Doc 9640
AN/940

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

NOTICE TO USERS

This document is an unedited version of an ICAO publication and has not yet been approved in final form. As its content may still be supplemented, removed, or otherwise modified during the editing process, ICAO shall not be responsible whatsoever for any costs or liabilities incurred as a result of its use.

Third Edition (advance unedited) — 2018

International Civil Aviation Organization

Published in separate English, Arabic, Chinese, French, Russian
and Spanish editions by the
INTERNATIONAL CIVIL AVIATION ORGANIZATION
999 Robert-Bourassa Boulevard, Montréal, Québec, Canada H3C 5H7

For ordering information and for a complete listing of sales agents
and booksellers, please go to the ICAO website at www.icao.int

First edition, 1995
Second edition, 2000
Third edition (advance unedited), 2018

Doc 9640, *Manual of Aircraft Ground De-icing/Anti-icing Operations*
Order Number: 9640
ISBN [TBD]

AMENDMENTS

Amendments are announced in the supplements to the *Products and Services Catalogue;* the Catalogue and its supplements are available on the ICAO website at www.icao.int. The space below is provided to keep a record of such amendments.

RECORD OF AMENDMENTS AND CORRIGENDA

AMENDMENTS		
No.	Date	Entered by

CORRIGENDA		
No.	Date	Entered by

FOREWORD

Safe aeroplane operations during all types of weather conditions are of the 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, Finland 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. While a second edition was published in 2000, the information contained therein became increasingly out of date with modern methods and the document was discontinued in 2011.

The third edition of Doc 9640 is based largely on the latest information as described in SAE document AS6285, "Aircraft Ground Deicing/Anti-icing Processes". Established by the aircraft de-icing industry as directed by the "SAE ICAO IATA Council for Globalized Aircraft Deicing Standards", SAE document AS6285 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. Subsequently, the third edition of Doc 9640 contains general information intended to increase the basic understanding of aeroplane 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.

Additional 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 Publications for a complete listing). Although 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.

The images in Figures II-1-1, III-6-1, III-9-1 and III-10-1 were reproduced by kind permission of the *National Aeronautics and Space Administration (NASA)* and are found in the online training course entitled, "A Pilot's Guide to Ground Icing" (https://aircrafticing.grc.nasa.gov/).

In order to keep this manual relevant and accurate, suggestions for improving it in terms of format, content or presentation are welcome. Any such recommendation or suggestion will be examined and, if found suitable, will be included in regular updates to the manual. Regular revision will ensure that the manual remains both pertinent and accurate. Comments on this manual should be addressed to:

The Secretary General
International Civil Aviation Organization
999 Robert-Bourassa Boulevard
Montréal, Quebec
Canada H3C 5H7

TABLE OF CONTENTS

GLOSSARY OF TERMS AND ABBREVIATIONS

When the following terms are used in this manual, they have the meanings indicated below.

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

Anti-icing. Anti-icing is a precautionary procedure by which clean aircraft 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 refueled with very cold fuel. 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 refueled fuel and time since refueling.

Clear ice. 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.

Critical surfaces. Wings, control surfaces, propellers, horizontal stabilizers, vertical stabilizers or any other stabilizing surface on an aircraft. These surfaces should be completely free of ice, snow, slush or frost before take-off. The critical surfaces should be determined by the aircraft manufacturer.

De-icing. The process which removes ice, snow, slush or frost from aircraft surfaces.

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 aircraft and remains on the surfaces to provide anti-icing capability.

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 aircraft'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 kilometer.

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. A deposit of small, white ice crystals formed on the ground or other surfaces. 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.

Hoar frost. A greyish-white crystalline deposit of frozen water vapour formed on surfaces in clear, still weather.

(*Note — this differs from the* World Meteorological Organization *(WMO*) *definition of hoar frost for the purposes of this document*.)

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 supercooled 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. Snow from which a snowball cannot readily be made and which has a temperature less than 0°C.

Wet snow. Snow which contains a great deal of liquid water.

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

ABBREVIATIONS

When the following abbreviations are used in this manual, they have the meanings indicated below.

APU	Auxiliary power-unit
ATC	Air traffic control
CAA	Civil aviation authority
CAC	Clean aircraft concept
CSFF	Cold-soaked fuel frost
ERP	Emergency response plan
FAA	Federal Aviation Administration
HOT	Holdover time

LWE	Liquid water equivalent
LWES	Liquid Water Equivalent System
METAR	Meteorological Terminal Air Report
SAE	Society of Automotive Engineers
TAF	Terminal Aerodrome Forecast
TC	Transport Canada

PUBLICATIONS

(referred to in this manual)

ICAO PUBLICATIONS

Annexes to the Convention on International Civil Aviation

Annex 6 — *Operation of Aircraft*, Part I — *International Commercial Air Transport — Aeroplanes*

Annex 14 — *Aerodromes*, Volume I — *Aerodrome Design and Operations*

Procedures for Air Navigation Services

Procedures for Air Navigation Services — Air Traffic Management (PANS-ATM, Doc 4444)

OTHER PUBLICATIONS

SAE International Standards:

AMS1424N:	Deicing/Anti-Icing Fluid, Aircraft, SAE Type I
AMS1428J:	Fluid, Aircraft Deicing/Anti-Icing, Non-Newtonian (Pseudoplastic), SAE Types II, III, and IV
ARP4902B:	Design of Aircraft Deicing Facilities
ARP6257:	Aircraft Ground De/Anti-Icing Communication Phraseology for Flight and Ground Crews
AS5681:	Minimum Operational Performance Specification for Remote On-Ground Ice Detection Systems
AS6285:	Aircraft Ground Deicing/Anti-Icing Processes
AS6286:	Training and Qualification Program for Deicing/Anti-Icing of Aircraft on the Ground

PART I

General

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 All aeroplanes are designed to fly clean. When an aeroplane is affected by snow, slush or ice (e.g. frost, ice pellets, hail) a potential safety hazard exists. 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. Along with such contamination, aeroplane efficiency decreases as a result of increased weight, increased stall speed, reduced lift, reduced stability and control, degraded thrust, and increased drag; even seemingly insubstantial contamination like frost may have a considerable adverse effect (see Figure I-1-1). Such contamination will significantly alter aeroplane flight characteristics. The primary influence is surface roughness relative to critical portions of an aerodynamic surface. Contamination can also occur on the fuselage, landing gear, engine nacelles, etc., and while this is not on critical surfaces and does not directly affect lift, it still increases overall drag. Additionally, interference with control surfaces, brakes and landing gear, and loss of radio communications may occur. Ice forming on pitot tubes and static ports or on angle of attack vanes may give false airspeed, angle of attack and engine power information for air data systems. 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. 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 (CAC)" (see Part I, Chapter 2).

