications. From an airport perspective this pre-planning can reduce congestion and improve on time departure success rates and contribute to safe ground operations.

63. In summary, 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

64. 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

65. 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".

Final Anti-icing Fluid Application Start Time

66. 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 Pilot

67. 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).

68. 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.

<u>Note:</u> It is important that the Deicing Operator be able to relay instructions to the aircraft PIC quickly and clearly.

Aircraft Alignment During Deicing

69. Most pilots will prefer to align their aircraft into the prevailing wind when preparing for a deicing / anti-icing operation, in order to reduce or prevent any fluid(s) being used from blowing back onto the flight deck windows. However, depending upon the location of the deicing location at an airport, and the traffic flow patterns on the ground at that airport, it may not be possible to align the aircraft directly into the prevailing wind for deicing purposes.

Post De/Anti-icing

70. 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

71. 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).
- Notificationto switch to hand signals (if applicable).

Critical Surface Inspections

72. 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;
- Spoilers and speed brakes;
- 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 and APU air intakes, inlets, and exhausts; and
- Landing gear.

73. 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. Conversely, the pilot must be informed when contamination of the aircraft critical surfaces still exists and that further deicing is required. The pilot's decision to terminate the flight may be based solely upon information obtained from the Deicing Operator.

Note: The "clean aircraft concept" policy is facilitated, in part, by the Critical Surface Inspection, which is a pre-flight external inspection of critical surfaces conducted by a qualified person, to determine if they are contaminated by frost, ice or snow.

Pre-Take-Off Contamination Inspection

74. 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, except where the operator has established a program in accordance with GOFR 622.11 and complies with that program. The pilot may need the assistance of qualified personnel to perform this inspection.

75. Unless other procedures have been specifically approved, a tactile external inspection must be conducted on all aeroplanes without leading edge devices (i.e., hard-wing), such as the DC9-10, the CRJ-50 and the F-28.

76. The components that can be inspected vary according to aircraft design. In some aircraft, the entire wing, and portions of the empennage are visible from the cockpit or the cabin. In other aircraft, these surfaces are so remote that only portions of the upper surface of the wing are in view. The under surface of wings and the landing gear are visible only in high wing type aircraft. A practice in use by some operators is to perform a visual inspection of wing surfaces, leading edges, engine inlets, and other components of the aircraft that are in view from either the cockpit or cabin, whichever provides the maximum visibility. The PIC may call upon the assistance of other qualified personnel. The pre-take-off inspection should concentrate on the leading edge in conjunction with the trailing edge. The trailing edge control surfaces and/or spoilers usually provide an early indication of imminent fluid failure on the leading edge. **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**.

77. 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.

78. Conducting a pre-take-off inspection in the manner described requires the PIC and other crew members, including flight attendants, to be knowledgeable of ground deicing and

anti-icing procedures and danger signs. This inspection should ensure that ground deicing and anti-icing were conducted in a thorough and uniform manner and that critical surfaces not in view from the cockpit or cabin are also clean.

Representative Aircraft Surfaces

Note: Transport Canada no longer maintains a list of approved representative aircraft surfaces.

79. Particularly for large aircraft where very limited portions of the aircraft can be seen from inside the aircraft, approved Representative Surfaces may be used to judge the condition of the aircraft's critical surfaces during ground icing conditions.

80. Representative Surfaces are intended to be used as a tool in gauging the contaminated state of critical surfaces on an aircraft after having used deicing and anti-icing fluids to clean the aircraft and then protect the aircraft from the freezing precipitation occurring during ground icing conditions.

81. An aircraft's representative surface is a portion of the aircraft that can be readily and clearly observed by flight crew from inside the aircraft and is used to judge whether or not the surface has become contaminated. By determining the state of the representative surface, it can then be reasonably expected that other critical surfaces will be in the same (or better) condition.

82. Prior to take-off, a visual check of the representative surfaces may be carried out by the pilot in command to ensure that contamination is not present at this stage of his flight; depending upon the requirements of the approved ground icing program. If conclusive, the aircraft may proceed to take-off, otherwise the aircraft must be de-iced again.

Take-off After Holdover Times Have Been Exceeded

83. 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.

84. 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".

85. Section 622.11 (6.3) of the **General Operating and Flight Rules (GOFR)** states, in part: "When holdover time tables are used as decision making criteria, take-off after holdover times have been exceeded can occur only if a pre-take-off contamination inspection is conducted, or the aircraft is de-iced/anti-iced again".

86. 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.**

87. 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

88. 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.

89. 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 loose 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.

90. 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.

Helicopters

CAUTION:

Note: The SAE has not published documents that support the use of FPD fluids on Rotorcraft. Rotorcraft manufacturers have not formally approved the use of FPD fluids and should therefore be consulted prior to using fluids.

91. For helicopters, the PIC must remember that ice exacts a very high performance penalty. Take-off with small quantities of ice on the rotor blades can also significantly reduce the autorotative capabilities of the rotor blades. Some of the special problems associated with helicopter operations in ground icing and other types of contamination conditions are outlined as follows:

- Footing during the external inspection, particularly on the upper deck, could be hazardous,
- Ice in inspection panel latches or doors may not allow access to critical areas. Attempting to force panels open may result in expensive damage,

- A coat of ice that has gone unnoticed on the main rotor blades or tips could result in asymmetric shedding during start up. The different blade weights and thrust characteristics results in a dramatic increase in vibration and poor control response. This could cause the aircraft to bounce off the pad and roll over or the pilot loses control on take-off. As well, ice is shed with a force that can be both destructive and deadly,

- Above normal torque may be required to hover and taxi,

- An ice build up on the fuselage or moisture that has pooled inside of structures and frozen may cause an adverse shift in the centre of gravity,

- An ice build up on skids or wheels could result in dynamic rollover if only one side breaks free when power is applied,

- An ice build up around exposed hydraulic actuators, or pitch change linkages may bind the controls in one or more axes, causing loss of control on take-off,

- An ice build up on a tail rotor may result in a loss of yaw control when the aircraft is first lifted into the hover. Asymmetric shedding could also cause damage to the airframe or gearbox attachment area,

- An ice build up in the particle separator may partially thaw at low power and be released into the intake with the first high power application. This is likely to occur early in flight at low airspeed, or on climb out, with a restricted land back option.

92. Following the Clean Aircraft Concept for helicopters is straightforward. The smart plan is to avoid surface contamination by placing the aircraft in a hangar whenever possible. Where operators do not have this option, other measures must be taken.

Suggestions For Other Measures:

- Use waterproof material covers for the main and tail rotors and transmission deck. Ideally, covers will protect the windshield, the pitot static system and a good portion of the fuselage. As well, install inlet and exhaust plugs. Install covers and plugs at the end of each day or whenever the aircraft is not scheduled for use to ensure it is protected during periods of unexpected surface contamination conditions;

- Use a combustion heater with sufficient outlet hose to allow the application of heat to the transmission area, rotor components and engine compartment, and to assist in the removal of frozen covers;

- Remove the covers and then examine the fuselage for contamination to ensure ice or snow from the covers has not fallen onto the fuselage or into engine intakes;

- Remove any contamination adhering to the fuselage or tail boom by any of the procedures outlined for aeroplanes, subject to the aircraft manufacturers' recommendations;

- Free skids, wheels or any part of the landing gear that is frozen to the ground or snow cover.

Emerging Technology Options

Alternate Technologies

93. The cost and potential environmental impact of deicing with conventional fluids, has driven the demand for the development of alternate deicing technologies. When considering the benefits of these technologies, it is important to understand that while the methodology may differ from that used with conventional fluids, the basic principles of de/anti-icing still apply. Recent technologies employ such scientific principles as: the latent heat of fusion; the sensing of vibrating elements; the employment of ultrasonic sensors; and the use of infrared (IR) detection cameras. Other technologies will no doubt evolve with time.

Infrared Heat Systems

94. Transport Canada approval for operational use of these systems at airports and on commercial aeroplanes had not been undertaken at the time of publication.

Forced Air Deicing

95. Airlines have shown increased interest in the use of forced air deicing to blow frozen contaminants off an aircraft surface, corresponding to the development by several manufacturers of forced air systems mounted on conventional deicing vehicles.

96. Some forced air deicing systems use high-pressure air or an air/fluid mix, while others are based on delivering large air volumes at low pressure. Some nozzle arrangements deliver air at a very high speed from the nozzle. A columnar air stream can be maintained over an extended distance to lengthen the effective reach of the high-speed air stream. Other designs demonstrate a very rapid decrease in speed of the air stream after it exits the nozzle. The air stream exiting the nozzle may be hotter than the ambient air because of the heat of compression.

97. Because the use of forced air systems is a relatively new process, no firm recommendations on operational use of those tested systems can be made. Some operators have been authorized to utilize forced air deicing to remove dry snow.

98. The use of forced air to remove contaminants, particularly snow, is a maturing technology. The concerns regarding the effect of large quantities of deicing fluid on the environment, in particular, has resulted in renewed forced air research efforts in recent years.

99. The results of the research are promising but as with any technology, there are compromises to be made when using forced air systems. Nonetheless, ongoing research is revealing that there is significant potential for forced air systems both in terms of economic savings and environmental relief. The use of Forced Air is subject to approval from aircraft manufacturer.

Note: A subsequent inspection of the critical surfaces will be required after the use of Forced Air.

Forced Air Alone

100. The use of forced air alone to remove contaminants is reasonably efficient when used to remove loose snow, but requires more diligence when used to remove adhering contaminants.

101. The effectiveness of forced air, at removing contaminants from the critical surfaces, depends upon a number of factors including: air stream velocity, air stream temperature, operator training and experience, outside air temperature, weather conditions and others.

Forced Air Augmented with Type I Fluid

102. Heated Type I fluid is injected into the high-speed air stream. One advantage of this deicing method compared to the air alone system is that heated Type I fluid carries more thermal energy than just air alone. Heat is the principle mechanism for removing adhering contaminants from an aircraft's critical surfaces; hence the ability to remove contaminants is enhanced with this method.

Forced Air with Type II, III and/or Type IV Fluids

103. These fluids are injected in the air stream, or applied over the air stream. The combination of anti-icing fluid and high speed forced air introduces some new concerns as well as some benefits. The anti-icing fluids must be handled correctly in order to retain their viscosity characteristics. One of the effects of injecting Type II & IV fluids into a high-speed air stream is that of shear. If these fluids are sheared significantly they lose some of their viscosity. The significance of this shear concern is that if the fluids are sheared excessively, the HOT values will not be valid for the fluid. It is anticipated that the concern about loss of viscosity will be addressed as forced air system design and operation are advanced.

Safety Issues

104. The high-speed airflow present in forced air systems can cause serious injury. Proper training and the use of protective equipment are required.

105. The noise level of forced air systems is typically very high. Hearing protection is a necessity when operating or working near these systems.

106. The high velocity air stream removes frozen contaminants from the aircraft and propels them at high speed. Personnel near a deicing operation that is using a forced air system must be alerted to the fact that high-speed debris is present.

107. Transport Canada has not evaluated a forced air system for operational use, at the time of publication of this document.

108. Transport Canada, Commercial and Business Aviation Branch, Operational Standards Division (AARXB), should be contacted to discuss any proposal to use these systems during Commercial aircraft ground icing operations.

Ground Ice Detection Systems (GIDS)

109. The development of ground ice detection sensor technologies has been stimulated by the difficulty in determining if an aircraft is free of frozen contaminants prior to take off. The human has a limited ability to accurately evaluate the condition of an aircraft's critical surface during ground icing operations. The limitations include: poor lighting conditions, visibility restrictions due to blowing snow, the difficulty in determining whether or not clear ice is present, and others. The advanced technologies used in GIDS may be able to overcome some of the human limitations.

110. GIDS are intended to be used during airplane ground operations to inform the ground crew and/or the flight crew and/or a relevant system about the condition of monitored airplane surfaces.

111. GIDS may provide a complementary or, when approved, a functional alternative to the visual and tactile checks required by regulatory agencies, including the European Joint Aviation Authorities (JAA), the United States Federal Aviation Administration (FAA) and Transport Canada Civil Aviation (TCCA), to determine the condition of airplane critical surfaces under operating conditions involving freezing contamination.

Occupational Safety and Health (OSH)

112. Pilots must be aware of the potential health effects of deicing and anti-icing fluids. Proper precautions must be taken during the deicing and anti-icing process to ensure the well being of passengers and flight crew. Passengers and crew should be shielded from all FPD fluid vapours by turning off all cabin air intakes during the deicing and anti-icing process. Exposure to vapours or aerosols of any FPD fluid may cause transitory irritation to the eyes. Exposure to ethylene glycol vapours in a poorly ventilated area may cause nose and throat irritations, headaches, nausea, vomiting, and dizziness.

113. All glycols cause some irritation upon contact with the eyes or the skin, although the irritation is described as "negligible", chemical manufacturers recommend avoiding skin contact with FPD fluids and wearing protective clothing when performing normal deicing and anti-icing operations.

114. Ethylene and diethylene glycol are moderately toxic for humans. Swallowing small amounts of ethylene or diethylene glycol may cause abdominal discomfort, pain and dizziness, and can affect the central nervous system and kidneys. Because the glycol

contained in FPD fluids is considerably diluted with water and other additives, it is unlikely that deicing personnel could ingest a lethal amount accidentally in the normal performance of their duties. Detailed information on health effects and proper safety precautions for any commercial FPD fluid is contained in the material safety data sheet for that fluid. This sheet is available from the fluid manufacturer and should be on file with the operator providing the deicing or anti-icing service.

Practices For Pilots To Ensure a Clean Aircraft and Pilot Issues

- Be knowledgeable of the adverse effects of surface roughness on aircraft performance and flight characteristics.
- Do not allow deicing and anti-icing until you are familiar with the ground deicing practices and quality control procedures of the service organization.
- Be knowledgeable of the function, capabilities, limitations, and operations of the ice protection systems installed on the aircraft.
- Be aware the FPD fluids used during ground deicing and anti-icing are not intended for, and do not provide, ice protection during flight.
- Be knowledgeable of ground deicing and anti-icing practices and procedures being used on your aircraft, whether this service is being performed by your company, a service contractor, a fixed base operator, or others.
- Be knowledgeable of critical areas of your aircraft and ensure that these areas are properly de-iced and anti-iced.
- Ensure that proper precautions are taken during deicing process to avoid damage to aircraft components and surfaces.
- Ensure that deicing and anti-icing are performed at the latest possible time before taxi to the take-off position.
- Ensure that the mandatory critical surface inspection is performed following the final application of FPD fluid.

