

# MANUAL OF AIRCRAFT GROUND DE-ICING/ANTI-ICING OPERATIONS

SECOND EDITION — 2000



*Approved by the Secretary General  
and published under his authority*

**INTERNATIONAL CIVIL AVIATION ORGANIZATION**

# Manual of Aircraft Ground De-icing/Anti-icing Operations

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SECOND EDITION — 2000





## Foreword

Safe aeroplane operations during all types of weather conditions are of utmost concern to all air carriers, airport authorities, air traffic control, and users of air transport services. A review of the history of aeroplane accidents in the air transportation industry revealed that a substantial number are related to winter operations. An examination of these accidents showed a need for formally developed regulations and procedures governing aeroplane de-icing/anti-icing operations, directed towards all segments of aviation, including aeroplane manufacturers, airline operators, and engineering, maintenance and service organizations. This material was intended, in particular, for use by flight crews of all aeroplane types and categories, as well as aeroplane maintenance and service personnel.

The International Air Transport Association (IATA) convened a Global De-icing/Anti-icing Task Force, which met for the first time in Helsinki in September 1992. In October 1993, this Task Force became the IATA Global De-icing/Anti-icing Industry Forum. In a cooperative effort between IATA and ICAO, a drafting group was formed to develop a “stand-alone” ground de-icing/anti-icing document, which would be published by ICAO. The meetings, convened throughout the year for the purpose of developing this document, were attended by representatives of civil aviation authorities, airline operators, aeroplane manufacturers, ground equipment and fluid manufacturers, pilot associations and airport authorities. The result was the publication of the first edition of the *Manual of Aircraft Ground De/Anti-icing Operations* (Doc 9640) in 1995.

This second edition comprises a summary of information essential to the planning and execution of de-icing/anti-icing operations during conditions which are conducive to aeroplane icing on the ground. It contains general information which is intended to increase the basic understanding of aircraft ground de-icing/anti-icing operations and to facilitate the development of standardized procedures and guidance material for the various segments of the aviation industry. It includes the full range of de-icing/anti-icing fluids and information on data updating. A general description of the various factors relating to aeroplane icing on the ground is provided, and the minimum procedural requirements necessary to conduct safe and efficient operations during conditions requiring aeroplane de-icing/anti-icing activities are addressed. It is the individual operator’s responsibility, however, to comply with the requirements imposed by aeroplane, equipment and fluid manufacturers, regulatory and environmental authorities, and individual operator programmes.

Reference material used to prepare this publication includes documentation from regulatory authorities, airlines, aeroplane manufacturers, equipment and fluid manufacturers, industry, and academic, standardization and professional associations (see Bibliography for complete listing). Even though no reference is made in this document to any specific instructions or recommendations given by aeroplane, equipment or fluid manufacturers, nevertheless these must also be taken into consideration.



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# Glossary of Terms and Abbreviations

## GLOSSARY OF TERMS

These terms, as used in this document, have the following meanings:

**Active frost.** A condition when frost is forming. Active frost occurs when the surface temperature is at or below 0°C and at or below the dew point.

**Anti-icing.** Anti-icing is a precautionary procedure by which clean aeroplane surfaces are protected against the formation of ice and frost and the accumulation of snow and slush for a limited period of time.

**Cold-soak effect.** The wings of aeroplanes are said to be “cold-soaked” when they contain very cold fuel as a result of having just landed after a flight at high altitude or from having been refuelled with very cold fuel. Whenever precipitation falls on a cold-soaked aeroplane when on the ground, clear icing may occur. Even in ambient temperatures between -2°C and +15°C, ice or frost can form in the presence of visible moisture or high humidity if the aeroplane structure remains at 0°C or below. Clear ice is very difficult to detect visually and may break loose during or after take-off. The following factors contribute to cold-soaking: temperature and quantity of fuel in fuel cells, type and location of fuel cells, length of time at high altitude, temperature of refuelled fuel and time since refuelling.

**Critical surfaces.** Surfaces of the aeroplane that shall be completely free of ice, snow, slush or frost before take-off. The critical surfaces shall be determined by the aeroplane manufacturer.

**De-icing.** The process which removes ice, snow, slush or frost from aeroplane surfaces. This may be accomplished by mechanical methods, or by pneumatic methods or through the use of heated fluids. Mechanical methods may be preferred under extremely cold conditions or when it has been determined that the frozen contaminant is not adhering to the aeroplane surfaces. When using heated fluids and optimum heat transfer is desired, fluids should be applied at a distance from the aeroplane surfaces in accordance with the approved operator procedure and fluid manufacturer recommendations.

**De-icing/anti-icing.** A procedure combining both the de-icing process and the anti-icing process and which can be performed in one or two steps:

**One-step de-icing/anti-icing.** This procedure is carried out with heated anti-icing fluid. The fluid is used to de-ice the aeroplane and remains on the aeroplane surface to provide anti-icing capability. The Society of Automotive Engineers (SAE)/International Organization for Standardization (ISO) Type I, II, III and IV fluids can be used, but the protection provided by Type I fluid is less than that provided by Type II, III and IV fluids.

**Two-step de-icing/anti-icing.** This procedure contains two distinct steps. The first step, de-icing, is followed by the second step, anti-icing, as a separate fluid application. After de-icing, a separate overspray of anti-icing fluid is applied to protect the aeroplane’s critical surfaces, thus providing maximum anti-icing protection.

**Drizzle.** Fairly uniform precipitation composed exclusively of fine drops (diameter less than 0.5 mm (0.02 in)) very close together. Drizzle appears to float while following air currents although, unlike fog droplets, drizzle falls to the ground.

**Fog and ground fog.** A visible aggregate of minute water particles (droplets) in the air reducing the horizontal visibility at the Earth’s surface to less than 1 kilometre.

**Freezing fog.** A fog formed of supercooled water droplets which freeze upon contact with exposed objects and form a coating of rime/clear ice.

**Freezing rain and freezing drizzle.** Rain or drizzle in the form of supercooled water drops which freeze upon impact with any surface.

**Frost.** Referred to as “hoar frost”. A deposit of ice having a crystalline appearance, generally assuming the form of scales, needles or fans. Frost is formed by sublimation, i.e. when water vapour is deposited upon a surface whose temperature is at or below freezing.

**High humidity.** An atmospheric condition where the relative humidity is close to saturation.

**Holdover time.** Holdover time (HOT) is the *estimated* time the anti-icing fluid will prevent the formation of ice and frost and the accumulation of snow on the protected (treated) surfaces of an aeroplane.

**Precipitation intensity.** Intensity of precipitation is an indication of the amount of precipitation collected per unit time interval. It is expressed as light, moderate or heavy. Intensity is defined with respect to the type of precipitation occurring, based either on rate of fall for rain and ice pellets or visibility for snow and drizzle. The rate of fall criterion is based on time and does not accurately describe the intensity at a particular time of observation.

**Rain.** Precipitation of liquid water particles, either in the form of drops of more than 0.5 mm in diameter or smaller drops which, in contrast to drizzle, are widely separated.

**Rime.** A deposit of ice, produced by freezing of super-cooled fog or cloud droplets on objects at temperatures below or slightly above freezing. It is composed of grains separated by air, sometimes adorned with crystalline branches.

**Shear force.** Shear force is a force applied laterally on an anti-icing fluid. When applied to a Type II, III or IV fluid, the shear force will reduce the viscosity of the fluid; when the shear force is no longer applied, the anti-icing fluid should recover its viscosity. For instance, shear forces are applied whenever the fluid is pumped, forced through an orifice or when subjected to airflow. If excessive shear force is applied, the thickener system could be permanently degraded and the fluid viscosity may fall outside the range set by the manufacturer and tested for certification. Fluid degraded in this manner should not be used for operational purposes.

**Slush.** Water-saturated snow which with a heel-and-toe slap-down motion against the ground will be displaced with a splatter.

**Snow.** Precipitation of ice crystals, mostly branched in the form of six-pointed stars. The crystals are isolated or agglomerated to form snowflakes.

*Dry snow.* When the ambient temperature is below freezing.

*Wet snow.* When the ambient temperature is near or above freezing.