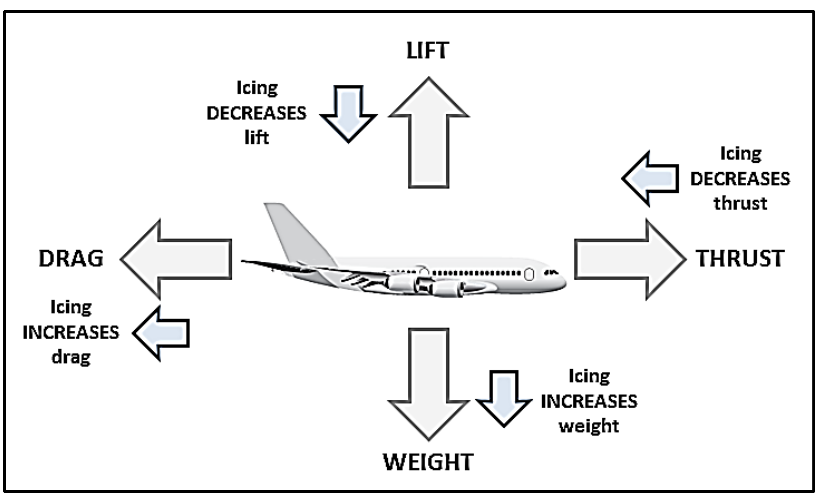

Figure I-1-1. The effects of icing on the forces of flight

1.3 A wing has a critical angle of attack when the lift starts to decrease and the aeroplane is said to stall. Before the critical angle of attack, as angle of attack increases, more lift is produced. This is needed during take-off. When the wing is contaminated by small amounts of frost, the critical angle of attack is decreased and the airfoil may stall even before a stall warning.

1.4 Most aeroplanes used in commercial air transport operations, as well as some other aeroplane types, are certificated for flight in icing conditions. Certified aeroplanes 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 demonstrating 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 certified and considered airworthy only after extensive flight tests have been performed. These test programmes are predominantly conducted with a "clean aircraft" flying in a clean environment with the exception of dedicated testing to assess the impact of icing in both natural icing conditions and using artificial ice shapes. If ice formations, other than those assessed in this dedicated testing 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.

1.5 The 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 freezing point depressant 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 aeroplane surfaces.

1.6 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.

1.7 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 refueled 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 or frost 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) radiation cooling;

f) wind speed and direction;

g) aeroplane surface temperature (including the temperature of fuel in the wing tanks, i.e. 'cold soaked fuel frost' effect);

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).

1.8 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 check.

Chapter 2

THE CLEAN AIRCRAFT CONCEPT (CAC)

2.1 This chapter explains the clean aircraft concept (CAC) and describes how deposits of ice influence the performance of aeroplanes. Variables that may influence the formation of snow and frost are summarized and techniques to adhere with the CAC are presented.

2.2 The CAC is a crucial element for the safety of flight. An aeroplane is considered to be clean when all surfaces are completely clean or when surfaces are protected by de-icing/anti-icing fluid and the surface aerodynamic characteristics are unaffected.

2.3 During conditions conducive to aeroplane icing during ground operations, take-off must 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.

2.4 Some aeroplane manufacturers allow take-off with a certain amount of cold-soaked fuel frost (CSFF) on under wing surfaces. Refer to the manufacturer's manual for more information. The CSFF is further explained in Part II, Chapter 1.

2.5 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.

2.6 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. They can also affect the de-icing/anti-icing capabilities of de-icing fluids/anti-icing fluids. As a result, a highly accurate time for the protection provided by an anti-icing fluid cannot be established. These variables are listed in Part I, Chapter 1.

2.7 Numerous techniques for complying with the CAC 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 CAC, must be carried out.

Chapter 3

GROUND DE-ICING/ANTI-ICING PROGRAMME ELEMENTS

3.1 This chapter provides guidance for establishing an acceptable ground de-icing/anti-icing programme. A ground de-icing/anti-icing programme is necessary to meet the Annex 6, Part I, 4.3.5.6 Standard which states:

> 4.3.5.6 A flight to be planned or expected to operate in suspected or known ground icing conditions shall not take off unless the aeroplane has been inspected for icing and, if necessary, has been given appropriate de-icing/anti-icing treatment. Accumulation of ice or other naturally occurring contaminants shall be removed so that the aeroplane is kept in an airworthy condition prior to take-off.

3.2 A ground de-icing/anti-icing programme should include at least the following:

a) a management plan;

b) aeroplane specific procedures;

c) HOT tables and procedures;

d) clean aircraft concept (CAC);

e) contamination checks;

f) communications;

g) training;

h) aeroplane de-icing/anti-icing;

i) an emergency response plan (ERP); and

j) a reporting system.

3.3 *Management plan.* In order to have efficient operational control, a management plan should be established by the air operator to coordinate and implement the plan for proper application of the approved de-icing/anti-icing plan. The management plan should provide guidance for responsibility, implementation, use and update of manuals and coordination.

3.4 *Aeroplane specific procedures.* The air operator should specify the de-icing/anti-icing procedures for each type of aeroplane serviced in the programme. Ground personnel are required to undertake a specific training for each aeroplane with different design characteristics.

3.5 *HOT tables and procedures.* The programme should include HOT tables and procedures for use by the air operator. Responsibilities of flight crew, flight followers, maintenance and ground personnel that are related to the use of HOTs should be defined. The air operator should provide HOT tables for use by its employees. The HOTs given on these tables should not exceed those given by the regulator.