Techniques For Implementing the Clean Aircraft Concept

- Establish training programs to update crewmembers on the hazards of winter operations, adverse effects of ice formations on aircraft performance and deicing and pre-take-off procedures during ground icing operations.
- Establish training programs for maintenance or other personnel who perform aircraft deicing to ensure thorough knowledge of the adverse effects of ice formations on aircraft performance and flight characteristics, critical components, specific ground deicing and anti-icing procedures for each aircraft type, and the use of ground

deicing and anti-icing equipment including detection of abnormal operational conditions.

- Procedures are utilized, that all critical areas are inspected, and that all critical components of the aircraft are clean prior to departure.

- Perform thorough planning of ground deicing activities to ensure that proper supplies and equipment are available for forecast weather conditions and that responsibilities are specifically assigned and understood. This is to include service contracts.

- Monitor weather conditions very closely to ensure that planning information remains valid during the ground deicing or anti-icing process and subsequent aircraft operations. Type or concentration of FPD fluids, deicing or anti-icing procedures, and departure plans should be altered accordingly.

- When applicable, use two stage deicing process where ice deposits are first removed, and secondly all critical components of the aircraft are coated with an appropriate mixture of FPD fluid to prolong the effectiveness of the anti-icing.

- Ensure thorough co-ordination of the ground deicing and anti-icing process so that the final treatments are provided just prior to take-off.

- At non-centralized locations, provide and use remote sites near the take-off position for deicing, anti-icing and final inspection, to reduce the time between deicing and take-off.

- Use multiple aircraft deicing or anti-icing units for faster and more uniform treatment during precipitation.

- Be knowledgeable of the variables that can reduce holdover time and the general effects of those variables

- Be aware that the HOT Guidelines are not exact values and that as the ground icing conditions and circumstances change, the applicable HOT values will change. Continued vigilance is required at all times during ground icing conditions.

- Ensure communication with the deicing/anti-icing crew is maintained at all times. It is essential that the PIC know exactly what surfaces are being treated and when deicing/anti-icing operations are complete and crews are clear.

- Do not start engines or engage rotor blades until it has been determined that all ice deposits have been removed and that all ground personnel and equipment are clear. Ice particles shed from rotating components may damage the aircraft or injure ground personnel.

- Be aware that certain operations, such as power back, may produce recirculation of ice crystals, snow, or moisture.

- Be aware that operations in close proximity to other aircraft can cause snow, ice particles or moisture to be blown onto critical aircraft components, or can cause dry snow to melt and refreeze.

- When aircraft are operating on slush or wet surfaces, ground crew should be particularly alert for contamination of the wheel wells, the underside of the belly and the control surfaces. Do not take-off if snow or slush is observed splashing onto critical areas of the aircraft, such as wing leading edges, during taxi.

- Be aware that SAE Type II and Type IV fluids should be used on aircraft with rotation speeds (V_r) above 100 knots.

- Use FPD fluids that are approved for use by the aircraft manufacturer. Some fluids may not be compatible with aircraft materials and finishes, and some may have characteristics that impair aircraft performance and flight characteristics or cause control surface instabilities.

- Do not use substances that are approved for use on pneumatic boots (to improve deicing performance) for other purposes unless the aircraft manufacturer approves such uses.

- Use FPD fluid types and concentrations that will delay ice formations for as long as possible under the prevailing conditions.

- Establish quality assurance programs to ensure that FPD fluids being purchased and used are of the proper characteristics, that proper ground deicing and anti-icing

- Do not attempt a take-off, under any circumstances, if there is, for any reason, doubt as to the condition of the critical surfaces. **When in doubt…ask investigate, check!**

Summary Chapter 4

- The best method of ensuring that an aircraft is clean of contamination is by preventing the contamination from collecting in the first place.
- Measures include hangers and wing covers.
- Manual methods to remove frozen contamination are brooms, brushes, ropes and scrapers.
- Heat from a portable forced air heater can effectively remove frost and ice from critical surfaces.
- Polishing frost is not considered an acceptable method of preparing an aircraft for flight.
- 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.
- An aircraft may be deiced by any suitable method such as hangering or manual methods.
- Deicing is normally accomplished using heated water or solutions of heated water and FPD fluids, often followed by anti-icing using cold, rich solutions that have a lower freezing point.
- Deicing and anti-icing with FPD fluids may be performed as a one-step or two-step process.
- For aerodynamic reasons, ensure that the deicing and anti-icing procedures are conducted in a symmetrical fashion.
- Generally, the fuselage should be de-iced and anti-iced from the top down.
- On many aircraft, deicing of the wing begins at the leading edge wing tip, sweeping in the aft and inboard direction. This procedure avoids increasing the snow load on outboard wing sections
- For turbo-jet engines, FPD fluids should not be used for deicing internal components.
- Particular care should be exercised for the APU inlet because fluid ingestion could cause an APU runaway condition, flameout or, in an extreme case, an APU rotor burst which often results in a fire.
- Follow procedures to protect the aircraft during deicing/anti-icing with the main engines running.

- The Deicing Operator must routinely provide information to the pilot and advise of any problems or malfunctions.
- Critical surface inspections should be performed immediately after final application of the anti-icing fluid.
- 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, except where the operator has established a program in accordance with the **Ground Icing Operations Standards** and complies with that 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.
- The SAE has not published documents that support the use of FPD fluids on Rotorcraft.
- Recent technologies employ such scientific principles as: the latent heat of fusion; the sensing of vibrating elements; the employment of ultrasonic sensors; and the use of infrared (IR) detection cameras.
- Transport Canada, Commercial and Business Aviation Branch, Operational Standards Division (AARXB), should be contacted to discuss any proposal to use these new systems for commercial aircraft ground icing operations.

Conclusion

Ground deicing and anti-icing procedures vary greatly depending primarily on aircraft type, type of contamination accumulation on the aircraft and FPD fluid type. Pilots should become familiar with applicable Canadian Aviation Regulations and Standards, the procedures recommended by the aircraft manufacturer in the Pilot Operating Manual, Aircraft Flight Manual, Maintenance Manual and, where appropriate, the aircraft service manual. As well, they should comply with all company operations manual provisions.

You may reproduce this training package as required and it can be found at:
http://www.tc.gc.ca/CivilAviation/communications/publications.htm

Copies of the current Transport Canada Ground Icing Operations Update (TP 14052) and the Holdover Time Guidelines may be obtained from your Regional Commercial and Business Aviation representative or the following website:
http://www.tc.gc.ca/CivilAviation/commerce/HoldoverTime/menu.htm

NASA Glenn Research facility has developed numerous in-flight icing media, which address problems, encountered while in-flight such as, tailplane stall, Super cooled Liquid Drops (SLD), aircraft icing certification criteria plus computer based icing training sessions. They are available from: **http://icebox-esn.grc.nasa.gov/**

Or by writing to the following address:
Icing Branch
NASA GRC
21000 Brookpark Rd.
MS 11-2
Cleveland, OH 44135
216-433-3900
216-977-7469 (fax)

The videos When in Doubt... Small Aircraft, Large Aircraft, and Ground Crew, and accompanying training packages, as well as the copies of the current CBAAC's and Transport Canada Ground Icing Operations Update (TP 14052) may be obtained from the Civil Aviation Communication Center at:

Toll Free: 1-800-305-2059
In the National Capital Area: (613) 993-7284 or from the following website:
http://www.tc.gc.ca/aviation

Part 2- Additional Information for Groundcrew

Chapter 5 Ground Crew Supplement

Role of Ground Crew

1. Your role in "The Clean Aircraft Concept" starts before you get to the apron. If the conditions that promote icing are present, you have to be alert before you get out there. When in doubt, ask the weather office for the most up-to-date forecasts. Find out what kind of temperatures and precipitation aircraft will experience on the apron. If precipitation is forecast, find out what kind.

2. Check your manuals for the correct de-icing procedures for the various aircraft you'll be servicing. Some aircraft have specific control surface settings for de-icing. The pilot should know them and you should be familiar with these recommendations as well.

3. Ground Crew are an important part of the flight team. The aircraft crew usually meet before a flight and good pilots involve everyone in the watch for contamination. But cabin and cockpit crew can't see all the aircraft surfaces from inside the aircraft. **You have to be their eyes and hands.**

Trained Personnel

4. Only properly trained personnel shall be employed in the aircraft de/anti-icing process in accordance with the Approved Ground Icing Program. Personnel are required to read, understand and follow the precautions listed in the fluid manufacturer’s product information bulletin (known as the Material Safety Data Sheet –MSDS), and on the product label, prior to using these materials.

Initial Training

5. At a minimum, <u>initial training for ground deicing crews and maintenance personnel</u> must cover the following (additional training may be required for larger and more complex organizations):

- Company policy
- Effects of Contamination
- Weather conditions requiring de/anti-icing
- De/Anti-icing Vehicle and Equipment
- Fluids & Fluid Application methods and techniques
- HOT considerations
- Inspection Procedures
- Safety

Recurrent Training

6. At a minimum, recurrent training for ground deicing crews and maintenance personnel must cover the following (additional training may be required for larger and more complex organizations):

- A review of current de-icing and anti-icing operations and inspection procedures;
- A review of any changes to the program;
- A review of the latest available research and development on ground de-icing and anti-icing operations; and
- Issuance of an information circular prior to commencement of winter operations to all involved personnel. The circular must review procedures and present any new information.

7. All trained personnel must be tested on all information covered in their respective initial and recurrent training programs.

8. An air operator that contracts de-icing/anti-icing services from another organization is responsible for ensuring that the training program of the contractor and application of de-icing/anti-icing operation standards meet the operator's own AGIP criteria. The operator is responsible for documenting the contractor's procedures and training.

Recommended Practices

11. 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 (ARP) 4737.

Record Keeping

12. An accurate, detailed record keeping system must be in place to allow easy access to all information pertaining to the deicing/anti-icing operation and fluids management. Care must be taken to ensure that not only is the information is accurate but also that it is recorded in a timely fashion and retained for a minimum of two years.

Fluid Description

13. 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.

14. 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.

15. 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.

Note: It is the heat contained by the Type I (de-ice) fluid and the hydraulic pressure (high pressure spray) that removes the frozen contaminants. The glycol provides some protection during precipitation conditions until Type II, III or IV fluid is applied.

Colour

16. 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.

Note: 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.

Qualified Fluids

17. A list of **qualified** de-icing and anti-icing fluids and the HOT tables are included in the current Ground Icing Operations Update TP-14052E. If reliable holdover times are to be achieved, only qualified fluids, stored, dispensed and applied in accordance with the manufacturers' instructions are acceptable. The qualified fluids have undergone laboratory testing to quantify their protection endurance and to confirm aerodynamic acceptability during simulated take-off conditions.

18. 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. Chemical property tests are also conducted. The operator is ultimately responsible for ensuring that only qualified fluids are used.

19. It is expected that additional fluids will be qualified from time to time. Operators are encouraged to contact suppliers or manufacturers to determine the qualification status of any de-icing or anti-icing fluid that does not appear in the CBAAC. However, the operator will be required to prove that fluids not on the approved list have been properly tested.

Industry Fluid Specifications.

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

Note: The status of ISO ground icing related documents has become uncertain, therefore only current SAE Specifications and documents are recognized by Transport Canada.

21. The SAE specifications are SAE Aerospace Material Specification (AMS) 1424, entitled: “Aircraft Deicing/Anti-icing Fluid SAE Type I”; and, SAE AMS 1428, entitled: “Deicing/Anti-icing Fluid SAE Type II, III and IV”.

22. Users should request certificates of conformance to these SAE specifications from the fluid manufacturers.

Freezing Point

23. The freezing points are determined by the American Society for Testing Materials (ASTM) D 1177 method, which measure the temperature of the first ice crystal formation.

24. Frequent determinations of the freezing point of fluids are required to ensure that the desired freezing point is maintained.

25. 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.

Refractometer Use in Determining a Glycol Based Fluid’s Freezing Point

26. The freezing point can be measured directly, using a method such as ASTM D 1177, however, this method is cumbersome for use in the field. The freezing point of fluids can be easily monitored in the field by measuring their refraction. The magnitude of the refraction is related to the concentration of glycol contained in the solution and therefore to the fluid freezing point.

27. The fluid manufacturers should be consulted for further operational information on the procurement and the training required for refractometer use in the field.

FPD Fluid Strength When Applied

28. The ratio of FPD ingredients to water, or fluid strength, is a significant factor in the de-icing 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. The reasons for this caution are explained below:

- Pure ethylene glycol has 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%.

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

30. Check the concentrations of the fluids you have available and know how they react under various conditions. If you do a quality assurance test as part of your procedure, don't skimp. If the test results are borderline, get help from your supervisor. Check with your supervisor, operations or maintenance to get the most up-to-date information available.

FPD Temperature Buffer

31. Temperature buffer is the temperature difference between the freezing point of the fluid as applied, and the ambient temperature. Remember from Part One that this buffer allows for absorption of precipitation.

32. Generally, the holdover time is increased with an expansion of the temperature buffer. Therefore, if the choice is available, use the maximum buffer. However, greater buffers require the use of more glycol, which is more costly and which increases the burden for collection and processing of FPD spillage and runoff. FPD fluid mixtures and their attendant buffers should be determined after consideration of the following factors in the listed order of priority:

- Safety;
- Environmental impact;
- Cost.

33. For SAE Type I fluids, the freeze point buffer of the anti-icing should be as great as possible but not less than 10°C (18°F).

34. For SAE Type II, III and IV, the freeze point buffer should not be less than 7°C (13°F).

Guidelines on the Use of Representative Surfaces

35. The Air Operator's Ground Icing Operations program must specify the ground and flight crew training to be conducted regarding the purpose, procedures and limitations with respect to Representative Surfaces. Training on the assessment procedures to be followed to determine whether or not the fluid has failed should be included in the program.

36. This technique may be used when the aircraft manufacturer has identified representative aircraft surfaces which can be readily and clearly observed by flight crew during day and night operations, and which are suitable for judging whether or not critical surfaces are contaminated.

