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Aircraft Ground Deicing/Anti-Icing Training and Qualification Program

RATIONALE

This document provides the industry standards and guidance for the training and qualifying of staff, plus the expected contents of this training for effective deicing and anti-icing of aircraft on the ground.

AS6286 forms one part of three related SAE Aerospace Standards (AS) and should be read in conjunction with AS6285 and AS6332. Collectively, AS6285, AS6286, and AS6332 are known to the International Community as the Global Aircraft Deicing Standards. The lead document is AS6285, which all the other documents support and should therefore be in agreement with.

Exposure to weather conditions conducive to ice formation can cause the accumulation of frost, snow, slush, and ice on aircraft surfaces and components. These contaminants can adversely affect aircraft performance and controllability. In addition, they can adversely affect the operation of mechanical devices such as control surfaces, sensors, flaps, and landing gear. If frozen deposits are present other than those accounted for in the aircraft certification process, then the performance and safety of the aircraft will be compromised.

Regulations governing aircraft operations in ground icing conditions shall be followed. The International Civil Aviation Organization ICAO "Annex 6, Part I" mandates specific rules for the safe operation of aircraft during ground icing conditions, and all member states subsequently are required to have regulations in place to ensure conformance with these. Paraphrased, these rules specify that no one may dispatch or take off an aircraft with frozen deposits on components of the aircraft that are critical to safe flight. A critical surface or 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. This is known as the "clean aircraft" concept.

This document specifies the standards for training and qualifying staff, plus the expected contents of their training. It provides guidance for the setting up of a proper training and qualification program for the deicing and anti-icing of aircraft on the ground. Although references are made to the other two global standards, some background information to support a training program is provided to make the material a better tool for the preparation and execution of the training and qualification process. Standard teaching plans and a practical assessment method are included. This material was compiled using various international documents, with support from SAE standards and individually contributed editorial comments. Its purpose is to serve as a "global deicing training manual." In addition, each organization involved in aircraft ground deicing and anti-icing is responsible for complying with local regulations and requirements imposed by manufacturers of aircraft, equipment, and fluids, in addition to regulatory and environmental authorities.

Changes made are:

1. Final qualification - see 6.1.
2. Qualification and QC program - see 6.1.
3. Record keeping and test types - see 6.6.2.
4. Active Frost - see A.5.2.
5. Cold dry snow and ice crystals - see A.9.2
6. Precipitation intensity - see A.13.5.1.
7. Post deicing report - see A.14.1.4

TABLE OF CONTENTS

1. SCOPE 7
1.1 Field of Application 7
1.2 Agreements and Contracts 7
1.3 Hazardous Materials 7

2. REFERENCES 7
2.1 Applicable Documents 7
2.1.1 SAE Publications 7
2.1.2 FAA Publications 8
2.1.3 ICAO Publications 8
2.1.4 ISO Publications 8
2.1.5 Transport Canada Publications 8
2.2 Related Publications 9
2.3 Definitions and Abbreviations 9
2.3.1 Definitions 9
2.3.2 Abbreviations 9

3. THE REQUIREMENTS FOR CLEAN AIRCRAFT IN WINTER - ORGANIZATION AND TRAINING 10
3.1 The Requirement for Clean Aircraft in Winter Operations 10
3.2 Organizational Requirements 11
3.3 The Essential Elements of a Deicing Training Program 11
3.3.1 Organization 11
3.3.2 Training of Deicing Personnel 12
3.3.3 Computer-Based Training 12
3.4 The Complementary Fit between AS6286, AS6285, and AS6332 12

4. AUTHORITY AND ROLES IN DEICING/ANTI-ICING 13
4.1 Senior Management Team 13
4.2 Winter Program Manager and Head of Deicing Training 13
4.2.1 Winter Program Manager 13
4.2.2 Head of Deicing Training (see DI-L70, 4.11) 13
4.3 Operational and Support Levels of Training and Qualification 14
4.3.1 Duration and Content of Training 14
4.4 Deicing Vehicle Driver, DI-L10 14
4.5 Deicing Operator, DI-L20 15
4.6 Deicing Supervisor, DI-L30 15
4.7 Pre/Post Deicing Inspector, DI-L30B 15
4.8 Deicing Instructor, DI-L40 16
4.9 Deicing Coordinator, DI-L50 16
4.10 Fluid Quality Inspector (Laboratory Staff Only), DI-L60 16
4.11 Head of Deicing Training, DI-L70 17

4.12 Flightcrew (Winter Operations), DI-L80 17
4.13 Cabin Crew (Icing Awareness), DI-L80B 17

5. TRAINING SUBJECTS AND THEIR FIT WITH DEICING ROLES 17
5.1 Recommended Elements of Deicing Training 17
5.2 The Fit Between the Recommended Elements of Deicing Training and the Deicing Roles 18

6. TRAINING AND QUALIFICATION PROCESS 20
6.1 Theoretical and Practical Training, Annual Assessments, and Record Keeping 20
6.2 Theoretical Elements - Standard Teaching Plan 24
6.3 Theoretical Elements - Examination Process 25
6.4 Practical Elements - Standard Teaching Plan 26
6.5 Practical Elements - Assessment Process 28
6.6 Training System and Records 28
6.6.1 Training System and Renewal 28
6.6.2 Records 29
6.6.3 Quality of Training 29
6.7 Computer-Based Deicing Simulator (CBDS) Standards 29

7. LANGUAGE PROFICIENCY RATING SCALE 32

8. CONTRACT DEICING/ANTI-ICING 34
8.1 General Training Recommendation 34
8.2 Training by Outside Contracted Party 34
8.3 Contractor Training Staff Competence 34
8.4 Management Plan 34

9. GUIDANCE FOR RUNNING DEICING TRAINING SESSIONS 34
9.1 General 34
9.2 The Learning Process 34
9.3 The Teaching Process 35
9.4 Teaching Methods 35
9.5 Instructional Aids 36
9.6 Evaluation 36

10. NOTES 37
10.1 Revision Indicator 37

APPENDIX A THEORETICAL ELEMENTS GUIDANCE CONTENT 38

A0 TE0: AN INTRODUCTION TO THIS APPENDIX 38

A1 TE1: TRAINER AND COURSE INTRODUCTION 38
A.1.1 The Trainer 38

A.2 TE2: BASIC KNOWLEDGE OF AIRCRAFT PERFORMANCE 39
A.2.1 How Planes Take Off and Fly 39
A.2.2 How Lift is Generated 40
A.2.3 The Limit of Using Angle of Attack to Generate Lift 41
A.2.4 The Aerodynamic Operating Envelope 42

A.3 TE3: EFFECTS OF FROZEN CONTAMINATION ON AIRCRAFT PERFORMANCE 42
A.3.1 General 42
A.3.2 Frozen Contamination and the Effect Upon Aerodynamics 43
A.3.3 Aircraft Icing 44
A.3.3.1 Ground Icing and Deicing/Anti-Icing 44
A.3.3.2 In-Flight Icing 44
A.3.3.4 Frozen Contamination and Aircraft Components 44
A.3.4 The Effect of Frost on Lift 45

A.3.5 Effects of Frost on Stall ... 45
A.3.6 Other Effects on Performance ... 45

A.4 TE4: THE CLEAN AIRCRAFT CONCEPT, REGULATORY BODIES, AND RECOMMENDATIONS ... 46
A.4.1 The Clean Aircraft Concept ... 46
A.4.2 Regulatory Requirements ... 46
A.4.3 The SAE Aircraft Global Deicing Standards ... 46
A.4.4 SAE Global Aircraft Ground Deicing Standards ... 47
A.4.5 Other Related SAE Standards and Documents ... 48
A.4.6 The Main Purpose of Aircraft Deicing and Anti-Icing ... 48

A.5 TE5: Meteorological considerations for ice formation ... 49
A.5.1 General Weather Conditions and Aircraft Ground Icing ... 49
A.5.1.1 General Considerations of Aircraft Ground Icing ... 49
A.5.1.2 Frost Formation ... 50
A.5.2 Definitions of Freezing Weather Conditions ... 50
A.5.3 Weather Conditions or Situations That May Also Lead to the Buildup of Frozen Contamination on an Aircraft ... 52
A.5.3.1 Clear Ice ... 52
A.5.3.2 Cold-Soak Effect and Clear Ice ... 52
A.5.3.3 Incidental Water Spray ... 52
A.5.4 Weather Conditions Assessed for Holdover Time Tables ... 52
A.5.5 Airport Weather Reporting ... 53
A.5.5.1 Interpreting Weather Data ... 53
A.5.5.2 METAR ... 54
A.5.5.3 TAF ... 54
A.5.6 Potential Weather Effects on Aircraft Operations ... 55

A.6 TE6: HOW TO CHECK THE AIRCRAFT CRITICAL SURFACES ... 56

A.7 TE7: POST DEICING/ANTI-ICING CHECK ... 56

A.8 TE8: GENERAL TECHNIQUES FOR REMOVING FROZEN DEPOSITS FROM AN AIRCRAFT ... 57
A.8.1 Deicing/Anti-Icing Operations - General Information ... 57
A.8.1.1 Deicing Operations ... 57
A.8.1.2 Anti-Icing Operations ... 57
A.8.1.3 Tasks Prior to Deicing/Anti-Icing Treatment ... 57
A.8.1.4 Contamination Check to Establish the Need for Deicing ... 58
A.8.2 One-Step and Two-Step Deicing/Anti-Icing ... 59
A.8.2.1 General Information ... 59
A.8.2.2 One-Step Deicing/Anti-Icing ... 59
A.8.2.3 Two-Step Deicing/Anti-Icing ... 59

A.9 TE9: DEICING/ANTI-ICING BY FLUIDS - PROCEDURES IN GENERAL ... 60
A.9.1 The Critical Aspects of the Deicing Process ... 60
A.9.2 The General Deicing Process ... 60
A.9.2.1 Cold Dry Snow or Ice Crystals ... 61
A.9.3 The General Anti-Icing Fluid Application Strategy ... 61
A.9.3.1 Use of a Type I Fluid for Anti-Icing ... 61
A.9.3.2 Use of a Type II, Type III, or Type IV Fluid for Anti-Icing ... 62

A.10 TE10: BASIC CHARACTERISTICS OF AIRCRAFT DEICING/ANTI-ICING FLUIDS ... 62
A.10.1 The Use of Aircraft Deicing/Anti-Icing Fluids ... 63
A.10.2 Deicing/Anti-Icing Fluid Information and Fluid Types ... 63
A.10.3 The Typical Process for Deicing and Anti-Icing of Aircraft ... 64
A.10.4 Understanding the Technology of Deicing and Anti-Icing Fluids ... 65
A.10.4.1 The Simple Concepts ... 65
A.10.5 The Properties of Anti-Icing Thickened Fluids - Newtonian Versus Non-Newtonian Flow ... 65
A.10.6 Characterizing Deicing and Anti-Icing Fluids ... 66

A.11 TE11: TYPES OF FLUID CHECKS REQUIRED AND THE EQUIPMENT FOR DOING THIS 67
A.11.1 General Fluid Handling and Storage Notes 67
A.11.2 Quality Control Checks to be Performed 67
A.11.3 Pumping and Heating, Storage Tanks 67

A.12 TE12: DEICING/ANTI-ICING EQUIPMENT OPERATING PROCEDURES 68
A.12.1 Variations of Deicing/Anti-Icing Vehicles 69
A.12.2 Equipment Safety Precautions 69
A.12.3 Emergency Requirements 69
A.12.4 Operational Use of Equipment and Quality Control 69
A.12.5 Equipment Communication Requirements 70
A.12.6 Equipment Fluid Use and Spray Alternatives 71
A.12.7 Data Collection 71
A.12.8 Basic Vehicle Components 72
A.12.9 Typical Deicing/Anti-Icing Vehicle Layout 73
A.12.10 Safety Equipment 74
A.12.11 Before-Use Checks 74

A.13 TE13: FLUID APPLICATION AND THE USE PLUS LIMITATIONS OF THE HOLDOVER TIME (HOT) TABLES 74
A.13.1 The Clean Aircraft Concept and Fluid Use 75
A.13.2 Spray Areas 75
A.13.3 Aircraft Surfaces 75
A.13.4 Other Areas to Deice/Anti-Ice 76
A.13.5 Interpreting Deicing/Anti-Icing Fluid and Holdover Time (HOT) Tables 77
A.13.5.1 The Purpose of a Holdover Time (HOT) Table 77
A.13.5.2 Type I Fluid HOT Table Example (Table A2) 78
A.13.5.3 Type II/IV Fluid Generic Holdover Time Table Example (Tables A3.1 and A3.2) 79
A.13.5.4 Types I/II/III/V Holdover Time Table for Frost 81
A.13.6 Local Frost Prevention for Cold-Soaked Wing Areas 81