3.6 *CAC.* It should be stated in the programme that the aeroplane must be free of all frozen contaminants before take-off. Also, critical surfaces of the aeroplane should be described and those surfaces to be checked prior to take-off should be listed. Some aeroplanes are allowed to take-off with some contamination on the wings; refer to the aircraft flight manual of the respective aeroplane for more information.

3.7 *Contamination checks.* Contamination checks should be included in the programme. These, as a minimum, should include pre-take-off check (within the HOT), pre-take-off contamination check (once HOT has been exceeded) and post de-icing/anti-icing check. The air operator should have procedures in place to conduct these checks.

3.8 *Communications*. Communication between the flight crew and ground personnel during de-icing/anti-icing operations is critical. Since multiple service providers work with many air operators, it is recommended that standardized phraseology is included in the programme to be applied during de-icing/anti-icing operations.

3.9 *Training*. Each approved ground de-icing programme should include a training programme for flight crew, dispatchers and ground personnel, and the air operator should ensure that these personnel are familiar with procedures and other required information. The training programme itself should have a quality assurance (QA) system in order to maintain a high level of competence. Also, a tracking system for records should be established to ensure that all required personnel are trained as required.

3.10 *Aeroplane de-icing/anti-icing*. A section describing fluids, equipment and operating measures should be in the programme. The section should describe how fluids are tested, stored, used and contained. Equipment available for operations should be included, describing what the air operator must know when testing, inspecting and operating the equipment in order to perform all functions safely. Lastly, the flight crew, maintenance crew, and/or ground de-icing crew should be aware of the multiple measures that can be used to minimize frozen contamination accretion while on the ground. The different methods available to remove the frozen contamination should be familiar to operational personnel and methods to protect cleaned surfaces should also be listed if considered necessary.

3.11 *Emergency response plan (ERP)*. An ERP should be included in the programme in case an emergency occurs during the de-icing/anti-icing process. There should be a means to communicate during the emergency between parties involved.

3.12 *Reporting system*. A reporting system should be established in order to ensure the quality of the programme. The reporting structure within the organization should also be clearly explained.

____

PART II

WEATHER AND ICING CONDITIONS

Chapter 1

AEROPLANE ICING ON THE GROUND

1.1 This chapter explains the atmospheric and ambient conditions that may cause icing on the aeroplane on the ground.

1.2 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, ice pellets, drizzle, fog or high humidity combined with the cold-soak effect (see Figure II-1-1). Some freezing precipitation and cold-soaked frost contamination occurs at ambient temperatures 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.

1.3 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 when the surface temperature decreases.

1.4 Cold-soaking on wings or other tank areas due to cold fuel is a major contributor in frost-related operational issues. Such frost is known as cold-soaked fuel frost (CSFF). The cold fuel causes the aeroplane surface temperature to decrease close to or below 0ºC which freezes the moist air on the surface of tanks. The CSFF contamination is type specific. There are measures (e.g. refuelling policy and fuel tank transfers) to minimize this phenomenon or mitigate its effects. Frost may also develop due to cold-soaked solid aeroplane parts.

1.5 Due to variations in local conditions (wind direction, proximity to heat sources, etc.), aeroplane icing contamination is not necessarily symmetrical.

Figure II-1-1. Examples of icing on aeroplane surfaces
(Images reproduced by kind permission of the National Aeronautics and Space Administration (NASA).)

Chapter 2

ICE DETECTION AND WARNING SYSTEMS

2.1 This chapter provides information about ground-based and aeroplane-mounted ice detection and warning systems. Intent and design of ice detection and warning systems are further explained and the objectives to be met are listed.

2.2 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.

2.3 *Ground-based devices* should be able to detect and indicate the presence of clear ice on the critical surfaces of the aeroplane prior to de-icing. In addition, residual clear ice post-de-icing should be detected (both with and without ongoing precipitation). The deterioration of the properties of the anti-icing fluid should be evaluated, even during continued freezing conditions. They will normally consist of area surveying equipment or systems and will meet aeroplane manufacturer, air operator and civil aviation authority (CAA) requirements, as appropriate. A set of operating procedures for each specific ground-based ice detection system should be developed and the manufacturer should identify clearly all operational limitations. Ground-based device performance standards for detecting frost, snow and slush on a critical surface have not been established.

2.4 *Aeroplane-mounted devices* consist 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, air operator and CAA 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.

2.5 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.

2.6 During system integration and installation, both the ground-based devices and aeroplane-mounted devices will be compatible with the physical and environmental conditions and meet the requirements established by air 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.

2.7 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) support/assist the pilot-in-command in decision-making (primary device);

c) help to more accurately estimate the duration of the HOT; or

d) minimize the need to return for additional de-icing/anti-icing.

Note.— See SAE document AS5681 — Minimum Operational Performance Specification for Remote On-Ground Ice Detection Systems *(latest version) for more information on ground-based ice detection devices.*

Chapter 3

DETERMINATION OF PRECIPITATION TYPE AND RELATED METHODS

3.1 This chapter discusses how to prevent precipitation contamination on aeroplanes and explains using the Meteorological Terminal Air Report (METAR) and Terminal Aerodrome Forecast (TAF) for planning purposes. The information and methods that can assist in making de-icing/anti-icing decisions are also discussed.

3.2. Under frozen or/and freezing precipitation conditions and frost, including radiation cooling frost, aircraft need to be treated (anti-iced) to prevent their contamination.

3.3 An anti-icing treatment is typically achieved with anti-icing fluids which provide temporary protection against contamination adhering to the aeroplane for a period of time (holdover time (HOT)) assuming that the current conditions do not change.

3.4 For a given anti-icing fluid, the HOT is dependent[1] on ambient temperature, precipitation type and precipitation intensity. It is therefore necessary for the pilot to know these conditions in order to estimate the HOT that the anti-icing fluid provides.

Note.— See Part III, Chapter 4 — Holdover time (HOT) *for more information.*

3.5 Snow intensity may be estimated based on visibility. Other types of precipitation and their intensity and ambient temperature are reported by airports or meteorological services.

3.6 A METAR is a routine weather report issued usually at hourly intervals. It is a description of the meteorological elements observed at an airport at a specific time. A TAF is a concise statement of the expected meteorological conditions at an airport during a specified period of validity and it usually covers a 24-hour period. Both METAR and TAF use the same weather code.