37. When the aircraft is deiced and anti-iced, it is desirable for the representative surface to be treated first during the final application of fluid. Whether or not this procedural methodology is appropriate for any particular aircraft design needs to be determined.

38. Representative Surfaces may not be particularly effective during conditions when clear ice is forming on the aircraft's critical surfaces. Clear ice is even difficult to identify under ideal lighting conditions from outside the aircraft. Additional aircraft type specific procedures, such as tactile inspections, may be required.

39. Other surfaces which are visible from inside the aircraft should also be inspected whenever possible, in addition to the Representative Surfaces. For example, under very good lighting conditions it may be possible to examine the surface of the wing beyond the Representative Surface.

40. For large aircraft where it is necessary for one pilot to leave the flight deck in order to accomplish the pre-take off contamination inspection, there is the potential for the disruption of "checklist flow". The operator's ground icing plan should therefore specify at what point the inspection should take place in order to minimize any such disruption.

41. Flight crew must be made aware that the use of representative surfaces for contamination detection may not be feasible in poor weather under very poor lighting conditions. The presence of contaminants on the cabin or cockpit windows may also make it difficult to properly observe the Representative Surfaces. Under conditions such as these it is prudent to have an external inspection conducted, to return for deicing and anti-icing or to delay the flight until conditions improve and a safe take off can be assured.

42. Air Operators that have established a program in accordance with TC **Ground Icing Operations Standards** may have representative aircraft surfaces designated and approved for their aircraft. Representative surfaces that can be clearly observed by flight crew from inside the aircraft may be suitable for judging whether or not critical surfaces are contaminated.

43. Many operators have painted a portion of the representative surface in a darker colour to aid in the visual detection of contamination. Some have designated representative surfaces on both sides of the aircraft in the event that, due to strong wind during taxi, one side of the aircraft becomes contaminated before the other.

44. Research has indicated that fluid failure occurs **last** at the mid chord sections of wings. Therefore, whether painted or not, areas located at mid chord sections of wings and previously used for checking fluid conditions are not suitable for evaluating fluid failure and should no longer be used exclusively as representative surfaces. Tests have shown that first fluid failure occurs in the areas of the leading and trailing edges on aircraft with leading edge devices and that first fluid failure occurs in the areas of the spoilers, wing tip and the trailing edges on hard wing aircraft. (Note: The leading edges should always be checked because they are critical to aircraft performance.)

45. Pre-take-off contamination inspections should be concentrated on the leading edge close to the fuselage (the wing high lift area) and ahead of the aileron (the roll control area) where these are visible. Dependent upon aircraft configuration, wing spoilers may also be used to provide an indication of fluid condition.

46. In addition to the representative surface, other aircraft critical surfaces which are visible from inside the aircraft should be inspected for contamination whenever possible.

47. The operational advantage of a check from inside the aircraft is obvious in this circumstance. However, as stated in the TC standard, the operator's program must specify the conditions, such as weather, lighting and visibility under which such an inspection may be conducted. In some cases, even the presence of residual deicing and anti-ice fluid on cabin windows may make a proper visual check difficult or impossible.

48. In any event, flight crew personnel should be aware that the use of a representative surface for contamination detection might not be feasible in some circumstances. A return to the deicing facility will be the only safe alternative, if any doubts exist, regarding the condition of the aircraft.

The decision to take off following the pre-take-off inspection is the responsibility of the PIC.

Deicing and Anti-icing Procedures

49. Most aircraft ground icing related accidents have occurred when the aircraft was not de-iced prior to take-off. The de-icing process is intended to restore the aircraft to a clean configuration so neither degradation of aerodynamic characteristics nor mechanical interference from contaminants will occur.

50. 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. Various techniques of aircraft ground de-icing and anti-icing have been developed. The most common technique is to use FPD fluids in the ground de-icing process and to anti-ice with a protective film of FPD fluid to delay formations of frost, ice or snow.

Deicing/Anti-icing Fluid on the Cockpit Windscreen.

51. The inherent properties of the fluids often results in the aircraft windshield wipers being rather inefficient at removing the fluids from the windscreen. In fact, the wipers will often merely smear the fluid resulting in a smudged windscreen, which makes it extremely difficult for the pilots to see out of the cockpit, especially during nighttime operations.

52. Deicing Operators should be aware of this phenomenon and realize that even small amounts of deicing fluid covering flight deck windows can cause pilots to lose visual contact with the operation taking place around the aircraft. If this situation occurs, especially when hand signals are used as the only means to communicate, the communication between the pilot and the deicing operator may be impossible, and the overall safety of the operation may be compromised.

53. In some instances it will not be possible to prevent deicing fluid build-up on the windscreens; however, the deicing operator should be aware of the negative implication of this situation. When an aircraft has been given depart clearance from the pad, the actual departure may need to be delayed while the pilot attempts to remove the fluid using windshield wipers, or while he waits for the fluid to run down the windscreen and thin out for better forward visibility.

The very fact that deicing spray can reduce visibility from the cockpit down to nil, makes a compelling argument for the use of a hard wire or radio communication link between the PIC and the deicing crew.

Adequate Nighttime Flood Lighting

54. Deicing an aircraft in a dimly lit, low visibility environment can be both difficult and unsafe. The ability to enter and exit the deicing area safely is hampered, especially at night when conditions like blowing snow has reduced visibility. The lighting should be sufficiently bright to allow for “day like” operations to take place. Nighttime lighting should be shielded to prevent glare for pilots of aircraft taxiing, landing or taking off in close proximity to the deicing facility.

55. Good flood lighting, whether it is permanently fixed, portable or vehicle mounted, should be installed in consideration of the following points:

- Adequate nighttime lighting at the deicing facility will allow pilots to see clearly and therefore follow the hand signals of the Deicing Operator.
- Deicing crews will require sufficient nighttime flood lighting to enable them to provide the best possible deicing/anti-icing treatment.
- Pilots will also need a well lit environment within which to conduct a pre-take-off contamination inspection.

Fluid Application Procedures

56. SAE document ARP 4737 and the fluid manufacturers recommendations should be consulted in establishing sound operations de/anti-icing procedures.

57. The deicing/anti-icing operation should be performed as close in time to the takeoff procedure as possible. This generally means that the location chosen on an airport for deicing is as near to the end of the operational runway as is possible.

58. De/anti-icing near the beginning of departure runways reduces the interval between the anti-icing process and take off. It is this interval that determines whether takeoff can be achieved prior to fluid failure. Once the fluid has failed, the aircraft must be de/anti-iced again. Under no circumstances shall a second application of anti-icing fluid be applied over a contaminated anti-icing fluid layer.

59. Research has indicated that if the fluid is not applied correctly, the HOT Guideline values are not achievable.

CAUTION:

Types II, III & IV fluids, in particular, must be applied using specialized equipment. If these fluids are not applied in the correct manner and with the correct equipment, as recommended by the fluid manufacturer, they will NOT function as designed and will therefore NOT provide the expected protection as indicated in the HOT tables.

Fluid application procedures from SAE ARP 4737 Caution and Fluid Application Reminder, are outlined in the Table entitled: "Type I Deicing Fluid Application Procedures for Type I fluids", and in the Table entitled: "SAE Type II/IV Anti-Icing Fluid Application procedures" for Types II, III and IV fluids, available at the Transport Canada HOT website.

60. Depending on the prevalent weather conditions, available equipment, technology, fluids and the desired holdover time, a one step or a two step de/anti-icing procedure may be appropriate. The aircraft must be treated symmetrically for aerodynamic reasons, as recommended in ARP 4737.

61. Individual aircraft manufacturers provide guidance on specific anti-icing or deicing procedures for their particular aircraft models. An Air Operator must obtain and follow the aircraft manufacturers' guidance.

62. It is also necessary for the Air Operator to understand aircraft deicing and anti-icing standard practices, such as those published in SAE document ARP 4737. The Regulations, Standards and Guidance published by Transport Canada must also be followed.

63. The effectiveness of anti-icing fluid in protecting the aircraft's critical surfaces from the adherence of frozen contaminants is dependant upon the correct execution of the deicing process. The proper procedures and equipment must be employed to ensure that when both deicing and anti-icing with fluids have been accomplished the aircraft is safe for take off. This assurance requires that a thoroughly qualified and trained deicing crew accomplish the tasks.

64. Cold soaked wings can be considerably below the ambient temperature therefore frost can build up in localized wing areas. When active frost is anticipated, SAE Type II or IV may be applied to the surfaces to prevent frost accumulation. Both wings should receive a symmetrical treatment for aerodynamic reasons.

Note: The following guidance is general in nature and is not intended to be fluid manufacturer specific.

One-Step Deicing/Anti-icing

65. Generally, in Canada the use of a one step process suggests that there isn't any active precipitation occurring at the time of deicing. However, in Europe the one step method is used with Type II & Type IV anti-icing fluids in a diluted and heated state, and applied with a specialized nozzle. Also, in Canada's Northern communities, given the extremely low temperatures, the only fluid option has been the Type I fluids, and a one step procedure is sometimes used despite the associated short Hold Over Times.

66. The thickened fluids, Types II, III & IV, should not be used unheated on an aircraft contaminated with any snow ice or frost. The aircraft surfaces must first be cleaned before application of an unheated fluid Two Step Deicing/Anti-icing.

Two Step Deicing/Anti-icing

67. Generally is used when the aircraft is contaminated and when precipitation is active. If a two step procedure is used, the first step is typically performed using a deicing fluid; however, alternate deicing technology or mechanical methods may be used depending upon circumstances.

68. The selection of fluid type and concentration depends on the ambient temperature, the weather conditions and the desired holdover time. When performing a two-step process, the freezing point of a fluid used for the first step must not be less than 3°C above ambient temperature. The freezing point of a SAE Type I fluid used for one-step or as the second step of the two-step operation must be at least 10°C below the ambient temperature. The second step must be completed as quickly as possible following first step fluid application (not more than 3 minutes). The two step process may need to be performed area by area.

69. When deicing fluid is used in step 1, the application of the second step fluid will flush away the first step fluid and leave a film of anti-icing fluid which is designed to be of adequate thickness. If freezing of the deicing fluid has occurred, step 1 must be repeated. Refer to SAE ARP 4737 document for additional details.

70. SAE Type I fluids have limited effectiveness as an anti-icing fluid due to their short holdover time. SAE Type II or IV fluids used as deicing/anti-icing agents may have a temperature application limit of -25°C. The application limit may be lower provided a 7°C buffer between the freezing point and the ambient temperature is maintained and the fluid has been demonstrated to be aerodynamically acceptable at this ambient temperature.

First Step:

- Apply heated ADF until all of the frozen contaminants have been removed from the aircraft's critical surfaces. The ADF fluid is typically heated so that it will arrive at the application nozzle at around 60-82°C (140-180°F).

- No frozen contaminants shall remain after application of an ADF, including under the fluid.

- Aircraft surfaces should be treated symmetrically for aerodynamic reasons.

Second Step:

- Apply the AAF to aircraft surfaces before any freezing of the ADF occurs. Typically the application of AAF should occur within 3 minutes of deicing with an heated ADF.

CAUTION:

- **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. Consult the fluid manufacturer for further information.**

- **Ensure Type IV fluids are applied evenly and thoroughly and that an adequate thickness has been applied in accordance with the fluid manufacturer's recommendations.**

71. Figure 2 demonstrates how an aircraft must be systematically and symmetrically de-iced and anti-iced in weather conditions conducive to icing. Each aircraft surface requires a specific cleaning technique.

72. Generally, the fuselage should be de-iced and anti-iced from the top down. Clearing the top of the fuselage manually instead of by spraying requires that personnel use caution not to damage protruding equipment (e.g., antennae) while deicing. 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 or crazing of the windows. Deicing the top of the fuselage is especially important on aircraft with an aft-mounted centreline engine. The ingestion of ice or snow can result in compressor stalls or engine damage.

73. The radome or nose of the aircraft should be de-iced to eliminate snow or ice accumulations from being projected into the crew's field of vision during take-off. The nose also contains navigation and guidance equipment; therefore, it must be cleared of accumulations to ensure proper operation of the sensors.

74. The cargo and passenger doors must also be de-iced and anti-iced to ensure proper operation. All hinges and tracks should be inspected to ensure that they are free of accumulation. Although accumulation may not impair operation on the ground, it may freeze at flight altitude and prevent normal operation at the aircraft's destination. Frozen accumulation may also cause damage and leakage on cargo and passenger door latches and seals.

75. Sensor orifices and probes along the fuselage (e.g., static ports, pitot tubes, air intakes or temperature sensors) require caution during the application of FPD fluid. Direct spraying into these openings can damage the equipment, or residues could result in faulty readings.

76. The wings are the main lifting surfaces of the aircraft and must be free of contamination to operate efficiently. An accumulation of frost, ice or snow on the wing changes the airflow characteristics, reducing its lifting capabilities, increasing drag, increasing stall speed and changing pitching moments. The weight increase is slight and its effects are secondary to those caused by surface roughness.

77. On many aircraft, de-icing of the wing begins at the leading edge wing tip, sweeping in the aft and inboard direction. This procedure avoids increasing the snow load on

outboard wing sections, which under some very heavy snow conditions could produce excessive wing stresses. This method also reduces the possibility of flushing ice or snow deposits into the balance bays and cavities.

78. The various aircraft types that will be de-iced at a station need to be identified. The operators must be very familiar with any unique deicing considerations based upon aircraft type.

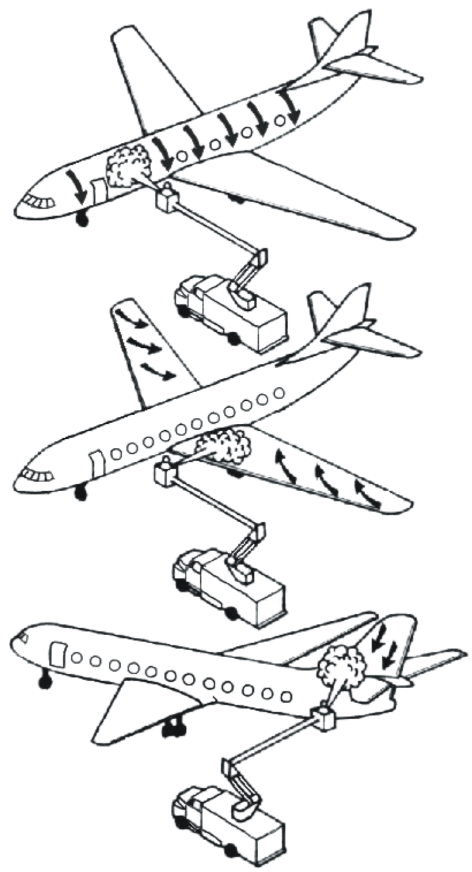

FIGURE 2. SYSTEMATIC AND SYMMETRICAL DEICING OF AIRCRAFT

79. 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.

