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SAE ARP4737H

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Superseding ARP4737G

Aircraft Deicing/Anti-icing Methods

RATIONALE

The purpose of this revision is to include additional recommendations and refine existing recommendations from operational experiences gained and advanced deicing technologies implemented since the previous publication.

FOREWORD

The purpose of this document is to provide guidelines for the methods and procedures used in performing the maintenance operations and services necessary for proper deicing and anti-icing of aircraft on the ground.

Exposure to weather conditions, on the ground, that are conducive to ice formation can cause accumulation of frost, snow, slush, or ice on aircraft surfaces and components that can adversely affect aircraft performance, stability, and control and operation of mechanical devices such as control surfaces, sensors, flaps, and landing gear. If frozen deposits are present, other than those considered in the certification process, the airworthiness of the aircraft may be invalid and no attempt should be made to fly the aircraft until it has been restored to the clean configuration.

Regulations governing aircraft operations in icing conditions shall be followed. Specific rules for aircraft are set forth in United States Federal Aviation Regulations (FAR), Joint Aviation Regulations (JAR), Canadian Air Regulations, and others. Paraphrased, these rules relate that NO ONE SHOULD DISPATCH OR TAKE OFF AN AIRCRAFT WITH FROZEN DEPOSITS ON COMPONENTS OF THE AIRCRAFT THAT ARE CRITICAL TO SAFE FLIGHT. A critical component is one which could adversely affect the mechanical or aerodynamic function of an aircraft. The intent of these rules is to ensure that no one attempts to dispatch or operate an aircraft with frozen deposits adhering to any aircraft component critical to safe flight.

The ultimate responsibility for the determination that the aircraft is clean and meets airworthiness requirements rests with the pilot in command of the aircraft.

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1. SCOPE

1.1 Field of Application

1.1.1 This document establishes the minimum requirements for ground based aircraft deicing/anti-icing Methods and procedures to ensure the safe operation of aircraft during icing conditions. This document does not specify requirements for particular airplane models.

NOTE: Particular airline or aircraft manufacturers' published manuals, procedures, or methods supplement the information contained in this document.

1.1.2 Agreements and Contracts

This information is recommended as a basis for maintenance operations and service support agreements.

1.1.3 Safety - Hazardous Materials

While the materials, methods, applications, and processes described or referenced in this specification may involve the use of hazardous materials, this specification does not address the hazards which may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and processes and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

1.1.4 All guidelines referred to herein are applicable only in conjunction with the referenced SAE specifications. Specific requirements for airplane model type are not included. Due to aerodynamic and other concerns application of deicing/anti-icing fluids shall be carried out in compliance with engine and aircraft manufacturers' requirements.

2. APPLICABLE DOCUMENTS

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

AMS1424 Deicing/Anti-Icing Fluid, Aircraft, SAE Type I

AMS1428 Fluid, Aircraft Deicing/Anti-Icing, Non-Newtonian (Pseudoplastic), SAE Types II, III, and IV

ARP1971 Aircraft Deicing Vehicle - Self-Propelled, Large and Small Capacity

ARP5149 Training Program Guidelines for Deicing/Anti-Icing of Aircraft on Ground

AS5635 Message Boards (Deicing Facilities)

AIR9968 Viscosity Test of Thickened Aircraft Deicing/Anti-Icing Fluids

2.2 U.S. Government Publications

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094 or from the FAA web site at http://www.faa.gov.

AC 20-117	Hazards Following Ground Deicing and Ground Operations in Conditions Conducive to Aircraft Icing
AC 120-60	Ground Deicing and Anti-icing Program
AC 150/5300-14	Design of Aircraft Deicing facilities
FSAT 00-05 and FSAW 00-02	Approving Infrared Technology for Aircraft Ground De-Icing/Anti-Icing Facilities.

3. DEFINITIONS

3.1 Abbreviations

C = Celsius

F = Fahrenheit

OAT = Outside Air Temperature

FP = Freezing point

h = Hours

min = Minutes

LOUT = Lowest Operational Use Temperature

3.2 Buffer/Freezing Points

The difference between OAT and the freezing point of the fluids used.

3.3 Fluids

CAUTION: SAE Type I fluids supplied as concentrates for dilution with water prior to use shall not be used undiluted, unless they meet aerodynamic performance and freezing point buffer requirement (reference AMS1424).

3.3.1 Deicing fluids are:

a. Heated water

b. SAE Type I fluid (see caution)

c. Heated concentrates or mixtures of water and SAE Type I fluid

d. Heated concentrates or mixtures of water and SAE Type II fluid

e. Heated concentrates or mixtures of water and SAE Type III fluid

f. Heated concentrates or mixtures of water and SAE Type IV fluid

Deicing fluid is normally applied heated to assure maximum deicing efficiency.

3.3.2 Anti-icing fluids are:

a. Heated SAE Type I fluid (see previous caution)

b. Heated mixtures of water and SAE Type I fluid

c. Concentrates or mixtures of SAE Type II fluid and water

d. Concentrates or mixtures of SAE Type III fluid and water

e. Concentrates or mixtures of SAE Type IV fluid and water

NOTE: Temperature of both a. and b. shall be at least 60 °C (140 °F) at the nozzle. Upper temperature limit shall not exceed fluid and aircraft manufacturer's recommendations.