A.14 TE14: DEICING/ANTI-ICING CODES AND COMMUNICATION PROCEDURES 82
A.14.1 Phraseology 82
A.14.1.1 Post Deicing/Anti-Icing Communication 82
A.14.1.2 Releasing or Dispatching the Aircraft and the Final Walk-Around 83
A.14.1.3 The Anti-Icing Code 83
A.14.1.4 The Post Deicing Report 84
A.14.1.5 Flightcrew Information 84
A.14.2 Off-Gate Deicing/Anti-Icing Communication 85
A.14.2.1 Radio Telephony Phraseology 85
A.14.2.2 ICAO Phraseology 86

A.15 TE15: AIRCRAFT IN GENERAL AND COMMON CRITICAL SURFACES AND INSTRUMENTS 88
A.15.1 Check of Critical Surfaces 88
A.15.2 Clear Ice Precautions 89
A.15.3 Critical Surfaces and Areas Not to Spray 89
A.15.4 Deicing/Anti-Icing Diagrams/No-Spray Areas 90
A.15.5 Proximity Sensor Activation Reporting Procedure 90
A.15.5.1 Communication for Proximity Sensor Activation by Physical Contact 90
A.15.6 Training Requirements for Ground Crew 90
A.15.6.1 Check Requirements 90

A.16 TE16: SAFETY PRECAUTIONS AND HUMAN FACTORS 91
A.16.1 The Definitions of Hazard and Risk and the Management of Safety 91
A.16.1.1 The Sources of Hazard During Deicing/Anti-Icing Operations and Their Mitigation 91
A.16.2 The Use of Chemicals in Deicing/Anti-Icing Fluids 91
A.16.3 The Use of Deicing/Anti-Icing Spraying Equipment 92
A.16.4 Hazards for Personnel 92

A.16.5 Human Factors ... 92

A.17 TE17: ENVIRONMENTAL IMPACT AND MITIGATION ... 93
A.17.1 The Meaning of Some of the Methods used to Gauge Environmental Impact ... 93
A.17.1.1 Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) ... 93
A.17.1.2 Biodegradability ... 93
A.17.1.3 Aquatic Toxicity ... 94
A.17.2 The Potential Environmental Impact of Deicing/Anti-Icing Fluids ... 94
A.17.2.1 Water Courses ... 94
A.17.2.2 Aquatic Creatures ... 94
A.17.3 Mitigating the Environmental Impact of Deicing/Anti-Icing Fluids ... 94

A.18 TE18: DEICING FACILITY OPERATION ... 95
A.18.1 Designated Deicing Facilities (DDF) ... 95
A.18.1.1 Management Plan ... 95

A.19 TE19: OPERATIONAL QUALITY MANAGEMENT, AUDIT FINDINGS, AND UPDATING PROCEDURES ... 96
A.19.1 The Need to Continually Improve the Operational Performance for Deicing/Anti-Icing ... 96
A.19.1.1 The Principles of Quality Management and the Main Concepts of AS6332 ... 96
A.19.1.2 The Need for Updated Procedures and Training ... 97

A.20 TE20: LOCAL RULES, RESTRICTIONS, AND AIRPORT PROCEDURES ... 98
A.20.1 Local Rules and Procedures Confirming to the SAE Global Deicing Standards ... 98
A.20.2 The Special Requirements for the Local Situation ... 98

APPENDIX B EXAMPLE TRAINING TIMES ... 99

B.1 DURATION OF TRAINING TYPICALLY REQUIRED ... 99

B.2 RECOMMENDED TIMING FOR THEORETICAL TRAINING ELEMENTS (SEE 6.2) ... 100

Figure 1 Aircraft deicing/anti-icing training roster ... 22
Figure 2 Aircraft deicing/anti-icing training program ... 23
Figure 3 Language proficiency table, Part 1 ... 33
Figure 4 Language proficiency table, Part 2 ... 33

Table 1 Fit between recommended elements of deicing training and deicing roles ... 19
Table 2 Theoretical elements - standard teaching plan (sections A, B, and C) ... 24
Table 3 Theoretical elements - standard teaching plan (section D) ... 25
Table 4 Practical elements - standard teaching plan, Part 1 of 2 ... 26
Table 5 Practical elements - standard teaching plan, Part 2 of 2 ... 27
Table 6 CBDS minimum operational and functional requirements, Part 1 of 2 ... 30
Table 7 CBDS minimum operational and functional requirements, Part 2 of 2 ... 31
Table 8 CBDS training capabilities ... 32

1. SCOPE

1.1 Field of Application

This document establishes the minimum training and qualification requirements for ground-based aircraft deicing/anti-icing methods and procedures. All guidelines referred to herein are applicable only in conjunction with the applicable documents. Due to aerodynamic and other concerns, the application of deicing/anti-icing fluids shall be carried out in compliance with engine and aircraft manufacturers' recommendations. The scope of training should be adjusted according to local demands. There are a wide variety of winter seasons and differences of the involvement between deicing operators, and therefore, the level and length of training should be adjusted accordingly. However, the minimum level of training shall be covered in all cases. As a rule of thumb, the amount of time spent in practical training should equal or exceed the amount of time spent in classroom training.

1.2 Agreements and Contracts

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

1.3 Hazardous Materials

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

2. REFERENCES

2.1 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 shall take precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

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

AMS1424/1 Deicing/Anti-Icing Fluid, Aircraft SAE Type I Glycol (Conventional and Non-Conventional) Based

AMS1424/2 Deicing/Anti-Icing Fluid, Aircraft SAE Type I Non-Glycol Based

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

AMS1428/1 Fluid, Aircraft Deicing/Anti-Icing, Non-Newtonian (Pseudoplastic), SAE Types II, III, and IV Glycol (Conventional and Non-Conventional) Based

AMS1428/2 Fluid, Aircraft Deicing/Anti-Icing, Non-Newtonian (Pseudoplastic), SAE Types II, III, and IV Non-Glycol Based

ARP1971 Aircraft Deicing Vehicle - Self-Propelled

ARP5660 Deicing Facility Operational Procedures

AS5900 Standard Test Method for Aerodynamic Acceptance of AMS1424 and AMS1428 Aircraft Deicing/Anti-Icing Fluids

AS6285 Aircraft Ground Deicing/Anti-Icing Processes

AS6286B Aircraft Ground Deicing/Anti-Icing Training and Qualification Program

AS6332 Aircraft Ground Deicing/Anti-Icing Quality Management

AS9100 Quality Management Systems - Requirements for Aviation, Space, and Defense Organizations

2.1.2 FAA Publications

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.

FAA Holdover Time Guidelines (current issue - annual publication)

FAA, Notice N 8900.ZZZ, “FAA-Approved Deicing Program for Winter 20xx-20yy” (current issue - annual publication)

FAA, Ground Deicing Program - Summary of Changes to FAA Holdover Time Guidelines and Associated Documents for Winter 20xx-20yy (current issue - annual publication).

FAA, Ground Deicing Program - General Information (current issue - annual publication)

2.1.3 ICAO Publications

Available from International Civil Aviation Organization, 999 University Street, Montreal, Quebec H3C 5H7, Canada, Tel: +1 514-954-8219, https://www.icao.int/.

ICAO Doc 9640 AN/940 Manual of Ground Deicing/Anti-icing Operations

ICAO Doc 9835 AN/453 Manual on the implementation of ICAO Language Proficiency Requirements

ICAO Annex 6, Operation of Aircraft, Part 1 - International Commercial Air Transport - Aeroplanes

ICAO Doc 4444 ATM/501 - Procedures for Air Navigation Services - Air Traffic Management

2.1.4 ISO Publications

Copies of these documents are available online at https://webstore.ansi.org/.

ISO 9001 Quality management systems - Requirements

2.1.5 Transport Canada Publications

Available from Transport Canada, Tower C, Place de Ville, 330 Sparks Street Ottawa, Ontario K1A 0N5, Tel: 1-800-305-2059, www.tc.gc.ca.

Transport Canada, Holdover Time (HOT) Guidelines Regression Information (current issue - annual publication)

Transport Canada Holdover Time Guidelines: Winter 20xx-20yy (current issue - annual publication)

Transport Canada, TP 14052E, “Guidelines for Aircraft Ground Icing Operations” (current issue - annual publication)

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

Aircraft Manufacturer and Operator Manuals

2.3 Definitions and Abbreviations

2.3.1 Definitions

HEAD OF DEICING TRAINING: The person responsible for ensuring the effective delivery of the deicing/anti-icing training of personnel for the whole organization. This person must have a complete understanding of the subject matter herein and a documented competence level. By agreement of the senior management team, this may also be the Program Manager/Responsible Person/Accountable Executive.

FLIGHTCREW TRAINER: The person responsible for deicing/anti-icing training for flightcrews.

QUALITY MANAGEMENT SYSTEM: The ability to demonstrate both management commitment to and the organizational ability to deliver the required level of product or service.

SENIOR MANAGEMENT TEAM: A team of individuals at the highest level of management of an organization who are responsible for ensuring the proper delegation and delivery of performance for the day-to-day tasks of managing winter operations.

WINTER PROGRAM MANAGER/RESPONSIBLE PERSON/ACCOUNTABLE EXECUTIVE/ACCOUNTABLE PERSON: The person responsible for ensuring that the processes needed to maintain the quality of systems to comply with the clean aircraft concept.

PREFLIGHT CONTAMINATION CHECK: A check of aircraft surfaces and components for contamination to establish the need for deicing.

2.3.2 Abbreviations

ATC	air traffic control
ATCT	air traffic control tower
CBDS	computer-based deicing simulator
CBT	computer-based training
QMS	quality management system

Refer to AS6285 for other definitions and abbreviations that are not listed within this section.

3. THE REQUIREMENTS FOR CLEAN AIRCRAFT IN WINTER - ORGANIZATION AND TRAINING

3.1 The Requirement for Clean Aircraft in Winter Operations

The smooth flow of air over the wings of an aircraft provides the lift necessary for flight. The continued optimization of aerodynamic surfaces over time has led to increasing efficiency gains and safety improvements. However, exposure to weather conditions on the ground that are conducive to ice formation can cause the accumulation of frost, snow, slush, or ice on aircraft critical surfaces and components that will adversely affect aircraft performance and control. The operation of mechanical devices, such as control surfaces, sensors, flaps, and landing gear, will also be affected. If frozen contamination is present, other than that approved via the aircraft certification process, the ability for the aircraft to fly safely may be greatly reduced and will cause potentially dangerous conditions. An aircraft ready for departure must be a clean aircraft that has no frozen contaminants adhering to any critical surface. Regulations governing aircraft operations in icing conditions shall be followed. The International Civil Aviation Organization ICAO "Annex 6, Part I" mandates specific rules for the safe operation of aircraft during ground icing conditions, and all member states are required to have regulations in place to ensure this:

> *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 aircraft has been inspected for icing and, if necessary, has been given appropriate deicing/anti-icing treatment. Accumulation of ice or other naturally occurring contaminants shall be removed so that the aircraft is kept in an airworthy condition prior to takeoff.*

A critical surface or component is one which could adversely affect the mechanical or aerodynamic function of an aircraft. As frozen contaminants of almost any kind can compromise the safety of an aircraft, deicing and anti-icing methods are used to ensure that aircraft critical surfaces are clean for takeoff. The purpose of these deicing and anti-icing techniques is best described by the clean aircraft concept. The clean aircraft concept means that an aircraft must be free of all frozen contamination that could prevent a safe takeoff. The most common deicing and anti-icing (commonly combined as "deicing/anti-icing") technique is the application of deicing/anti-icing fluids, although other mechanical and physical methods may be used. SAE fluid types are both deicing and anti-icing fluids, but the different types are commonly used as one or the other; thus, two separate fluids are often used to ensure a clean aircraft.

Deicing fluids are used to remove existing contamination. They are normally supplied as a concentrate.

For maximum effect, deicing fluids shall be applied close to the surface to minimize heat loss. Fluid temperature and pressure should not exceed aircraft maintenance manual requirements. The heat in the fluid effectively melts any frost, as well as light deposits of snow, slush, 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 contamination. The deicing fluid will prevent refreezing for a period of time, depending on aircraft skin and outside air temperature (OAT), the fluid used, the mixture strength, and the weather.

They are not primarily intended to prevent adherence of further active frozen contamination, although limited protection is afforded by the heat from the fluid. When that protection is relied upon to keep an aircraft clean for takeoff, then the Type I is being used as both a deicing and an anti-icing fluid. Other fluids and mixtures can be used to deice dependent on experience and availability, such as:

1. Heated water (only when above freezing conditions).
2. Heated mixture of water and Type I fluid.
3. Heated premix Type I fluid.
4. Heated Type II, III, or IV fluid.
5. Heated mixture of water and Types II, III, or IV fluid.

NOTE 1: All of the above have a specific effect (deicing or holdover time) based on the temperature in which they are used. These are all defined (except water which has no HOT) in the FAA and TC Holdover Time Tables. They are published each year, and only current tables shall be used for operational purposes.

NOTE 2: Unheated fluids are ineffective to deice.