80. It is important for operators to consider the configuration of their aircraft during de-icing. Manufacturers may indicate that their aircraft need to be in a specific configuration during the de-icing and anti-icing process. However, if an aircraft is in a clean configuration, that is with all high lift devices retracted, during de-icing the operator needs to consider what untreated areas of the wing are subsequently exposed to freezing precipitation once the devices are extended/deployed. The areas under a leading edge flap or slat, if not protected by anti-icing fluids, have the potential of becoming a contaminated critical surface prior to

take-off. Air operators need to consider this scenario and may need to develop additional procedures to ensure that the aircraft is taking off in an uncontaminated condition.

81. Two possible options include: delaying slat/flap deployment until just prior to take-off; and deploying the devices prior to de/anti-icing so that the surfaces under these devices are treated.

82. The tail surfaces require the same caution afforded the wing during the de-icing 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 balance bay area between moveable and stationary tail surfaces should be closely inspected. For some aircraft, positioning the horizontal stabilizer in leading-edge-down position allows the FPD fluid and contaminants to run off rather than accumulate in balance bays. For some aircraft, the horizontal stabilizer must be in the leading-edge-up position. Consult your manuals for complete information.

83. Balance bays, control cavities and gap seals should be inspected to ensure cleanliness and proper drainage. When contaminants do collect in the surface juncture, they must be removed to prevent the seals from freezing and impending the movement of the control surface.

No Spray Zones

84. Operators need to clearly understand where they can or can not spray de/anti-icing fluids. Examples of no spray zones include, but are not limited to:

- Engine inlets and openings;
- APU inlets;
- Engine exhaust openings;
- Aircraft brakes;
- Flight deck windows;
- Cabin windows;
- Passenger door handles;
- Static ports;
- Pitot heads;
- Air data sensors;
- Avionics vents; and
- Aircraft manufacturer specified “no spray” areas.

85. The above list includes items where direct spraying is not recommended; whereas indirectly washing the item with deicing fluid is acceptable (e.g. cabin windows). Consideration must also be given to factors which continuously vary with time, such as: the number and types of vehicles in use, a one step or a two step process, local weather conditions, local operational peculiarities, and so on.

86. Operators must be very familiar with any unique deicing considerations based upon aircraft type.

De-icing the Engine Area

87. Minimal amounts of FPD fluid should be used to de-ice the engine area and auxiliary power unit (APU). FPD fluids ingested in the APU can cause an auto shutdown, overspeed or rotors burst (which can lead to a fire) as well as, smoke and vapours to enter the cabin. Engine intake areas should be inspected for the presence of ice immediately after shutdown. Accumulations should be removed while the engine is cooling and before installation of plugs and covers. Any accumulation of water must be removed to prevent the compressor from freezing.

88. For turbo-jet engines, FPD fluids should not be used for de-icing internal components. Fluid residue on the engine fan or compressor blades can reduce engine performance or cause stall or surge. In addition, this could increase the possibility of glycol vapours entering the aircraft through the engine bleed air system.

89. Most turbo-jet and turbo-prop engine manufacturers recommend that thrust levers be advanced periodically to an N1 rpm of 70 to 80% while the aircraft is in ground operations to prevent ice accumulation that can result in reduced thrust, dynamic imbalance of the fan or compressor or excessive induction of shed ice. Pilots are made aware of these operating procedures in training. All procedures should comply with the procedures established by the manufacturer.

Ground De-Icing/Anti-Icing With Main Engines Running

90. A number of aircraft and engine manufacturers have published information on the advisability of de-icing/anti-icing with the main engines running, and when permitted, the procedures to be followed in order to protect the engines.

91. Experience shows that problems can be minimized if precautions are taken to limit the ingestion of de-icing/anti-icing fluid by the engines. The following procedures, which must be adapted to the specific aircraft type, were developed to protect the aircraft during de-icing/anti-icing with the main engines running:

- Operate as few engines as possible during the de-icing process;
- Operate at the lowest practicable power setting;
- If possible select air conditioning 'OFF';
- Avoid spraying fluid directly into the engine, APU, and air conditioning system intakes;
- Avoid a large run-off of fluid from adjacent surfaces into the intakes, e.g., from a vertical stabilizer into a tail-mounted engine or APU;
- Minimize the generation of spray in the vicinity of the intakes.

Fluid Application

Spray Pressure

92. During the deicing process, it is a combination of temperature and fluid velocity that dictate the efficiency with which the frozen contaminants are dislodged from the aircraft's surfaces. This is most effectively accomplished with a nozzle spray angle of approximately 45 degrees. The contaminants which are not removed from the surfaces by the initial impact of the fluid are melted off, or debonded, by virtue of the thermal energy contained in the heated deicing fluid.

93. Excess pressure can result in fluid velocities out of the nozzle that can cause impact damage to aircraft components. The aircraft manufacturer should be consulted to ensure that any proposed deicing procedures will not damage the aircraft and render it unsafe for flight.

94. When applying anti-icing (AAF) fluids to the aircraft surfaces only correct pumping equipment must be used to avoid shearing the fluid and thereby destroying the fluid's HOT capacity. The fluid manufacturer should be contacted to determine what methods should be employed in the application of their fluids.

Proper Coverage

95. 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. Adequate fluid quantities must be expended to accomplish the de/anti-icing tasks. Proper training will help ensure that the de/anti-icing task is accomplished in a manner that utilizes the fluids most effectively and that the aircraft is subsequently rendered safe for flight.

96. The deicing with fluids process is not completed until the aircraft's critical surfaces are completely free from frozen contamination. This can only be accomplished with the use of a sufficient quantity of deicing fluid to complete the task.

97. For the purpose of deicing, hot Type I fluid is generally applied directly onto the total aircraft surface to be de-iced. If applied only to the front part of the wing, allowing it to flow back to the aft part, the fluid will cool down significantly as it moves on the surface of the wing making it less effective, or even ineffective in melting frozen contamination on the aft part of the wing.

98. It is considered imperative that the leading edges of the wings and control surfaces be thoroughly cleaned of any contaminant. No frozen precipitation or contamination can be allowed to remain underneath the deicing fluid. Hot deicing fluid must be applied in sufficient quantity that the remaining fluid on the surfaces to be protected has a freezing point at least 10^{o}C below Outside Air Temperature (OAT). As the fluid is applied, it is being diluted by the melted ice, snow or whatever frozen accumulation it is removing. Its freezing point is thus increased.

99. Sufficient hot deicing fluid must be applied to make sure that fluid diluted by melted slush, snow or ice is flushed away. This is best accomplished by applying the fluid from the high point on the wing to the low point on the wing. Typically from wing tip to wing root.

100. The anti-icing with fluids process is not properly accomplished if an insufficient amount fluid has been used and which results in incomplete or inadequate coverage of the surfaces to be treated.

101. For the second step of a two step procedure, a sufficient amount of aircraft anti-icing fluid must be applied that can completely cover the surfaces and form an adequate coating. The HOT table values are based upon the application of sufficient fluid. Insufficient coverage results in a thin layer and reduced protection of uncertain duration.

102. The application process should be continuous and as short as possible. Anti-icing should be carried out as near to the departure time as possible in order to utilize available holdover time. While thickness will vary in time over the profile of the wing surface, the anti-icing fluid should be distributed uniformly. In order to control the uniformity, all horizontal aircraft surfaces should be visually checked during application of the fluid. The amount of fluid required, will be visually indicated by the fluid just beginning to run off the leading and trailing edges of the surfaces.

103. For a typical ethylene based Type IV fluid, between 1 mm and 3 mm thickness layer is required. It takes 2 litres of fluid to cover 1 square metre to a depth of 2 mm. Since application is never perfect, it will take more than 2 litres/square metre to achieve this 2 mm fluid thickness (In non-metric units, it will take at least 2 U.S. gallon/ 40 sq. ft. to achieve 0.08 inches). Conversion factors:

- litre = 0.5284 U.S. gallon;
- mm = about 0.08 inch; and
- 1 square metre = 10.76 square feet.

Note: For more detailed information on specific fluids, contact the de/anti-icing Fluid manufacturer.

Heat Loss

104. The heated ADF should be dispensed as close to the surface to be deiced as possible. Application of heated fluid from a distance results in the significant cooling of the fluid enroute to the aircraft surfaces which will reduce the fluid's ability to remove frozen contaminants. The thermal energy contained in heated ADF fluids has been shown to be a principle factor in the efficient removal of frozen contaminants from the aircraft's surfaces. Therefore, within limits, the hotter the fluid is when it reaches the aircraft's surfaces, the more effective it will be in removing the contaminants. The deicing operator training program will need to emphasize correct techniques to get the best performance from the fluid in use.

Areas to be Covered

105. The application strategy should adopt standard techniques while considering unique procedures necessary for specific aircraft design differences. Where possible, mechanical removal of snow, ice or slush accumulations should be considered as well as the proper execution of such procedures.

106. All windows and doors of the aircraft must be closed during spraying, engine may be shut down or idling and air-conditioning and/or APU air must be off, unless otherwise recommended by the airframe and engine manufacturer.

107. A spray to provide an even and uniformly distributed film should be used in a continuous process of application.

108. The surfaces to be treated are typically:

- Wing leading and trailing edges;
- Wing and controls upper surfaces;
- Horizontal stabilizer and elevator upper surfaces;
- Vertical stabilizer and rudder; and
- Fuselage upper surfaces on aircraft with rear fuselage mounted engines, depending on amount and type of precipitation.

109. Care must be taken to ensure that ice, snow and slush has not accumulated or has not been overlooked in critical places such as the flight control hinge areas, auxiliary power unit (APU) intake or between stationary and moveable surfaces. The front and rear sides of fan blades must be checked prior to start-up when engines are not running. Clear ice can form below a layer of snow or slush and can be hard to detect therefore the surface of the aircraft must be carefully examined after deicing. Care must be taken to avoid inadvertently spraying fluid directly onto the cabin and cockpit windows, doors and emergency exits, or into the intake of a running APU.

110. In general, deicing treatment must be done in a leading edge to trailing edge direction. Failure to follow this methodology may result in contamination being forced into the wing or stabilizer openings where it could re-freeze and jam control systems and thereby result in an unsafe condition.

Note: T-tail aircraft. These types of aircraft have the potential to tip due to the imbalance caused when the wings are clean and the tail surfaces have a heavy accumulation.

Excessive Application

111. Excess application can become a safety problem. The tarmac surfaces become slippery because of the fluid and the clean up process become onerous and expensive. Any accumulation of fluid on the ground must be cleaned up and disposed of in a safe and environmentally friendly manner.

112. Proper training of deicing crews will help minimize waste and deicing costs.

Inspection for Contaminants

113. As part of the walk-around, the aircrew will be looking very closely at the aircraft. If it's snowing or raining, an icy wing looks just like a wet wing.

114. You as ground crew must check your own area closely. **The best testing tools are your eyes and your hands.** If a surface looks suspect and conditions are ripe for freezing contamination, run your hand across the surface. If it is wet, you'll slosh water around. But if you feel thick water or a mild, gritty feeling, you are feeling snow and water or ice crystals and water. Light sheet ice is sometimes found over a coating of water. It will break or shift around when you feel it. Heavy ice, sticking to the aircraft, will feel pebbly, or feel too smooth. Heavy ice also looks slightly cloudy. Some ice is rough and hard to see through to the aircraft skin, while other ice is smooth and as clear as water. Snow accumulation is obvious: it looks like snow. But some areas of certain aircraft can fool you. For example, most jet engine intakes have a built-in heater to keep the intake clear of ice in flight and on the ground. If melted ice in the intake is allowed to refreeze (while overnight, for example) and snow falls on that refreezing water, you'll find what looks like some snow in the intake. Run your hand through it and you'll find a hard lump of ice with a fine cover of snow sitting in the intake.

Representative Aircraft Surfaces

<u>Note:</u> Transport Canada no longer maintains a list of approved representative aircraft surfaces.

115. Air carriers that have established a program in accordance with GOFR 622.11 may have representative aircraft surfaces designated and approved for their aircraft. Representative surfaces that can be clearly observed by flight crew from inside the aircraft may be suitable for judging whether or not critical surfaces are contaminated. Guidelines for the approval of representative surfaces have been developed.

116. Many operators have painted a portion of the representative surface in a darker colour to aid in the visual detection of contamination. Some have designated representative surfaces on both sides of the aircraft in the event that, due to strong wind during taxi, one side of the aircraft becomes contaminated before the other.

117. Research has indicated that fluid failure occurs **last** at the mid chord sections of wings. Therefore, whether painted or not, areas located at mid chord sections of wings and previously used for checking fluid conditions are not suitable for evaluating fluid failure and should no longer be used exclusively as representative surfaces.

118. Pre-take-off contamination inspections should be concentrated on the leading edge in conjunction with the trailing edge of the wing. Dependent upon aircraft configuration, wing spoilers may also be used to provide an indication of fluid condition.

119. In addition to the representative surface, other aircraft critical surfaces which are visible from inside the aircraft should be inspected for contamination whenever possible.

120. While not recommended, if ground operations are to be conducted in freezing precipitation conditions, TC strongly recommends the use of Type II, III or IV anti-icing fluids (in accordance with the aircraft manufacturer's instructions) in order to take advantage of their superior protection characteristics.

The decision to take off following the pre-take-off inspection is the responsibility of the PIC.

Collection and Disposal

121. Fluid runoff from deicing operations shall be contained, collected and disposed of in accordance with federal, provincial and municipal regulations and guidelines. Please note that laws and regulations governing disposal may change. It is the responsibility of the user to assure that disposal is appropriate and is in compliance with legal requirements.

Environmental Impact

122. The local Environment Canada representative should be contacted for information on the detailed requirements for protection of the environment from the adverse effects of deicing fluids.