3.7 Some of the weather precipitation types that can be extracted from a METAR and a TAF include, but are not limited to:

a) *Ice pellets*. Precipitation of transparent ice particles which fall from a cloud. These particles are usually spheroidal or irregular, rarely conical. Their diameter is less than 5 millimeters.

b) *Hail*. Precipitation of either transparent or partly or completely opaque particles of ice, usually spheroidal, conical or irregular in form with a diameter generally between 5 and 50 millimeters which fall from a cloud either separately or agglomerated into irregular lumps.

c) *Small hail*. Precipitation of translucent ice particles that fall from a cloud. These particles are almost always spherical and sometimes have conical tips. Their diameter may attain and even exceed 5 millimeters.

d) *Snow*. Precipitation of ice crystals, singly or agglomerated, which fall from a cloud.

[1] HOT can be affected by wind or jet blast effect and, in the case of Type 1 fluids, surface material heat transmissivity for heated applications.

e) *Snow grains*. Precipitation of very small opaque white particles of ice which fall from a cloud. These particles are fairly flat or elongated; their diameter is generally less than 1 millimeter.

f) *Freezing drizzle*. Supercooled drizzle which freezes upon impact to form a coating of clear ice on the ground and/or on exposed objects.

g) *Freezing fog*. A suspension of numerous minute ice particles in the air, reducing the visibility at the Earth's surface.

h) *Freezing rain*. Supercooled raindrops which freeze upon impact to form a coating of clear ice on the ground and/or on exposed objects.

i) *Freezing unknown*. Weather phenomenon that causes icing. Reported for unidentified precipitation only when automatic observing systems are used.

Note 1.– There are multiple other weather related factors to consider when determining the impact on icing of precipitation rate and intensity, such as wind effect.

Note 2.– Frost is not included in weather reports but it is a factor that should be considered when deciding on de-icing/anti-icing procedures.

3.8 The Liquid Water Equivalent System (LWES) is an automated weather measurement system that determines the liquid water equivalent (LWE) rate of the frozen or freezing precipitation. The LWE rate is then used by the system together with the appropriate anti-icing fluid endurance time data to determine the HOT. This information is typically presented electronically to the pilot as a HOT value or similar concepts that also incorporate the time of anti-icing fluid application.

PART III

DE-ICING/ANTI-ICING PROCESSES

Chapter 1

ROLES AND RESPONSIBILITIES

1.1 The roles and responsibilities of the CAA, the de-icing/anti-icing service provider and the air operator related to de-icing and anti-icing, are described in this chapter.

CIVIL AVIATION AUTHORITY

1.2 The CAA ensures that every air operator has a ground de-icing/anti-icing programme or procedures so that proper training, qualification and operational procedures are established. The programme requires that air operators comply with the clean aircraft concept (CAC).

1.3 The CAA 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 should include, but are not limited to:

a) runway condition reports;

b) aerodrome taxiway/apron condition reports; and

c) aerodrome sequence reports.

AIR OPERATOR

1.4 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.

1.5 The person responsible for the de-icing/anti-icing process must be clearly designated, trained and qualified. This person checks the aeroplane for the need to de-ice, initiates 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.

1.6 The pilot-in-command has the responsibility to ensure compliance with the CAC. The ground de-icing crew shares this responsibility by providing an aeroplane that complies with the CAC. To ensure compliance, the pilot-in-command evaluates:

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 HOT. 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 CAC at the time of take-off.

1.7 The ground de-icing/anti-icing programme clearly defines areas of responsibility for the air operator. All staff involved in ground de-icing/anti-icing activities should be trained and qualified in the procedures, communications and limitations of their area of responsibility. The ground de-icing/anti-icing programme covers all locations within the air operator's route network, including de-icing/anti-icing accomplished by a subcontracted de-icing/anti-icing service provider.

1.8 The de-icing/anti-icing procedures, including those subcontracted by the air operator, are subject to quality inspections as part of the air operator's QA programme.

DE-ICING/ANTI-ICING SERVICE PROVIDER

1.9 Service providers subcontracted by the air operator are responsible for safety and operability of the designated de-icing facilities or designated de-icing areas and for adherence to the procedures of each of the air operators to which they provide their services.

1.10 Service providers may also be responsible for the de-icing/anti-icing processes. They must be clearly designated, trained and qualified. Service providers check the aeroplane for the need to de-ice, initiates de-icing/anti-icing, if required, and are 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.

———————————

Chapter 2

AEROPLANE GROUND
DE-ICING/ANTI-ICING ALTERNATIVES

2.1 The cost and environmental impact of de-icing/anti-icing with conventional fluids has driven the demand for developing alternate de-icing technologies. It is fundamental that even though the methods are different compared to the methods used with conventional fluids, the basic objectives of de-icing/anti-icing processes still apply. Conventional and more recent technologies employ different principles such as forced air systems for de-icing of aircraft. This method can be used in conjunction with de-icing fluid applications to eliminate large amounts of frozen contamination.

2.2 *Forced air*. Forced air de-icing is another method to blow frozen contaminants or snow off aeroplane surfaces. Some forced air de-icing systems use high-pressure air or an air/fluid mix while others are based on delivering large air volumes at low pressure. The effectiveness of the method depends on a number of factors, including air stream velocity, air stream temperature, operator training and experience, outside air temperature and other weather conditions. The use of forced air is subject to approval from the aeroplane manufacturer.

2.3 *Mechanical techniques*. Mechanical means can also be used to remove contamination from aeroplane surfaces. These techniques can include: ropes where two persons seesaw back and forth across the surface being cleaned; brooms with which the aeroplane surface is swept clean of light contamination; or scrapers, which should be used in a pulling motion from leading edge to trailing edge, or from the highest point of the wing chamber to the lowest.

2.4 *Heated hangar*. Placing an aeroplane inside a heated hangar is a good technique to ensure that the aeroplane is de-iced and all critical surfaces are clean of contamination. If precipitation is present, anti-icing requirements must be addressed. Depending on the facility, it may be possible to apply anti-icing fluids before exiting the hangar. The HOT begins immediately after the start of the anti-icing application while the aeroplane is still in the hangar as the fluid runs off and thins.