Anti-icing fluids are designed and used to protect treated surfaces from contamination for a specified range of times (the "holdover time"). Fluid Types II, III, and IV are usually applied unheated. The holdover time allows the aircraft to move to the runway from the location where it was treated, and then remain in the takeoff queue for a limited time, without the danger of active frozen precipitation adhering to the treated surfaces prior to takeoff. Integral to the design of these fluids is that they must not excessively interfere with the smooth flow of air over the surfaces at takeoff. Anti-icing fluids therefore have two distinct performance criteria: (1) to remain on the aircraft, preventing active precipitation from adhering, until the start of the takeoff roll and (2) to flow off of the surfaces during the takeoff, which is referred to as the aerodynamic performance requirement. The SAE Standards AS6286, AS6285, and AS6332 have been written to give best-practice guidance for the use of deicing/anti-icing fluids to provide a clean aircraft for a safe takeoff.

3.2 Organizational Requirements

The organizational requirements for the effective and safe deicing/anti-icing of aircraft during winter weather are described in more detail in AS6332. A short summary is provided here as an introduction to these requirements. The main concepts contained in AS6332 are based on the quality management methods set out in ISO 9001 and can be summarized in two points:

- The need to demonstrate and consistently provide a product or service that meets customer and applicable regulatory requirements, plus
- Aims to enhance the product or service through effective systems and processes for continual improvement

For aircraft deicing/anti-icing, the safety-critical nature of this work requires complete conformance to the principle of the clean aircraft concept, as this is the critical customer and regulatory requirement. It involves both conformance to standards of operation and its continual improvement in line with the principles of quality management. The deicing service provider shall establish, document, implement, and maintain a quality management system (QMS) and continually improve its effectiveness. The deicing service provider shall:

- Determine the processes needed to manage effective aircraft deicing/anti-icing
- Determine the criteria and methods needed to ensure that the operation and control of these processes are effective
- Ensure the availability of resources necessary to support the operation and monitoring of these processes
- Monitor, measure (where applicable), and analyze these processes
- Implement actions necessary to achieve the planned results and to continually improve these processes

NOTE: The extent of the QMS documentation can differ from one organization to another due to:

  - The size of the organization and types of activities
  - The complexity of their processes and interactions and the competence of the personnel

3.3 The Essential Elements of a Deicing Training Program

3.3.1 Organization

An organization shall have in place within its management plan and organizational structure descriptions of key personnel (e.g., Head of Deicing Training, Program Manager, Deicing/Anti-Icing Training Instructor, etc.) and their duties pertaining to training, qualification, and oversight responsibilities. The management plan and the structure of the organization shall specify the individuals who are responsible for the deicing/anti-icing training program. The individuals specified with this responsibility shall have sufficient knowledge of deicing/anti-icing operations and training to be qualified for this position. Although this qualification may be renewed annually, it is recommended that the responsible individuals complete training and qualification on an annual basis through self-study, under the oversight of their superior or responsible designee (where applicable), as specified within the organization's management plan and organizational structure.

Deicing/anti-icing training shall be conducted exclusively by personnel who are trained, qualified, and proficient within the relevant subjects applicable to the personnel they are designated to instruct (e.g., flightcrew, dispatch, or ground personnel) or by other personnel or through other means under the oversight of such qualified individuals. Individuals designated to develop or facilitate deicing/anti-icing training should have some familiarization, background, and training in the area of education and facilitation techniques through relevant experience or education. This training may be performed as part of a train-the-trainer program. Individuals designated to conduct deicing/anti-icing training within an organization's management plan and organizational structure shall be required to complete initial and subsequent annual recurrent training in order to maintain their qualification. This training shall be facilitated internally within an organization by an individual responsible for this function as specified within the organization’s management plan and organizational structure (e.g., Training Manager/Head Trainer) or other personnel as designated, or by a third-party organization (e.g., air operator, contracted deicing/anti-icing training vendor, etc.).

3.3.2 Training of Deicing Personnel

Only trained and qualified personnel shall perform aircraft ground deicing/anti-icing procedures. A deicing training program shall be maintained and executed by the organization that performs the deicing. The training program shall address all elements of the training material, levels of qualifications, verification of success, functions, duties, responsibilities, quality control, and regular overview of instruction. The training program shall refer to current industry standards and regulations. All training records shall be kept as per the regulatory or company’s recordkeeping policy. The training program shall be reviewed at least annually to ensure that it covers all current aspects of deicing/anti-icing operations.

The Head of Deicing Training is responsible for developing the training program. The Head of Deicing Training may also be the instructor. In that case, previous deicing experience is strongly recommended. The company shall evaluate and approve the Head of Deicing Training for the task according to established requirements. This approval by the senior management team shall be documented.

3.3.3 Computer-Based Training

Computer-based training (CBT), e-learning/distance learning, and computer-based deicing simulators (CBDS) may be utilized in place of traditional instructor-facilitated training for theoretical training components and limited practical training components (dependent on the CBDS level utilized). It is recommended that CBT/e-learning/distance learning or CBDS training be facilitated and administered under the oversight of suitably qualified training personnel.

To simulate classroom interactivity, it is recommended that when a trainee requires assistance or has a question, there be various means in place so that the assistance can be obtained or question can be answered prior to completion of the course and before exams or evaluation. This may include the use of poll questions, email, online assistance, etc.

It is recommended that if CBT/e-learning or CBDS is used as part of the examination or evaluation process, effective measures should be in place to prevent academic dishonesty and plagiarism (i.e., individual login/password, random questions drawn from a question pool, measures to prevent skipping/fast-tracking of training, oversight by a proctor, etc.).

It is the responsibility of the CBT/e-learning or CBDS manufacturer/developer and user to ensure that all applicable requirements as stated within this document are met, as applicable to the personnel they are intended to instruct.

3.4 The Complementary Fit between AS6286, AS6285, and AS6332

While the AS6286 standard deals with the key requirements for training personnel for aircraft ground deicing/anti-icing, it is complementary to two other standards with which it should be read, interpreted, and understood. The three complementary standards are:

- AS6285: Aircraft Ground Deicing/Anti-Icing Processes
- AS6286: Aircraft Ground Deicing/Anti-Icing Training and Qualification Program
- AS6332: Aircraft Ground Deicing/Anti-Icing Quality Management

While this standard focuses on the training aspect of aircraft ground deicing/anti-icing, a complete understanding of the processes and quality management aspects are only available through the full appreciation of the other two standards.

4. AUTHORITY AND ROLES IN DEICING/ANTI-ICING

4.1 Senior Management Team

Senior management shall:

- Provide evidence of its commitment to the development and implementation of a suitable management system for the effective deicing/anti-icing of aircraft.
- Ensure that responsibilities and authorities are defined and communicated within the organization.
- Appoint a manager on an annual basis who may be known by a title such as Program Manager, Responsible Person, Accountable Executive, Accountable Person, or some other title identifiable as the responsible person accountable to senior management for the effective delivery of this service.
- Establish position requirements for and appoint a Head of Deicing Training. If agreed by senior management, the Program Manager/Responsible Person/Accountable Executive/Accountable Person and the Head of Deicing Training may be the same person.

For more detailed and specific guidance on the roles of the senior management team, the Program Manager, and the Head of Deicing Training, refer to the appropriate section of AS6332.

4.2 Winter Program Manager and Head of Deicing Training

4.2.1 Winter Program Manager

Senior management shall appoint a manager on an annual basis who, irrespective of other responsibilities, shall be responsible for:

- Ensuring that the process needed to maintain the quality of systems to deliver clean aircraft during winter operations are established and maintained
- Reporting to senior management on the performance and effectiveness of these systems and any need for improvement
- Ensuring that the need to conform to the clean aircraft concept is communicated throughout the organization

This person may be known by the title "Winter Program Manager/Responsible Person/Accountable Executive/Accountable Person," or some other title that identifies as responsible and accountable to senior management for the effective delivery of all winter services and activities.

4.2.2 Head of Deicing Training (see DI-L70, 4.11)

It is often common to abbreviate "deicing/anti-icing" as just "deicing," such as for the title of this position. Thus, when the term "deicing" is used, one must be mindful of the context and know whether it is also meant to include anti-icing.

Senior management shall appoint a manager on an annual basis who, irrespective of other responsibilities, shall be responsible for:

- Ensuring that their own understanding and competence is sufficient to hold this position
- Ensuring the effective delivery of the training program for the organization

If agreed by senior management, the Program Manager, Responsible Person, Accountable Executive, Accountable Person, and the Head of Deicing Training may be the same person.

4.3 Operational and Support Levels of Training and Qualification

The qualification level for all operational positions shall be clearly defined. Qualified people shall be fully aware of their approved functions. A person may hold several approvals depending on the job function. A suggested structure for levels and groups of qualifications is (DI-L = De Icing - Level):

DI-L10 Deicing Vehicle Driver

DI-L20 Deicing Operator

DI-L30 Deicing Supervisor

DI-L30B Pre/post deicing Inspector

DI-L40 Deicing Instructor

DI-L50 Deicing Coordinator

DI-L60 Fluid Quality Inspector (laboratory staff)

DI-L70 Head of Deicing Training

DI-L80 Flightcrew (winter operations) [basics of deicing/anti-icing]

Initial qualification is achieved after successful theoretical training (including a written examination) is completed, and practical training (including assessment where relevant) is also successful. Each qualification shall be renewed annually, including the theoretical instruction and written examination. The training topics do not need to be covered repeatedly for each initial level of qualification if the same person is performing several duties. In order to maintain each qualification, it is highly recommended that the company keep records of the experience of each individual. The level of experience is recommended to be such that each individual is familiar with all relevant elements of the qualification responsibilities and can perform the required task in a safe manner. The program and records shall reflect the experience in performing the tasks of the relevant qualification in actual conditions. If the experience is limited after the winter season, it is recommended that the annual recurrent training of the individual reflects this lack of adequate experience in order to have all relevant operational topics refreshed more thoroughly.

4.3.1 Duration and Content of Training

The length of time required for theoretical and practical training will vary among operators and will also vary depending on local conditions. All elements relevant to a specific deicing qualification level should be covered in training as recommended in Table 1 (see 5.2).

Guidance for course content to use in theoretical training is provided in Tables 2 and 3 (see 6.2). A written exam for theoretical training must be completed in accordance with the process described in 6.3. Tables 4 and 5 provide elements for practical training. Assessments of the trainee must be performed during practical training in accordance with the process described in 6.5.

4.4 Deicing Vehicle Driver, DI-L10

The deicing vehicle driver qualification (DI-L10) qualifies the person to maneuver the vehicle and perform the communication procedures, but it does not include any other deicing levels. There shall be a note of the restriction on this qualification if some of the duties are not performed as mentioned. The driver shall receive training covering relevant parts mentioned in the standard teaching plan. Also, where relevant, local procedures shall be taken into account and emphasized more than others.

Recommended times are in Appendix B.2 of this document. The practical part shall cover all types of vehicles and types of operation that can be in use, and it shall include an assessment. The length of training depends largely on the type of operation and number of different vehicles, but practical training shall not be shorter than the theoretical part. Local settings may demand more/less extensive training, and the recommendations given here are not binding. The qualification must be renewed annually, with a theoretical part including a written exam. All new equipment and operational changes require practical training as well.

4.5 Deicing Operator, DI-L20

The deicing operator qualification (DI-L20) includes the preflight contamination check (check for the need to deice the aircraft), performance of deicing/anti-icing treatment, and the post deicing/anti-icing check. This level of qualification includes driving the deicing vehicle (DI-L10) and the pre/post deicing inspector qualification level (DI-L30B). There shall be a note of restriction to this qualification if some of the duties are not performed as mentioned. The deicing operator shall receive training covering in detail all parts mentioned in the standard teaching plan (except coordination and instructional procedures). Where relevant, local procedures shall be taken into account and emphasized more than others (e.g., some airports perform only centralized deicing, and some perform a mixed gate and centralized operation).

Recommended times are in Appendix B.2 of this document. It is recommended that the practical part be adapted according to local requirements and operational needs. A qualified instructor shall assess the practical part with the trainee performing "a demonstration of skill" during actual deicing/anti-icing treatment of an aircraft. Prior to practical assessment, the trainee shall receive sufficient practical training in order to be able to perform deicing/anti-icing in a safe manner. The qualification must be renewed annually with a theoretical part including a written exam. All new equipment and operational changes may require additional practical training as well.

4.6 Deicing Supervisor, DI-L30

This level of qualification includes the performance of the post deicing/anti-icing check, driving the deicing vehicle (DI-L10) and the deicing operator qualification (DI-L20). There shall be a note of restriction to this qualification if some of the duties are not performed as mentioned. The person supervising the deicing/anti-icing and performing the required checks shall receive training covering relevant parts mentioned in the standard teaching plan. Local procedures shall be taken into account and emphasized more than others where relevant.