SAE Type II and IV fluids for anti-icing are normally applied unheated on clean aircraft surfaces but may be applied heated. SAE Type III fluids for anti-icing may be applied heated or unheated on clean aircraft surfaces.

3.3.3 Fluid terms are:

a. Newtonian fluids are defined as fluids whose viscosities are shear independent and time independent. The shear rate of a Newtonian fluid is directly proportional to the shear stress. The fluid will begin to move immediately upon application of a stress; it has no yield stress to overcome before flow begins.

NOTE: SAE Type I fluids are considered Newtonian.

b. Non-Newtonian fluids are defined as fluids whose viscosities are shear and time dependent and whose shear rate is not directly proportional to its shear stress. The fluid will not begin to move immediately upon application of a stress, it has a yield stress to overcome before flow begins.

NOTE: SAE Type II, III, or IV fluids containing thickeners demonstrate a pseudoplastic behavior which is defined as a decrease in viscosity with an increase in shear rate.

3.3.3.1 The lowest operational use temperature (LOUT) is the higher (warmer) of

1. The lowest temperature at which the fluid meets the aerodynamic acceptance test (according to AS5900) for a given type (high speed or low speed) of aircraft

and

2. The freezing point of the fluid plus the freezing point buffer of 10 °C for Type I fluid and 7 °C for Type II, III or IV fluids.

For applicable values refer to the fluid manufacturer's documentation.

3.4 Methods/Procedures

3.4.1 Deicing is a procedure by which frost, ice, slush, or snow is removed from the aircraft in order to provide clean surfaces.

3.4.2 Anti-icing is a procedure, which provides protection against the formation of frost or ice and accumulation of snow or slush on clean surfaces of the aircraft for a limited period of time (holdover time).

3.4.3 Deicing/anti-icing is a combination of the two procedures described previously. It can be performed in one or two steps.

3.4.3.1 One step deicing/anti-icing is carried out with an anti-icing fluid. The fluid used to deice the aircraft remains on aircraft surfaces to provide limited anti-icing capability.

3.4.3.2 Two step deicing/anti-icing consists of two distinct steps. The first step, deicing, is followed by the second step, anti-icing, as a separate process. Anti-icing fluid is applied to protect the relevant surfaces thus providing maximum possible anti-icing capability.

3.4.4 Holdover time is the estimated time anti-icing fluid will prevent the formation of frozen contamination on the protected surfaces of an aircraft.

3.5 Conditions Conducive to Aircraft Icing on Ground

3.5.1 Frost

Ice crystals that form from ice saturated air at temperatures below 0 °C (32 °F) by direct sublimation on the ground or other exposed objects.

3.5.2 Freezing Fog

A suspension of numerous minute water droplets which freezes upon impact with ground or other exposed objects, generally reducing the horizontal visibility at the earth's surface to less than 1 km (5/8 mile).

3.5.3 Snow

Precipitation of ice crystals, most of which are branched, star-shaped, or mixed with unbranched crystals. At temperatures higher than -5 °C (23 °F), the crystals are generally agglomerated into snowflakes.

3.5.3.1 Snow is defined to include snow grains. Snow grains are precipitation of very small white and opaque particles of ice that are fairly flat or elongated with a diameter of less than 1 mm (0.04 in). When snow grains hit hard ground, they do not bounce or shatter.

3.5.4 Freezing Drizzle

Fairly uniform precipitation composed exclusively of fine drops [diameter less than 0.5 mm (0.02 in)] very close together which freezes upon impact with the ground or other exposed objects.

3.5.5 Light Freezing Rain

Precipitation of liquid water particles which freeze upon impact with exposed objects, either in the form of drops of more than 0.5 mm (0.02 in) or smaller drops which, in contrast to drizzle, are widely separated. Measured intensity of liquid water particles are up to 2.5 mm or 25 g/dm^2/h (0.10 in/h) with a maximum of 0.25 mm (0.01 in) in 6 min.

3.5.6 Rain or High Humidity (On Cold Soaked Wing)

Water forming ice or frost on the wing surface, when the temperature of the aircraft wing surface is at or below 0 °C (32 °F).

3.5.7 Rain and Snow

Precipitation in the form of a mixture of rain and snow. For operation in light "rain and snow" treat as light freezing rain.

3.5.8 Slush

Snow or ice that has been reduced to a soft watery mixture by rain, warm temperature, and/ or chemical treatment.

3.5.9 Ice Crystals/Diamond Dust

A fall of unbranched ice crystals (snow crystals are branched) in the form of needles, columns, or plates.

CAUTION: There is no holdover time guideline for this condition.

3.5.10 Snow Pellets

Precipitation of white, opaque particles of ice. The particles are round or sometimes conical. Diameters range from about 2 to 5 mm (0.08 to 0.2 in). Snow pellets are brittle, easily crushed; they do bounce and may break on hard ground.

CAUTION: There is no holdover time guideline for this condition.

3.5.11 Moderate and Heavy Freezing Rain

Precipitation of liquid water particles which freeze upon impact with exposed objects, either in the form of drops of more than 0.5 mm (0.02 in) or smaller drops which, in contrast to drizzle, are widely separated. Measured intensity of liquid water particles larger than 2.5 mm or 25 g/dm^2/h (0.10 in/h).

CAUTION: There is no holdover time guideline for this condition.