**Visible moisture.** Fog, rain, snow, sleet, high humidity (condensation on surfaces), ice crystals can all produce visible moisture on aeroplanes, taxiways and runways exposed to and contaminated by these conditions.

#### ABBREVIATIONS

AEA	Association of European Airlines
APU	Auxiliary power-unit
ATC	Air traffic control
DIN	Deutsches Institut für Normung
FP	Freezing point
FPD	Freezing point depressant
ISO	International Organization for Standardization
OAT	Outside air temperature
SAE	Society of Automotive Engineers

# Chapter 1

## INTRODUCTION

1.1 As early as 1950, some States had established civil aviation regulations prohibiting take-off for aeroplanes with frost, snow, or ice adhering to wings, propellers or control surfaces of the aeroplane. The effects of such icing are wide-ranging, unpredictable and dependent upon individual aeroplane design. The magnitude of these effects is dependent upon many variables, but the effects can be both significant and dangerous.

1.2 Wind tunnel and flight tests indicate that ice, frost or snow formations on the leading edge and upper surface of a wing, having a thickness and surface roughness similar to medium or coarse sandpaper, can reduce wing lift by as much as 30 per cent and increase drag by up to 40 per cent. These changes in lift and drag will significantly increase stall speed, reduce controllability and alter aeroplane flight characteristics. Thicker or rough ice accumulation in the form of frost, snow, or ice deposits can have increasing effects on lift, drag, stall speed, stability and control, but the primary influence is surface roughness relative to critical portions of an aerodynamic surface. Ice on critical surfaces and on the airframe may also break away during take-off and be ingested into engines, possibly damaging fan and compressor blades. Ice forming on pitot tubes and static ports or on angle of attack vanes may give false attitude, airspeed, angle of attack and engine power information for air data systems. It is therefore imperative that take-off not be attempted unless it has been ascertained that all critical surfaces of the aeroplane, as well as all instrument probes, are free of adhering snow, frost or other ice formations. This vital requirement is known as the “Clean Aircraft Concept” (see Chapter 2).

1.3 Most aeroplanes used in commercial air transport operations, as well as some other aeroplane types, are certificated for flight in icing conditions. Aeroplanes so certificated were designed to have the capability to penetrate supercooled cloud icing conditions and have demonstrated this in flight. This capability is provided either by ice protection equipment installed on critical surfaces, such as the leading edge, or by demonstration that the ice formed, under supercooled cloud icing conditions, on certain unprotected components will not significantly affect aeroplane performance, stability and control. Ice,

frost and snow formed on these surfaces on the ground can have a totally different effect on aeroplane flight characteristics than ice formed in flight. Exposure on the ground to weather conditions that are conducive to ice formation can cause accumulation of frost, snow or ice on areas of the aeroplane where the ice protection provided is designed for in-flight use only. In addition, aeroplanes are considered airworthy and are certificated only after extensive analyses and testing have been accomplished. With the exception of analyses and testing to ascertain the flight characteristics of an aeroplane during flight in icing conditions, all analyses and certification testing are conducted with a clean aeroplane flying in a clean environment. If ice formations other than those considered in the certification process are present, the airworthiness of the aeroplane may be invalid and no attempt should be made to fly the aeroplane until it has been restored to the clean configuration.

1.4 Common practice developed by the aviation industry over many years of operational experience is to de-ice/anti-ice an aeroplane prior to take-off. Various techniques for ground de-icing/anti-icing aeroplanes were also developed. The most common of these techniques is the use of FPD fluids to aid the ground de-icing/anti-icing process and to provide a protective anti-icing film to delay the formation of frost, snow or ice on aircraft surfaces.

1.5 In scheduled airline operations where large numbers of aeroplanes are dispatched, the process of ensuring airworthiness must be a team effort where each member of the team has specific duties and responsibilities (Annex 6, Part I, refers). In private aeroplane operations, all functions may be performed by only one person — the pilot. In all cases, the pilot-in-command has the ultimate responsibility of ascertaining that the aeroplane is safe for flight.

1.6 The only known method for positively ascertaining that an aeroplane is clean prior to take-off is by close inspection. Under conditions of precipitation or fog, or where moisture can be splashed, blown or sublimated onto critical surfaces in sub-freezing weather, many factors influence whether and how much ice, frost or snow may

accumulate and result in surface roughness. Even in above-freezing weather conditions, for aeroplanes which have just landed after descending from high altitude or have refuelled with very cold fuel, the wings may be colder than 0°C due to fuel in the wing tanks being well below zero. This cold-soak effect may cause ice to form on the wing surfaces. Most of the factors that influence the accumulation of freezing precipitation and affect cold-soak are listed below:

- a) ambient temperature;
- b) relative humidity;
- c) precipitation type and rate;
- d) fog type and density;
- e) heat radiation;
- f) wind speed and direction;
- g) aeroplane surface temperature (including the temperature of fuel in the wing tanks);
- h) presence of de-icing fluid;
- i) de-icing/anti-icing fluid type and temperature;
- j) de-icing/anti-icing fluid aqueous solution (strength);
- k) de-icing/anti-icing fluid application procedure;
- l) time elapsed since anti-icing treatment;

- m) operation in close proximity to other aeroplane jet blast, equipment and structures;
- n) operations on snow, slush or wet surfaces;
- o) aeroplane component inclination angle, contour and surface roughness; and
- p) conditions under which the aeroplane is parked (outside, or fully or partially in the hangar).

1.7 Personnel must understand and have a thorough knowledge of:

- a) the adverse effects that ice, frost or snow on the critical surfaces and airframe can have on aeroplane performance and handling qualities;
- b) the various procedures that are available for aeroplane ground de-icing/anti-icing;
- c) the capabilities and limitations of these procedures;
- d) the variables that will influence the effectiveness of these procedures; and
- e) the critical areas of the particular aeroplane.

It is essential for all personnel to recognize that final assurance for a safe take-off rests in a thorough pre-take-off inspection or check.

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## Chapter 2

# THE CLEAN AIRCRAFT CONCEPT

2.1 During conditions conducive to aeroplane icing during ground operations, take-off shall not be attempted when ice, snow, slush or frost is present or adhering to the wings, propellers, control surfaces, engine inlets or other critical surfaces. This is known as the “Clean Aircraft Concept”. In this document, the Clean Aircraft Concept deals solely with fixed wing aeroplanes.

2.2 Any deposit of ice, snow or frost on the external surfaces of an aeroplane, except as permitted in the flight manual, may drastically affect its performance due to reduced aerodynamic lift and increased drag resulting from the disturbed airflow. Furthermore, slush, freezing snow or ice may cause moving parts, such as control surfaces and flap-actuating mechanisms, to jam, thus creating a hazardous situation. These adverse effects on the aerodynamic properties of the airfoil may result in a sudden departure from the commanded flight path and may not be preceded by any cockpit indications or aerodynamic warnings to the pilot.

2.3 A large number of variables can influence the formation of ice and frost and the accumulation of snow and slush causing surface roughness on an aeroplane. These variables include:

a) ambient temperature;

b) aeroplane skin temperature;

c) precipitation rate and moisture content;

d) de-icing/anti-icing fluid temperature;

e) the fluid/water ratio of the de-icing/anti-icing fluid;

f) relative humidity; and

g) wind velocity and direction.

They can also affect the de-icing capabilities of de-icing fluids and the anti-icing capabilities of anti-icing fluids. As a result, a well-defined time for the protection provided by an anti-icing fluid cannot be established.

2.4 Numerous techniques for complying with the Clean Aircraft Concept have been developed. Proper and adequate de-icing, followed by an application of appropriate anti-icing fluid, provides the best protection against contamination. A visual or physical check of critical aeroplane surfaces to confirm that the treatment has been effective and that the aeroplane is in compliance with the Clean Aircraft Concept must be carried out.