Recommended times are in Appendix B.2 of this document. This training is similar to that for the DI-L20 qualification, and there is therefore no need to hold two separate courses in order to be qualified for both levels. Local settings may demand a more extensive training, and these recommendations are not binding. It is recommended that the practical part be adapted according to local requirements and operational needs. A qualified instructor shall assess the practical part with the trainee performing "a demonstration of skill" during actual operation involving an aircraft. The qualification must be renewed annually with a theoretical part including a written exam.

4.7 Pre/Post Deicing Inspector, DI-L30B

This level of qualification includes the Contamination Check (check for the need to deice the aircraft) and the pre/post deicing/anti-icing checks. This level is more limited than the DI-L30 and is only focused on duties to determine the need for deicing/anti-icing and the checking procedures. There shall be a note of restriction to this qualification if some of the duties are not performed as mentioned. The person determining the need for deicing/anti-icing and performing the required checks shall receive training covering relevant parts mentioned in the standard teaching plan. Local procedures shall be taken into account and emphasized more than others where relevant.

Recommended times are in Appendix B.2 of this document. Practical training for licensed technical staff (e.g., aircraft mechanics) is not required. Theoretical and practical parts can be combined where relevant. This training is similar to that for the DI-L30 qualification, and there is therefore no need to hold two separate courses if the initial training is for DI-L30. Local settings may demand a more extensive training, and these recommendations are not binding. It is recommended that the practical part be adapted according to local requirements and operational needs. A qualified instructor shall assess the practical part with the trainee performing "a demonstration of skill" (excluding above mentioned licensed technical staff) during actual operation on an aircraft. The qualification must be renewed annually with a theoretical part including a written exam.

4.8 Deicing Instructor, DI-L40

Training shall be conducted by personnel who have demonstrated competence in the deicing/anti-icing subjects to be instructed and who have the skills to deliver the training effectively. The instructor shall have received the proper training for a DI-L20 qualification, including the performance of deicing/anti-icing treatment, supervision of deicing/anti-icing (DI-L30), and driving the deicing vehicle (DI-L10). The instructor shall have proper training in instructional methods and sufficient knowledge of the training subject (e.g., aircraft critical areas and systems, fluid types, deicing vehicles, etc.). It is also recommended that the instructor attends or performs practical training and deicing/anti-icing of an aircraft on an annual basis in order to maintain necessary experience and knowledge. There shall be a note of restriction to this qualification if some of the duties are not performed as mentioned. The deicing instructor shall receive training covering all parts mentioned in the standard teaching plan. Local procedures shall be taken into account and emphasized more than others where relevant. There may be cases where specialists in a related field (e.g., a meteorologist, air traffic control staff, etc.) are used as instructors for a particular subject. These specialists do not need to be qualified in deicing/anti-icing.

Recommended times are in Appendix B.2 of this document. If the instructor has previously had basic practical training, there is no need for a practical part unless there are changes in the procedures or the operation. The training for deicing instructors should be considered to be held as a separate session. The length of this training may be adjusted according to local demands. Local settings may also demand a more extensive training and these recommendations are not binding. The deicing instructor is qualified to assess any demonstration of skill where needed. The qualification must be renewed annually, with a theoretical part including a written exam. The annual recurrent training will renew all previous qualifications (DI-L10 to 40).

4.9 Deicing Coordinator, DI-L50

The deicing coordinator qualification (DI-L50) entitles the person to coordinate and manage the deicing/anti-icing operation and/or work as a team leader. This qualification is intended for coordinating deicing/anti-icing operations mainly at remote and/or centralized deicing facility areas or for other similar/anti-icing coordination functions at an airport. The qualification includes the performance of deicing/anti-icing treatment (DI-L20), supervision of deicing/anti-icing (DI-L30), and driving the deicing vehicle (DI-L10). There shall be a note of restriction to this qualification if some of the duties are not performed as mentioned. The deicing coordinator shall receive training covering in detail all parts mentioned in the standard teaching plan. Local procedures shall be taken into account and emphasized more than others where relevant.

Recommended times are in Appendix B.2 of this document. Local settings may demand a more extensive training, and these recommendations are not binding. The training for deicing coordinators should be considered to be held as a separate session where topics are covered regarding the appropriate way of coordination, management, and/or team leadership. The basic part of the training can otherwise be held together with the deicing training (DI-L20). The length of this training may be implemented according to local demands. The qualification must be renewed annually with a theoretical part including a written exam. The annual recurrent training will renew all previous qualifications (DI-L10 to 30B and DI-L50) unless specified otherwise (e.g., limited level).

4.10 Fluid Quality Inspector (Laboratory Staff Only), DI-L60

The fluid quality inspector (laboratory staff) qualification (DI-L60) includes the performance of the quality control of fluids. The qualification shall include training covering related parts mentioned in the standard teaching plan. Local procedures shall be taken into account. International standards and auditing requirements regarding fluid quality shall be taken into account. Fluid brand procedures shall be noted. In some cases, this qualification can be included in DI-L20 if local procedures so demand. However, appropriate training for quality checks and procedures shall be performed in any case. Both theoretical and practical training shall be performed. Local settings may demand more extensive training, and these recommendations are not binding. The qualification must be renewed annually with a theoretical part including a written exam. Any new fluid or procedural requirements need special attention.

NOTE: This level is not limited to laboratory staff. Anyone else having this qualification level would be considered as having an additional qualification, but it is not a mandatory requirement for staff outside of the laboratory.

4.11 Head of Deicing Training, DI-L70

The Head of Deicing Training is responsible for the deicing training program. The Head of Deicing Training shall have sufficient knowledge in deicing/anti-icing operations and training to be qualified for this position. The Head of Deicing Training qualification covers all other levels of qualification (DI-L10 to 50) with DI-L60 optional if required locally or for personal knowledge. The qualification must be renewed annually and will be renewed automatically as long as the responsibilities remain with the same person. These responsibilities include keeping up to date with the latest recommendations and standards involving relevant deicing/anti-icing issues. The Head of Deicing Training shall have received deicing instructor training and shall have sufficient knowledge in basic instructional methods (e.g., train the trainer) for this level of qualification. An annual refresher course is recommended but keeping up to date with deicing industry news and operational elements, as well as preparing the training program (and/or acting as an instructor), is sufficient.

The Head of Deicing Training may also be the instructor and, therefore, previous deicing experience is strongly recommended. The company shall evaluate and approve the Head of Deicing Training for the task, and this approval shall be documented. It is the responsibility of the Head of Deicing Training to review all related standards and recommendations in order to have the most up-to-date information at hand. All material used for training shall be reviewed and approved by the Head of Deicing Training. All training sessions shall receive appropriate material content according to the particular qualification. Any company standard training material shall be under revision control, and appropriate standards and recommendations shall be referred to.

4.12 Flightcrew (Winter Operations), DI-L80

The flightcrew is not normally engaged in daily ground deicing/anti-icing procedures, but knowledge of the process should be in place. The flightcrew may have their own company training regarding winter operations. This training should cover all relevant aspects of the ground deicing/anti-icing process. This is an important factor in order to be able to communicate with the ground crew about proper treatment procedures and to have sufficient general knowledge of these subjects. The person responsible for deicing/anti-icing training for flightcrews is the Flightcrew Trainer. The Flightcrew Trainer should agree and verify the training with the Head of Deicing Training and operation. The qualification must be renewed annually with a theoretical part including an examination.

4.13 Cabin Crew (Icing Awareness), DI-L80B

Cabin crews are required to have training in the awareness of the effects of frozen surface contaminants and the need to inform the flightcrew of any observed surface contamination. The cabin crew is not normally engaged in daily deicing/anti-icing procedures, but an awareness of the process should be in place. The cabin crew may have their own company training regarding winter operations. The ability to identify icing on an aircraft is an important factor in order to be able to communicate with the flightcrew about any ice contamination before and during flight.

5. TRAINING SUBJECTS AND THEIR FIT WITH DEICING ROLES

5.1 Recommended Elements of Deicing Training

The elements listed here are for use as a reference only. It is up to the individual instructors to give each and every one of the deicing operations the relevant instruction which can be based on the following subjects. These subjects shall be explained and understood according to the level of importance that each operation demands. The recommended area of operation may differ between regions, and it is thus important that the instructor notes local requirements and selects the level of instruction accordingly. Depending on the qualification being trained, the listed subjects are intended to be introduced during training but not necessarily mastered in some cases, as some elements can be for general knowledge.

In order to obtain an overview of the essential aspects of aircraft ground deicing/anti-icing, there are several elements that need to be appreciated. These include:

- The requirement for aircraft ground deicing/anti-icing
- The practical methodology for aircraft treatment with deicing/anti-icing fluids
- Special aspects of aircraft ground deicing/anti-icing
- Communication and pre/post deicing/anti-icing check procedures

While each of these areas can be expanded into further topics to discuss, these broad headings show the flow of what must be taught. Firstly, there needs to be an appreciation of why aircraft deicing/anti-icing is vital and the regulatory requirements in place to reinforce this. Secondly, while there are a number of techniques available for aircraft deicing, by far the most common method is the use of fluids, which is also the only way to provide anti-icing. Lastly, there are a number of precautions, restrictions, and a need to learn from both any newer standards and guidance, plus findings from operational events and audits to enable continual improvement of the operations to take place.

5.2 The Fit Between the Recommended Elements of Deicing Training and the Deicing Roles

Table 1 shows the fit between a more detailed list of deicing/anti-icing aspects and the operational roles outlined in Section 4. However, it should also be appreciated that outside of the operational roles listed in the table, there are two other roles which will be involved.

- Senior management team: As this team has the accountability for the overall operation of the airport and aircraft safety, there is a requirement to ensure that there is up-to-date guidance, regulatory understanding, and operational learning embedded in the planning from winter to winter and is reflected in appropriate procedures and training programs.

- Head of Deicing Training: This person shall ensure awareness of any need for updating both their own skills plus any theoretical and practical training for all of the other roles in the organization.

- The different training subjects required to obtain the different functions are often the same. The differentiation will be made by adapting the duration of the training subject to the specific needs of the function.

Table 1 - Fit between recommended elements of deicing training and deicing roles

Recommended Elements for Training	Deicing (DI-) Qualification Level Reference									
	L10	L20	L30	L30B	L40	L50	L60	L70	L80	L80B
A. The requirement for aircraft ground deicing/anti-icing										
Basic knowledge of aircraft performance		X	X	X	X	X		X		
Effects of frozen contamination on aircraft performance		X	X	X	X	X		X	X	
The clean aircraft concept, regulations, and recommendations	X	X	X	X	X	X	X	X	X	
Meteorological considerations on ice formation		X	X	X	X	X		X	X	X
B. The methods for checking the aircraft for contamination										
Contamination Check (to establish the need for deicing)		X	X	X	X	X		X	X	X
Post Deicing/Anti-Icing Check		X	X	X	X	X		X	X	X
C. The practical methods for aircraft treatment with deicing/anti-icing fluids										
General techniques for removing frozen deposits from aircraft surfaces		X	X		X	X		X	X	
Deicing/anti-icing by fluids - procedures in general	X	X	X	X	X	X		X	X	
Basic characteristics of aircraft deicing/anti-icing fluids		X	X		X	X	X	X	X	
Types of fluid checks required and the equipment for this		X	X	X	X	X	X	X	X	
Deicing/anti-icing equipment operating procedures	X	X			X	X		X		
Fluid application and the use plus the limitations of Holdover Time (HOT) tables		X	X		X	X		X	X	
Communication procedures and deicing/anti-icing code	X	X	X	X	X	X		X	X	
Aircraft in general and common critical areas of surfaces and instruments	X	X	X	X	X	X		X	X	X
D. Special aspects of aircraft deicing/anti-icing operations										
Safety precautions and human factors	X	X	X	X	X	X	X	X	X	
Environmental impact and mitigation	X	X	X	X	X	X	X	X	X	
Deicing facility operation	X	X	X	X	X	X	X	X	X	
Learning from season operations, audit findings, and updated standards for next season		X	X	X	X	X		X	X	
Local rules and restrictions and airport procedures	X	X	X	X	X	X		X	X	X

6. TRAINING AND QUALIFICATION PROCESS

6.1 Theoretical and Practical Training, Annual Assessments, and Record Keeping

Only trained and qualified personnel shall carry out aircraft ground deicing/anti-icing procedures. Theoretical and practical skills training shall be conducted by qualified instructors/trainers who have demonstrated the skills to deliver the training and who have competence (knowledge, skill, and experience) in the subjects to be instructed. Assessments shall be conducted by persons who have appropriate knowledge, skills, and experience in the functions being assessed. Training shall be a combination of theoretical (suitable and sufficient information and instruction relating to the topic being trained) and practical skills training to verify the trainees' understanding of, and ability to complete, the task being trained. Changes to methods and processes shall be communicated to relevant personnel, and additional information and training shall be delivered as appropriate. Companies providing deicing/anti-icing services shall have both a qualification program and a quality control program to monitor and maintain the level of competence.