3.5.12 Hail

Precipitation in the form of small balls of pieces of ice with a diameter ranging from 5 to > 50 mm (0.2 to > 2.0 in) falling either separately or agglomerated.

CAUTION: There is no holdover time guideline for this condition.

3.5.13 Active Frost

Active frost is a condition when frost is forming. Active frost occurs when aircraft surface temperature is both at or below 0 °C (32 °F) and at or below dew point.

3.5.14 Hoarfrost

A deposit of interlocking ice crystals formed by direct sublimination on objects. Thin hoarfrost is a uniform white deposit of fine crystalline texture, which usually occurs on exposed surfaces on a cold and cloudless night, and which is thin enough to distinguish surface features underneath, such as paint lines, markings, or lettering.

3.5.15 Ice Pellets

Precipitation of transparent (grains of ice) or translucent (small hail) pellets of ice, which are spherical or irregular and which have a diameter of 5 mm (0.2 in) or less. The pellets of ice usually bounce when hitting hard ground.

CAUTION: There is no holdover time guideline for this condition.

3.6 Check

An examination of an item against a relevant standard by a trained and qualified person.

3.7 Contamination Check

Check of aircraft surface for contamination (Check to establish the need for deicing)

3.8 Representative Surfaces

Aircraft surfaces may be identified which the flight crew can readily observe to determine whether or not ice, frost or snow is accumulating or forming on that surface.

3.9 Cold Soaked Wing

The wings of aircraft are said to be cold “soaked” when they contain very cold fuel after flight at high altitude or after refueling with very cold fuel.

4. TRAINING AND QUALIFICATION

Training Programs should follow the guidelines and recommendations published in ARP5149.

4.1 Deicing/anti-icing procedure must be carried out exclusively by trained and qualified personnel. For personnel performing the actual deicing/anti-icing treatment on aircraft, practical training with the deicing/anti-icing equipment shall be included. Training success shall be proven by exam which shall cover all training subjects laid down in 4.1.3. Pass mark shall be 75% or better. Only persons passing the exam can be qualified.

4.1.1 Both initial and annual recurrent training for flight crews and ground crews shall be conducted to ensure that all such crews obtain and retain a thorough knowledge of aircraft ground deicing/anti-icing policies and procedures, including new procedures and lessons learned.

4.1.2 Flight Crew and Dispatcher training program must include a detailed description of initial and annual recurrent ground training and testing for flight crew members concerning the specific requirements of the program and the duties, responsibilities and functions detailed in the program.

4.1.3 Flight Crew members, Ground Personnel and Dispatchers must be trained and tested or qualified on at least the subjects identified below as Flight, Ground or Dispatcher. Training subjects shall include but are not limited to (when applicable):

a. The use of holdover times (Flight, Dispatcher, Ground).

b. Aircraft deicing/anti-icing methods/procedures including checks to detect contaminated surfaces and responsibilities (Flight, Dispatcher, Ground).

c. Aircraft surface contamination and critical area identification (Flight, Dispatcher, Ground).

d. Types, purpose, characteristics, and effectiveness of deicing and anti-icing fluids as applicable (Flight, Dispatcher, Ground).

e. Deicing/anti-icing fluids handling/performance implications (Flight, Dispatcher, Ground).

f. Effects of frost, ice, snow, and slush on aircraft surfaces (Flight, Dispatcher, Ground).

g. Equipment and Facilities (Ground).

h. Contractor deicing (Flight, Dispatcher, Ground).

4.2 Records of personnel training and qualification shall be maintained for proof of qualification.

4.3 Companies providing deicing/anti-icing services should have both a Qualification Program and a Quality Assurance Program to monitor and maintain a high level of competence.

5. FLUID STORAGE AND HANDLING

Deicing/anti-icing fluid is a chemical product with environmental impact.

During fluid handling avoid any unnecessary spillage, comply with local environmental and health laws and the manufacturer's material safety data sheet (MSDS).

Different products should not be mixed without additional qualification testing.

Slippery conditions may exist on the ground or equipment following the deicing/anti-icing procedure. Caution should be exercised, particularly under low humidity or nonprecipitating weather conditions.

CAUTION: Prolonged or repeated heating of fluids (directly or indirectly) may result in loss of water which can lead to performance degradation of the fluid. For Type I fluids, the water loss may cause undesirable aerodynamic effects at low temperatures. For Type II, III and IV fluids the thermal exposure and/or water loss may cause a reduction in fluid viscosity leading to lower holdover times. For all fluid types ensure that the refractive index is within the limits recommended by the fluid manufacturer. For Type II, III and IV fluids additional viscosity checks are advisable if degradation is suspected.

5.1 Storage

5.1.1 Tanks should be dedicated to storage of the deicing and/or anti-icing fluid to avoid contamination with other fluids.

5.1.2 Storage tanks shall be constructed of materials compatible with the deicing/anti-icing fluid, as specified by the fluid manufacturer. Care should be taken to avoid using dissimilar metals in contact with each other, as galvanic couples may form and degrade thickened fluids.

5.1.3 Tanks shall be conspicuously labeled to avoid contamination, e.g., SAE TYPE I Aircraft Deicing Fluid.

5.1.4 Tanks shall be examined annually for corrosion and/or contamination. If corrosion or contamination is evident, tanks shall be repaired or replaced. To minimize corrosion at the liquid/vapor interface and in the vapor space, a high liquid level in the tanks is recommended.