____

Chapter 3

AEROPLANE GROUND DE-ICING/ANTI-ICING FLUIDS

3.1 This chapter explains the function and handling of de-icing and anti-icing fluids, lists different types of de-icing and anti-icing fluids, and explains their characteristics and typical use.

3.2 The basic function of a de-icing fluid is to eliminate frozen contamination adhered to the aeroplane's surfaces.

3.3 The basic function of an anti-icing fluid is to prevent frozen or freezing precipitation or expected frost adhering to the aeroplane's cleaned or de-iced surfaces.

3.4 The fluid Standards are widely recognized and are set by an international group of stakeholder experts under SAE, and, as per these Standards, fluids are classed as Type I, II, III and IV.

3.5 De-icing/anti-icing fluids are tested for compliance with the different criteria established in the Standards by certified laboratories. Fluids fulfilling the safety-related criteria established by the Standards are published annually by Transport Canada (TC) and the United States Federal Aviation Administration (FAA). Published Standards can be found on the website http://www.icao.int/safety/airnavigation/OPS/Pages/Aircraft-Ground-De-IcingAnti-Icing-Operations.aspx.

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

TYPE I FLUIDS

3.7 Type I fluids have a relatively low viscosity which changes mainly as a function of temperature. They are typically used for de-icing purposes although they also have some anti-icing protection capability. These fluids are normally heated when applied.

3.8 The majority of Type I fluids contain a high percentage of glycol (i.e. ethylene glycol, diethylene glycol, or propylene glycol or a mixture of these glycols) while a minority of Type I fluids are based on other chemicals. The remainder consists of water, corrosion inhibitors, wetting agents, anti-foaming agents and often orange dye. Type I fluids are available in concentrated or diluted (ready-to-use) forms.

3.9 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 are often further diluted for application.

Note.— See SAE document AMS1424 — Deicing/Anti-Icing Fluid, Aircraft SAE Type I *(latest version) for more information on Type I fluids. See also the latest versions of any associated sub-documents, for example, SAE AMS1424/1 and SAE AMS1424/2.*

TYPE II, III AND IV FLUIDS

3.10 Type II, III and IV fluids, contrary to Type I fluids, 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 and their use as a de-icer is normally due to the unavailability of Type I fluid.

3.11 Type II, III and IV fluids are used in diluted and undiluted forms. The majority of Type II, III 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 often dye (yellow for Type II, bright yellow for Type III and green for Type IV). The higher viscosity of the fluid compared to Type I fluid, combined with the wetting agents, results in a thick coating when sprayed on the aeroplane. To provide maximum anti-icing protection, Type II, III and IV fluids should be used in an undiluted condition.

Type II, III 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.

3.12 The airflow, during the take-off roll, exposes these fluids to a shear force that causes a reduction of viscosity, thereby allowing the fluid to flow off the critical portion of the wings prior to rotation so that the aerodynamic performance of the aeroplane is not adversely affected.

3.13 Falling precipitation will steadily dilute all types of anti-icing fluids until either the fluid coating freezes or frozen deposits start to accumulate. This is called "fluid failure". This can be avoided by using a fluid dilution with a higher viscosity providing 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 (see Part III, Chapter 4 Holdover time (HOT)) 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.

Note.— See SAE document AMS1428 — Fluid, Aeroplane De-Icing/Anti-Icing, Non-Newtonian (Pseudoplastic), SAE Types II, III, and IV *(latest version) for more information on Type II, III, and IV fluids.*

HANDLING OF FLUIDS

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

3.15 The physical properties and anti-icing function of Type I, II, III and IV fluids may be degraded when the fluid is subjected to chemical contamination, including rust in tanks, improper transportation or storage, excessive heating or when exposed to excessive shear forces during fluid transfer or use.

3.16 Quality control methods for de-icing/anti-icing fluids, as specified in the air operator programme, must be followed to identify degradation trends of fluid properties and to take appropriate action.

3.17 Examples of de-icing/anti-icing fluid tables can be found on the website http://www.icao.int/safety/airnavigation/OPS/Pages/Aircraft-Ground-De-IcingAnti-Icing-Operations.aspx.

____

Chapter 4

HOLDOVER TIME (HOT)

4.1 This chapter defines the term holdover time (HOT), and lists factors that affect the HOTs. The air operator's responsibility for publishing HOT tables based on different weather conditions and fluid types is described.

4.2 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 HOTs are generated by testing fluids under a variety of temperature and precipitation conditions simulating the range of weather experienced in winter.

4.3 Numerous factors that can affect the de-icing/anti-icing performance and HOTs 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; including jet blast;

e) aeroplane surface (skin) temperature; and

f) de-icing/anti-icing fluid (type, fluid/water ratio, temperature).

4.4 The air operator should publish the HOTs 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 HOTs 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.

4.5 At the completion of aeroplane de-icing/anti-icing, the pilot-in-command will be provided with the following information (see Part III, Chapter 7 for more details):

a) fluid type;

b) fluid/water ratio (Type II, III or IV only);

c) start time of the final de-icing/anti-icing application; and

d) confirmation that the aeroplane is in compliance with the CAC.

This basic information with weather data will assist the pilot-in-command in estimating an appropriate HOT from the range provided in the air operator's table.

4.6 The published HOT guidelines provide tables of the time-frames of protection that can be expected under various weather conditions. The times of protection shown in the HOT tables are to be used as *guidelines* only and are normally used in conjunction with pre-take-off check procedures.

4.7 The HOT begins with the start of the de-icing/anti-icing application in the case of a one-step operation, or the beginning of anti-icing in a two-step process and ends after an elapsed time equal to the appropriate HOT. A pilot must monitor the time elapsed from the start of the HOT identified and ensure that taxi and take-off are achieved before the HOT elapses. If not, additional de-icing/anti-icing will be required.

4.8 HOTS and de-icing/anti-icing procedures are continually updated by an international group of experts under the auspices of the SAE G-12 Holdover Time Committee. This group of experts is composed of representatives from the world's airlines, anti-icing fluid manufacturers, aircraft manufacturers, aviation regulatory authorities and research organizations. The HOT guidelines documents are published by TC and the FAA.