Attendance at training sessions shall be recorded and kept for verification of the qualifications of each person. Records of theoretical sessions and exams, as well as records of practical training and training while working (where applicable), must be retained for each person qualified. The record shall clearly show that instruction has been given and received with signed documents the usual evidence. A training schedule for each qualified person shall be maintained. The record shall identify the date when the particular subject matter was delivered to the trainee. The trainer shall sign or initial that the training has been delivered. The trainee shall, as an acknowledgement and understanding of the training, sign or initial the appropriate subject matter on the training record form. Training content and records shall be made available for review by an authorized air operator representative or regulatory authority. Where electronic or computer-based training record systems are maintained, the content shall include, as a minimum, the trainee's name, test mark achieved, date of training, and course reference. The same procedure shall be followed where contract deicing is used. Names, dates, and the scope of training must be clearly stated. Practical evaluation and demonstration of skills for ground crew personnel shall be performed as part of a ground crew training and qualification program.

The area of deicing training shall be divided into the following parts:

- Theoretical
- Practical
- Annual Recurrent

Initial qualification of deicing/anti-icing personnel shall be accomplished under strict supervision of a qualified individual by at least one of the following:

1. On live aircraft during live deicing/anti-icing operations – recommended/preferred method
2. By spraying on a mock-up surface/aircraft or deicing simulators that would simulate an actual live deicing/anti-icing operation

If trainees have satisfactorily completed all simulated practical evaluations and demonstrations of skills required as part of the training and qualification program, then they may participate in deicing/anti-icing operations under strict supervision of a qualified individual, until such time as the final qualification can be achieved.

For annual recurrent qualification:

The practical evaluation and demonstration of skills for normal equipment and operational methods is expected.

The practical training and demonstration of knowledge or skills where new equipment or operational methods are utilized is required.

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

Training programs must include a detailed description of initial and annual recurrent training and qualification concerning the specific requirements of the program and the duties, responsibilities, and functions detailed in the program. An ongoing review plan is advisable to evaluate the effectiveness of the deicing/anti-icing training received. The program shall have a tracking system that ensures all required personnel have been satisfactorily trained. Records of personnel training and qualification (see Figures 1 and 2) shall be maintained as proof of qualification. Where an individual has passed an examination but has not achieved a perfect grade, it is recommended that incorrect answers are reviewed with the individual to promote error-free learning. The training shall be divided into different groups according to levels of qualification and operational expertise.

AIRCRAFT DEICING/ANTI-ICING TRAINING ROSTER

Date________ Location________ Course Number________

Name	Employee Classification	Employee Number	Company	Station	Course Result	Training Hours	Remarks

EXAMPLE

Instructor (1) Name________ Signature________ Employee Number________	Instructor (2) Name________ Signature________ Employee Number________

Figure 1 - Aircraft deicing/anti-icing training roster

COURSEWARE DEVELOPMENT GUIDE

Aircraft Deicing/Anti-icing Training Program

INSTRUCTIONAL AIDS	TOPIC / MAJOR POINTS	NOTES / REFERENCES
	EXAMPLE	

Figure 2 - Aircraft deicing/anti-icing training program

6.2 Theoretical Elements - Standard Teaching Plan

From Table 1 in Section 5, it is evident that there are a number of areas under each heading that can be taught as separate modules. This allows the personnel who may need to appreciate the different aspects of deicing to only need to be involved in their relevant subjects. Tables 2 and 3 offer guidance on how sessions may be run. Reference is made to the appropriate documents to support each session.

Table 2 - Theoretical elements - standard teaching plan (sections A, B, and C)

Subject	Guidance Content (References)
Course Introduction (AS6286)	
TE1. Introduction	Trainer to introduce themselves. They will explain how they are qualified to train the subject, plus their experience. They will give an overview of the course content, the teaching method, and the requirement for a validation exam and pass mark
A. The requirement for aircraft ground deicing/anti-icing (AS6286 Appendix A)	
TE2. Basic knowledge of aircraft performance	Four forces that act on an aircraft. Airflow over and under the wings. Why an aircraft can take off. How lift is generated. The critical angle of attack. The aerodynamic window of operation. The biggest contributor to aircraft lift.
TE3. Effects of frozen contamination on aircraft performance	The effect of frozen contamination on lift and drag and the aerodynamic window of operation. The critical component areas for lift and maneuverability of the aircraft. The effect of a small layer of frost. Other effects of frozen contamination.
TE4. The clean aircraft concept, regulations, and recommendations	The "clean aircraft" concept. The regulatory requirements of various national authorities. The role of SAE International and the key global aircraft ground deicing standards. The main purpose of aircraft deicing and anti-icing.
TE5. Meteorological considerations on ice formation	General weather conditions and ice formation. Typical weather types leading to frozen contamination on the aircraft. Weather situations needing special attention. Weather conditions included in/excluded from the holdover time tables. Some forms of weather reporting. Effects of weather on airport operation.
B. The methods for checking the aircraft for contamination	
TE6. Contamination check (to establish the need for deicing)	How to examine the aircraft critical flight surfaces (wings, vertical stabilizer, horizontal stabilizers), top fuselage, undercarriage, nose radome, pitot-static orifices, angle of attack devices, windscreens.
TE7. Post deicing/anti-icing check	How to perform a post deicing/anti-icing check of the aircraft to make sure that no contamination (frozen deposits) remains after deice/anti-ice, the aircraft is clean and in proper condition for flight.
C. The practical methods for aircraft cleaning with deicing/anti-icing fluids (ARP1971, AS6285)	
TE8. General techniques for removing frozen deposits from aircraft surfaces	The various ways in which deicing can be carried out. The only way in which anti-icing can be carried out. The need to prepare equipment, procedures, and people. The areas of an aircraft to check for frozen contamination. Descriptions of one-step and two-step deicing/anti-icing.
TE9. Deicing/anti-icing by fluids - procedures in general	Critical aspects of deicing and the general process. Special care for composite wing deicing. The general process for using anti-icing fluids effectively. Use of Type I for anti-icing. The general use of Type II, III, and IV fluids.
TE10. Basic characteristics of aircraft deicing/anti-icing fluids	Why deicing/anti-icing fluids are the most usual way of deicing aircraft. The three safety requirements of deicing/anti-icing fluids. The differences between Type I, II, III, and IV fluids, and the colors of these. The unusual characteristics of anti-icing fluids and the precautions needed. The two ways to classify fluid performance. Incompatibility of certain types of fluids, e.g., EG & PG are not compatible with acetate or formate based fluids. Understanding of AMS1424/1 & /2 and AMS1428/1 & /2 and what is allowed to be applied to the aircraft per the manufacturer's Aircraft Maintenance Manual.
TE11. Types of fluid checks required and the equipment for this	The general handling and storage requirements of deicing/anti-icing fluids. The quality control checks to be performed on these fluids. Pumping, heating, and storage tank requirements.
TE12. Deicing/anti-icing equipment operating procedures	The variations of deicing vehicles, and the types of safety precautions to be taken. The operation of filling stations. Clear communications with the flightcrew. Equipment use, spray alternatives, and data collection. Basic vehicle components and safety equipment. **Refer to ARP1971.**
TE13. Fluid application and the use plus the limitations of holdover time tables	Details of the "clean aircraft" concept. The main areas of the aircraft to spray. The key aircraft areas to anti-ice. The purpose of holdover time (HOT) tables and how to read these. The difference between generic and fluid brand HOT tables. The importance of using the correct dilution when reading the appropriate HOT table.
TE14. Deicing/anti-icing codes and communication procedures	The anti-icing code/post deicing report. Communication to flightcrew with reference to **AS6285**. Operator/driver communication, two-way communication.
TE15. Aircraft in general and common critical surfaces and instruments	The critical aircraft surfaces to inspect. The precautions to take against clear ice. Critical areas not to spray. Understanding the use of the "no spray" diagrams in AS6286B (Revision B, dated 2016-11).

Table 3 - Theoretical elements - standard teaching plan (section D)

Subject	Guidance Content	Reference
D. Special aspects of aircraft deicing/anti-icing operations (ARP5660, AS6332, AS6286B [Revision B, dated 2016-11])		
TE16. Safety precautions and human factors	Safety assessment by hazard identification and risk management. Personal safety (contamination, working at height, etc.). Safety of others (contamination, struck by vehicle, etc.). Aircraft safety (damage prevention). Personal Protective Equipment (gloves, visors, clothing, etc.).	
TE17. Environmental impact and mitigation	Environmental impact and mitigation.	
TE18. Deicing facility operation	The need for special procedures for central deicing facilities and remote deicing facilities with reference to **ARP5660**.	
TE19. Learning from season operations, audit findings, and updated procedures.	Review of season operational performance with reference to **AS6332**. Review of any incidents, both local and in the industry. Review findings from internal and external audits as appropriate. Consolidate learning with updates to procedures and instructions for next winter season.	
TE20. Local rules and restrictions, airport procedures	Local procedures, permits, requirements, documentation, and operations. Compliance with all SAE Standards referenced.	

6.3 Theoretical Elements - Examination Process

The examination process contains a theoretical exam, for which a minimum passing score of 75% shall be required. The practical part (where applicable) only contains a pass/fail determination. Since 75% is a passing score for the theoretical part, this means that up to 25% may still be misunderstood. This "gap" shall be noted and wrong answers corrected with the trainee such that 100% understanding is achieved in order to secure a safe deicing operation. The written exam can be performed as an open-book exam so that pertinent holdover time tables and other data sources such as refractive index tables can be referenced. Normal deicing procedures should be basic knowledge, so there should not be any material available during the test explaining these subjects.

The examination for any particular course should be built so that all relevant subjects are covered by the questions. The level of difficulty per question should reflect the level of qualification and the relevance of the subject for that particular qualification. As a rule of thumb, a minimum of one question per subject relating to the qualification level should be included in the written exam. The minimum number of questions shall reflect the qualification level and may vary accordingly; however, this minimum amount should not be less than 15 questions (starting with the least demanding level of qualification/training hours). The theoretical examination shall be in accordance with national requirements and/or local regulations. The questions should be multiple choice containing a minimum of three possible answers per question. If there are differing procedures from normal deicing operations, then written answers can be used to explain this. The exam questions shall be periodically reviewed and updated to cover all current standards and regulations.

The Head of Deicing Training shall include the following elements in the training program:

- The questions should always be based on facts and not perceptions
- The question should not be misleading and should be clearly written such that it is not possible for it to be incorrectly interpreted
- Misinterpretations may lead to remembering the subject in an incorrect way
- The question series should cover all aspects of operation and include the local arrangements (if any)
- Evaluation should include oral quizzing where practical items are covered (e.g., reading holdover time tables and/or refractive index limits, etc.)

6.4 Practical Elements - Standard Teaching Plan

Upon the successful completion of the theoretical part of the training, practical training will need to be carried out at the airport. A standard teaching plan for this part of the training is shown in Tables 4 and 5. The following points shall be noted:

- The teaching plan shows most of the elements expected for practical hands-on training. However, this must also be subject to local management guidance, requirements, and resources.
- All elements in Tables 4 and 5 are applicable to DI-L10, DI-L20, DI-L40, and DI-L70. Any exceptions to this are noted in the appropriate element. These exceptions are noted for DI-L30, DI-L30B, DI-L50, and DI-L60.
- Most of the operations below require the use of a suitable deicing truck and aircraft.
- The timescale for most of these elements is open to allow for the development of the required level of skill for the trainee.

Table 4 - Practical elements - standard teaching plan, Part 1 of 2

Element		Content
PE1	Overview of deicing/anti-icing equipment and its operation plus facilities (e.g., storage tanks)	Deicing/anti-icing equipment, vehicle description (type, make, nozzles, guns, tanks, etc.). Vehicle operation. Safety features. Manual versus proportional mixing. Facilities. Storage requirements. Filling. Heating equipment (as applicable for engine ice removal).
PE2	Cab layout and operation	Pre-operation checks. Seat and mirror adjustment. Gear shift selection. Park brake. Heater and pump controls. Boom controls (if fitted). Communication and connections (headset). Start and stop procedures. Driving controls (wipers, lights, and indicators, etc.).
PE3	Deicing unit control panel	Start/restart/stop. Emergency stop procedures. System indicators. Switches.
PE4	Basket operation	Emergency stop procedures. Emergency boom lowering procedures. Harness attachment point(s) and harness use. Communications and connections (headset). Light switch operations. Pump delivery selection/pump override/pump operation. Anti-ice/deice and snow gun operation. Boom controls. Extend/retract/raise/lower/rotate. Personal Protective Equipment.
PE5	Auxiliary engine operation (if fitted)	Start/restart/stop/emergency stop procedures. Manual accelerator control. Fire extinguisher operation.
PE6	Fluid heater operation (if fitted)	Start/Shut down procedures. High flame/low flame indicators. No flow indicator. Low fluid indicator. Pump pressure gauge.
PE7	Ground hose operation	Position of hose. Operation of ground gun. Fluid flow rate.
PE8	Pre-Spray checks	All doors/hatches closed. All personnel clear. Aircraft configuration.
PE9	Communication (also, DI-L30, DI-L30B and DI-L50)	Communication with Flight Deck. Engineering (i.e., Aircraft Configuration). Anti-icing code/Post deicing report. Communication between driver and sprayer. Multiple vehicle operations, vehicle to vehicle Centralized operation. Coordination.
PE10	Vehicle positioning	Optimum positioning for spraying. Communication with operative. Driving safely around the aircraft.