NOTE: Although deicing/anti-icing fluids are generally noncorrosive, their vapor can be corrosive.

5.1.5 Storage temperature limits for the fluid shall comply with manufacturer's requirements.

5.1.6 Stored fluid shall be checked routinely to assure that no degradation/contamination has taken place, e.g., at delivery and annually prior to the winter season.

5.2 Fluid Transfer Systems

5.2.1 The performance characteristics of SAE Type II, III and IV deicing/anti-icing fluids may be degraded by excessive mechanical shearing or chemical contamination. Therefore, only compatible pumps, control valves, piping and application devices shall be used. The design of fluid transfer systems shall be in accordance with the fluid manufacturers' recommendations.

5.2.2 Fluid transfer systems shall be dedicated to the specific fluid being handled to prevent inadvertently mixing fluids of different types or manufacturers.

5.2.3 All fill ports and discharge points shall be conspicuously labeled to prevent contamination due to inadvertent product mixing.

5.3 Application Equipment

5.3.1 Application equipment shall be clean before being initially filled with deicing/anti-icing fluid in order to prevent fluid contamination.

5.3.2 Concentration Checks

Fluids or fluid/water mixture samples shall be taken from the de-icing/anti-icing equipment nozzles on a daily basis when the equipment is in use. Perform a refractive index check on the samples taken. The sample shall be protected against precipitation.

NOTE 1: Equipment without a mixing system
Samples may be taken from the mix tank instead of the nozzle. Insure the fluid is at a uniform mix.

NOTE 2: Equipment with proportional mixing systems
Operational setting for the flow and pressure shall be used. Allow the selected fluid concentration to stabilize before taking sample.

NOTE 3: Equipment with automated fluid mixture monitoring system
The interval for refractive index checks has to be determined by the handling company in accordance with the system design.

5.3.3 Combustion heaters and trucks should not be operated in confined or poorly ventilated areas to prevent asphyxiation.

5.3.4 Requirements for suitable equipment are described in ARP1971.

5.4 Special Considerations for SAE Type II, III, and IV Deicing/Anti-icing Fluids

5.4.1 See 5.2.1.

5.4.2 Fluid acceptance will require the agreed documentation (e.g.: certificate of conformance, certificate of analysis) from the supplier, visual inspection and a refractive index verification.

5.4.3 It is recommended that Winter Operation Programs ensure and verify that Anti-Icing fluids are not degraded beyond acceptable limits.

5.4.4 SAE Type II, III, and IV deicing/anti-icing fluids, if heated, shall be heated in a manner to preclude fluid degradation in storage or application. The integrity of the fluid following heating shall be checked periodically. Factors like heating rate and heating time cycles should be considered in determining frequency of fluid inspections. Refer to fluid manufacturers' recommendations.

5.4.5 If in-service viscosity testing is accomplished, it should be done as described in AIR9968.

6. METHODS/PROCEDURES

These procedures establish the recommended methods for deicing and anti-icing of aircraft on the ground to provide safe takeoff. When aircraft surfaces are contaminated by frozen moisture, they shall be deiced prior to dispatch. When freezing precipitation exists and the precipitation is adhering to the surfaces at the time of dispatch, aircraft surfaces shall be deiced/anti-iced. If both deicing and anti-icing are required, the procedure may be performed in one or two steps (see 3.4). The selection of a one- or two-step process depends upon weather conditions, available equipment, available fluids, and the holdover time to be achieved. If a one-step procedure is used, then both 6.1 and 6.2 apply. See 6.3.1 for guidance regarding fluid limitations.

NOTE: When maximum holdover times are desired, use of unheated, undiluted SAE Type II and IV fluid should be considered. For SAE Type III fluid maximum holdover times, undiluted heated or undiluted unheated fluids should be considered.

6.1 Deicing

Ice, slush, snow, or frost may be removed from aircraft surfaces by fluids or mechanical methods, alternate technologies or combinations thereof.

NOTE: Alternate technology may be used to accomplish the deicing process, provided that the requirements in section 7 are accomplished.

NOTE: Pre-step process to be done prior to deicing/anti-icing

A pre-step process prior to the deicing process, in order to remove large amounts of frozen contamination (e.g. snow, slush or ice), may be considered to reduce the quantity of glycol-based deicing fluid that is needed.

This pre-step process may be performed with various means (e.g., brooms, forced air, heat, heated water, heated fluids with negative buffer freezing point). If the pre-step procedure is used, make sure that the subsequent deicing process removes all frozen contamination including the contamination that may have formed on surfaces and or in cavities due to the pre-step process.

6.1.1 Requirements

Ice, slush, snow, and frost shall be removed from aircraft surfaces prior to dispatch or prior to anti-icing.

The following sub-sections establish the procedures to be used to accomplish the deicing process with either deicing fluids or infrared deicing facilities.

6.1.1.1 Contamination Check (Check to establish the need for deicing) This check shall be performed in accordance with Section 8. It shall cover all critical parts of the aircraft and shall be performed from points offering sufficient visibility of these parts (e.g. from the de-icer itself or another elevated piece of equipment). Any contamination found on components of the aircraft that are critical to safe flight shall be removed by a de-icing treatment followed by anti-icing treatment if required.