## Chapter 3

# AEROPLANE ICING ON THE GROUND

3.1 Many atmospheric and ambient conditions can cause aeroplane icing on the ground. The principal conditions are frost, snow, freezing fog, freezing drizzle, freezing rain, and rain, drizzle, fog or high humidity combined with the cold-soak effect. The latter type of icing can occur at ambient temperatures well above the freezing point. It is also important to understand that mixed and changing atmospheric conditions can overlap during aeroplane operations on the ground, requiring constant vigilance by both flight and ground crews. Clear ice or failed anti-icing fluid can be very difficult to identify.

3.2 Other conditions that are conducive to icing contamination on aeroplane surfaces are:

- a) operations on ramps, taxiways and runways contaminated by water, slush or snow. These substances may be deposited on aeroplane surfaces by

wind, aeroplane operations, jet blast, or ground support equipment; and

- b) warm aeroplane surfaces exposed to frozen precipitation during below-freezing conditions. The warm aeroplane surfaces may cause melting and refreezing of the precipitation.

3.3 In many cases, de-icing/anti-icing procedures may be ineffective in providing sufficient protection for continued operations. This can occur when there is freezing rain, freezing drizzle, heavy snow, or any condition where high water content is present in freezing precipitation.

3.4 At very low ambient temperatures (below approximately  $-30^{\circ}\text{C}$ ), some heated Type I fluids are no longer effective, and other methods of frozen contamination removal must be used.

## Chapter 4

# AEROPLANE GROUND DE-ICING/ANTI-ICING FLUIDS

4.1 The basic function of de-icing/anti-icing fluids is to lower the freezing point of freezing precipitation as it collects on the aeroplane and thus delay the accumulation of ice, snow, slush or frost on critical surfaces. De-icing/anti-icing fluids are classed as Type I, II, III and IV. **Type I fluids** have a relatively low viscosity which changes mainly as a function of temperature. **Type II, III and IV fluids**, however, contain a thickener system and have, therefore, a higher viscosity which changes as a function of shear force, fluid/water ratio and fluid temperature. Type II, III and IV fluids have better anti-icing properties than Type I fluids.

4.2 All de-icing/anti-icing fluids must meet the *use* criteria established by the operator, fluid manufacturer and aeroplane manufacturer and must also be manufactured in accordance with ISO specifications.

### TYPE I FLUIDS

4.3 Type I fluids are available in concentrated or diluted (ready-to-use) forms. Concentrated Type I fluids contain a high percentage of glycol (i.e. ethylene glycol, diethylene glycol, or propylene glycol or a mixture of these glycols). The remainder consists of water, corrosion inhibitors, wetting agents, anti-foaming agents and sometimes dye.

4.4 Type I fluids must be heated to provide an effective de-icing capability. Concentrated Type I fluids must be diluted with water to achieve a freezing point that is in accordance with the appropriate application procedure. Due to aerodynamic performance and/or freezing-point considerations, Type I fluids as applied are often further diluted for application.

### TYPE II, III AND IV FLUIDS

4.5 Type II and IV fluids are available in diluted and undiluted forms. Undiluted Type II and IV fluids contain a

significant amount of ethylene glycol, diethylene glycol or propylene glycol. The remainder of the mixture is water, a thickener, corrosion inhibitors, wetting agents and sometimes dye. The high viscosity of the fluid, combined with the wetting agents, results in a thick coating when sprayed on the aeroplane. To provide maximum anti-icing protection, Type II and IV fluids should be used in an undiluted condition. Type II and IV fluids, however, are also used in a diluted condition for de-icing/anti-icing applications at the higher ambient temperatures and low precipitations. For de-icing purposes, the fluid must be heated.

4.6 Type III fluid can be a diluted Type II or IV fluid that meets the performance aerodynamic test for turbo-propeller-driven aeroplanes.

4.7 Type II, III and IV fluids have high viscosity, resulting in a much thicker coating of fluid on the wings than Type I. The airflow during the take-off roll exposes these fluids to a shear force that causes a loss of viscosity, thereby allowing the fluid to flow off the critical portion of the wings prior to rotation.

4.8 Falling precipitation will steadily dilute all types of anti-icing fluids until either the fluid coating freezes or frozen deposits start to accumulate. By increasing the viscosity of the fluid (as in Type II or IV), a higher film thickness and, hence, a greater volume of fluid can be applied. The greater volume of fluid can absorb more freezing precipitation before its freezing point is reached and therefore its holdover time is increased. This protective advantage becomes important during freezing precipitation conditions when longer taxi times are expected. In general, Type IV fluids provide longer protection than Type II or III fluids.

4.9 **Under no circumstances** shall an aeroplane that has previously been anti-iced receive a further coating of anti-icing fluid directly on top of the contaminated film. When it becomes necessary to apply another coating of anti-icing fluid, the aeroplane surfaces must first be de-iced before the final coating of anti-icing fluid is applied.

**HANDLING OF ANTI-ICING FLUIDS**

4.10 All fluids must be handled in accordance with fluid manufacturers' recommendations, health and environmental regulations, and operator requirements.

4.11 The protective properties of Type II, III and IV fluids will be degraded when the fluid is subjected to

contamination, improper transportation or storage, excessive heating or when exposed to excessive shear forces during fluid transfer or use.

4.12 Quality control methods for handling de-icing/anti-icing fluids, as specified in the approved operator programme, must be strictly followed at all times.

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## Chapter 5

# HOLDOVER TIMES

5.1 Holdover time (HOT) is the *estimated* time the anti-icing fluid will prevent the formation of ice and frost and the accumulation of snow on the protected (treated) surfaces of an aeroplane. These holdover times are generated by testing fluids under a variety of temperature and precipitation conditions simulating the range of weather experienced in winter.

5.2 Numerous factors that can affect the de-icing/anti-icing capabilities and holdover times of de-icing/anti-icing fluids have been identified. These factors include, but are not limited to:

- a) type and rate of precipitation;
- b) ambient temperature;
- c) relative humidity;
- d) wind direction and velocity;
- e) aeroplane surface (skin) temperature; and
- f) de-icing/anti-icing fluid (type, fluid/water ratio, temperature).

As a result, a well-defined time for the protection provided by an anti-icing fluid cannot be established.

5.3 The operator should publish the holdover times in the form of a table or diagram to account for the various types of ground icing conditions that may be encountered and the different types and concentrations of fluids used. A range of holdover times for a particular condition is recommended to account, to some degree, for the variation in the existing local meteorological conditions, particularly the aeroplane skin temperature and the rate of precipitation being encountered.

5.4 At the completion of aeroplane de-icing/anti-icing, the pilot-in-command will be provided with the following information:

- a) fluid type;

- b) fluid/water ratio (Type II, III or IV only);
- c) start time of the final anti-icing application; and
- d) confirmation that the aeroplane is in compliance with the clean aircraft concept.

This basic information will assist the pilot-in-command in estimating an appropriate holdover time from the range provided in the operator's table.

5.5 The sample ISO holdover time guidelines (Tables 3, 4 and 5 of the Attachment) give examples of the time-frames of protection that can be expected under various weather conditions. The times of protection shown in these tables are to be used as *guidelines* only and are normally used in conjunction with pre-take-off check procedures.

5.6 The holdover time begins with the start of the final de-icing/anti-icing application and ends after an elapsed time equal to the appropriate holdover time chosen by the pilot-in-command.

### CAUTION

Due to the many variables that can influence holdover times, the time of protection may be reduced or extended, depending on the intensity of the weather conditions. High wind velocity and jet blast can also cause degradation of the protective film of the anti-icing fluid. If these conditions occur, the time of protection may be shortened considerably. This may also be the case when the aeroplane skin temperature is significantly lower than the outside air temperature.

Weather conditions for which no holdover time guidelines exist are referenced in the holdover time guidelines.

# Chapter 6

## DE-ICING/ANTI-ICING CHECK PROCEDURES

### GROUND DE-ICING/ANTI-ICING CHECKS

6.1 The pilot-in-command is responsible for ensuring that the aeroplane complies with the Clean Aircraft Concept prior to take-off. Certain checks are required before an aeroplane can be safely dispatched. These checks can be grouped under three main headings:

- a) checks prior to the application of de-icing/anti-icing fluids;
- b) checks after the application of de-icing/anti-icing fluids; and
- c) special checks.