123. Aircraft deicing or anti-icing fluids that are allowed to enter surface waters can have an adverse effect on aquatic life. For this reason, it is recommended that the runoff from deicing operations be contained and diverted to either a water treatment system or a glycol reclamation system.

124. A portion of the deicing fluid applied to the aircraft surfaces during deicing operations drains onto the apron surface and subsequently enters drainage runoff or percolates into subsurface soils.

125. Although some glycol has been found in the air and groundwater, the most significant environmental concern is associated with storm water discharges to surface waters. As glycol has a high biochemical oxygen demand (BOD), the discharge of untreated runoff containing aircraft deicing fluids into receiving waters creates an unacceptable pollution problem and a potential hazard to aquatic life.

126. To ensure that airport effluent does not negatively impact on the environment, a number of airports throughout Canada have implemented a program of sampling and analyzing storm water. Water quality programs have also been established at Local Airport Authorities and Canadian Airport Authorities. Although existing environmental legislation does not specifically require water monitoring, federal, provincial, and municipal laws do specify water quality standards and guidelines to be followed by industry.

127. To ensure responsible environmental management of glycol based chemicals used in deicing operations the Air Operator, Service Provider and local Airport Authority shall prepare detailed glycol management plans and procedures.

Fluid Contamination

128. Fluid contamination can generally be avoided by following established procedures and practices. The following is a list of considerations that should be undertaken as a minimum:

New Equipment

129. New equipment placed into service should be thoroughly cleaned. Pay particular attention to new deicing trucks, which are often shipped with an antifreeze solution in the pump and piping system. Drain the system and rinse with clean water before filling the truck with deicing fluid and introducing it into service.

Weatherproof Covers.

130. Make certain that the tank covers of the trucks and the storage tanks are weatherproof and do not allow water into the tank; however, recognize that proper venting is still required. If it is suspected that water or contaminants have entered the tanks, check the product in the tanks to ensure that it meets specification(s) and if necessary thoroughly clean the tanks and ensure that the covers are repaired to a weatherproof state.

Internal Inspection of Tanks.

131. Some deicing/anti-icing trucks have the anti-icing fluid tank sharing a common wall with the deicing fluid tank. Some tank walls can develop cracks, allowing deicing and anti-icing fluids to mix. The presence of even small amounts of deicing fluid in the anti-icing fluid can cause significant anti-icing fluid performance and thus effect the HOT times. Valves and hoses can also leak and allow fluid mixing or contamination. Routine inspection is required to help prevent these issues from arising.

Transfer of Fluid

132. Transfer of fluid from deicing equipment into storage tanks should not be accomplished without appropriately testing the fluid. If the fluids were contaminated this action would result in the contamination of the fluid in the storage tank.

Dedicated Equipment

133. Use dedicated storage and handling facilities for deicing fluids. Make certain that loading and unloading lines are clean. Routine inspections are required.

Labeling

134. Conspicuously label storage tanks, loading and transfer lines, valves, deicing/anti-icing truck tanks, and pumps for instant identification to minimize the risk of product

contamination. Before transferring any fluid, check the label on both the source and receiving vessels, as required by WHMIS regulations.

Forbidden Mixtures

135. Do not mix deicing fluids with any other product unless approved by the fluid manufacturer.

Occupational Safety and Health (OSH)

136. We should all be aware of the potential effect on health of de-icing and anti-icing fluids. Proper precautions must be taken during the de-icing and anti-icing process to ensure the well being of passengers and flight crew. Passengers and crew should be shielded from all FPD fluid vapours by turning off all cabin air intakes during the de-icing and anti-icing process. Exposure to vapours or aerosols of any FPD fluid may cause transitory irritation to the eyes. Exposure to ethylene glycol vapours in a poorly ventilated area may cause nose and throat irritations, headaches, nausea, vomiting, and dizziness.

137. All glycols cause some irritation upon contact with the eyes or the skin. Although the irritation is described as "negligible", chemical manufacturers recommend **avoiding skin contact with FPD fluids and wearing protective clothing and equipment** when performing normal de-icing and anti-icing operations.

138. Ethylene and diethylene glycol are moderately toxic for humans. Swallowing small amounts of ethylene or diethylene glycol may cause abdominal discomfort, pain and dizziness, and can affect the central nervous system and kidneys. Because the glycol contained in FPD fluids is considerably diluted with water and other additives, it is unlikely that de-icing personnel could ingest a lethal amount accidentally in the normal performance of their duties. Detailed information on health effects and proper safety precautions for any commercial FPD fluid is contained in the material safety data sheet for that fluid. This sheet is available from the fluid manufacturer and should be on file with the operator providing the de-icing or anti-icing service.

Techniques for Implementing the Clean Aircraft Concept

- Establish training programs to update crewmembers on the hazards of winter operations, adverse effects of ice formations on aircraft performance and de-icing and pre-take-off procedures during ground icing operations.

- Establish training programs for maintenance or other personnel who perform aircraft de-icing to ensure thorough knowledge of the adverse effects of ice formations on aircraft performance and flight characteristics, critical components, specific ground de-icing and anti-icing procedures for each aircraft type, and the use of ground de-icing and anti-icing equipment including detection of abnormal operational conditions.

- Establish quality assurance programs to ensure that FPD fluids being purchased and used are of the proper characteristics, that proper ground de-icing and anti-icing procedures are utilized, that all critical areas are inspected, and that all critical components of the aircraft are clean prior to departure.

- Perform thorough planning of ground de-icing activities to ensure that proper supplies and equipment are available for forecast weather conditions and that responsibilities are specifically assigned and understood. This is to include service contracts.

- Monitor weather conditions very closely to ensure that planning information remains valid during the ground de-icing or anti-icing process and subsequent aircraft operations. Type or concentration of FPD fluids, de-icing or anti-icing procedures, and departure plans should be altered accordingly.

- When applicable, use two stage de-icing process where ice deposits are first removed, and secondly all critical components of the aircraft are coated with an appropriate mixture of FPD fluid to prolong the effectiveness of the anti-icing.

- Ensure thorough co-ordination of the ground de-icing and anti-icing process so that the final treatments are provided just prior to take-off.

- Ensure communication with the de-icing/anti-icing crew is maintained at all times. It is essential that the PIC know exactly what surfaces are being treated and when de-icing/anti-icing operations are complete and crews are clear.

- When feasible, provide and use remote sites near the take-off position for de-icing, anti-icing and final inspection, to reduce the time between de-icing and take-off.

- Use multiple aircraft de-icing or anti-icing units for faster and more uniform treatment during precipitation.

- Use FPD fluids that are approved for use by the aircraft manufacturer. Some fluids may not be compatible with aircraft materials and finishes, and some may have characteristics that impair aircraft performance and flight characteristics or cause control surface instabilities.

- Do not use substances that are approved for use on pneumatic boots (to improve de-icing performance) for other purposes unless the aircraft manufacturer approves such uses.

- Use FPD fluid types and concentrations that will delay ice formations for as long as possible under the prevailing conditions.

Critical Surface Inspections

139. Critical surface inspections should be performed immediately after final application of the fluid to verify that the aircraft critical surfaces are free of contamination. (Refer to the *Ground Icing Operations Standards* if applicable to your operation.) 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. 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;
- Spoilers and speed brakes;
- 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 and APU air intakes, inlets, and exhausts; and
- Landing gear.

140. 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.

Emergency Service

Transport Canada maintains a 24-hour emergency service for all chemical products (Call CANUTEC at 613-996-6666 collect).

Many fluid manufacturers also have a 24-hour emergency service for their products. The user should obtain the manufacturer's emergency phone number for ready reference.

<u>DO NOT WAIT</u>, if in doubt, call a specialist for advice.

Conclusion

Ground de-icing and anti-icing procedures vary greatly depending primarily on aircraft type, type of contamination accumulation on the aircraft and FPD fluid type. Ground crew should become familiar with applicable Canadian Aviation Regulations and Standards, the procedures recommended by the aircraft manufacturer in the Aircraft Flight Manual, Maintenance Manual and, where appropriate, the Aircraft Service Manual. As well, they should comply with all Company Operations Manual provisions.

You may reproduce this training package as required and it can be found at:
http://www.tc.gc.ca/CivilAviation/communications/publications.htm

Copies of the current Transport Canada Ground Icing Operations Update (TP 14052) and the Holdover Time Guidelines may be obtained from your Regional Commercial and Business Aviation representative or the following website:
http://www.tc.gc.ca/CivilAviation/commerce/HoldoverTime/menu.htm

For further information regarding Ground Icing issues please refer to the latest Commercial and Business Aviation publication titled " Guidance for Aircraft Operations under Icing Conditions", and can be downloaded from the following website:
http://www.tc.gc.ca/CivilAviation/commerce/HoldoverTime/menu.htm

NASA Glenn Research facility has developed numerous in-flight icing media, which address problems, encountered while in-flight such as, tailplane stall, Supercooled Liquid Drops (SLD), aircraft icing certification criteria plus computer based icing training sessions. They are available from: **http://icebox-esn.grc.nasa.gov/**

Or by writing to the following address:
Icing Branch
NASA GRC
21000 Brookpark Rd.
MS 11-2
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The videos When in Doubt... Small Aircraft, Large Aircraft, and Ground Crew, and accompanying training packages, as well as the copies of the current CBAAC's and Transport Canada Ground Icing Operations Update (TP 14052) may be obtained from the Civil Aviation Communication Center at:

Toll Free: 1-800-305-2059
In the National Capital Area: (613) 993-7284 or from the following website:
http://www.tc.gc.ca/aviation

Chapter 6-Aircraft Critical Surface Contamination Examination Questions

To assist air operators in establishing Surface Contamination Training, Transport Canada has made available this training package concerning the adverse effect of critical surface contamination on aircraft performance.

This publication is to be used with reference to the Canadian Aviation Regulations (CARs) Parts VI and VII, Ground Icing Operations Update TP-14052E, the Aeronautical Information Publication (A.I.P.) - Canada, and industry publications.

When developing a knowledge verification examination to meet the CARs requirements, air operators may select appropriate questions from this publication and add questions specific to their operation. References are given to assist in determining the correct response to each question.

Comments or suggestions with respect to this publication should be referred to:

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1.0 Air Law, The Clean Aircraft Concept

1.01 Frost, ice or snow on top of deicing or anti-icing fluids

(1) is not considered as adhering to the aircraft and a take-off may be made.
(2) must be considered as adhering to the aircraft and a take-off should not be attempted.
(3) is only considered as adhering to the aircraft when Vr speeds are below 100 kt.
(4) is not considered as adhering if the aircraft has been de-iced and then anti-iced.

1.02 Where conditions are such that frost, ice or snow may reasonably be expected to adhere to the aircraft, no person shall take-off or attempt to take-off in an aircraft unless

(1) it has been de-iced.
(2) it has been inspected immediately prior to take-off to determine whether any frost, ice or snow is adhering to any of its critical surfaces.
(3) its skin temperature is warm enough to ensure that adhering frost, ice or snow will slide off on take-off.
(4) its power and runway length are sufficient to allow acceleration to Vr plus 10% before rotation.

1.03 Prior to take-off, the PIC cannot confirm that the aircraft is "clean". Take-off

(1) may be commenced provided the maximum holdover time has not been exceeded.
(2) may be commenced provided the anti-ice fluid used was of the type that prevents ice or snow from sticking to the critical surfaces.
(3) may be commenced provided the amount of frost, ice, or snow does not exceed that specified in the company operations manual.
(4) must not be attempted until confirmation is obtained that the aircraft is clean.

1.04 One engine is kept running during a quick turn around in icing conditions because you are unable to restart it with existing internal or external power. When taxiing for take-off, you are advised that there is a significant amount of wet snow on the aircraft. As your operating instructions require both engines to be shut down for deicing, you should

(1) take off but delay rotation until Vr plus 10%.
(2) take off as wet snow will slide off as the aircraft becomes airborne.
(3) taxi back to the apron, shut down the engine you are able to restart and have the critical surfaces carefully de-iced.
(4) cancel the flight until proper equipment is available or necessary repairs made.

1.05 The only positive assurance that an aircraft is "clean" prior to take-off can be achieved by

(1) confirmation from the crew chief that the fluid used has the required holdover time.
(2) ensuring the aircraft is not subjected to excessive ground delays.
(3) close inspection by the PIC or designated flight crew member.
(4) ensuring take-off is within the applicable holdover time table.

1.06 Who may inspect an aircraft immediately prior to take-off to determine whether any frost, ice or snow is adhering to any of its critical surfaces?

The PIC and

A. a flight crew member of the aircraft designated by the PIC to carry out the inspection.
B. the operations officer.
C. the deicing crew.
D. a person designated by the operator who has received the required surface contamination training.
E. any Aircraft Maintenance Engineer.

(1) A, B, C, D, E.
(2) A, B, C, D.
(3) A, B, C.
(4) A, D.

1.07 When a crew member of an aircraft observes frost, ice or snow adhering to the wings of an aircraft before take-off, the crew member

(1) shall immediately report that observation to the PIC.
(2) need not report that observation if the aircraft has recently been de-iced.
(3) shall immediately report that observation to the designated crew member.
(4) unless designated, need not report that observation.

1.08 Before commencing take-off the PIC is advised that there is frost, ice or snow adhering to the wings of the aircraft.

The PIC

(1) may take off without a further wing inspection if the aircraft has been recently de-iced.
(2) shall request a go/no go decision from company operations.
(3) shall request the deicing crew to inspect the wings before take-off.
(4) or another flight crew member designated by the PIC shall inspect the wings before take-off.

1.09 No person shall commence a flight in an aircraft

(1) unless it has been de-iced if frost, ice, or snow conditions exist.
(2) unless assured that adhering frost, ice or snow will slide off on take-off.
(3) if frost, ice, or snow is adhering to any of its critical surfaces.
(4) if frost, ice, or snow adhering to the critical surfaces cannot be removed on take-off by the aircraft deicing systems.

1.10 An air carrier shall provide training to crew members on the adverse effects of aircraft surface contamination

(1) biannually.
(2) on initial hiring and annually.
(3) biennially.
(4) on initial hiring only.