4.9 Current HOT tables are published by both TC and the FAA on their public websites, and can be found using the term 'aircraft ground de-icing' in the website search function.

CAUTION

Due to the many variables that can influence (HOTs), the time of protection may be reduced or extended, depending on the intensity of the weather conditions. Heavy precipitation, high moisture content, high wind velocity and jet blast can reduce HOT below the lowest time in HOT guidelines. HOT may be reduced when aircraft skin temperature is lower than outside air temperature.

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

____

Chapter 5

AERODROME DE-ICING/ANTI-ICING FACILITIES

5.1 The need, design, component and location requirements for the aerodrome de-icing/anti-icing facilities are explained in this chapter. The clearance and separation responsibilities of the local regulatory authorities are explained and a general description of a winter operations plan is included.

NEED FOR A FACILITY

5.2 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

5.3 A de-icing facility should be properly planned, designed and constructed to perform as intended. 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.

5.4 All de-icing/anti-icing facilities should be designed, sited and sized in accordance with the provisions in Annex 14, Volume I, Chapter 3, section 3.15, together with the clearance and separation Standards established by the local CAA. Additionally, proximity to fixed and movable objects must be considered.

5.5 Numerous factors affect the basic design of any de-icing/anti-icing facility. A de-icing facility can artificially constrain an aerodrome's capacity if it is not planned and designed to handle anticipated levels of demand. 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 air traffic control (ATC) units during de-icing/anti-icing operations.

COMPONENTS

5.6 De-icing/anti-icing facilities should include, but are not limited to the following components:

a) de-icing/anti-icing pads for the manoeuvering of aeroplanes;

b) de-icing/anti-icing system comprising of 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.

5.7 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 used glycol.

5.8 The size and number of de-icing/anti-icing facilities at an aerodrome should 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 air 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.

FACILITY LOCATION

5.9 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 HOT of the de-icing/anti-icing fluid used is not exceeded.

5.10 In calculating the taxi time from the de-icing/anti-icing facility to the departure runway, air 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.

5.11 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

5.12 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

5.13 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 HOTs to be exceeded.

Remote pad de-icing/anti-icing facilities

5.14 Remote de-icing/anti-icing facilities located near runway departure ends or along taxiways are recommended when taxi times from terminals or off-terminal de-icing/anti-icing locations frequently exceed HOTs. The proper design of these facilities can also improve flow control by permitting repeat de-icing/anti-icing of aeroplane critical surfaces without the aeroplane having to return to more distant treatment sites.

AIR TRAFFIC CONTROL (ATC) WINTER OPERATIONS PLAN

5.15 It is the responsibility of the CAA 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.

5.16 The ATC winter operations plan should 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 should 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.

5.17 This plan should 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.

5.18 In developing the plan, a full account should be taken of the relevant climatological information pertaining to the aerodrome concerned. The plan should 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.

5.19 Details of the ATC winter operations plan should be included in all air traffic controllers' manuals. It should 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 should, where appropriate, contain provisions at the aerodrome for centralized de-icing/anti-icing, remote pad de-icing/anti-icing, and for secondary de-icing/anti-icing.

Note.— See SAE document ARP4902 — Design of Aircraft Deicing Facilities *(latest version) for more information on aerodrome de-icing/anti-icing facilities.*

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 CAC 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. This check is the "contamination check". The aeroplane critical surfaces, fuselage, landing gear and other components, as indicated by the aeroplane manufacturer, should be checked for ice, snow, slush or frost in accordance with an approved air operator plan. For specific aeroplane types, additional requirements exist and these special checks are not always covered by the contamination check. 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 The post de-icing check ensures that the treated surfaces are no longer contaminated. This check is made visually immediately following the application of de-icing/anti-icing fluids and is carried out by a qualified person in accordance with the approved air operator plan and procedures (see Figure III-6-1). This check should include any part of the aeroplane on which a de-icing/anti-icing treatment was performed according to the requirements identified during the contamination check.

6.4 The pre-take-off check, which is the responsibility of the pilot-in-command, continuously ensures that the weather conditions are those considered for the HOT determination and an assessment as close to the time of take-off as possible to confirm that the HOT has not been exceeded.

6.5. The pre-take-off contamination check is an examination of the critical surfaces for contamination. This check shall be performed when the condition of the critical surfaces of the aeroplane cannot be effectively assessed by a pre-take-off check or when the applied HOT has been exceeded. This check may be performed from inside or outside the aircraft, or both, depending on the specific operator procedures.

6.6 The pilot-in-command has the responsibility to continually monitor the weather and aeroplane condition to ensure compliance with the CAC. If stipulated by the CAA, aeroplane manufacturer, or operational specification or if requested by the pilot-in-command, an external check of the aeroplane's critical surfaces should be conducted by qualified ground personnel.

6.7 If the requirement of the CAC 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

6.8 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 should be included in the approved air operator programme.

6.9 A functional flight control check using an external observer may be required after de-icing/anti-icing depending upon aeroplane type. This is particularly important in the case of an aeroplane that has been subjected to extreme ice or snow conditions.

Figure III-6-1. Post application inspection can be critical for revealing any frozen contamination
(Image reproduced by kind permission of the National Aeronautics and Space Administration (NASA).)

Chapter 7

DE-ICING/ANTI-ICING COMMUNICATIONS

7.1 This chapter introduces de-icing/anti-icing communications and lists information that should be provided prior to starting and after finishing the de-icing and anti-icing procedures.

7.2 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.

7.3 There are different practices regarding how phraseology is used when carrying out de-icing/anti-icing procedures. Depending on the location, the script that is constructed from the standardized phrases can be different; however, the ultimate goal of communication still remains the same.

7.4 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 air operator's procedures.

7.5 Upon completion of the de-icing/anti-icing procedure and the associated check of the aeroplane, the flight crew should 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 CAC; this information should be given in the form of an anti-icing code.