### CHECKS PRIOR TO THE APPLICATION OF DE-ICING/ANTI-ICING FLUIDS

6.2 The first check in this process is the walk-around or pre-flight check, normally accomplished by the ground or flight crew. The aeroplane critical surfaces, fuselage and landing gear shall be checked for ice, snow, slush or frost in accordance with an approved operator plan. If ice, snow, slush or frost is discovered, de-icing/anti-icing of the aeroplane must be carried out.

### CHECKS AFTER THE APPLICATION OF DE-ICING/ANTI-ICING FLUIDS

6.3 A check to ensure compliance with the Clean Aircraft Concept is made immediately following the application of de-icing/anti-icing fluids and is carried out by a qualified person in accordance with the approved operator plan and procedures.

6.4 The pre-take-off check, which is the responsibility of the pilot-in-command, ensures that the critical surfaces of the aeroplane are free of ice, snow, slush or frost just prior to take-off. This check shall be accomplished as close to the time of take-off as possible and is normally made from within the aeroplane by visually checking the wings or other surfaces.

6.5 The pre-take-off check procedures are a critical part of the ground operation and become the only means by which the pilot-in-command can ensure that the aeroplane is in compliance with the Clean Aircraft Concept prior to take-off. If stipulated by the regulatory authority, aeroplane manufacturer, or operational specification or if requested by the pilot-in-command, an external check of aeroplane critical surfaces shall be conducted by qualified ground personnel.

6.6 The pilot-in-command has the responsibility to continually monitor the weather and aeroplane condition to ensure compliance with the Clean Aircraft Concept. If this requirement cannot be satisfied by either an internal or external check of aeroplane critical surfaces, then another de-icing/anti-icing of the aeroplane must be accomplished. Special equipment or procedures may be required to carry out this check at night or under severe weather conditions.

### SPECIAL CHECKS

6.7 A check for the presence of clear ice, frequently caused by cold-soaked fuel in the wing tanks, may be required during rain or high humidity conditions and for certain types of aeroplanes. This type of ice is very difficult to detect, especially in conditions of poor lighting or when the wings are wet. Special check procedures are required to detect this type of icing and shall be included in the approved operator programme.

# Chapter 7

## RESPONSIBILITIES

### REGULATORY AUTHORITY

7.1 The regulatory authority ensures that every operator shall have an approved de-icing/anti-icing programme or procedures. The programme shall require that operators comply with the Clean Aircraft Concept.

7.2 The regulatory authority ensures that relevant and appropriate meteorological and other data are readily available to the respective aerodrome users prior to and during aerodrome winter operations requiring de-icing/anti-icing activities. The data shall include, but not be limited to:

- a) runway condition reports;
- b) aerodrome taxiway/apron condition reports; and
- c) aerodrome sequence reports.

7.3 The de-icing/anti-icing programme shall clearly define areas of responsibility for the operator. All persons involved in ground de-icing/anti-icing activities shall be trained and qualified in the procedures, communications and limitations of their area of responsibility. The de-icing/anti-icing programme shall cover all locations within the operator's route network including de-icing/anti-icing accomplished by subcontract.

### OPERATOR

7.4 Ground de-icing/anti-icing is, technically, a part of the operation of the aeroplane. The person in charge of the de-icing/anti-icing procedure is responsible for accomplishing this procedure and verifying the results of the de-icing/anti-icing treatment. Additionally, the de-icing/anti-

icing application information reported to the flight deck crew is also a part of the technical airworthiness of the aeroplane.

7.5 The person responsible for the de-icing/anti-icing process must be clearly designated, trained and qualified. This person shall check the aeroplane for the need to de-ice, shall initiate de-icing/anti-icing, if required, and is responsible for the correct and complete de-icing/anti-icing treatment of the aeroplane. The final responsibility for accepting the aeroplane after de-icing/anti-icing rests, however, with the pilot-in-command.

7.6 The pilot-in-command has the responsibility to ensure compliance with the Clean Aircraft Concept. The ground de-icing crew share this responsibility by providing an aeroplane that complies with the Clean Aircraft Concept. To ensure compliance, the pilot-in-command shall evaluate:

- a) actual and forecast weather conditions;
- b) taxi times and conditions;
- c) de-icing/anti-icing fluid characteristics; and
- d) other relevant factors.

This information is used to determine the estimated holdover time. The pilot-in-command is responsible for continually monitoring the condition of the aeroplane after de-icing/anti-icing has been completed and for ensuring that the aeroplane complies with the Clean Aircraft Concept at the time of take-off.

7.7 The de-icing/anti-icing procedures, including those subcontracted by the operator, shall be subject to quality inspections as part of the operator's quality assurance programme.

## Chapter 8

# AERODROME DE-ICING/ANTI-ICING FACILITIES

### NEED FOR A FACILITY

8.1 Safe and efficient aeroplane operations are of primary importance in the development of any aerodrome de-icing/anti-icing facility. Aerodrome de-icing/anti-icing facilities are required at aerodromes where ground snow and icing conditions are expected to occur. This would include aerodromes which serve aeroplanes that can develop frost or ice on critical surfaces as a result of having very cold fuel in their fuel tanks, even though the aerodrome itself is not experiencing ground icing conditions.

### FACILITY DESIGN

8.2 Design considerations should include siting, sizing, environmental issues and the operational needs of aerodrome users in an effort to maximize the de-icing/anti-icing capacity while maintaining maximum safety and efficiency. The design of a de-icing/anti-icing facility should, to the extent practicable, meet the needs of air carriers, aerodrome authorities and other elements of the aviation community, as outlined in aeroplane ground de-icing/anti-icing programmes. The facility should be designed to offer the maximum in safety, efficiency and flexibility to the user.

8.3 Numerous factors affect the basic design of any de-icing/anti-icing facility. In determining the de-icing/anti-icing operational capacity of the aerodrome, it is recommended that the aerodrome have facilities with a de-icing/anti-icing capability equivalent to the maximum peak hour departure rate that can be managed by the ATC units during de-icing/anti-icing operations.

8.4 Environmental concerns are becoming increasingly important in the design of any facility. It therefore follows that de-icing/anti-icing facilities must be designed

in accordance with local environmental rules and regulations. Environmental factors that have to be considered are:

- a) protecting the environment against toxic substances;
- b) isolating and collecting used glycol and any other de-icing/anti-icing contaminants to prevent run-off into the aerodrome storm drainage system; and
- c) recycling the used glycol.

8.5 The size and number of de-icing/anti-icing facilities on an aerodrome shall be determined by at least the following factors:

- a) *Methods and procedures used.* The aerodrome should plan for the two-step de-icing/anti-icing procedure for all de-icing/anti-icing operations even though some operators may choose the one-step procedure on some occasions. As the longer of the two processes, the two-step procedure increases estimated processing times and may therefore require more and larger de-icing/anti-icing facilities. This method of planning should help to ensure that the aerodrome is able to achieve the maximum aeroplane departure flow rates.
- b) *Variations in meteorological conditions.* Precipitation type, rate and frequency all affect aerodrome de-icing/anti-icing operations. Aerodromes that normally experience heavy, wet snowfalls or freezing rain will require more de-icing/anti-icing facilities in order to maintain aeroplane departure flow rates. When these conditions occur frequently, consideration should also be given to locating de-icing/anti-icing facilities as close to the runway as is practical.
- c) *Types of aeroplanes receiving treatment.* The application time required to de-ice/anti-ice various

types of aeroplanes, for the same weather conditions, can vary substantially. Narrow-body aeroplanes require less time than their wide-body counterparts, and aeroplanes with centre-mounted fuselage engines require more time than aeroplanes with only wing-mounted engines.

- d) *Minimizing time between de-icing/anti-icing and take-off.* Locating remote pad facilities with storage capabilities as close as practical to the runway can mitigate operational limitations.
- e) *Bypass taxi capability.* To further maximize departure flow rates for all aeroplanes, the location and size of de-icing/anti-icing facilities should be such that they allow for bypass taxiing during de-icing/anti-icing operations.