6.1.2 Deicing Fluids

This section establishes the procedures for removal of the frozen precipitation by fluids.

See 6.3.1 for guidance regarding fluid limitations.

6.1.2.1 General

For maximum deicing effect, heated fluids should be applied close to the surface of the aircraft skin to minimize heat loss. Fluid temperatures should not exceed aircraft manufacturer's recommendations.

NOTE: The heat in the fluid effectively melts any frost, as well as light deposits of slush, snow, and ice. Heavier accumulations require the heat to break the bond between the frozen deposits and the structure; the hydraulic force of the fluid spray is then used to flush off the residue. The deicing fluid will prevent refreezing for a period of time depending on aircraft skin temperature, OAT, fluid used, mixture strength, and the weather.

6.1.2.2 Removal of Frost and Light Ice

A nozzle setting giving a fan spray is recommended.

NOTE: Providing the hot fluid is applied close to the aircraft's skin, a minimal amount of fluid will be required to melt the deposit.

6.1.2.3 Removal of Snow

A nozzle setting sufficient to flush off deposits and minimize foam production are recommended. Foam could be confused as snow.

NOTE: The method adopted will depend on the equipment available and the depth and type of snow; i.e., light and dry or wet and heavy. In general, the heavier the deposits, the heavier the fluid flow that will be required to effectively and efficiently remove it from the aircraft surfaces. For light deposits of both wet and dry snow, adopt a similar procedure as for frost removal. Wet snow is more difficult to remove than dry snow and unless deposits are relatively light, selection of a high fluid flow will be found to be more effective. Under certain conditions it will be possible to use the heat, combined with the hydraulic force of the fluid spray to melt and subsequently flush off frozen deposits. However, where snow has bonded to the aircraft skin, the procedures detailed in 6.1.2.4 should be utilized. Heavy accumulation of snow will always be difficult to remove from aircraft surfaces and vast quantities of fluid will invariably be consumed in the attempt. Under these conditions serious consideration should be given to removing the snow using a pre-step process (see 6.1 Note).

6.1.2.4 Removal of Ice

Heated fluid shall be used to break the ice bond.

NOTE: The high thermal conductivity of metal skin is utilized when a stream of hot fluid is directed at close range onto one spot, until the bare metal is just exposed. This bare metal will then transmit the heat laterally in all directions raising the temperature above the FP and thereby breaking the adhesion of the frozen mass with the aircraft surface. By repeating this procedure a number of times the adhesion of a large area of frozen snow or glazed ice can be broken. The deposits can then be flushed off with either a low or high flow, depending on the amount of the deposit.

CAUTION: Consult aircraft manufacturers' limitations for maximum fluid application pressure.

6.1.2.5 General Deicing Fluid Application Strategy

For effective removal of snow and ice the following techniques should be adopted. Aircraft may require unique procedures to accommodate design differences.

6.1.2.5.1 Wings/Tail Plane

Spray from tip inboard to root from highest point of surface camber to lowest. However, it is possible that aircraft configuration and local conditions may dictate a different procedure.

6.1.2.5.2 Vertical Surfaces

Start at top and work down.

6.1.2.5.3 Fuselage

Spray along top centerline and then outboard. Ensure that it is clear of ice and snow in accordance with the aircraft manufacturers' manuals. Hoarfrost may be allowed in accordance with the aircraft manufacturers' manuals.

6.1.2.5.4 Landing Gear and Wheel Bays

Keep application of deicing fluid in this area to a minimum. Do not spray deicing fluid directly on wheels and brakes.

NOTE: It may be possible to mechanically remove accumulations such as blown snow, however, where deposits have bonded to surfaces they can be removed by the application of hot air or by spraying with hot deicing fluids.

6.1.2.5.5 Engines

Deposits of snow should be mechanically removed from engine intakes prior to departure. Any frozen deposits that may have bonded to either the lower surface of the intake or the fan blades may be removed by hot air or other means recommended by the engine manufacturer. If use of deicing fluid is permitted, do not spray directly into engine core.

6.1.3 Infrared Deicing Facility

This sub-section establishes the procedures for removal of frozen precipitation by using infrared deicing technology. Specific information on facility requirements, as well as their inclusion in aircraft ground deicing programs, can be found in publications listed in Section 2 of this document.

6.1.3.1 General Requirements

Ice, slush, snow, and frost shall be removed from aircraft surfaces prior to dispatch from the facility or prior to anti-icing.

6.1.3.2 Deicing

Deicing using infrared energy is accomplished through heat that breaks the bond of adhering frozen contamination. The application of infrared energy may be continued to melt and evaporate frozen contaminants. Wet surfaces require an application of heated deicing fluids to preclude refreezing after removal of infrared energy source. When required, for operations other than frost or leading edge ice removal and when OAT is at or below 0 °C (32 °F), an additional treatment with hot deicing fluid shall be performed within the facility to prevent re-freezing of water which may remain in hidden areas.

CAUTION: If the aircraft requires re-deicing and de/anti-icing fluids had been applied before flight, conventional de/anti-icing with fluids shall be performed.

6.1.3.3 Inspection

The aircraft shall be inspected in accordance with the requirements of Section 7.