7.6 The anti-icing code which is to be recorded should be communicated to the flight crew in the following sequence:

a) the fluid type (i.e., Type I, II, III, or IV);

b) the fluid name (manufacturer and brand/trade name) of the Type II, III, or IV anti-icing fluid, if applicable;

Note.— Communication of this element is not required for Type I fluid.

c) the concentration of fluid (dilution) within the neat fluid/water mixture, expressed as a percentage by volume for Type II, III, or IV (i.e., 100% ("neat") = 100% fluid, 75% = 75% fluid and 25% water, 50% = 50% fluid and 50% water);

Note.— Communication of this element is not required for Type I fluid.

d) the local time (hours and minutes), either for a:
- one-step de-icing/anti-icing operation: at the start of the final treatment; or
- two-step de-icing/anti-icing operation: at the start of the second step (anti-icing);

e) the date in the following format: day, month, year (DDMMMYY (e.g. 31JAN18 = January 31, 2018); and

Note.— This element is required for record keeping and is optional for flight crew notification.

f) the statement, "Post-de-icing/anti-icing check completed."

7.7 *After* de-icing/anti-icing completion and *prior* to moving the aeroplane, the flight crew must receive an "all clear" signal from the ground crew indicating that all de-icing related equipment is away from the aircraft.

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

Note.— See the Procedures for Air Navigation Services — Air Traffic Management *(Doc 4444) and SAE document AS6285 (latest version) for more information on de-icing/anti-icing communications. Guidelines for establishing clear concise standardized communication and phraseology between aircraft flight and ground crews during aircraft de-icing operations are also contained in SAE document ARP6257.*

EXAMPLE 1

Example of an off-gate de-icing/anti-icing communication procedures script:

- GC = Ground crew
- P = Pilot

GC: "Standing by to de-ice. Confirm brakes set and treatment required."

P: "Brakes set, request… (specify type of de-icing/anti-icing fluid and areas to be treated.)"

GC: "Hold position and confirm aircraft configured."

P: "Aircraft configured, ready for de-icing."

GC: "De-icing starts now."

GC: "De-icing on (areas treated) complete. Advise when ready for information."

GC: "Anti-icing code is: Type of fluid (Type I, II, III, or IV), percentage of fluid (except for Type I), HOT time started at (time), date)."

GC: "Post de-icing check completed, personnel and equipment clear of aircraft."

EXAMPLE 2

Examples of the format to be used for flight crew notification:

"Type IV/full fluid name/100%/1400 hrs LT/20 March 2018";

"Type II/full fluid name/75%/1200 hrs LT/02 January 2017"; or

"Type I/0800 hrs LT/04 April 2018".

Chapter 8

DE-ICING/ANTI-ICING METHODS

8.1 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 de-icing/anti-icing techniques are further discussed in Chapter 2, Aeroplane ground de-icing/anti-icing alternatives.

8.2 Applying de-icing/anti-icing fluids close to the skin of the aeroplane avoids surface damage and minimizes heat loss. Depending on the type of application equipment and spray pattern, direct spraying at angles approaching 90 degrees should be avoided. Instead, the operator should use a lower angle such as 45 degrees or less to avoid damaging aeroplane surfaces. Spraying directly at the nose cone, cockpit windows and fuselage windows should also be avoided to ensure that the pilot's view is not impeded by fluid runoff during the aircraft acceleration phase, and to avoid damage to the nose cone and to mitigate the risk of the window cracking from thermal shock. Unique procedures for different levels of contamination and to accommodate aeroplane design differences may be required. Any specific parts requiring treatment should be mentioned prior to the start of the procedure. 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. Aeroplane 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 and wheels.

e) *Engines/auxiliary power-units (APUs)*. Avoid spraying fluids into engines or APU inlets. Consult manufacturers' recommendations. Ensure that engines are free to rotate before start up and that the front and back of the 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 ports or air stream direction detector probes and angle of attack sensors.

g) *Vents and outlet valves*. Avoid spraying directly onto electronic bay vents, fuel tank vents, air outlet valves or any other similar type of opening.

8.3 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.

8.4 At very low ambient temperatures (below approximately –30°C), some fluids are no longer effective and other methods of frozen contamination removal must be used. Fluids should not be used in temperatures that are below their lowest operational use temperature.

Note.— Aeroplanes must be treated symmetrically.

8.5 De-icing/anti-icing can be carried out as a one-step process using a 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 (subject to certain outside air temperature restrictions) to ensure removal of all ice contamination followed immediately by application of an anti-icing fluid. 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 HOT.

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

8.7 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.

8.8 *Under no circumstances* should an aeroplane that has previously been anti-iced receive a further coating of anti-icing fluid directly on top of the contaminated fluid 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. It should be ensured that any residues from previous treatment are flushed off. Performing only the anti-icing step should not be permitted.

CAUTION

Repeated applications of Type II, III or IV fluids, without an application of Type I or hot water, may cause fluid to collect in aerodynamically quiet areas, cavities, and gaps, which can dry out and leave dried residues. These dried residues may rehydrate following a period of high humidity and/or rain conditions, and then freeze in temperatures below zero. It may also block or impede critical flight control systems and may require removal prior to flight.

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

Note.— See SAE document AS6285 — Aircraft Ground De-Icing/Anti-Icing Processes *(latest version) for more information.*

Chapter 9

DE-ICING/ANTI-ICING FLUID RESIDUE

9.1 This chapter introduces the de-icing/anti-icing fluid residue issue and explains checks and removal of the residue.

9.2 Type II, III or IV de-icing/anti-icing fluids can accumulate and dry out on critical areas of an aeroplane not exposed to airflow. If dried residues then come into contact with water, they can absorb this water (rehydrate) and swell. This expanded residue can then refreeze during flight causing potential issues for the safety of the flight. This often occurs when multiple treatments of de-icing/anti-icing fluids have been sprayed on the aeroplane. Safe winter operations includes inspecting for and removing dried de-icing/anti-icing fluid residues in hidden places in the wings and stabilizers, and any contamination must be removed prior to take-off. After a number of incident reports, many air operators of the affected aeroplane types have amended their maintenance procedures to carry out suitable inspections and dried out fluid residue removal.

9.3 The frozen residue can cause the flight control system to jam by restricting or preventing the movement of cables, control rods or bearings located under aeroplane fairings, blocking the area between the elevator and horizontal stabilizer or by restricting the elevator control tabs (see Figure III-9-1). The swelled rehydrated residue can also cause an increase in weight.