### COMPONENTS

8.6 De-icing/anti-icing facilities have the following components:

- a) de-icing/anti-icing pads for the manoeuvring of aeroplanes;
- b) de-icing/anti-icing system comprising one or both of the following:
  - 1) mobile vehicles, and
  - 2) fixed equipment;
- c) bypass taxiing capability;
- d) environmental run-off mitigation measures;
- e) permanent or portable night-time lighting system; and
- f) support facilities that may include:
  - 1) storage tanks and transfer systems for de-icing/anti-icing fluids; and
  - 2) de-icing crew shelter.

### FACILITY LOCATION

8.7 The primary consideration in determining the location of an aerodrome de-icing/anti-icing facility is the

time required to taxi from the facility to the take-off runway. This is because the taxi time begins at the conclusion of the anti-icing process and ends with take-off. The taxi time should be such that throughout the time required for an aeroplane to taxi to the runway and take off, the holdover time of the de-icing/anti-icing fluid used remains in effect.

8.8 In calculating the taxi time from the de-icing/anti-icing facility to the departure runway, operators should take into account that taxi times are slower in winter. They should also consider whether there are any other time-related factors specific to the aerodrome that may contribute to the taxi time, such as crossing active runways.

8.9 Other factors that might affect the location of an aerodrome de-icing/anti-icing facility are:

- a) environmental issues and considerations;
- b) types of fluid applicators (mobile de-icing/anti-icing vehicles, revolving turrets or gantry types);
- c) access for mobile de-icing/anti-icing vehicles or other de-icing/anti-icing operations support vehicles;
- d) types and size of aeroplanes required to be de-iced/anti-iced;
- e) winter taxi routes in use on the aerodrome;
- f) airspace protection and obstacle clearance;
- g) safety clearances on the ground; and
- h) navigation/approach aid clearances on the ground.

### Terminal de-icing/anti-icing

8.10 For some aerodromes, de-icing/anti-icing facilities at gates or adjacent to the terminal can adequately meet the de-icing/anti-icing demands of the aerodrome user and the aerodrome authority and still allow acceptable taxi times to the departure runway during ground icing conditions.

### Off-terminal de-icing/anti-icing

8.11 De-icing/anti-icing facilities away from the terminal are recommended when terminal de-icing/anti-

icing facilities (including apron facilities) cause excessive gate delays and/or taxi times that frequently cause holdover times to be exceeded.

#### **Remote pad de-icing/anti-icing facilities**

8.12 Remote de-icing/anti-icing facilities located near departure runway ends or along taxiways are recommended when taxi times from terminals or off-terminal de-icing/anti-icing locations frequently exceed holdover times. The proper design of these facilities can also improve flow control by permitting repeat de-icing/anti-icing of aero-

plane critical surfaces without the aeroplane having to return to more distant treatment sites.

#### **CLEARANCE AND SEPARATION STANDARDS**

8.13 All de-icing/anti-icing facilities shall be designed, sited and sized in accordance with the clearance and separation standards established by the local regulatory authority. Additionally, proximity to fixed and movable objects must be considered.

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## **Chapter 9**

# **AIR TRAFFIC CONTROL (ATC) WINTER OPERATIONS PLAN**

9.1 It is the responsibility of the regulatory authority to provide a comprehensive air traffic control plan that relates to winter operations and de-icing/anti-icing activities and to coordinate the merging of the ATC winter operations plans of contiguous national areas.

9.2 The ATC winter operations plan shall provide for the management of safe and efficient aeroplane movements within the aerodrome traffic area during winter operations and de-icing/anti-icing activities. The plan shall meet the needs of the aerodrome users while complying with the requirements of the individual aeroplane and ground de-icing/anti-icing programmes and facilities.

9.3 This plan shall provide for the implementation of an ATC programme during winter operations and de-icing/anti-icing activities that will ensure optimum aeroplane arrival and departure “flow through” rates.

9.4 In developing the plan, full account should be taken of the relevant climatological information pertaining to the aerodrome concerned. The plan shall provide for the distribution of necessary meteorological information from a reliable meteorological source to support the management of safe and efficient aeroplane operations and de-icing/anti-icing activities.

9.5 Details of the ATC winter operations plan shall be included in all air traffic controllers’ manuals. It shall provide for the shortest possible taxi time to the departure runway for take-off after the completion of the de-icing/anti-icing of an aeroplane. It shall, where appropriate, contain provisions for centralized de-icing/anti-icing and remote pad de-icing/anti-icing and for secondary de-icing/anti-icing at the aerodrome.

## Chapter 10

# DE-ICING/ANTI-ICING COMMUNICATIONS

10.1 The communications between ground and flight crews are an integral part of the de-icing/anti-icing process and must be included in every de-icing/anti-icing procedure.

10.2 Prior to starting the de-icing/anti-icing process, it is essential that the ground and flight crews verify that the aeroplane is properly configured in accordance with the manufacturer's recommendations and the operator's procedures.

10.3 Upon completion of the de-icing/anti-icing procedure and the associated check of the aeroplane, the flight crew shall be provided with information about the final step of the de-icing/anti-icing process which ensures that the aeroplane is in compliance with the Clean Aircraft Concept; this information shall be given in the form of de-icing/anti-icing code.

10.4 The de-icing/anti-icing codes, which are to be recorded, shall be communicated to the flight crew in the following sequence:

Element A: specify type of fluid used, i.e. "Type I", "Type II", "Type III" or "Type IV".

Element B: specify the percentage of de-icing/anti-icing fluid in the fluid/water mixture, e.g. "100" for 100% fluid, "75" for 75% fluid and 25% water (not required for Type I fluid).

Element C: specify in local time, in hours and minutes, the beginning of the final de-icing/anti-icing step, e.g. "1330".

Element D: specify date as day, month, year, e.g. "20 March 1999" (only required for record keeping; optional for crew notification).

The transmission of elements A, B and C to the flight crew confirms that the de-icing/anti-icing was completed and that the aeroplane is clean.

10.5 Examples of the format to be used for flight crew notification are shown below.

"Type IV/100/1400/20 March 1998"

"Type II/75/1200/02 January 1999"

"Type I/0800/04 April 2000"

10.6 **After** de-icing/anti-icing and **prior** to departure, the flight crew must receive an "all clear" signal from the ground crew that it is safe to taxi.

10.7 Communications between flight crews and ATC regarding any activities related to de-icing/anti-icing (e.g. holdover times, taxi times, ATC flow control rates) shall follow the communications procedures as outlined in the ATC aerodrome winter operations plan.

# Chapter 11

## DE-ICING/ANTI-ICING METHODS

11.1 De-icing/anti-icing is generally carried out by using heated fluids dispensed from spray nozzles mounted on specially designed de-icing/anti-icing trucks. Other methods include de-icing/anti-icing gantry spraying systems, small portable spraying equipment, mechanical means (brushes, ropes, etc.), infra-red radiation, and forced air.

11.2 De-icing/anti-icing fluids are applied close to the skin of the aeroplane to minimize heat loss. Unique procedures to accommodate aeroplane design differences may be required. Spraying usually starts with the fuselage. General techniques are outlined below.

- a) *Fuselage*. Spray along the top centre line and then outboard. Avoid spraying directly on windows.
- b) *Wings and horizontal stabilizers*. Spray from the leading edge towards the trailing edge, and from the highest point of the surface camber to the lowest point. Aircraft configuration and/or local conditions may require a different procedure.
- c) *Vertical surfaces*. Start at the top and work downwards, spraying from the leading edge toward the trailing edge.
- d) *Landing gear and wheel bays*. Keep application of de-icing/anti-icing fluid in this area to a minimum. High-pressure spraying is **not** recommended. Do not spray directly onto brakes/wheels.
- e) *Engines/APUs*. Avoid spraying fluids into engines or APUs. Consult manufacturers' recommendations. Ensure that engines are free to rotate before start up and that the front and back of fan blades are free of ice. Air-conditioning bleed systems must be switched off during de-icing/anti-icing operations when engines or APUs are running. Do not spray directly onto exhausts or thrust reversers.

- f) *Instrument sensors*. Avoid spraying directly onto pitot heads, static vents or air stream direction detector probes and angle of attack sensors.