1.11 Persons other than crew members who require annual training on the adverse effects of aircraft surface contamination are those

(1) designated by the air carrier to carry out inspections in relation to the identification, reporting and inspection of surface contamination.
(2) involved in flight operations safety awareness programs.
(3) baggage handlers and refuellers who service the air carrier's aircraft.
(4) designated by the air carrier to de-ice its aircraft.

1.12 Candidates taking the training program on adverse effects of aircraft surface contamination

(1) need not have their results recorded.
(2) shall be tested orally on the use of deicing and anti-icing equipment.
(3) shall be tested to verify they understand and are able to apply the concepts taught.
(4) shall write an examination on the concept and use of deicing and anti-icing equipment.

1.13 Persons who are involved in flight operations and who are not required to undergo periodic training on the adverse effects of aircraft surface contamination shall be

(1) advised of their responsibility for inspection of surface contamination.
(2) designated as backup for identification and reporting of surface contamination.
(3) tested on their understanding of reporting and inspection concepts.
(4) given a safety awareness program on the subject.

1.14 A flight attendant observes snow adhering to the wings of an aircraft. The flight attendant

(1) shall report that observation to the head flight attendant.
(2) shall immediately report that observation to the PIC.
(3) need not report that observation if the aircraft was de-iced.
(4) need not report that observation if the aircraft was anti-iced.

1.15 The PIC notes that frost caused by cold-soaking fuel is adhering to the underside of the wings. Take-off may

(1) not be attempted until the aeroplane is de-iced.
(2) not be attempted under any circumstances as the frost, if removed, will quickly reform.
(3) be made at the discretion of the PIC.
(4) be made provided it is conducted in accordance with the aircraft manufacturer's instruction.

1.16 A take-off with frost adhering to the underside of a wing may

(1) not be made under any circumstance.
(2) be made if it is conducted in accordance with the aircraft manufacturer's instructions.
(3) be made providing the grains of frost are no larger than .004 inches in diameter.
(4) be made providing the affected area has been treated with an undiluted Type I fluid.

1.17 Who may inspect an aircraft immediately prior to take-off to determine whether any frost, ice or snow is adhering to any of its critical surfaces?

(1) The PIC.
(2) A flight crew member of the aircraft who is designated by the PIC.
(3) A person designated by the operator of the aircraft who has received the required surface contamination training.
(4) All of the above.

1.18 Select the correct statements regarding the use of representative aircraft surfaces.

A. The operator's Ground Icing Operation Program must specify the conditions under which they may be used to comply with the Pre-Take-Off Inspection.
B. They must be areas that can be clearly observed by the flight crew.
C. Their surfaces should not be altered in any way that makes them appear different from the surrounding surfaces.
D. A maximum of one surface will be approved for each aircraft.
E. They may be used after the holdover time is exceeded to decide if a take-off may be made.

(1) A, B, C, E.
(2) A, B, E.
(3) A, C, D.
(4) B, D, E.

1.19 What are the requirements to allow operators in Canada with rear-mounted engines to take off with hoar frost on the fuselage?

(1) The fuselage shall be de-iced if other contaminants are present.
(2) A copy of the exemption shall be attached to the aircraft deicing/anti icing procedures in the operations manual.
(3) Hoar frost shall be the only contaminant on the fuselage.
(4) All the above.

2.0 Theory and Aircraft Performance

2.01 Aircraft certified for flight in known icing conditions have been designed and have demonstrated system capability of providing adequate protection against the adverse effects of airframe icing

(1) both in flight and on the ground.
(2) in flight only.
(3) on the ground only.
(4) under all inflight icing conditions.

2.02 Stall warning systems are calibrated to give an effective warning

(1) in icing conditions if all components are heated.
(2) in icing conditions when the backplate is heated.
(3) under all conditions.
(4) under clean wing conditions.

2.03 Aircraft performance may be seriously affected by frost, ice or snow on the wings and control surfaces primarily because of the

(1) increase in gross weight.
(2) disruption of smooth airflow.
(3) strong possibility that the control hinges will freeze.
(4) adverse movement of the C of G.

2.04 Frost, ice or snow on a wing will

(1) increase the stall speed but will not affect the rate of climb.
(2) decrease the stall speed and reduce the rate of climb.
(3) increase the stall speed and reduce the rate of climb.
(4) not affect the stall speed or the rate of climb.

2.05 Contamination on an aircraft wing is dangerous primarily because

(1) the aircraft may become airborne in ground effect but be unable to climb.
(2) drag will prevent the aircraft accelerating to take-off speed.
(3) its weight will cause the centre of pressure to move forward and reduce the rate of climb.
(4) of all of the above factors.

2.06 Frost, ice or snow formation on the leading edge and upper surface of a wing, having a thickness and surface roughness similar to medium or coarse sandpaper, can reduce the wing lift by as much as . . . . . and increase drag by as much
as . . . . . .

(1) 10%, 20%.
(2) 30%, 40%.
(3) 50%, 75%.
(4) 75%, 100%.

2.07 The adverse effects of frost, ice or snow on aircraft include

(1) decreased thrust and lift, and increased drag and stall speed.
(2) trim changes and altered stall characteristics.
(3) altered handling qualities.
(4) all of the above.

2.08 Frost, ice or snow on an aircraft may

(1) increase the stall speed but the stall characteristics remain the same.
(2) increase the drag but take off acceleration remains unaltered.
(3) decrease the lift and alter stall and handling characteristics.
(4) decrease thrust and stall speed.

2.09 A significant part of the loss of wing lift can be attributed to

(1) under wing contamination.
(2) leading edge contamination.
(3) flap contamination.
(4) trailing edge contamination.

2.10 The use of SAE Types II and IV fluids on large aircraft

(1) will not cause any performance degradation or require weight or other take-off compensation.
(2) will require weight and take-off compensation for all those with a Vr of 100 kt and below.
(3) should be restricted to those with a Vr above 100 kt.
(4) should be restricted to those with a Vr above 85 kt.

2.11 The use of SAE Types II and IV fluids could cause significant performance degradation for aeroplanes with rotation speeds

(1) of 85 kt to 100 kt only.
(2) of 85 kt and below only.
(3) above 100 kt.
(4) of 100 kt and below.

2.12 One of the key determinants in using anti-icing fluids on a particular aeroplane is the

(1) time taken to accelerate to Vr.
(2) time taken to accelerate to V1.
(3) distance travelled to accelerate to V2min.
(4) distance travelled to accelerate to V3.

2.13 Who should determine what effect SAE Types II and IV fluid dryout, remaining on the aircraft, will have on aircraft performance or handling qualities during flight?

(1) The fluid manufacturer.
(2) The aircraft manufacturer.
(3) The aircraft operator.
(4) The deicing contractor.

2.14 Undiluted propylene glycol, having a strength of about 88% glycol, at temperatures less than -10□C has been found to cause lift reductions of about

(1) 10%.
(2) 20%.
(3) 30%.
(4) 40%.

2.15 Frost and ice could form or snow could adhere to the surface of an aircraft if its skin temperature is

(1) at or below freezing and the surrounding air is above freezing.
(2) below freezing and the surrounding air is cool and humid.
(3) at or below freezing and the surrounding air is well below freezing.
(4) all of the above.

2.16 After extended flight at a temperature of –20°C, an aircraft arrives for a quick turn around at an aerodrome where the temperature and dew point are 10°C and 9°C respectively. The pilot could expect

(1) blockage of the fuel vent system.
(2) ice formation over the entire wing surface.
(3) no adverse problems.
(4) frost to form in the area of the wing fuel tanks.

2.17 An aircraft which has been de-iced in a heated hanger is rolled out into sub-zero temperatures. The pilot should be particularly alert for

(1) freezing of wet surfaces or pooled water.
(2) frost formation.
(3) sublimation of water vapour into ice crystals.
(4) all of the above.

2.18 When aircraft are operating on slush or wet surfaces, ground crew should be particularly alert for contamination of

(1) the wheel wells.
(2) the underside of the aircraft.
(3) the control surfaces.
(4) all of the above.

2.19 An aircraft is refuelled with sub-zero temperature fuel in conditions of high humidity. The pilot could expect

(1) clear ice to form around integral fuel cells.
(2) frost to form around integral fuel cells.
(3) no icing or frost problems.
(4) frost to form around integral fuel cells only if the ambient air temperature is below zero.

2.20 After extended flight at a temperature of –20°C, an aircraft arrives for a quick turn around at an aerodrome where there is light drizzle with a temperature of +8°C. The pilot could expect

(1) no adverse problems.
(2) ice to form on top of the wing in the area of the fuel tanks.
(3) frost to form on top of the wing in the area of the fuel tanks.
(4) ice to form on the bottom of the wing and frost to form on the top.

2.21 When an aircraft that has experienced frost formation on the wing because of the cold-soaking phenomenon is de-iced,

(1) the maximum holdover table values are applicable.
(2) the frost tends to reform quickly, even when removed.
(3) no further deicing will be required.
(4) the minimum holdover table values are applicable.

2.22 A very critical cold-soaking phenomenon situation arises at aerodromes where there is

(1) drizzle with an ambient temperature around +15°C.
(2) rain with an aircraft skin temperature of +8°C.
(3) dry snow with an aircraft skin temperature between +8°C and +14°C.
(4) wet snow with an ambient temperature around 0°C.

3.0 Deicing / Anti-icing Fluids

3.01 Holdover time is

(1) a fixed time for fluid breakdown specified by the manufacturer.
(2) a fixed time for fluid breakdown specified by the ISO and SAE standards.
(3) the estimated time that an application of deicing/anti-icing fluid is effective in preventing frost, ice or snow from adhering to treated surfaces.
(4) the estimated time to fluid shear from the aircraft surfaces.

3.02 The term "holdover time" as applied to anti-icing or deicing fluids is the

(1) recommended maximum storage time in approved containers.
(2) recommended maximum time the fluid should be allowed to remain on the aircraft surface to avoid corrosion.
(3) estimated spray application time.
(4) estimated time the fluids will prevent frost, ice, or snow from forming or accumulating on the treated surface of an aircraft.

3.03 Pure 100% ethylene glycol should not be used for deicing in non-precipitation conditions because

(1) the freezing point is higher than fluids with a proper glycol/water ratio.
(2) this fluid is highly corrosive unless diluted with water.
(3) undiluted, it is highly flammable.
(4) it could cause a loss of efficiency of the lifting surfaces due to its higher viscosity.

3.04 Undiluted propylene glycol at temperatures less than -10°C is quite viscous and may produce a reduction in lift of approximately

(1) 10%.
(2) 20%.
(3) 30%.
(4) 40%.

3.05 The reason deicing fluid acts as an anti-icing fluid for a very limited time is because

(1) it does not mix well with water.
(2) it mixes well with water.
(3) it has a relatively high viscosity.
(4) the FPD has a relatively high freezing point.

3.06 Substances approved for use on pneumatic boots to improve deicing performance

(1) may also be used to enhance anti-icing of the wing and tailplane leading edges.
(2) are not to be used for other purposes unless approved by the aircraft manufacturer.
(3) may also be used in anti-icing windows.
(4) are not to be used for other purposes under any circumstances.

3.07 Snow falling on an aircraft that has been de-iced will cause the deicing fluid to lose its effectiveness because

(1) its molecular sheer structure breaks down.
(2) the melting snow lowers its temperature.
(3) it becomes saturated, allowing the water to reach the aircraft skin and freeze.
(4) the freezing point at the top of the film of fluid is less than at the bottom.

3.08 The heating of freezing point depressant (FPD) fluids

(1) decreases their deicing effectiveness.
(2) increases their deicing effectiveness.
(3) has no effect on their deicing effectiveness.
(4) has no effect on their anti-icing effectiveness.

3.09 SAE Type II and Type IV anti-icing fluids are usually applied

(1) directly to snow and ice covered aircraft.
(2) after the aircraft has been de-iced conventionally.
(3) mixed with hot water in a 50/50 ratio.
(4) with deicing fluid in one pass.

3.10 SAE Type II and Type IV anti-icing fluids are effective anti-icers because they

(1) adhere to stationary lifting surfaces.
(2) shed most of the fluid during take-off.
(3) provide longer protection than type I deicing fluid.
(4) accomplish all of the above.

3.11 SAE Type II and Type IV anti-icing fluids

(1) do not affect the lift of the wing.
(2) are contaminants and are designed to flow off on take off.
(3) reduce surface friction and decrease drag.
(4) change the angle of attack required for lift-off.

3.12 Select the correct statements about SAE Type II and Type IV anti-icing fluids.

A. They do not adhere to the stationary lifting surfaces.
B. Their viscosity is very low, even at low airspeed.
C. They are recommended for use on all types of commercial aircraft.
D. They readily flow off the surfaces of large aircraft on take-off.

(1) A, B, C.
(2) B, C, D.
(3) C.
(4) D.

3.13 SAE Type II anti-icing fluids provide

(1) the required "clean" aircraft condition before the application of deicing fluid.
(2) a degree of holdover time protection from further frost, ice or snow accumulation.
(3) unlimited holdover time protection from further frost, ice or snow accumulation.
(4) holdover time protection against further accumulation based solely on the viscosity.

3.14 The performance of SAE Type II anti-icing fluid applied with improper equipment may be reduced by at least

(1) 80% to 90%.
(2) 50% to 80%.
(3) 30% to 40%.
(4) 20% to 60%.

3.15 The use of SAE Type II and Type IV anti-icing fluids are recommended for aircraft with rotation speeds above

(1) 75 kt.
(2) 85 kt.
(3) 95 kt.
(4) 100 kt.

3.16 The acceptable Decision Criteria Times are the

(1) median times in the holdover tables.
(2) times shown in the Ground Icing Operations Standard.
(3) shortest time within the applicable holdover timetable cell.
(4) longest time within the applicable holdover timetable cell.

3.17 A Type II fluid has met an acceptance test down to -42ºC. The reported freezing point as measured by the deicing operator is – 40ºC. The OAT is -35ºC. Calculate the Lowest Operational Use Temperature (LOUT).

(1) -33 º C.
(2) -35 º C.
(3) -40 º C.
(4) -42 º C.

3.18 Refer to Appendix: SAE Type I Fluid Holdover Times (Table 1)

Moderate snow is falling and the reported outside air temperature is -5°C. Your aircraft is de-iced and anti-iced with SAE Type I fluid. What is the minimum holdover time you could expect?