9.4 It is important to remember that the de-icing/anti-icing process should not be performed from the trailing edge forward as this can cause fluid to collect and remain in areas not exposed to airflow and can also affect or remove the grease on hinges and other moving parts of the aeroplane. The presence of dried residues and/or rehydrated residues should be checked systemically in scheduled inspections and cleaning processes. Failure to keep the aeroplane free of this residue might result in a degradation of the airworthiness of the aeroplane. The dried fluid residue can be very difficult to notice and spraying a water mist onto the surfaces may help locate the residue since it causes the dried fluid residue to swell into a gel form. The residue inspection and cleaning processes are further explained in the aeroplane maintenance manual.

9.5 It is suggested that the use of heated Type I fluid using a two-step procedure or high-pressure washing with water mist, may reduce the occurrence of fluid dry-out. The fluid residue can collect in aeroplane areas regardless of whether anti-icing fluids are applied in diluted or undiluted form, and regardless of whether Type II, III, or IV anti-icing fluids are applied.

9.6. Another adverse effect on an aircraft's performance may result when thickened fluids are applied on the aeroplane. In particular, it has been reported on various occasions that an aeroplane did not rotate during take-off as expected; the pilot noted that the controls felt heavy and the aeroplane reacted very slowly to pilot commands. This is an aerodynamic effect caused by the existing thickened fluid on the horizontal stabiliser and elevator. Some aeroplane manufacturers have determined take-off performance values for treated aircraft.

Note.— See SAE document AS6285 — Aircraft Ground De-Icing/Anti-Icing Processes *(latest version) for more information.*

Figure III-9-1. Images showing residual anti-icing fluid frozen on a wing, and fluid dryout and re-hydration on control mechanisms, potentially restricting control movement
(Images reproduced by kind permission of the National Aeronautics and Space Administration (NASA).)

Chapter 10

EQUIPMENT

INTRODUCTION

10.1 This chapter describes recommendations for performance and methods for verification of fluid systems/equipment, 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 recommendations relating to function, safety and performance. An example of such ground de-icing/anti-icing fluid is shown in Figure III-10-1.

FUNCTIONAL INFORMATION

10.2 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 air 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 equipment 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 equipment operator's basket/cabin is able to carry a second person.

RECOMMENDATIONS FOR FLUID SYSTEM PERFORMANCE

10.3 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 the 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 fluid system components (e.g. pumps, heating systems, nozzles and pipes) that can 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 equipment operator's manual. This will be useful information for the air 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 equipment operator should regularly check the accuracy of the fluid mix at the nozzle.

VERIFICATION OF
FLUID SYSTEM FUNCTION

10.4 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.

10.5 To verify a fluid system in relation to viscosity 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 per cent Type II, III or IV fluid and purge the fluid system until only this fluid comes out of the nozzle;

e) spray onto a suitable clean surface such as aluminium plates or plastic sheets laid on a flat surface, or the upper surface of an aircraft wing;

Note.— The fluids should be sprayed in a similar manner as that used in an actual anti-icing operation. A small squeegee can be used to move the fluid to the edge of the sheet or wing so it can be collected in a clean nonmetallic, wide-mouthed sample bottle. Nozzle samples may also be sprayed into clean containers such as a large trash can or containers with clean plastic liners such as trash bags. With all of these collection methods, samples should be sprayed onto the wing/sheet or into the container at a similar distance from the nozzle and at the same flow rate and nozzle pattern setting as that used in the actual anti-icing operation.

f) at a minimum, carry out the test with maximum flow rates and widest spray pattern;

g) compare the samples from the bag against viscosity specification limits; and

h) record the parameters of the fluid temperatures, fluid flow rates and spray pattern of the nozzle.

Figure III-10-1. Typical de-icing/anti-icing ground equipment
(Image reproduced by kind permission of the National Aeronautics and Space Administration (NASA).)

———————

PART IV

TRAINING AND QUALITY ASSURANCE (QA)

Chapter 1

TRAINING AND QUALIFYING OF PERSONNEL

1.1 Standards for personnel carrying out the de-icing/anti-icing procedures are explained in this chapter and policies and procedures that the ground and flight crews must learn in training are listed.

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

1.3 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 aeroplane 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 air 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, as applicable;

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 HOT guidelines;

n) anti-icing codes and communication procedures;

o) special provisions and procedures for contract de-icing and anti-icing when performed by sub-contractors (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 learned from the previous winter.

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

1.5 The air operator should maintain accurate records of the training and qualifying of both flight and ground personnel. This proof of qualification should be for both initial and annual recurrent training and qualification. A record of the training and qualification will be placed on the individual's file.

Note.— See SAE document AS6286 — Training and Qualification Program for Deicing/Anti-Icing of Aircraft on the Ground *(latest version) for more information on training of de-icing/anti-icing personnel. See also the latest versions of any associated sub-documents, for example, SAE AS6286/1, SAE AS6286/2, etc.*

Chapter 2

QUALITY ASSURANCE (QA) PROGRAMME

2.1 The air operator's responsibility in establishing a de-icing/anti-icing quality assurance (QA) programme and minimum elements of the programme are explained and clarified in this chapter.

2.2 To meet QA requirements, the air operator must provide evidence that it fully complies with the rules and procedures in any specific field. Air operators should establish a QA programme to ensure correct de-icing/anti-icing operation at all stations where applicable. The QA programme should include at least the following elements:

a) *auditing* of all parts of the de-icing/anti-icing operation is required to check the ongoing compliance with all regulations issued by authorities and conformity with procedures and specifications of air operators, manufacturers and handling agents;

b) *training* of all personnel involved in the de-icing/anti-icing operation is carried out to ensure the correct performance of all related tasks;

c) *methods and procedures* have to be defined and documented to guide personnel in 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 document 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* must be maintained in such a way that quality operation is ensured; and

h) *fluids* must be handled in such a way that fluid quality is ensured.

Note.— See SAE document AS6332 — Aircraft Ground Deicing/Anti-Icing Quality Management *(latest version) for more information on QA programmes set by the air operator.*

— END —