Table 5 - Practical elements - standard teaching plan, Part 2 of 2

Element		Content
PE11	Vehicle safety around aircraft	Approaching aircraft (i.e., engines/anti-collision lights). Vehicle brake check. Vehicle height. Vehicle speed. Awareness of other ramp users. Accident/Incident reporting and safety reporting.
PE12	Fluid spraying	Critical surfaces. No-spray areas. Fluid temperature. Spraying distance (heat retention). Spray patterns (nozzle settings).
PE13	Other de/anti-icing procedures (also DI-L30B)	Pre-deicing treatments. Local frost prevention. Deicing engines, sensors, probes, etc. Related checks.
PE14	Driving the deicing truck	Maneuvering the vehicle. Handling characteristics. Emergency situations. Fault situation.
PE15	Deicing scenarios (where applicable)	Gate deicing. Remote/centralized deicing. Multiple vehicle deicing.
PE16	Emergency situations (clarify theoretical elements in practice) (also DI-L30)	Safety at work. Collisions and other accidents. Procedures and situations. Human Factor situations. Environmental control.
PE17	Quality checks (if applicable) (also DI-L60)	Fluids, limits, and reporting. Sampling. Measurement instruments and use. Filling station, fluid quality. Fluid delivery.
PE18	Contamination check (also DI-I30 and DI-L30B)	Different contaminations on the aircraft. Aircraft types. Clear ice checks, tactile check. Reporting/communication. Final release, anti-icing code. Safety elements, human factors.
PE19	Spraying and using hot air (practice as needed) (also DI-L30)	Fuselage, underwing, wing, and tail. Engine and propeller ice. Landing gear instruments.
PE20	Practical validation	Each trainee shall be able to demonstrate competence in: 1. Driving/positioning equipment/quality control and fluid handling/communication/reporting and/or spraying (as applicable)/pre-post check. 2. Trainees shall also be tested on the operation of the vehicle, in particular, safety aspects and features (as applicable). 3. Actual deicing/anti-icing operations on an aircraft (as applicable) shall be assessed before initial qualification and evaluated over a period of time (i.e., events), as applicable. 4. A verbal assessment of things learned during training shall be performed.

6.5 Practical Elements - Assessment Process

A practical assessment shall be performed as applicable for the qualification to be achieved. The practical assessment shall be performed in actual operational conditions involving an aircraft (as applicable) before initial qualification. Further evaluations may be performed as applicable for the local demands and/or company requirements. The practical assessment shall include a verbal assessment of the trained theoretical topics, as well as the practical parts trained. In order to have an "independent" evaluation, it is recommended that the assessment be performed by another qualified instructor rather than the instructor who has trained the trainee. The parts to be covered during the practical assessment shall include all of the material for the qualification level at hand. These are to demonstrate competence in (as applicable):

- Driving vehicles
- Positioning equipment
- Quality control and fluid handling
- Contamination check
- Post deicing/anti-icing check
- Communication
- Reporting and documentation
- Spraying
- No spray areas
- Local operational requirements

The trainees shall also be tested on the operation of the vehicle, in particular, its safety aspects and features. The practical assessment should focus on the most common operational aspects that are locally experienced, e.g., typical aircraft at the station and typical deicing/anti-icing operations. The training syllabus under 6.4 describes the practical training in more detail, and the assessment shall reflect those parts that were trained.

6.6 Training System and Records

6.6.1 Training System and Renewal

All training should be performed according to a pre-established training program. This program should include all levels of training and their relevant requirements. The theoretical part should be categorized according to the qualification, thus dividing the training sessions from each other. This training program will easily identify what course is leading to which qualification. This numbering system presented here does not need to be the same for every company but is a logical sequence to follow if desired. To remain qualified to perform certain deicing duties, annual recurrent training is required. An annual recurrent course should be presented as a training session that renews previous qualifications. This recurrent training does not have to be performed exactly or before the date of the previous qualification. A prior year's qualification remains valid for the beginning of the next deicing season but must be renewed before the year's end.

As an example: If a trainee was qualified on November 1, 2015, the qualification renewal shall be completed between November 1 and December 31, 2016. This date-range flexibility eases the burden of training large groups at the beginning of the deicing season. However, it is highly recommended that the training be performed as early in the season as practicable. Conducting training sessions before the beginning of the season is also an option for theoretical aspects.

Local regulation could overrule the end-of-year requirement.

NOTE: Initial and recurrent training courses:

Management (of the trainee's company) is responsible for the level of competence of staff attending courses. If employees are competent through continuous activity in deicing, they only require "refresher" training. If employees have a lengthy absence from practical activities (e.g., no active deicing was performed for two consecutive seasons), they would normally require initial or requalification training.

6.6.2 Records

Records shall be kept of all tests and scores, for both the theoretical exam and the practical assessment. A test record shall indicate the trainee, the qualification being sought, the date of the test, the evaluating instructor, and the score. A failed examination can be retaken, and this must be noted in the record. The evaluation process must lead to a qualification before the trainee shall be allowed to carry out the required role. Any restriction to a qualification shall be documented. A certificate should be given to the person to verify all training and qualifications. A copy of the certificate should be kept. All documentation for the current season should be kept easily at hand for verification by approved deicing staff. Records shall be retained in accordance with applicable timelines established by local regulatory, air operator, or organizational record retention requirements.

6.6.3 Quality of Training

Only trained and qualified persons shall perform deicing/anti-icing procedures. This applies to both ground and flightcrews. The deicing operator is responsible for performing, evaluating, and recording any and all training performed for company personnel and subcontractors, as well as developing and/or executing a training-quality program. Training subjects shall include those presented in Section 6. Both initial and annual recurrent training is required, including practical training where applicable. The training shall cover all relevant topics, and qualifications shall be issued to all trainees who pass the evaluations.

Material used for training shall be of the latest edition of any relevant standards and documentation, including customer manuals. A system of revision of manuals shall be established with the company concerned. Material used for reference or training only shall be marked accordingly.

A periodic quality review of the deicing/anti-icing training program shall be conducted and a training-quality program established. These should include a method of evaluating and monitoring the effectiveness of the deicing/anti-icing training delivered. Various measures of trainees' successful completion of their evaluations may be employed (e.g., score trends; percentage of first-try passes; re-takes and additional training required, etc.). Training records described in 6.6.2 should be maintained in a manner that ensures that they are easily retrievable by persons responsible for executing these program-quality reviews.

6.7 Computer-Based Deicing Simulator (CBDS) Standards

As computer-based deicing simulator (CBDS) systems are commonly used as part of deicing/anti-icing training programs, this section identifies which components of CBDS systems may be used in lieu of, or as a part of, a particular training curriculum. Due to their current limitations, CBDS systems cannot fully replicate all aspects of deicing vehicle familiarity training, and thus, the use of CBDS systems shall not replace the requirement to perform hands-on training on the actual deicing vehicle type for training aspects not encompassed by a CBDS's capabilities.

In order to determine and qualify a particular CBDS's capabilities, the capabilities are defined by "Levels." Levels A, B, C, and D (ranked by generic purpose and by realism to full-scale replica) CBDS systems are defined, and deicing training capabilities shall be categorized based on the capabilities of each level of simulator. Tables 6 and 7 define the minimum capability requirements for each CBDS level. Table 8 defines training requirements that CBDSs may be used in place of or to complement. Once a CBDS has been evaluated and qualified, based upon the operational/functional requirements specified in Tables 6 and 7, and the CBDS level has been established, Table 8 may then be utilized to determine the components of a training program for which the CBDS may be used in place of traditional real-world practical training. Regardless of level, a CBDS system may be used to complement theoretical, practical, and deicing vehicle familiarity training. Where a CBDS system is designed based on a specific equipment manufacturer's vehicle type, this system can still be utilized to complement some elements of training where other equipment types may be utilized, as they have the capability to demonstrate generic deicing and anti-icing requirements. The evaluation and qualification of a CBDS system in order to determine the level category based upon minimum operational/functional requirements specified in Tables 6 and 7, and subsequent training capabilities in Table 8 as determined through Tables 6 and 7, shall be the collaborative responsibility of the CBDS manufacturer and end CBDS user owner.

Table 6 - CBDS minimum operational and functional requirements, Part 1 of 2

	CBDS Level				Remarks
Hardware Requirements	**A**	**B**	**C**	**D**	
Contains a computer system and associated hardware (keyboard, mouse/track pad, monitor, and sound system), capable of operating system to potential required.	X	X	X	X	
Contains an audio and visual system capable of meeting all the standards of this appendix.	X	X	X	X	
Contains a sound system (i.e., speakers, headset) that is capable of replicating primary and secondary sounds.	X	X	X	X	
Contains a visual system (i.e., monitors, displays, goggles) that is capable of displaying all pertinent scenery and surroundings, additional controls and inputs as required, and relevant data as required by the operator.	X	X	X	X	
Contains a visual system whereby the operator can adjust viewing angles and directions as required.			X	X	
Has a multi-monitor visual system or head-motion-controlled goggles to depict 3D realism.				X	Optional
Contains a suitable workstation/platform to support the placement of equipment required to operate CBDS.	X	X	X	X	
Contains a seat position for operator.	X	X	X	X	
Contains a seat position for an instructor, in close proximity to the operator (either within workstation or adjacent to).	X	X	X	X	
Contains controls to simulate fluid application including nozzle and/or joystick (open bucket or enclosed cab types) and has capability to adjust between various nozzle settings.	X	X	X	X	
Contains controls to select between fluid types.	X	X	X	X	
Contains controls to simulate boom elevation/lowering, extension/retraction, spray arm extension/retraction, and basket/cab rotation.	X	X	X	X	
Contains full scale replica of equipment controls/joysticks, switches, and other devices as found in equipment type represented.			X	X	Controls provided by OEM manufacturer
Controls oriented and located relative to actual location found in equipment type represented.		X	X	X	Controls provided by OEM manufacturer
Controls feel dynamics which replicate the vehicle simulated.			X	X	Controls provided by OEM manufacturer
Control inputs shall mimic the logic and result in the same manner as found in the equipment type represented (e.g., "dead-man pedal," etc.).		X	X	X	Controls provided by OEM manufacturer
Contains an operating cab/basket position.	X	X	X	X	
Contains a driver position (not necessary for one person operation from the operating cab/basket position).			X	X	
Has the capability to network between multiple CBDS systems and display real-time activity of the primary and secondary users during a scenario/exercise.		X	X	X	Optional
Has a motion system that physically maneuvers the operating cab/basket platform amongst multiple degrees of freedom (3 or 6). Areas simulated include all vehicle centrifugal motions, and can also include wind, jet blast, and collision.				X	Optional