### **Aeroplanes have to be treated symmetrically.**

11.3 De-icing/anti-icing can be carried out as a one-step process using heated de-icing/anti-icing fluid to both de-ice and anti-ice, or as a two-step process using heated de-icing fluid or hot water to de-ice, followed immediately by an anti-icing fluid to anti-ice. Fluid temperature and pressure restrictions must be observed. Selection of the one- or two-step method depends upon local situations, such as weather conditions, available equipment, available fluids, and holdover time.

11.4 De-icing/anti-icing an aeroplane as close to its departure time and/or departure runway as possible provides the minimum interval between de-icing/anti-icing and take-off, thus conserving holdover time.

11.5 Fluid application and aeroplane-related limits such as correct fluid mixtures, fluid temperature, pressure at the nozzle, application procedure, and spraying techniques have to be observed.

### **CAUTION**

The repeated application of Type II or Type IV fluid, without subsequent application of Type I or hot water, may cause a residue to collect in aerodynamically quiet areas. This residue may rehydrate and freeze under certain temperature, high humidity and/or rain conditions. It may also block or impede critical flight control systems and may require removal.

After prolonged periods of de-icing/anti-icing, it is advisable to check aerodynamically quiet areas and cavities for residues of thickened de-icing/anti-icing fluid. Consult airframe manufacturers for details and procedures.

## Chapter 12

# ICE DETECTION AND WARNING SYSTEMS

12.1 On the basis of their planned function and location, ground ice detection and warning systems may be separated into two principal categories — ground-based devices and aeroplane-mounted devices.

12.2 *Ground-based devices* will be designed to detect ice, snow, slush or frost on the critical surfaces of the aeroplane and/or to evaluate the condition of the anti-icing fluid. They will normally consist of area surveying equipment or systems and will meet aeroplane manufacturer, operator and regulatory authority requirements, as appropriate.

12.3 *Aeroplane-mounted devices* are those which are any combination of point sensors, area surveying equipment or performance monitoring devices. They will be designed to detect ice, snow, slush or frost on the critical surfaces of the aeroplane and/or to evaluate the condition of the anti-icing fluid. They will also meet aeroplane manufacturer, operator and regulatory authority requirements. Operational requirements of aeroplane-mounted systems ensure a design that will cover the same operational environment for which the aeroplane has been certified. The warning information will be simple, straightforward and consistent with the current display philosophy adopted by the industry.

12.4 The desired intent of systems using aeroplane-mounted devices is to confirm to the flight crew that aeroplane critical surfaces are free of adhering frozen contaminants prior to take-off.

12.5 During system integration and installation, both the ground-based devices and aeroplane-mounted devices will meet the requirements established by operators, aeroplane manufacturers and regulatory authorities. The design of these devices should be compatible with de-icing/anti-icing philosophies, fluids and procedures. These devices may be either advisory or primary in nature.

12.6 The information provided by ground-based and aeroplane-mounted devices should assist in meeting the following objectives:

- a) assist the pilot-in-command in operational decision-making (advisory device);
- b) relieve the pilot-in-command of decision-making (primary device);
- c) help to more accurately estimate the duration of the holdover time; and
- d) minimize the need to return for additional de-icing/anti-icing.

## Chapter 13

# TRAINING OF PERSONNEL

13.1 De-icing/anti-icing procedures must be carried out only by trained and qualified personnel.

13.2 Both initial and recurrent training for flight crews and ground crews are to be conducted to ensure that all such crews obtain and retain a thorough knowledge of ground de-icing/anti-icing policies and procedures, including new procedures and lessons learned. Training subjects are to include, but are not limited to:

- a) recognition of relevant weather phenomena;
- b) effects of frost, ice, snow and slush on performance, stability and control;
- c) basic characteristics of de-icing/anti-icing fluids;
- d) general techniques for de-icing (removing deposits of frost, ice, snow and slush from aeroplane surfaces) and for anti-icing;
- e) de-icing/anti-icing procedures in general, specific measures to be performed on different aeroplane types, and procedures specifically recommended by the operator, aeroplane manufacturer or fluid manufacturer;
- f) types of checks required and procedures and responsibilities for checks;
- g) de-icing/anti-icing equipment operating procedures, including actual operation of equipment;
- h) quality control procedures;

- i) techniques for recognizing frozen precipitation on aeroplane critical surfaces;
- j) health effects, safety precautions and accident prevention;
- k) emergency procedures;
- l) fluid application methods and procedures;
- m) use and limitations of holdover time guidelines;
- n) de-icing/anti-icing codes and communication procedures;
- o) special provisions and procedures for contract de-icing and anti-icing (if applicable);
- p) environmental considerations for de-icing and anti-icing operations, i.e. locations for de-icing and anti-icing, reporting spillage, and hazardous waste control; and
- q) new procedures, new developments, and lessons from the previous winter.

13.3 Additionally, training for ground personnel shall include procedures and methods for the storage and handling of de-icing and anti-icing fluids.

13.4 The operator shall maintain accurate records of the training and qualifying of both flight and ground personnel. This proof of qualification shall be for both initial and annual recurrent training.

# Chapter 14

## EQUIPMENT

14.1 This chapter describes recommendations for performance and methods for verification of fluid systems, both of which are important for the reliability of the de-icing operation. It is not intended to specify a comprehensive set of technical design criteria for de-icing/anti-icing equipment for aeroplanes, but only those relating to function, safety and performance.

### FUNCTIONAL INFORMATION

14.2 To optimize the snow and ice removal effect, the fluid system of the de-icing/anti-icing equipment should be designed for spraying heated fluid. The size and design of the de-icing/anti-icing equipment should be agreed upon between manufacturer and user, as the operational conditions can vary considerably from one aerodrome to another. Open basket de-icing/anti-icing equipment is often preferred, but for locations where operators are de-icing/anti-icing for long periods, or de-icing/anti-icing aeroplanes with engines running, an enclosed cabin offers much better working conditions with regard to exposure to noise, weather, glycol aerosols, etc. As training of operators is of major importance in order to perform a fast, technically safe and environmentally safe de-icing/anti-icing operation, it is necessary that the operator's basket/cabin is able to carry a second person.

### RECOMMENDATIONS FOR FLUID SYSTEM PERFORMANCE

14.3 Agreement on size and configuration of the fluid tanks should be made between manufacturer and user to suit the conditions on the aerodrome concerned. The equipment should be able to handle all types of commercially available de-icing/anti-icing fluids, approved to aerospace specifications. Non-corrosive materials (e.g. stainless steel) are most suitable for the tank and pipe system of de-icing equipment and are essential if the equipment is designed for

spraying Type II, III or IV fluids. There is a general demand for Type II, III or IV fluids and, as a result, for the selection of components for the fluid system (e.g. pumps, heating systems, nozzles and pipes) that will apply the thickened fluid within the fluid manufacturer's specification and without fluid degradation. Pumping relief valves and bypass valves, therefore, are not acceptable since they damage thickened fluids. If de-icing equipment is provided with a mixing system, the accuracy of this system should be stated in the operator's manual. This will be useful information for the operator when determining the safety margin of the de-icing operation and when examining whether the mixing system is working properly. The safety of the system will be improved if there is a means of easily detecting when the accuracy of the fluid mix is not within the stated tolerance. The operator should regularly check the accuracy of the fluid mix at the nozzle.

### VERIFICATION OF FLUID SYSTEM FUNCTION

14.4 To verify the accuracy of a fluid mixing system:

- a) fill the tanks with sufficient volume (water, and Type I, II, III or IV fluid);
- b) start up the mixing system and select the desired fluid mix;
- c) purge the system until only the selected fluid mix comes out of the nozzle;
- d) spray into a container lined with a plastic bag of appropriate size and strength until a sufficient volume of fluid is in the bag; and
- e) remove the bag from the container and compare the refractive index of the fluid mix with the refractive

index of a manually mixed sample. The accuracy of all fluid mix ratios used should be tested.