6.1.3.4 Anti-icing

If anti-icing is required, it shall be accomplished in accordance with 6.2. If anti-icing is performed inside the facility, infrared power levels must be adjusted as required during the anti-icing process to prevent the re-accumulation of frozen contamination due to the effect of blowing snow through the facility and maintain fluid integrity for the time the aircraft is in the facility. Dehydration of the fluid can negatively impact the fluid performance.

6.1.4 Deicing/anti-icing near the beginning of the departure runway provides the minimum interval between deicing/anti-icing and takeoff.

6.2 Anti-icing

Ice, snow, or frost will, for a period of time, be prevented from adhering to or accumulating on aircraft surfaces by the application of anti-icing fluids. This section provides recommended procedures for the use of anti-icing fluids.

6.2.1 Required Usage

Anti-icing fluid shall be applied to the aircraft surfaces when freezing rain, snow, or other freezing precipitation may adhere to the aircraft (at the time of dispatch).

6.2.2 Optional Usage

Anti-icing fluid may be applied to aircraft surfaces at the time of arrival (preferably before unloading begins) on short turnarounds during freezing precipitation, and on overnight aircraft. This will minimize ice accumulation prior to departure and often makes subsequent deicing easier. This practice has the potential to build up residues. An appropriate inspection and cleaning program shall be established.

6.2.2.1 In anticipation of weather conditions that require deicing, anti-icing fluid may be applied to clean aircraft surfaces prior to aircraft being exposed to the freezing precipitation. This will minimize the possibility of snow and ice bonding or reduce the accumulation of frozen precipitation on aircraft surfaces and facilitate subsequent deicing. Prior to flight the aircraft must be deiced, unless the integrity of the fluid can be ensured. Deice in accordance with Appendix A Table A1, whenever possible, to reduce the potential for residue build up.

NOTE: Dehydration of Type II, III and IV fluid can negatively impact the fluid performance.

6.2.3 General

For effective anti-icing an even layer of sufficient thickness of fluid is required over the prescribed aircraft surfaces which are free of frozen deposits. For maximum anti-icing protection, undiluted, unheated SAE Type II or IV fluid should be used. For maximum anti-icing protection, undiluted SAE Type III fluid may be applied heated or unheated. The high fluid flow pressure normally associated with Newtonian deicing fluids are not required. When Non-Newtonian fluids are used, pump speeds and nozzle spray patterns should be adjusted to produce a medium spray pattern.

CAUTION: SAE Type I deicing fluids provide limited holdover effectiveness when used for anti- icing purposes.

6.2.4 Anti-icing Fluid Application Strategy

The 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. The anti-icing fluid should be distributed uniformly. In order to control the uniformity, all horizontal aircraft surfaces shall be visually checked during application of the fluid. The amount required will be visually indicated by the fluid just beginning to run off the leading and trailing edges.

6.2.5 Deicing/anti-icing near the beginning of the departure runway provides the minimum interval between deicing/anti-icing and takeoff.

6.3 Limits/Precautions

6.3.1 Fluid Related Limits

6.3.1.1 Temperature Limits (see appropriate tables)

When performing two step deicing/anti-icing, the FP of the fluid used for the first step shall not be more than 3 °C (5 °F) above ambient temperature (refer to 6.3.3.2).

6.3.1.1.1 SAE Type I Fluids

The FP of the SAE Type I fluid mixture used for either one step deicing/anti-icing or as a second step in the two step operation shall be at least 10 °C (18 °F) below the ambient temperature.

6.3.1.1.2 SAE Type II, III and IV fluids used as deicing/anti-icing agents may have a lower temperature application limit of -25 °C (-13 °F). The application limit may be lower, provided a 7 °C (13 °F) buffer is maintained between the FP of the concentrated fluid and OAT. In no case shall this temperature be lower than the lowest operational use temperature as defined by the aerodynamic acceptance test.

6.3.1.1.3 Ice, snow or frost dilutes the fluid. Apply enough hot deicing fluid to ensure that refreezing does not occur and all contaminated fluid is driven off.

6.3.1.2 Application Limits (see applicable tables)

Under no circumstances shall an aircraft that has been anti-iced receive a further coating of anti-icing fluid directly on top of the contaminated film. If an additional treatment is required before flight, a complete deicing/ anti-icing shall be performed (see application Tables A1 and A2). Ensure that any residues from previous treatment are flushed off. Anti-icing only is not permitted.

CAUTION: The application of Type II, III and IV fluid, especially when used in a one step process or in the first step of a two step process, may cause residues to collect in aerodynamically quiet areas, cavities and gaps. This may cause flight control problems. The application of hot water or heated Type I fluid in the first step of a two step process will minimize the formation of residues. Residues may rehydrate and freeze under certain temperature, high humidity and/or rain conditions and may block or impede critical flight control systems. If a Type II, III or IV fluid is used in a one step process or in the first step of a two step process, then an appropriate inspection and cleaning program shall be established dependent on the operator's experience and fleet type. Whenever suitable, deice and anti-ice with only Type I.

Flight control problems associated with frozen or unfrozen residues have been observed to be particularly prevalent when thickened fluids are used to remove frost during a period of dry weather followed by hydration of the residues by water from rain, condensation, cleaning, or wet snow in flight.

NOTE: When checking for residues, their visibility may be facilitated by misting with water.