Table 7 - CBDS minimum operational and functional requirements, Part 2 of 2

Software Requirements	A	B	C	D	
Contains a computer system and associated software (CPU, graphics card, sound card, etc.), capable of operating system to potential required.	X	X	X	X	
Computer capacity, accuracy, resolution, and dynamic response sufficient for the qualification level sought.	X	X	X	X	
Real-time, in-the-loop simulation.		X	X	X	
Has the capability to network between multiple CBDS systems and display real-time activity of the primary and secondary users during a scenario/exercise.		X	X	X	Optional
Capable of setting predetermined scenarios.		X	X	X	
Capable of setting up individual operator login and password in order to track progress.		X	X	X	
Capability of recording participant activity for later playback and evaluation.			X	X	
Contains visual replica of operating cab/basket.		X	X	X	
Contains all relevant instrumentation and indications as on equipment, including lighting.			X	X	
Equipment depicted shall act and appear as equipment type represented.			X	X	
Motions associated with maneuvering of any component shall be precise to specifications of the equipment type represented (i.e., turning radius, operating height, etc.).			X	X	
Motion (force) cues perceived by the operator representative of the vehicle motions.		X	X	X	
Depicts ground maneuvering operating characteristics of equipment type represented, including motion when of parts and equipment when brought to a stop, deceleration, braking, and turning radius.		X	X	X	
Depicts boom/basket/spray arm maneuvering operating characteristics of equipment type represented.		X	X	X	
Contains any associated requirements applicable to the equipment type represented.		X	X	X	
Contains primary sounds, such as engine noise, ambient noise, vehicle component noises (boom, wipers, forced air blower, etc.), aircraft engine/APU noise, precipitation, wind noise, etc.		X	X	X	
Contains secondary sounds, including applicable equipment alarms, and warnings (i.e., spraying of a no-spray area), proximity sensor contact, and crash.		X	X	X	
Contains realistic aircraft with general permissible spray areas and no-spray areas.	X	X	X	X	
Accurately depicts permissible spray areas and no-spray areas specific to the aircraft type selected. Should a no-spray area be directly sprayed at, indicates a warning to the Operator.		X	X	X	
Depicts aircraft contamination and is removable once fluid applied.	X	X	X	X	
Accurately depicts various forms of aircraft contamination and contamination amount and type is adjustable.			X	X	
Demonstrates removal of contamination once fluid is applied.	X	X	X	X	
Accurately depicts the way in which deicing and anti-icing fluid moves through the air, flows across the surfaces of aircraft, and exchanges heat with the air, contaminates, and aircraft surface.			X	X	
Demonstrates removal of contamination using forced air (where equipped).	X	X	X	X	Optional
Accurately depicts the way in which forced air flows, including velocities, and removal of contamination relative to dispersion angle.			X	X	Optional
Contamination removable is variable, dependent on the quantity of fluid applied and the quantity of contamination present.			X	X	
Shows effects of winds (including cross wind, high wind speeds, and gusts), precipitation type and intensity, fog, and jet blast/prop wash (where engines-on deicing is simulated).			X	X	
Shows special effects associated with aircraft de/anti-icing, i.e., collision, braking, bumps, jet blast (both exhaust plumes and effects of maneuvering within).			X	X	
Outside air temperature is displayed and is adjustable.			X	X	
Fluid temperature is displayed, and visual cues (steam) are present where fluid is heated.			X	X	
Fluid quantities are displayed.			X	X	
Time from start of simulation scenario is displayed and tracked.		X	X	X	
Daylight/darkness capability, with artificial and non-artificial lighting.			X	X	
Scenery showing generic deicing location and common airport surroundings and fixtures.		X	X	X	
Scenery showing precise site-specific deicing location and specific airport surroundings and fixtures.			X	X	Optional
Scenery showing static positioned in proximity to a live aircraft, whereby precise equipment movement simulation is required in order to prevent conflict.			X	X	Optional

Table 8 - CBDS training capabilities

Training Capabilities	CBDS Level				Remarks
	A	B	C	D	
Check of critical surfaces.		X	X	X	Generic aircraft representation.
Deicing fluid application techniques and requirements.	X	X	X	X	
Forced Air deicing techniques and requirements.	X	X	X	X	Where equipped.
Anti-icing fluid application techniques and requirements.	X	X	X	X	
Contamination removal techniques dependent on type and amount.	X	X	X	X	
Vehicle maneuvering.		X	X	X	Recommend being combined with real world hands-on training on actual equipment.
Vehicle patterns applicable to aircraft type/code/group.		X	X	X	
On-gate/stand deicing.		X	X	X	
CDF/DDF deicing.		X	X	X	Recommend site specific scenery be included to represent local requirements.
Deicing in adverse conditions (i.e., night, low visibility, high winds, etc.).			X	X	
Engines running deicing.			X	X	Where performed.
Propeller aircraft deicing.			X	X	Where performed and a propeller aircraft must be included in the CBDS aircraft library.
Aircraft familiarization, including location of no-spray areas, and different operating procedures/requirements.		X	X	X	Recommend complementing with real world hands-on training. Recommend a variety of aircraft be included in the CBDS aircraft library.
Communications - cab/basket operator to driver operator; operator to deicing coordinator and/or operator to aircraft.	X	X	X	X	An instructor presence is required unless system can accurately simulate interactive communication.
Multiple vehicle deicing.		X	X	X	Networking capability required.
Post de/anti-icing check requirements.		X	X	X	
Tactile check (based on aircraft type and locations on aircraft).		X	X	X	Recommend complementing with real world hands-on training.
Deicing equipment familiarity and basic safety guidelines.			X	X	Recommend complementing real world hands-on training.

7. LANGUAGE PROFICIENCY RATING SCALE

This section describes the requirements for determining English language proficiency that shall be used to communicate applicable deicing/anti-icing information in the English language. Where this is a requirement, personnel shall, at a minimum, meet the equivalency of a Level 4 Operational rating, as specified in the *ICAO "Language Proficiency Rating Scale"* shown as Figures 3 and 4. This scale is taken from *Appendix A of ICAO Doc. 9835 AN/453, Manual on the Implementation of ICAO Language Proficiency Requirements, First Edition, 2004*. Further information pertaining to these requirements can be found in that document.

1.1 Expert, Extended and Operational Levels

Level	PRONUNCIATION Assumes a dialect and/or accent intelligible to the aeronautical community	STRUCTURE Relevant grammatical structures and sentence patterns are determined by language functions appropriate to the task	VOCABULARY	FLUENCY	COMPREHENSION	INTERACTIONS
Expert 6	Pronunciation, stress, rhythm, and intonation, though possibly influenced by the first language or regional variation, almost never interfere with ease of understanding.	Both basic and complex grammatical structures and sentence patterns are consistently well controlled.	Vocabulary range and accuracy are sufficient to communicate effectively on a wide variety of familiar and unfamiliar topics. Vocabulary is idiomatic, nuanced, and sensitive to register.	Able to speak at length with a natural, effortless flow. Varies speech flow for stylistic effect, e.g. to emphasize a point. Uses appropriate discourse markers and connectors spontaneously.	Comprehension is consistently accurate in nearly all contexts and includes comprehension of linguistic and cultural subtleties.	Interacts with ease in nearly all situations. Is sensitive to verbal and non-verbal cues and responds to them appropriately.
Extended 5	Pronunciation, stress, rhythm, and intonation, though influenced by the first language or regional variation, rarely interfere with ease of understanding.	Basic grammatical structures and sentence patterns are consistently well controlled. Complex structures are attempted but with errors which sometimes interfere with meaning.	Vocabulary range and accuracy are sufficient to communicate effectively on common, concrete, and work-related topics. Paraphrases consistently and successfully. Vocabulary is sometimes idiomatic.	Able to speak at length with relative ease on familiar topics but may not vary speech flow as a stylistic device. Can make use of appropriate discourse markers or connectors.	Comprehension is accurate on common, concrete, and work-related topics and mostly accurate when the speaker is confronted with a linguistic or situational complication or an unexpected turn of events. Is able to comprehend a range of speech varieties (dialect and/or accent) or registers.	Responses are immediate, appropriate, and informative. Manages the speaker/listener relationship effectively.
Operational 4	Pronunciation, stress, rhythm, and intonation are influenced by the first language or regional variation but only sometimes interfere with ease of understanding.	Basic grammatical structures and sentence patterns are used creatively and are usually well controlled. Errors may occur, particularly in unusual or unexpected circumstances, but rarely interfere with meaning.	Vocabulary range and accuracy are usually sufficient to communicate effectively on common, concrete, and work-related topics. Can often paraphrase successfully when lacking vocabulary in unusual or unexpected circumstances.	Produces stretches of language at an appropriate tempo. There may be occasional loss of fluency on transition from rehearsed or formulaic speech to spontaneous interaction, but this does not prevent effective communication. Can make limited use of discourse markers or connectors. Fillers are not distracting.	Comprehension is mostly accurate on common, concrete and work-related topics when the accent or variety used is sufficiently intelligible for an international community of users. When the speaker is confronted with a linguistic or situational complication or an unexpected turn of events, comprehension may be slower or require clarification strategies.	Responses are usually immediate, appropriate, and informative. Initiates and maintains exchanges even when dealing with an unexpected turn of events. Deals adequately with apparent misunderstandings by checking, confirming, or clarifying.
Levels 1, 2 and 3 are on subsequent page						

Figure 3 - Language proficiency table, Part 1

1.2 Pre-Operational, Elementary and Pre-elementary Levels

Level	PRONUNCIATION Assumes a dialect and/or accent intelligible to the aeronautical community	STRUCTURE Relevant grammatical structures and sentence patterns are determined by language functions appropriate to the task	VOCABULARY	FLUENCY	COMPREHENSION	INTERACTIONS
Levels 4, 5 and 6 are on preceding page						
Pre-operational 3	Pronunciation, stress, rhythm, and intonation are influenced by the first language or regional variation and frequently interfere with ease of understanding.	Basic grammatical structures and sentence patterns associated with predictable situations are not always well controlled. Errors frequently interfere with meaning.	Vocabulary range and accuracy are often sufficient to communicate on common, concrete, or work-related topics, but range is limited and the word choice often inappropriate. Is often unable to paraphrase successfully when lacking vocabulary	Produces stretches of language, but phrasing and pausing are often inappropriate. Hesitations or slowness in language processing may prevent effective communication. Fillers are sometimes distracting.	Comprehension is often accurate on common, concrete, and work-related topics when the accent or variety used is sufficiently intelligible for an international community of users. May fail to understand a linguistic or situational complication or an unexpected turn of events.	Responses are sometimes immediate, appropriate, and informative. Can initiate and maintain exchanges with reasonable ease on familiar topics and in predictable situations. Generally inadequate when dealing with an unexpected turn of events.
Elementary 2	Pronunciation, stress, rhythm, and intonation are heavily influenced by the first language or regional variation and usually interfere with ease of understanding.	Shows only limited control of a few simple memorized grammatical structures and sentence patterns.	Limited vocabulary range consisting only of isolated words and memorized phrases.	Can produce very short, isolated, memorized utterances with frequent pausing and a distracting use of fillers to search for expressions and to articulate less familiar words.	Comprehension is limited to isolated, memorized phrases when they are carefully and slowly articulated.	Response time is slow and often inappropriate. Interaction is limited to simple routine exchanges.
Pre-elementary 1	Performs at a level below the Elementary level.	Performs at a level below the Elementary level.	Performs at a level below the Elementary level.	Performs at a level below the Elementary level.	Performs at a level below the Elementary level.	Performs at a level below the Elementary level.

Figure 4 - Language proficiency table, Part 2

NOTE: The Operational Level (Level 4) is the minimum required proficiency level for radiotelephony communication. Levels 1 through 3 describe Pre-Elementary, Elementary, and Pre-Operational levels of language proficiency, respectively, all of which describe a level of proficiency below the ICAO language proficiency requirement. Levels 5 and 6 describe Extended and Expert levels, at levels of proficiency more advanced than the minimum required standard. As a whole, the scale provides benchmarks for training and testing, and in assisting candidates to attain the ICAO Operational Level (Level 4).

8. CONTRACT DEICING/ANTI-ICING

8.1 General Training Recommendation

Many air operators use other service providers to perform their deicing/anti-icing operations. Training for contractor deicing/anti-icing services should include at least one of the following criteria in 8.2 through 8.4.

8.2 Training by Outside Contracted Party

A contract training program meeting the requirements of this document can be implemented.

8.3 Contractor Training Staff Competence

All contractors must meet AS6286 requirements and any approved program requirements of their clients.

The client is responsible for the assurance of competence post-training.

8.4 Management Plan

The air operator will develop, coordinate with other affected parties, implement, and use a management plan to ensure proper execution of its approved deicing/anti-icing program. The air operator's management plan shall identify the manager responsible for the overall deicing/anti-icing program and each subordinate manager. It shall describe each manager's functions and responsibilities, relative to properly managing the air operator's deicing/anti-icing program. To manage the overall QMS, refer to AS6332.

9. GUIDANCE FOR RUNNING DEICING TRAINING SESSIONS

9.1 General

This section is intended as a guide for instructors who are responsible for deicing training (either theoretical or practical), producing the relevant material, and evaluating the training processes. It is important that there is a training program established that all instructors follow. Deicing operations as a ground service may seem less important to emphasize, but this attitude should not be taken. Deicing operations have a direct impact on the safety of the flight, and the instruction should make this point very clear in all areas of the process. Deicing operators are all adults, and the teaching process should be directed to an audience with variable life backgrounds. The instructor should show consistency in teaching, instill high standards for the process, detect and correct unsafe habits, and show professionalism and knowledge of the subject. If the trainer is not interested in the subject, then the trainee will not take the process seriously. Even if the operational aspects may seem easy and manageable, a knowledge of all relevant items is needed to clarify the "what, why, and how" of the whole process. The main purpose of this training education is to help the deicing operator translate facts and knowledge into the required professional action.

9.2 The Learning Process

Learning is an individual process. Each trainee sees a learning situation from a different perspective. The knowledge required to perform deicing/anti-icing operations cannot be poured into the trainee's head; the trainee can only learn from individual experiences. The learning of a physical skill requires actual experience in performing that skill. Do not assume that something once told will be remembered instantly. The theoretical aspect needs "practice and drill" to be effectively learned. The trainees must be taught correctly from the beginning because it is much harder to "unteach" incorrect habits than to teach them anew. Normal individuals acquire most of their knowledge through sight and visual aids and far fewer just through listening. Thus, when teaching something that the trainee can see and hear (for both theoretical and practical training), most of the learning process will be achieved.