14.5 To verify a fluid system in relation to degradation of Type II, III or IV fluids:

- a) make sure that the Type II, III or IV fluid tank is completely clean and free of water;
  - b) fill the tank with a sufficient volume of Type II, III or IV fluid;
  - c) take two reference samples of the fluid from the tank. Make sure that the sample is representative of the tank content;
  - d) select 100% Type II, III or IV fluid and purge the fluid system until only this fluid comes out of the nozzle;
  - e) spray into a container lined with a plastic bag of appropriate size and strength until a sufficient volume of fluid is in the bag;
  - f) as a minimum, carry out the test with maximum flow rates and widest spray pattern;
  - g) compare the samples from the bag with the reference samples concerning Brookfield viscosity and holdover time; and
  - h) record the parameters of the fluid temperatures, fluid flow rates, and spray pattern of the nozzle.
-

## Chapter 15

# QUALITY ASSURANCE PROGRAMME

Operators shall establish a quality assurance programme to ensure correct de-icing/anti-icing operation at all stations where applicable. The programme shall include at least the elements listed below.

- a) *Auditing* of all parts of the de-icing/anti-icing operation is required to check the ongoing conformance with all regulations issued by authorities, operators, manufacturers and handling agents.
- b) *Training* of all personnel involved in the de-icing/anti-icing operation is carried out to guarantee the correct performance of all related tasks.
- c) *Methods and procedures* have to be defined to allow the clear and safe accomplishment of all the

tasks that are necessary for de-icing/anti-icing an aeroplane.

- d) *Training records* of all de-icing/anti-icing personnel are necessary to guarantee that all training and skill requirements are fulfilled.
- e) *Qualification* of all de-icing/anti-icing personnel is required to ensure correct performance of all tasks.
- f) *Publications* are required for the aeroplane de-icing/anti-icing operation to ensure the correct accomplishment of all tasks.
- g) *Equipment and fluids* have to be maintained in such a way that the correct quality is ensured.

## Chapter 16

# UPDATING OF HOLDOVER TIME GUIDELINES AND DE-ICING/ANTI-ICING PROCEDURES

16.1 Holdover times and de-icing/anti-icing procedures are continually updated by an international group of experts under the auspices of the SAE G-12 Committee on Aircraft Ground De-icing/Anti-icing through its Holdover Time Subcommittee. This group of experts is composed of representatives of the world's airlines, anti-icing fluid manufacturers, aircraft manufacturers, aviation regulatory authorities and research organizations.

16.2 De-icing/anti-icing fluids are qualified to the appropriate specification by certified laboratories. Qualified fluids are tested jointly by the United States Federal Aviation Administration (FAA) and Transport Canada to establish the fluid endurance time data, from which the holdover time guidelines are generated by the Holdover Time Subcommittee. The de-icing/anti-icing procedures are developed by the Methods Subcommittee who recommend their approval. The holdover time guidelines and procedures are approved for use by the SAE Aerospace Council.

16.3 The approved documents are published by:

a) Transport Canada in an Advisory Circular;

b) the United States Federal Aviation Administration in a Flight Standards Information Bulletin for Air Transportation (FSAT);

c) the SAE in Aerospace Recommended Procedure ARP 4737; and

d) the ISO in ISO 11076.

16.4 The FAA and Transport Canada publications are published annually and are usually available prior to the start of winter in the northern hemisphere. The SAE and ISO publications appear later. The FAA and Transport Canada also publish a list of the qualified de-icing/anti-icing fluids, together with holdover time guidelines for specific fluids that have superior performance to the generic tables.

16.5 Examples of Type I, II and IV de-icing/anti-icing fluid holdover time guidelines and Type I and Type II/IV de-icing/anti-icing fluid application tables are shown in the attachment. Current editions of these tables can also be found on the web sites of Transport Canada ([www.tc.gc.ca](http://www.tc.gc.ca)) and the FAA ([www.faa.gov](http://www.faa.gov)).

### ADDITIONAL WEB SITES

For holdover time guidelines and other information: FAA: [www.faa.gov](http://www.faa.gov)  
For the northern winter 2000/2001: [www.faa.gov/avr/afs/fsat/fst0011c.doc](http://www.faa.gov/avr/afs/fsat/fst0011c.doc)

Transport Canada: [www.tc.gc.ca](http://www.tc.gc.ca)  
For the northern winter 2000/2001: [www.tc.gc.ca/tdc/news/2000/hot.htm](http://www.tc.gc.ca/tdc/news/2000/hot.htm)

Society of Automotive Engineers: [www.sae.org](http://www.sae.org)

Association of European Airlines: [www.aea.be/publications](http://www.aea.be/publications)

ICAO: [www.icao.int/groundice](http://www.icao.int/groundice) (from April 2001)  
The ICAO site provides links to other sites where up-to-date information can be obtained.



# ATTACHMENT

This attachment contains 5 tables:

Table 1 — Guidelines for the application of ISO Type I fluid/water mixtures (minimum concentrations) as a function of OAT

Table 2 — Guidelines for the application of ISO Type II and Type IV fluid/water mixtures (minimum concentrations) as a function of OAT

Table 3 — Guideline for holdover times anticipated for ISO Type I fluid mixtures as a function of weather conditions and OAT

Table 4 — Guideline for holdover times anticipated for ISO Type II fluid mixtures as a function of weather conditions and OAT

Table 5 — Guideline for holdover times anticipated for Type IV fluid mixtures as a function of weather conditions and OAT

These tables are examples only and are not for operational use. For the most current information, visit the websites of the United States FAA ([www.faa.gov](http://www.faa.gov)) or Transport Canada ([www.tc.gc.ca](http://www.tc.gc.ca))

**EXAMPLE ONLY — NOT FOR OPERATIONAL USE****Table 1. Guidelines for the application of ISO Type I fluid/water mixtures (minimum concentrations) as a function of OAT**

OAT	One-step procedure	Two-step procedure	
	De-icing/anti-icing	First step De-icing	Second step Anti-icing <sup>2</sup>
-3°C (27°F) and above	FP of heated fluid <sup>1</sup> mixture shall be at least 10°C (18°F) below actual OAT	Water heated to 60°C (140°F) minimum at the nozzle or a heated mix of fluid and water	FP of fluid mixture shall be at least 10°C (18°F) below actual OAT
below -3°C (27°F)		FP of heated fluid mixture shall not be more than 3°C (5°F) above actual OAT	
<p>1. To be applied before first-step fluid freezes, typically within 3 minutes.</p> <p>2. Clean aircraft may be anti-iced with unheated fluid.</p> <p><i>Note.— For heated fluids, a fluid temperature not less than 60°C (140°F) at the nozzle is desirable. Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendations.</i></p> <p>CAUTION: Wing skin temperatures may be lower than OAT. A stronger mix (more glycol) can be used under these conditions.</p>			

°C Degrees Celsius  
°F Degrees Fahrenheit

OAT Outside air temperature  
FP Freezing point

**EXAMPLE ONLY — NOT FOR OPERATIONAL USE**

**Table 2. Guidelines for the application of ISO Type II and Type IV fluid/water mixtures (minimum concentrations) as a function of OAT**

OAT	Concentration of neat fluid/water mixture in vol%/vol%		
	One-step procedure	Two-step procedure	
	De-icing/anti-icing	First step De-icing	Second step Anti-icing <sup>1</sup>
−3°C (27°F) and above	50/50 heated <sup>2</sup> Type II or IV	Water heated to 60°C (140°F) minimum at the nozzle or a heated mix of Type I, II or IV with water	50/50 Type II or IV
below −3°C (27°F) to −14°C (7°F)	75/25 heated <sup>2</sup> Type II or IV	Heated suitable mix of Type I, II or IV with FP not more than 3°C (5°F) above actual OAT	75/25 Type II or IV
below −14°C (7°F) to −25°C (−13°F)	100/0 heated <sup>2</sup> Type II or IV	Heated suitable mix of Type I, II or IV with FP not more than 3°C (5°F) above actual OAT	100/0 Type II or IV
below −25°C (−13°F)	ISO Type II/Type IV fluid may be used below −25°C (−13°F) provided that the freezing point of the fluid is at least 7°C (13°F) below OAT and that aerodynamic acceptance criteria are met. Consider the use of ISO Type I when Type II or IV fluid cannot be used (see Table 1).		
<p>1. To be applied before first-step fluid freezes, typically within 3 minutes.</p> <p>2. Clean aircraft may be anti-iced with unheated fluid.</p> <p><i>Note.— For heated fluids, a fluid temperature not less than 60°C (140°F) at the nozzle is desirable. Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendations.</i></p> <p><b>CAUTION:</b></p> <ul style="list-style-type: none"> <li>— Wing skin temperatures may be lower than OAT. A stronger mix (more glycol) can be used under these conditions. As fluid freezing may occur, 50% Type II or IV fluid shall not be used for the anti-icing step of a cold-soaked wing.</li> <li>— An insufficient amount of anti-icing fluid, especially in the second step of a two-step procedure, may cause a substantial loss of holdover time. This is particularly true when using a Type I fluid mixture for the first step (de-icing).</li> </ul>			