6.3.2 Aircraft Related Limits

The application of deicing/anti-icing fluid shall be in accordance with the requirements of the airframe/engine manufacturers and local procedures.

6.3.3 Procedure Precautions

6.3.3.1 One Step Deicing/Anti-icing

It is performed using heated deicing/anti-icing fluids (see 3.3.2). The correct fluid concentration is chosen with regard to desired holdover time, dictated by OAT and weather conditions.

CAUTION: Wing skin temperature may differ and in some cases may be lower than OAT. A mix with higher glycol concentration can be used under the latter condition.

6.3.3.2 Two Step Deicing/Anti-icing

When the first step is performed with deicing fluid (see 3.3.1). The correct deicing fluid mixture is chosen with regard to OAT. The second step is performed with anti-icing fluid (see 3.3.2). This fluid and its concentration are chosen with regard to desired holdover time, which is dictated by OAT and weather conditions. The second step shall be performed before first step fluid freezes (typically within 3 min); if necessary area by area. Use a second step spraying technique to cover completely the first step fluid (for example using the method described in 6.2.4) in a sufficient amount of second step fluid. Where re-freezing occurs following the initial treatment, both first and second step must be repeated. When a fluid conforming to AMS1428 is used to perform step two in a two step deicing/anti-icing operation, and the fluid used in step one is a Type I fluid conforming to AMS1424, a test shall be made to confirm that the combination of these fluids does not significantly reduce the WSET performance of the AMS1428 fluid.

CAUTION: Wing skin temperature may differ and in some cases may be lower than OAT. A mix with higher glycol concentration can be used under these conditions.

CAUTION: In order to maximize holdover time the second step fluid must be applied to insure minimum dilution and reaction with the first step fluid.

6.3.3.3 With regard to holdover time provided by the applied fluid, the objective is that it be equal to or greater than the estimated time from start of anti-icing to start of takeoff based on existing weather conditions.

6.3.3.4 Aircraft shall be treated symmetrically, that is, left hand and right hand side shall receive the same and complete treatment.

CAUTION: Aerodynamic problems could result if this requirement is not met.

6.3.3.5 Engines are normally shut down but may remain running at idle during deicing/anti-icing operations. Air conditioning and/or APU air must be selected OFF, or as recommended by the airframe and engine manufacturer. Avoid spraying deicing/anti-icing fluid directly into the engine inlet core.

6.3.3.6 General

Do not spray deicing/anti-icing fluids directly onto brakes, wheels, exhausts, or thrust reversers.

Caution should be exercised in the use of glycol-water deicing/anti-icing solutions in and around electrical/electronic circuitry with noble metal (including silver), coated wiring or terminals which could make contact with fluid. Exothermic reactions, which may result in fire have been reported. This may occur where defectively insulated wires, switches, or circuit breakers carrying direct current are encountered.

6.3.3.7 Deicing/anti-icing fluid shall not be directed into the orifices of pitot heads, static vents, or directly onto air stream direction detectors probes/angle of attack airflow sensors.

6.3.3.8 All reasonable precautions shall be taken to minimize fluid entry into engines, other intakes/outlets, and control surface cavities. Refer to manufacturer documentation.

6.3.3.9 Do not direct fluid onto flight deck or cabin windows as this can cause crazing of acrylic or penetration of the window seals.

6.3.3.10 All doors and windows should be closed to prevent:

a. Floor areas from being contaminated with slippery fluids

b. Upholstery from becoming soiled

6.3.3.11 Any forward area from which fluid may blow back onto windscreens during taxi or subsequent takeoff shall be free of fluid residues prior to departure.

6.3.3.12 If SAE Type II, III, or IV fluids are used, all traces of the fluid on flight deck windows shall be removed prior to departure, particular attention being paid to windows fitted with wipers.

NOTE: Deicing/anti-icing fluid can be removed by rinsing with approved cleaner and a soft cloth or flushing with type I fluid.

6.3.3.13 Landing gear and wheel bays shall be kept free from buildup of slush, ice, or accumulations of blown snow.

6.3.3.14 When removing ice, snow, or slush from aircraft surfaces care shall be taken to prevent it entering and accumulating in auxiliary intakes or control surface hinge areas.

6.3.3.15 Ice can build up on aircraft surfaces during flight through dense clouds or precipitation. When ground OAT at the destination is low, it is possible for flaps and other moveable surfaces to be retracted and for accumulations of ice to remain undetected between stationary and moveable surfaces. It is, therefore, important that these areas are checked prior to departure and any frozen deposits removed.

6.3.3.16 Under freezing fog, or other freezing precipitation conditions, it is necessary for the front and rear side on the fan blades to be checked for ice buildup prior to start-up. Any deposits discovered are to be removed by directing air from a low flow hot air source or other means recommended by the aircraft and engine manufacturer.

6.3.3.17 A flight control check should be considered according to aircraft type (see relevant manuals). This check should be performed after deicing/anti-icing.

6.3.4 Clear Ice Precautions

6.3.4.1 Clear ice can form on aircraft surfaces below a layer of snow or slush. It is, therefore, important that surfaces are closely examined following each deicing operation, in order to ensure that all deposits have been removed.