(1) 5 minutes.
(2) 6 minutes.
(3) 8 minutes.
(4) 11 minutes.

3.19 Refer to Appendix: SAE Type II Fluid Holdover Times (Table 2)

Freezing fog is present and the outside air temperature is -2°C. Your company uses the Ground Icing Operations Standard and your aircraft is anti-iced with an undiluted SAE Type II fluid. What is the acceptable Decision Criteria Time for these weather conditions?

(1) 25 minutes.
(2) 35 minutes.
(3) 1 hour.
(4) 1 hour, 30 minutes.

3.20 Refer to Appendix: SAE Type IV fluid Holdover Guidelines (Table 3)

Snow is falling and the temperature is -2°C. The ground operator has just completed the deicing/anti-icing of your aircraft and advises you that the holdover time is between 25 and 35 minutes. According to the Holdover Times Table, the SAE Type IV fluid concentration used on your aircraft was

(1) 100/0.
(2) 75/25.
(3) 50/50.
(4) 25/75.

3.21 Refer to Appendix: SAE Type IV fluid Holdover Times (Table 3)

Light freezing rain is falling with an OAT of 0°C and a 50/50 mixture of SAE Type IV fluid is used. What is the acceptable Decision Criteria Time for these weather conditions?

(1) 5 minutes.
(2) 10 minutes.
(3) 15 minutes.
(4) 30 minutes.

3.22 Refer to Appendix: SAE Type IV Fluid Holdover Times (Table 3)

Freezing drizzle is present and the outside temperature is -12°C. Your company uses the Ground Icing Operations Standard and your aircraft is anti-iced with a 100/0 mixture of SAE Type IV anti-icing fluid. What is the acceptable Decision Criteria Time for these weather conditions?

(1) 0 minutes.
(2) 15 minutes.
(3) 20 minutes.
(4) 40 minutes.

3.23 Refer to Appendix: Snow Visibility vs Snowfall Intensity Chart (Table 4)

The daytime visibility in snowfall is 1/2 of a statute mile and the temperature is -8^0 C. The snowfall rate that will be used to determine which HOT table value is appropriate for the fluid in use is

(1) light.
(2) moderate.
(3) heavy.
(4) very heavy.

4.0 Preventative Measures and Deicing Procedures

4.01 Cold snow is falling onto a cold wing and swirling across the surface. Under these conditions

(1) anti-icing fluid should be applied to the critical surfaces.
(2) Deicing fluid should be applied to the critical surfaces.
(3) the pilot may assume the accumulated snow will blow off on take-off.
(4) the application of deicing or anti-icing fluid may not be prudent.

4.02 When deicing an aircraft, it is important to know

(1) the kind of contamination.
(2) the concentration is correct for the conditions.
(3) the recommended holdover times and keep track of the time.
(4) all of the above.

4.03 The areas that should be de-iced or anti-iced first are

(1) the engine ducts.
(2) the tailplane.
(3) the fuselage top.
(4) surfaces that are visible from the cockpit.

4.04 Select the correct statements regarding the use of Type I deicing fluid.

A. With the types of deicing fluid now in use, the entire aircraft may be sprayed.
B. As a guideline, start at the top and work down, but work symmetrically.
C. Some aircraft require specific control surface settings for deicing.
D. Deicing fluid may be sprayed directly on windows.

(1) A, B.
(2) A, D.
(3) B, C.
(4) C, D.

4.05 When deicing windows

(1) spray the fuselage above the windows and allow the fluid to flow down.
(2) use only hot water to avoid damage from the deicing fluid.
(3) spray directly on the top of the windows and allow the fluid to flow down.
(4) use anti-icing fluid as it is the only approved de-icer for windows.

4.06 Select the correct statements regarding ground deicing and anti-icing with the main engines running.

A. The engine should be operated at high power.
B. The air conditioning should be selected ON.
C. Avoid spraying fluid directly into the APU inlet.
D. Minimize the generation of spray in the vicinity of the engine intakes.

(1) A, B, D.
(2) A, C.
(3) B. D.
(4) C. D.

4.07 Where variances in deicing procedures are noted, the final authorities are the

(1) company operations manual and the Airworthiness Manual.
(2) company Operating Certificate and the Airworthiness Manual.
(3) CARs, the company operations manual and the manufacturer's flight and maintenance manuals.
(4) CARs, the A.I.P. Canada, and the company Operating Certificate and Safety Awareness Program data.

4.08 To make an informed decision on deicing/anti-icing of an aircraft, a pilot requires a knowledge of the

(1) procedures available.
(2) capabilities and limitations of procedures in various weather conditions.
(3) use and effectiveness of FPD fluids.
(4) all of the above.

4.09 Holdover times for FPD fluids should be considered

(1) as guidelines only, unless the Operator's Ground Icing Operations Program allows otherwise.
(2) valid only for the 100% concentration time in the holdover tables.
(3) valid for the longest times shown on the holdover tables.
(4) guidelines in all cases.

4.10 Holdover time is calculated as beginning at the

(1) start of the final application of deicing/anti-icing fluid and ending when the fluid shears on take-off.
(2) end of the final application of deicing/anti-icing fluid and ending when the fluid shears on take-off.
(3) end of the final application of deicing/anti-icing fluid and expiring when the fluid is no longer effective.
(4) start of the final application of deicing/anti-icing fluid and expiring when the fluid is no longer effective.

4.11 Which methods should be used to remove heavy, wet snow or ice from an aircraft?

A. Undiluted Type I FPD fluid.
B. A broom or squeegee.
C. A rope sawed across the surface.
D. Heated solutions of FPD fluids and water.

(1) A, C, D.
(2) A, C.
(3) B, C.
(4) B, D.

4.12 Pure propylene glycol fluids

(1) may be used in non-precipitation conditions.
(2) are not to be used in non-precipitation conditions.
(3) are not to be used in precipitation conditions.
(4) are applied heated as the second step in the two step process.

4.13 Ice or frost that has formed on a wing as a result of the cold-soaking phenomenon may be prevented from reforming by

(1) refueling the wing tanks with warm fuel.
(2) Deicing within ten minutes of take-off.
(3) Deicing with undiluted Type I fluid.
(4) using all of the above methods.

4.14 Pre-take-off contamination inspections should be concentrated on

(1) surfaces at the mid-chord section of the wing.
(2) the leading edge in conjunction with the trailing edge of the wing.
(3) representative surfaces.
(4) surfaces where anti-icing fluid was last applied.

4.15 Which statement is correct regarding the inspection of the critical surfaces immediately before take-off during conditions of heavy snow.

(1) The inspection is required irrespective of the elapsed time since anti-icing.
(2) Take-off must be initiated within 15 minutes of the inspection.
(3) The inspection is not required where the operator is using a program in accordance with the Ground Icing Operations Standard.
(4) The inspection is not required where a remote deicing facility is used and the take-off is initiated within the holdover time.

4.16 Which statement is correct regarding take-off after holdover times have been exceeded.

(1) Operations must cease immediately.
(2) Inspections are not required after deicing at a Central De-ice Facility.
(3) There must be at least 5 minutes of holdover time remaining after the pre-take-off inspection.
(4) Take–off must be within 5 minutes of completion of the pre-take-off inspection.

Examination Question References

LEGEND

CARs	-	Canadian Aviation Regulations
TP-14052	-	Ground Icing Operations Update
AIP	-	Aeronautical Information Publication - Canada
WID - S (vid)	-	"When in Doubt... Small Aircraft" video
WID - L (vid)	-	"When in Doubt... Large Aircraft" video
WID - G (vid)	-	"When in Doubt... Ground Crew" video
WID - S&L	-	"When in Doubt... Small and Large Aircraft" booklet
HOT Tables	-	Holdover Times Tables - Appendix
FGU (27)	-	From the Ground Up - 27th Edition
FGU (28)	-	From the Ground Up - 28th Edition

1.0 Air Law, The Clean Aircraft Concept

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CAUTION:

The above tables are marked "For Sample Questions Only" and are not to be used for aircraft operations.

Copies of the current the Holdover Guidelines may be obtained from the following website:

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

Or the Civil Aviation Communications Centre at:

Toll Free: 1-800-305-2056
In the National Capital Area: (613) 993-7284
http://www.tc.gc.ca/aviation

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(For Sample Questions Only)

TABLE 2 SAE TYPE I FLUID HOLDOVER GUIDELINES FOR WINTER 2003-2004

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

OAT		Approximate Holdover Times Under Various Weather Conditions (minutes)								
°C	°F	Frost[2]	Freezing Fog	Very Light Snow[1]	Light Snow[1]	Moderate Snow[1]	Freezing Drizzle[3]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[4]
-3 and above	27 and above	45	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	
below -3 to -6	below 27 to 21	45	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6		
below -6 to -10	below 21 to 14	45	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5	CAUTION: No holdover time guidelines exist	
below -10	below 14	45	5 – 9	7	4 – 7	2 – 4				

°C = Degrees Celsius °F = Degrees Fahrenheit OAT = Outside Air Temperature FP = Freezing Point

NOTES

1 To use these times, the fluid must be heated to a minimum temperature providing 60°C (140°F) at the nozzle and an average rate of at least 1 L/m^2 (2 gal./100 sq. ft.) must be applied to deiced surfaces, OTHERWISE TIMES WILL BE SHORTER.

2 During conditions that apply to aircraft protection for ACTIVE FROST.

3 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.

4 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.

5 Type I Fluid / Water Mixture is selected so that the FP of the mixture is at least 10°C (18°F) below OAT.

CAUTIONS

- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may also be reduced when aircraft skin temperature is lower than OAT.**
- **The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.**
- **Fluids used during ground deicing do not provide ice protection during flight.**

(For Sample Questions Only)

TABLE 3 SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2003-2004[1]

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

OAT		Type II Fluid Concentration	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F	Neat Fluid/Water (Vol% / Vol%)	Frost[2]	Freezing Fog	Snow	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[5]
		100/0	12:00	0:35 – 1:30	0:20 – 0:55	0:30 – 0:55	0:15 – 0:30	0:05 – 0:40	
above 0	above 32	75/25	6:00	0:25 – 1:00	0:15 – 0:40	0:20 – 0:45	0:10 – 0:25	0:05 – 0:25	
		50/50	4:00	0:15 – 0:30	0:05 – 0:15	0:05 – 0:15	0:05 – 0:10		
		100/0	8:00	0:35 – 1:30	0:20 – 0:45	0:30 – 0:55	0:15 – 0:30	CAUTION:	
0 to -3	32 to 27	75/25	5:00	0:25 – 1:00	0:15 – 0:30	0:20 – 0:45	0:10 – 0:25	No holdover	
		50/50	3:00	0:15 – 0:30	0:05 – 0:15	0:05 – 0:15	0:05 – 0:10	time	
below -3 to -14	below 27 to 7	100/0	8:00	0:20 – 1:05	0:15 – 0:35	0:15 – 0:45[3]	0:10 – 0:25[3]	guidelines	
		75/25	5:00	0:20 – 0:55	0:15 – 0:25	0:15 – 0:30[3]	0:10 – 0:20[3]	exist	
below -14 to -25	below 7 to -13	100/0	8:00	0:15 – 0:20	0:15 – 0:30				
below -25	below -13	100/0	Type II fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of Type I when Type II fluid cannot be used.						

°C = Degrees Celsius °F = Degrees Fahrenheit OAT = Outside Air Temperature Vol = Volume

NOTES

1 Based on tests of neat fluids with the lowest viscosity deliverable on the aircraft, yet meeting Type II WSET and HHET.
2 During conditions that apply to aircraft protection for ACTIVE FROST.
3 The lowest use temperature is limited to -10°C (14°F).
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
6 Snow includes snow grains.
7 Ensure that the lowest operational use temperature (LOUT) is respected.

CAUTIONS

- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may also be reduced when aircraft skin temperature is lower than OAT.**
- **The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.**
- **Fluids used during ground deicing do not provide ice protection during flight.**

(For Sample Questions Only)

TABLE 4 SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2003-2004[1]

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

OAT		Type IV Fluid Concentration	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)						
°C	°F	Neat Fluid/Water (Vol% / Vol%)	Frost[2]	Freezing Fog	Snow	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing	Other[5]
		100/0	18:00	1:05 – 2:15	0:35 – 1:05	0:40 – 1:10	0:25 – 0:40	0:10 – 0:50	
above 0	above 32	75/25	6:00	1:05 – 1:45	0:30 – 1:05	0:35 – 0:50	0:15 – 0:30	0:05 – 0:35	
		50/50	4:00	0:15 – 0:35	0:05 – 0:20	0:10 – 0:20	0:05 – 0:10		
		100/0	12:00	1:05 – 2:15	0:30 – 0:55	0:40 – 1:10	0:25 – 0:40	CAUTION:	
0 to -3	32 to 27	75/25	5:00	1:05 – 1:45	0:25 – 0:50	0:35 – 0:50	0:15 – 0:30	No holdover	
		50/50	3:00	0:15 – 0:35	0:05 – 0:15	0:10 – 0:20	0:05 – 0:10	time	
below -3 to -14	below 27 to 7	100/0	12:00	0:20 – 1:20	0:20 – 0:40	0:20 – 0:45[3]	0:10 – 0:25[3]	guidelines	
		75/25	5:00	0:25 – 0:50	0:20 – 0:35	0:15 – 0:30[3]	0:10 – 0:20[3]	exist	
below -14 to -25	below 7 to -13	100/0	12:00	0:15 – 0:40	0:15 – 0:30				
below -25	below -13	100/0	Type IV fluid may be used below -25°C (-13°F) provided the freezing point of the fluid is at least 7°C (13°F) below the OAT and the aerodynamic acceptance criteria are met. Consider use of Type I when Type IV fluid cannot be used.						

°C = Degrees Celsius °F = Degrees Fahrenheit OAT = Outside Air Temperature Vol = Volume

NOTES

1 Based on tests of neat fluids with the lowest viscosity deliverable on the aircraft, yet meeting Type IV WSET and HHET.
2 During conditions that apply to aircraft protection for ACTIVE FROST.
3 The lowest use temperature is limited to -10°C (14°F).
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 Heavy snow, snow pellets, ice pellets, moderate and heavy freezing rain, and hail.
6 Snow includes snow grains.
7 Ensure that the lowest operational use temperature (LOUT) is respected.