°C Degrees Celsius

OAT Outside air temperature

°F Degrees Fahrenheit

FP Freezing point

**EXAMPLE ONLY — NOT FOR OPERATIONAL USE****Table 3. Guideline for holdover times anticipated for ISO Type I fluid mixtures as a function of weather conditions and OAT**

OAT	Approximate holdover times under various weather conditions (hours:minutes)						
	Frost <sup>1</sup>	Freezing fog	Snow	Freezing drizzle <sup>2</sup>	Light freezing rain	Rain on cold-soaked wing	Other <sup>3</sup>
above 0°C (32°F)	0:45	0:12-0:30	0:06-0:15	0:05-0:08	0:02-0:05	0:02-0:05	CAUTION: No holdover time guidelines exist
0°C to -10°C (32°F to 14°F)	0:45	0:06-0:15	0:06-0:15	0:05-0:08	0:02-0:05		
below -10°C (14°F)	0:45	0:06-0:15	0:06-0:15				

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

2. Use LIGHT FREEZING RAIN holdover times if positive identification of FREEZING DRIZZLE is not possible.

3. Other conditions are: heavy snow, snow pellets, ice pellets, hail, moderate freezing rain and heavy freezing rain.

*Note 1.— ISO Type I Fluid/Water Mixture is selected so that the freezing point of the mixture is at least 10°C (18°F) below actual OAT.*

*Note 2.— ISO Type I fluids used during ground de-icing/anti-icing are not intended for and do not provide ice protection during flight.*

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 the aircraft skin temperature is lower than OAT. Therefore, the indicated times should be used only in conjunction with a pre-take-off check.

OAT Outside air temperature

°C Degrees Celsius

°F Degrees Fahrenheit

**EXAMPLE ONLY — NOT FOR OPERATIONAL USE**

**Table 4. Guideline for holdover times anticipated for ISO Type II fluid mixtures as a function of weather conditions and OAT**

OAT	ISO Type II fluid concentration Neat fluid/water (Vol%/Vol%)	Approximate holdover times under various weather conditions (hours:minutes)						
		Frost <sup>1</sup>	Freezing fog	Snow	Freezing drizzle <sup>2</sup>	Light freezing rain	Rain on cold-soaked wing	Other <sup>4</sup>
above 0°C (32°F)	100/0	12:00	1:05-2:15	0:20-1:00	0:30-1:00	0:15-0:30	0:05-0:40	CAUTION: No holdover time guidelines exist
	75/25	6:00	0:50-1:45	0:15-0:40	0:20-0:45	0:10-0:25	0:05-0:25	
	50/50	4:00	0:15-0:35	0:05-0:15	0:05-0:20	0:05-0:10		
0°C to -3°C (32°F to 27°F)	100/0	8:00	0:35-1:30	0:20-0:45	0:30-1:00	0:15-0:30		
	75/25	5:00	0:25-1:00	0:15-0:30	0:20-0:45	0:10-0:25		
	50/50	3:00	0:15-0:35	0:05-0:15	0:05-0:20	0:05-0:10		
below -3°C to -14°C (27°F to 7°F)	100/0	8:00	0:30-1:05	0:15-0:35	0:15-0:45 <sup>3</sup>	0:10-0:30 <sup>3</sup>		
	75/25	5:00	0:20-0:50	0:15-0:25	0:15-0:30 <sup>3</sup>	0:10-0:20 <sup>3</sup>		
below -14°C to -25°C (7°F to -13°F)	100/0	8:00	0:15-0:20	0:15-0:30				
below -25°C (-13°F)	100/0	ISO Type II fluid may be used below -25°C (-13°F) provided that the freezing point of the fluid is at least 7°C (13°F) below the actual OAT and the aerodynamic acceptance criteria are met. Consider use of ISO Type I when ISO Type II fluid cannot be used (see Table 3).						

1. During conditions that apply to aircraft protection for ACTIVE FROST.  
 2. Use LIGHT FREEZING RAIN holdover times if positive identification of FREEZING DRIZZLE is not possible.  
 3. No holdover time guidelines for this condition exist below -10°C (14°F).  
 4. Other conditions are: heavy snow, snow pellets, ice pellets, hail, moderate freezing rain and heavy freezing rain.

*Note.— ISO Type II fluids used during ground de-icing/anti-icing are not intended for and do not provide ice protection during flight.*

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 the aircraft skin temperature is lower than OAT. Therefore, the indicated times should be used only in conjunction with a pre-take-off check.

°C Degrees Celsius

OAT Outside air temperature

°F Degrees Fahrenheit

Vol Volume

**EXAMPLE ONLY — NOT FOR OPERATIONAL USE****Table 5. Guideline for holdover times anticipated for Type IV fluid mixtures as a function of weather conditions and OAT**

OAT	ISO Type IV fluid concentration Neat fluid/water (Vol%/Vol%)	Approximate holdover times under various weather conditions (hours:minutes)						
		Frost <sup>1</sup>	Freezing fog	Snow	Freezing drizzle <sup>2</sup>	Light freezing rain	Rain on cold-soaked wing	Other <sup>4</sup>
above 0°C (32°F)	100/0	18:00	1:05-2:15	0:35-1:05	0:40-1:00	0:25-0:40	0:10-0:50	CAUTION: No holdover time guidelines exist
	75/25	6:00	1:05-1:45	0:20-0:40	0:30-1:00	0:15-0:30	0:05-0:35	
	50/50	4:00	0:20-0:35	0:05-0:20	0:10-0:20	0:05-0:10		
0°C to -3°C (32°F to 27°F)	100/0	12:00	1:05-2:15	0:30-0:55	0:40-1:00	0:25-0:40		
	75/25	5:00	1:05-1:45	0:20-0:35	0:30-1:00	0:15-0:30		
	50/50	3:00	0:20-0:35	0:05-0:15	0:10-0:20	0:05-0:10		
below -3°C to -14°C (27°F to 7°F)	100/0	12:00	0:40-1:30	0:20-0:40	0:20-0:55 <sup>3</sup>	0:10-0:30 <sup>3</sup>		
	75/25	5:00	0:25-1:00	0:15-0:25	0:20-0:55 <sup>3</sup>	0:10-0:30 <sup>3</sup>		
below -14°C to -25°C (7°F to -13°F)	100/0	12:00	0:20-0:40	0:15-0:30				
below -25°C (-13°F)	100/0	Type IV fluid may be used below -25°C (-13°F) provided that the freezing point of the fluid is at least 7°C (13°F) below the actual OAT and the aerodynamic acceptance criteria are met. Consider use of Type I fluid when Type IV fluid cannot be used (see Table 3).						

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

2. Use LIGHT FREEZING RAIN holdover times if positive identification of FREEZING DRIZZLE is not possible.

3. No holdover time guidelines for this condition exist below -10°C (14°F).

4. Other conditions are: heavy snow, snow pellets, ice pellets, hail, moderate freezing rain and heavy freezing rain.

*Note.— ISO Type IV fluids used during ground de-icing/anti-icing are not intended for and do not provide ice protection during flight.*

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 the aircraft skin temperature is lower than OAT. Therefore, the indicated times should be used only in conjunction with a pre-take-off check.

°C Degrees Celsius

OAT Outside air temperature

°F Degrees Fahrenheit

Vol Volume

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