6.3.4.2 Significant deposits of clear ice can form in the vicinity of the fuel tanks, on wing upper surfaces as well as underwing. Aircraft are most vulnerable in regard to this type of buildup when one or more of the following conditions exist:

a. Wing temperatures remain well below 0 °C (32 °F) during the turnaround transit.

b. Ambient temperatures between -2 °C (28 °F) and +15 °C (59 °F) are experienced, although clear ice may form at other temperatures if conditions (a), (c), and (d) exist.

c. Precipitation occurs while the aircraft is on the ground.

d. When frost or ice is present on lower surface of either wing.

6.3.4.3 Clear ice formation is extremely difficult to detect. Therefore, when the above conditions prevail, or when there is otherwise any doubt that clear ice may have formed, a close examination shall be made prior to departure, in order to ensure that all frozen deposits have in fact been removed.

NOTE: Low wing temperatures associated with this type of buildup normally occur when large quantities of cold fuel remain in wing tanks during the turnaround/transit and any subsequent refueling is insufficient to cause a significant increase in fuel temperature.

6.4 Local Frost Prevention in Cold Soaked Wing Areas

Wing surface temperatures can be considerably below ambient due to contact with cold fuel and/or close proximity to large masses of cold soaked metal in the wing structure. In these areas frost can build up on wing surfaces and may result in the entire wing being deiced and anti-iced prior to the subsequent departure.

This section provides recommendations for the prevention of local frost formation in cold soaked wing tank areas during transit stops in order to make deicing and anti-icing of the entire wing unnecessary under such circumstances. This procedure does, however, not supersede standard deicing and anti-icing procedures in accordance with 6.1 and 6.2, and it shall be applied in coordination with these subsections. This procedure also does not relieve the user from any requirements for treatment and checks in accordance with aircraft manufacturer manuals.

6.4.1 Definition of Local Frost Buildup

Local frost buildup is the limited formation of frost in localized wing areas cooled by cold fuel or large masses of cold metal in the wing structure; this type of frost does not cover the entire wing.

6.4.2 Procedure

Using suitable spray equipment, apply a proper coating of undiluted SAE Type II, III or IV fluid to the wings in the limited cold soaked areas where the formation of frost may be expected due to contact of the wing with cold fuel or masses of cold metal.

NOTE: A proper coating completely covers the treated area with visible fluid.

6.4.3 Limits/Precautions for Local Frost Prevention

6.4.3.1 Procedure Limitation

This Local Frost Prevention Procedure is not a substitute for standard deicing and anti-icing procedures in accordance with 6.1 and 6.2, clear ice checks or any other aircraft manufacturer requirement, nor the requirement that aircraft surfaces shall be clear of frost, slush, snow, and ice accumulations.

6.4.3.2 Operator Approval

This procedure shall only be carried out if approved by the operator of the aircraft to be treated.

6.4.3.3 Training

This procedure shall only be carried out by properly trained and qualified personnel.

6.4.3.4 Application Limits

This Local Frost Prevention Procedure shall be applied to clean wings immediately following arrival of the aircraft. Application is acceptable at the latest when frost just starts to form, but in this case the fluid shall be applied at a minimum temperature of 50 °C (122 °F). If precipitation occurred between application of the fluid and dispatch of the aircraft and/or if precipitation is expected before takeoff, a two-step deicing/anti-icing procedure shall be performed (refer to 6.1 and 6.2).

6.4.3.5 Symmetrical Treatment Requirement

Both wings shall receive the same and symmetrical treatment; the same area in the same location on each wing shall be sprayed including when conditions would not indicate the need for treatment of both wings.

CAUTION: Aerodynamic problems could result if this requirement is not met.

6.4.3.6 Holdover Time

A holdover time shall not be assigned to Local Frost Prevention since this treatment does not cover the entire aircraft or wing surface respectively.

6.4.4 Final Check-Local Frost Prevention

A tactile (by touch) check of treated areas and a visual check of untreated areas of both wings shall be performed immediately before the aircraft leaves the parking position. These checks are conducted to insure that both wings are clean and free of frost. The applied anti-icing fluid shall remain in a liquid state and shall show no indication of failure (e.g., color change to white, a loss of gloss, or the presence of ice crystals in the fluid film).

6.4.5 Flight Crew Information-Local Frost Prevention

The following information shall be provided to the flight crew:

“Local frost prevention was accomplished.”

7. GENERAL AIRPLANE REQUIREMENTS AFTER DEICING/ANTI-ICING

After application of the deicing/anti-icing procedures the critical aircraft surfaces shall be “clean.” In order to accomplish this “clean” condition, the following paragraphs apply:

7.1 Wings, Tail, and Control Surfaces

Shall be free of ice, slush, snow, or frost. Some coating of frost may be permissible on wing tank lower surfaces cold-soaked by fuel. Consult aircraft manufacturers’ manuals for specific requirements.

7.2 Pitot Heads, Static Ports, Airstream Direction Detector Probes, and Angle of Attack Sensors

Clear of ice, frost, snow, slush, fluid residues, and protective covers.

7.3 Engine Inlets

Clear of internal ice and snow and fan shall be free to rotate.

7.4 Airconditioning Inlets/Exits

Clear of ice, frost, and snow. Outflow valves clear and unobstructed.

7.5 Landing Gear and Landing Gear Doors

Unobstructed and clear of ice, slush, frost, and snow.

7.6 Fuel Tank Vents

Clear of ice, frost, slush, and snow.