CAUTION

- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may also be reduced when aircraft skin temperature is lower than OAT.**
- **The only acceptable decision criteria time is the shortest time within the applicable holdover time table cell.**
- **Fluids used during ground deicing do not provide ice protection during flight.**

(For Sample Questions Only)

TABLE 5 VISIBILITY IN SNOW VS. SNOWFALL INTENSITY CHART[1]

Lighting	Temperature Range		Visibility in Snow (Statute Miles)			
	ºC	ºF	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

1 Based on: *Relationship between Visibility and Snowfall Intensity* (TP 14151E), Transportation Development Centre, Transport Canada, to be published in November 2003; and *Theoretical Considerations in the Estimation of Snowfall Rate Using Visibility* (TP 12893E), Transportation Development Centre, Transport Canada, November 1998. HOW TO READ THE TABLE Assume that the daytime visibility in snowfall is 1 statute mile and the temperature is -7°C. Based on these conditions, the snowfall intensity is light. This snowfall intensity is used to determine which holdover time guideline value is appropriate for the fluid in use.

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Acronyms

Notes: 1. For the purposes of this icing document the following abbreviations apply.

#	Abbreviation	Definition	Remarks
1	AAF	Aircraft Anti-Icing Fluid	As indicated
2	AC	Advisory Circular	FAA term for guidance
3	ADF	Aircraft Deicing Fluid	As Indicated
4	AEA	Association of European Airlines	Provides direction—non regulatory
5	AO	Air Operator	Regulatory
6	AMS	Aerospace Material Specification	SAE document designation
7	ARP	Aerospace Recommended Practice	SAE document designation
8	ASTM	American Society for Testing of Materials.	Per the name
9	BOD	Biological Oxygen Demand	
10	CAR	Canadian Aviation Regulation	Subordinate to Aeronautics Act
11	CASS	Commercial Air Service Standard	Subordinate to CAR
12	CBAAC	Commercial and Business Aviation Advisory Circular	Regulatory
13	CEPA	Canadian Environmental Protection Act	As indicated
14	CDF	Central Deicing Facility	At Large Airports
15	COM	Company Operations Manual	Regulatory
16	FAA	Federal Aviation Administration	US Regulator
17	FPD	Freezing Point Depressant	Deicing/Anti-icing Fluids
18	GOFR	General Operating and Flight Rules	Part 6 of the CAR's
19	GIDS	Ground Ice Detection System	Devices either spot or area
20	ICAO	International Civil Aviation Organization	World wide rep of CivAv
21	IFR	Instrument Flight Rules	Std.
22	IR	Infrared	Energy type
23	LOUT	Lowest Operational Use Temperature	Limitation on a fluid's use
24	MSDS	Material Specification Data Sheet	Details re contents of fluid
25	OAT	Outside Air Temperature	As indicated
26	OSH	Occupational Safety and Health	Personnel safety at the workplace
27	QAP	Quality Assurance Program	
28	QAS	Quality Assurance System	Regulatory
29	SAE	Society of Automotive Engineers	Independent Aerospace
30	SMS	Safety Management System	Canadian Regulatory req'mt
31	TC	Transport Canada	Canadian Regulator
32	TDC	Transportation Development Centre	TC Research Centre
33	TP	Transport Canada Publication	Generic
34	VFR	Visual Flight Rules	Std.

Glossary

The following definitions are presented in the context of this Training Manual only. These definitions are not necessarily intended to apply universally to other documents.

A

Aircraft Deicing Facility.

Means a facility where:

Frost, snow or ice are removed (deicing) from an aircraft in order to provide clean surfaces; and/or
Critical surfaces of the aircraft receive protection (anti-icing) against the formation of frost or ice, or the accumulation of snow or slush for a limited period of time.
Fluid Storage, Equipment Maintenance, Environmental Mitigation, Control Centre

Aircraft Deicing Pad.

A designated area on an aircraft deicing facility intended to be used for parking an aircraft to conduct deicing or anti-icing activities, consisting of an inner area for the parking of an aircraft to receive deicing/anti-icing treatment. On a centralized deicing facility, the aircraft deicing pad also includes an outer area for manoeuvring deicing vehicles (safe zone). The outer area provides the vehicle lane width necessary for deicing vehicles to safely perform during the deicing operation.

Air Operator
The holder of an air operator certificate.
Air operator certificate
A certificate issued under the CARs that authorizes the holder of the certificate to operate a commercial air service.

Anti-icing

Anti-icing is a precautionary procedure that provides protection against the formation of frost and/or ice and the accumulation of slush and/or snow on treated surfaces of an aircraft for a period of time during active frost, frozen precipitation, and freezing precipitation.

The application of a freezing point depressant to a surface either following deicing or in anticipation of subsequent winter precipitation is intended to protect the critical surfaces from ice adherence for a limited period of time. The fluid is capable of absorbing freezing or frozen precipitation until the fluid freezing point coincides with the ambient temperature. Once this fluid freezing point has been reached, the fluid is no longer capable of protecting the aircraft from ground icing conditions.

Apron
Means that part of an aerodrome, other than the manoeuvering area, intended to accommodate the loading and unloading of passengers and cargo, the refueling, servicing, maintenance and parking of aircraft, and any movement of aircraft, vehicles and pedestrians necessary for such purposes.

C

Central Deicing Facility (CDF)

A Transport Canada approved facility at an airport for the purpose of conducting deicing and anti-icing operations.

Clean Aircraft Concept.

When conditions exist during ground operations that are conducive to aircraft icing, 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.

Cold Soaking (revisit title)

Ice can form even when the outside air temperature (OAT) is well above 0°C (32°F). An aircraft equipped with 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 of water. If an aircraft has been at a high altitude, where cold temperature prevails, for a period of time, the aircrafts' major structural components such as the wing, tail and fuselage will assume the lower temperature, which will often be below the freezing point. This phenomenon is known as cold soaking. While on the ground, the cold soaked aircraft will cause ice to form when liquid water, either as condensation from the atmosphere or as rain, comes in contact with critical surfaces.

Contamination

Means any frost, ice, slush or snow that adheres to the critical surfaces of an aircraft.

Critical Surfaces

"Critical surfaces" of an aircraft means the wings, control surfaces, rotors, propellers, horizontal stabilizers, vertical stabilizers or any other stabilizing surface on an aircraft and, in the case of an aircraft that has rear-mounted engines, includes the upper surface of its fuselage.

Critical Surface Inspection

A critical surface inspection is a pre-flight external inspection of critical surfaces conducted by a qualified person as specified in CAR Part VI, subsection 602.11(5), to determine if they are contaminated by frost, ice, snow or slush. This inspection is mandatory whenever ground icing conditions exist and, if the aircraft is deiced / anti-iced with fluid, must take place immediately after the final, application of fluid or where an approved alternative method of deicing is used, upon completion of this process. After the inspection, a report completed by a qualified individual must be submitted to the pilot-in-command.

Critical Surface Inspection Report

This report must be made to the pilot-in-command and, if applicable, state the time at which the last full application of deicing or anti-icing fluid began, the type of fluid used, the ratio of the fluid mixture. Should the standard documented method not be used, the sequence in which the critical surfaces were de-iced or anti-iced must be stated. In addition, the report must confirm that all critical surfaces are free of contamination.

D

Defrosting.

The removal of frost from an aircraft's critical surfaces and their subsequent protection.

Deicing

Deicing is a procedure by which frost, ice, slush or snow is removed from an aircraft to render them free of contamination.

Deicing is a general term for the removal of ice, snow, slush or frost from an aircraft's critical surfaces, by mechanical means, by the use of heat, or by the use of a heated fluid or a combination thereof. When frost, snow or ice is adhering to a surface, the surface must be heated and fluid pressure used to remove the contaminant.

Deicing Operator

The organization providing de/anti-icing related services to air operators at a given location. The Deicing Operator may be a qualified third party, another airline, or the Air Operator. The Deicing Operator must provide a service in accordance with the air operator's approved ground icing program, where such a program exists.

F

Fluid Deicing/Anti-icing Methods.

These are methods of using acceptable fluids for the removal of frozen contamination from an aircraft's critical surfaces and then for preventing the formation and/or accumulation of contamination on an aircraft for a limited period of time. The details are contained in The Society of Automotive Engineers (SAE) document ARP4737, entitled: "Aircraft deicing/anti-icing Methods".

Fluid Dryout

Fluid residue that may remain in aerodynamically quiet areas throughout a flight

Fluid Endurance Time.

Endurance times of anti-icing fluids are measured in laboratory and field tests under specific contamination and temperature conditions using flat test plates in accordance with the SAE documents AMS 1424 & AMS 1428. These tests are considered to replicate the failure of fluid during aircraft operations.
Fluid Failure.

Typically, in the case of snow, a layer of snow eventually accumulates on the surface of the fluid and is no longer being absorbed by the fluid. The appearance of a build up becomes evident. There is a distinct loss of shine or gloss on the surface of the fluid.

Forced Air Deicing Method

This is a method of deicing using a concentrated flow of air under pressure to remove contamination from an aircraft, which may be used in conjunction with deicing fluids.

Freezing Point Depressant (FPD) Fluids

The generic term applied to all types of deicing fluids.

G

Ground Ice Detection System (GIDS)

A ground ice detection system is designed to detect frozen contaminants on an aircraft. These systems can be either ground based or aircraft based systems. GIDS may be either a spot sensor or an area sensor system. If approved by Transport Canada, such a system may be used as an alternative to other inspection methods.

Ground Icing Conditions

With due regard to aircraft skin temperature and weather conditions, ground icing conditions exist when frost, ice, or snow is adhering or may adhere to the critical surfaces of an aircraft.

Ground Icing Conditions also exist when active frost, frozen or freezing precipitation is reported or observed.

Ground Icing Operations Program

A Ground Icing Operations Program consists of a set of procedures, guidelines, and processes, documented in manuals, which ensure that an Air Operator's aircraft does not depart with frost, ice, snow or slush adhering to critical surfaces. This program is mandatory for CAR 705 operations and must be approved by Transport Canada.

H

Hail

Hail is precipitation consisting of small balls or pieces of ice with a diameter ranging from 5 mm to greater than 50 mm falling either separately or agglomerated.

Hoar-frost

A uniform, thin white deposit of fine crystalline texture that forms on exposed surfaces during calm, cloudless nights when the temperature falls below freezing and the humidity of the air at the surface is close to the saturation point. It is not associated with precipitation. The deposit is thin enough that the underlying surface features, such as paint lines, markings or lettering can be distinguished.

Holdover Time (HOT)

Holdover time is the estimated time that an application of anti-icing fluid is effective in preventing frost, ice, slush or snow from adhering to treated surfaces. 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. The fluid is no longer effective when its ability to absorb more precipitation has been exceeded. This can produce a visible surface build-up of contamination. (as measured in endurance time tests and published in "Holdover Time Guidelines").

Holdover time is the estimated time that the fluid prevents reformation of contamination on critical surfaces. Holdover time commences at the beginning of the final fluid application.

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.

Fluid holdover times, as published by , Commercial and Business Aviation, Transport Canada are found published in "Holdover Time Guidelines" as tables and may be used either as guidelines or decision-making criteria in assessing whether it is safe to take off. When holdover times are used as decision-making criteria, only the lowest time value in a cell shall be used.

The procedures to be followed after the holdover time has expired must be clearly documented. The use of holdover time guidelines is mandatory if they are part of the Air Operator's approved ground icing program.

I

Ice.
The solid form of water. Clear Ice is often difficult to detect visually on an aircraft's critical surfaces. It can be present in a transparent form, which may make the aircraft's critical surfaces appear to be wet.

Ice Pellets

These are 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. Now internationally recognized, ice pellets include two fundamentally different types of precipitation, which are known in the United States as (a) sleet, and (b) small hail. Thus a two-part definition is given:

- 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. Note that the term "sleet" in British terminology and in some parts of the U.S. refers to a mixture of rain and snow and therefore should not be used.

- 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 de/anti-icing 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.

Infrared Heat Deicing Method

This is a method of deicing using infrared (IR) thermal energy.

L

Lowest Operational Use Temperature (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 a freezing point buffer of 7°C for type I or 10°C for type II III & IV.

M

Manoeuvring Area.

Means that part of an aerodrome to be used for the take-off, landing and taxiing of aircraft, excluding aprons.

P

Pilot-in-Command.

The pilot responsible for the operation and safety of an aircraft during flight time. (Flight time being: the time from the moment an aircraft first moves under its own power for the purpose of flight until the moment it comes to rest at the next point of landing).

Precipitation rate.

The rate at which precipitation is either measure or judge to be falling. Winter precipitation is a key factor in estimating the Holdover Time for an anti-icing fluid. It is the indication of moisture content.

Pre-Take-Off Contamination Inspection.

A pre-take-off contamination inspection is an inspection conducted by a qualified person, immediately prior to take-off, to determine if an aircraft's critical surfaces are contaminated by frost, ice, slush or snow. This inspection is mandatory under some circumstances.

Pre-Take-Off Contamination Inspection Report.

This report must be made to the pilot-in-command and, when a documented inspection method has not been used, must describe how the inspection was conducted. The report must also confirm that all critical surfaces are free of contamination.

R

Representative Surface.

Aircraft representative surfaces are those surfaces which can be readily and clearly observed by flight crew during day and night operations, and which are suitable for judging whether or not critical surfaces are contaminated. Examination of one or more representative aircraft surfaces may be used for the Pre-Take-off Contamination

Inspection, if a tactile examination is not required. Transport Canada must approve the use of these aircraft specific surfaces.

S

Slush.

A mixture of frozen and liquid water, which may include chemicals.

Snow Grains
These are a precipitation that comprises very small white and opaque grains of ice. These grains are fairly flat or elongated; their diameter is less than 1 mm. When they hit hard ground, they do not bounce or shatter.

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.

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Taxiway.

Means a defined path on a land aerodrome established for the taxiing of aircraft and intended to provide a link between one part of the aerodrome and another.

Tactile Inspection.

A tactile inspection requires that a person physically contact specific aircraft surfaces. Tactile inspections, under certain circumstances, may be the only way of confirming that the critical surfaces of an aircraft are not contaminated. For some aircraft, tactile inspections are mandatory, as part of the deicing/anti-icing inspection process, to ensure that the critical surfaces are free of frozen contaminants.