There is no room for trial and error in practical deicing operations. It is therefore a major responsibility for the instructor to organize demonstrations and explanations and to direct trainee practice so that the trainee has adequate opportunities to understand the interrelationship of the many kinds of experiences that have been taught and understood. Adults tend to have their own idea of many processes since they may have previous experiences in many related work areas. It must be made clear from the beginning that there cannot be any improvising when it comes to the safety of deicing operations. When the trainee is motivated to learn and has the opportunity to perform the skill learned, then it will become an understanding process of theory and practice, which are linked together.

The deicing/anti-icing training is an annual process. Every refresher training course should naturally include any changed procedures and should also provide a refresher of basic operational issues. Even if the deicing crews have some practical experience gained over the years, forgetting basic procedures is normal. That is why things not often used or covered in training are usually the things that are forgotten and should therefore be repeated in refresher training. It is also important to give meaningful examples for issues so they will be easier to remember and the trainee can adapt the knowledge in practice whenever needed.

9.3 The Teaching Process

The instructor should prepare each instructional session according to the level of the deicing qualifications (see Section 4). All aspects may be relevant to cover, but some issues can be more important for one group while other issues can be more important for another group. The training should be specific and not taught as a general subject. After the preparation, a presentation of the deicing procedure should be performed in a manner such that the trainees can remember the procedures in practical application. The review and evaluation of trainees' command of the procedures are performed with theoretical tests and practical assessments where applicable. A review and evaluation are always recommended because it is the only way to ensure that there are no misconceptions of deicing operations.

There are some elements that need to be noted when teaching deicing operations to a group with different background knowledge of aviation procedures (if they have any experience at all). The main thing is to have a good arrangement of material and procedures to be taught. The trainee should not have to find out procedures for themselves in basic training. Some guidance to remember is to keep the trainees motivated and informed, and to present all information consistently. It is important to identify mistakes and review the related issue to correct any misconceptions. The instructor should admit errors in teaching instead of trying to improvise if they do not remember. Elements about which the instructor is uncertain can be clarified later. Good human relations promote more effective learning.

English is not the native language in many cases, even though much of the material available is only available in English. It is the responsibility of the Head of Deicing Training to make available any relevant material. This material can be in any language, but the reference must be explained and covered in training. Deicing procedure material is not all that should be delivered. All pertinent information that has something to do with the entire deicing operation should be included (e.g., airport regulations, winter programs, customer requirements, etc.). All material should be distributed in basic training. Trainees in refresher training should receive all new information, but basic material should be available for easy access. There may be more than one instructor teaching the procedures, and in this case, an instructor briefing is recommended to clarify what is to be taught by whom (and the related material).

9.4 Teaching Methods

There are several ways to conduct deicing training. The instructional session depends on the group at hand. Deicing procedures are usually presented in a "lecture method," which is not always the most effective way. There are many elements that simply are not possible to teach in another way, but the interest of the group must be established. The lesson should be organized with an introduction, development, and conclusion. The trainees must be made aware of their responsibility and develop a receptive attitude toward the subject. The appearance and attitude of the instructor toward the subject is critical in giving trainees their first indication of the importance of deicing. The introduction should get the trainees' attention, motivate them, and give an overview of the area to be covered. In short, the introduction sets the stage for learning. When developing the lesson, the instructor must logically organize the material to show the relationships between the main points. There are many subjects that need to be explained which might not seem relevant at first but are important for an understanding of how deicing operations reflect these elements. Meaningful transitions from one point to another keep the trainees oriented and helps them understand how each issue relates to the deicing procedures. Examples of real cases are often used, and this has a good effect for showing "what if" scenarios. When concluding the training, it is important to focus on the main deicing procedures, providing a brief overview of the operation. An effective conclusion retraces the important elements of the lesson and relates them to the objective.

Although most of the subjects must necessarily be explained using a lecture method, a more effective alternative method is an "illustrated talk," where the instructor reflects the ideas to the trainees with the help of visual aids (pictures, films, etc.). Depending on the size of the group, a guided discussion method may be used. This method of instructing gets the trainees more involved, but the trainees should have some knowledge of the subject in order to make the lessons productive. Some subjects can be taught by demonstration-performance methods (such as ice/frost formation, refractive index tests, etc.), and this technique can be a healthy change from the theoretical part. Case studies can also be used for some subjects (such as vehicle incidents, aircraft icing, etc.) to cover lessons learned and encourage a brief discussion of the importance of deicing. Human factors are an important element of the training since case studies may give a valuable insight into the real operation that may perhaps otherwise be overlooked.

The teaching of instructors may be easier in the sense that they have previous knowledge, and the emphasis can be set on issues more important and relevant for their particular operation. It is important to cover the basic ideas of correct deicing operation and set standards, according to which all procedures are to be followed. After reviewing new and changed issues, a discussion of deicing procedures within the group may be a good way of retrieving information on how each person sees a particular procedure. It may be that information of correct deicing procedures has changed down the line, particularly in large companies when instructors train others. All misconceptions must be corrected, and emphasis on approved procedures shall be made. This can also be the case when teaching subcontractors and their trainers. The problem may be that control of proceedings is not as good within a subcontracted company as in the main company. For subcontractor trainers, it is important that the correct procedures are understood, and the training elements are covered, since there may not be any further control of instruction.

9.5 Instructional Aids

Instructional aids should be used whenever possible while teaching deicing subjects because the material is in large provided as a lecture. Getting and holding trainees' attention is essential to learning. The instructor should present an overview of the material before distributing or showing the related subject material. The use of any instructional aids should be planned and fit in for a specific subject. Pictures, films, examples, and related tools can be used. There is a large amount of related material available for deicing, standards and recommendations, vehicle and aircraft documentation, videos, etc., and the material should not be unfamiliar to the instructor. Instead of simply distributing the material, an explanation of the content should be provided. It must therefore be clear to the instructor what the film or printed material contains in order to explain it correctly. This is especially so when using material that originates from outside of the company. Note that there are many old films and pictures of deicing operations, and their use is not recommended unless they still present the subject correctly.

Computer-based Training (CBT) and presentation is a modern way of teaching that also gets the trainees' attention. However, computers and their deicing programs are not available everywhere. Computer-based instruction must be presented in a manner that is understandable for the trainee. If "self-study" programs are available for deicing, then a briefing should be held on the subjects so that the content is correctly read and understood. CBT programs can be a helpful aid to reinforce something already presented. However, one caution is that any additional study program can also be harmful if English is the instructional language but the trainee lacks sufficient understanding of all terms and directions. Whenever using copied material, videos, CBT-programs, etc., it must be made clear what the current procedures are and what information is only for reference.

9.6 Evaluation

The training program must contain procedures of training and evaluation. The evaluation process must be considered when building up the time schedule for training. It must be made clear to trainees in the beginning that deicing training contains an evaluation process. This may motivate the trainees to be more active toward the subjects. The evaluation does not benefit safety when it is introduced by surprise. Theoretical evaluation is performed with exams, and practical evaluation can be performed by an assessment of operation. Note that a good debriefing can clear up misconceptions better than simply failing or approving trainees. Evaluation of the deicing training is one last process during which misconceptions can still be corrected. It is very important that the evaluation benefits the trainee as well as the deicing operation. The ultimate goal of the training process is to result in safe deicing operations.

10. NOTES

10.1 Revision Indicator

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

PREPARED BY SAE G-12T TRAINING AND QUALITY PROGRAMS COMMITTEE

APPENDIX A - THEORETICAL ELEMENTS GUIDANCE CONTENT

A0 TE0: AN INTRODUCTION TO THIS APPENDIX

The purpose of AS6286 Appendix A is to outline the principles and methodology of aircraft ground deicing. This document has been written to support the needs of training as defined in Tables 2 and 3 of the main AS6286 document. It does not seek to repeat or reinterpret the operating methods and instructions that are to be found in other SAE aircraft ground deicing standards, rather it seeks to fill in the concepts and accepted approach to aircraft safety during winter weather when there is the potential for aircraft safety to be lower due to frozen contamination. These other key aircraft ground deicing standards are:

AS6285	Aircraft Ground Deicing/Anti-Icing Processes
AS6332	Aircraft Ground Deicing/Anti-Icing Quality Management
ARP1971	Aircraft Deicing Vehicle - Self-Propelled
ARP5660	Deicing Facility Operational Procedures

NOTE: As AS6286 Appendix A is not an instruction for aircraft deicing processes or procedures, in the case of any conflict between the advice given here and these other standards, the other standards take precedence.

A1 TE1: TRAINER AND COURSE INTRODUCTION

At the end of this section, the trainee should understand in detail:

- The name and background of the trainer
- The way in which the trainer has been qualified to do the training job and also approved by senior managers to do this training as part of their commitment to safety for the airport operation
- An overview of the content of the training course, the way in which it will be taught, the schedule of the training session and any breaks that have been built into the day
- The requirement for a final exam and the achievement of a suitable pass mark

A.1.1 The Trainer

Aircraft deicing trainers are likely to be very experienced in carrying out aircraft deicing and so senior members of any airport operations team. However, training others in the safe and efficient ground deicing of aircraft requires a very different set of skills - planning, managing time, managing course content, managing people, checking for understanding, etc. Some ideas of the fundamentals of training are included in the main AS6286 document in Section 9. A suggested schedule of training is shown in Tables 2 and 3 of AS6286. The rest of this AS6286 Appendix outlines the essential content expected for Tables 2 and 3 and supports the more process and instructive elements in the other SAE Standards with which the trainer should be familiar.

SECTION A: THE REQUIREMENT FOR AIRCRAFT GROUND DEICING/ANTI-ICING

A.2 TE2: BASIC KNOWLEDGE OF AIRCRAFT PERFORMANCE

At the end of this section, the trainee should be able to describe in detail:

- The four forces that act on an aircraft
- Airflow over and under the wings, and the pressures on the wings
- Why an airplane can take off
- How lift is generated
- The critical angle of attack
- The aerodynamic window of operation
- The biggest contributor to airplane lift

A.2.1 How Planes Take Off and Fly

Airplanes can fly because they are able to efficiently manage four forces acting on them. When these are balanced, the airplane can fly straight and level.

Figure A1 - The four forces that act on an airplane

a. Weight: the weight of the airplane due to gravity

b. Lift: a force primarily derived from the wings that can overcome gravity

c. Thrust: a force required to generate lift and overcome drag

d. Drag: the forces that are acting to hold back the airplane

However, to get an airplane into the air, it needs to lift off from the ground and climb to its cruise height. The key to understanding aerodynamics is to understand how lift is generated by the wings from the applied thrust. Airplanes on level ground will usually have their wings tilted slightly upward. As they accelerate down a runway, air flows under and over the wings. As a result of this, the air below the wing is compressed and is higher in pressure, and the air above the wing is expanded and has a lower pressure. The combination of these two effects leads to enough lift to overcome both the weight and drag of the aircraft, which then takes off. A simple picture is shown in Figure A2, showing the **airfoil** shape of the wing cross-section. In summary, for an airplane to take off, the **lift** generated by the airplane must be greater than the **weight** and **drag** of the airplane.

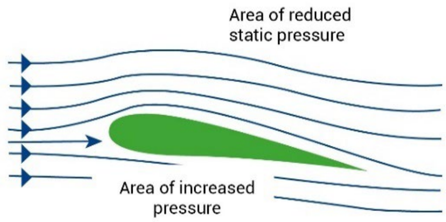

Figure A2 - Flow of air over an airfoil

A.2.2 How Lift is Generated

To have a better understanding of lift, a further idea needs to be added when describing the airfoil. The airfoil illustrated in Figure A2 is shown as tilted at an angle to the airflow. This tilt is referred to as the "**Angle of Attack**." The combination of thrust (speed) and the airfoil Angle of Attack then generates lift.

Lift needs **Thrust** (speed) plus **Airfoil Angle of Attack**

Physically, the combination of the speed and angle of attack is to divert airflow downward. By pushing air down, the wing itself is pushed up - lifted. This airflow is summarized in Figure A3, showing a smooth flow both above and below the wing. The important point is the deflection of air downward, causing the wing, and hence the airplane, to be pushed upward. The smooth (laminar) airflow is also required to ensure good lift (see Figure A3). Similarly, helicopters work by using a rotating wing (the rotors) to push air downward, causing the helicopter to go upward.

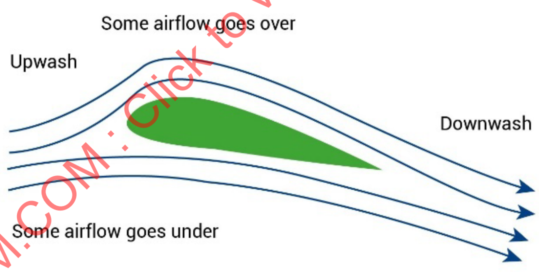

Figure A3 - Airflow around a wing

This reliance on the angle of attack is easy to show. Some airplanes (stunt fliers, for example) can fly upside down. This is done by maintaining the right angle of attack of the wing plus the required speed. Lift can be achieved in either orientation with the same wing.

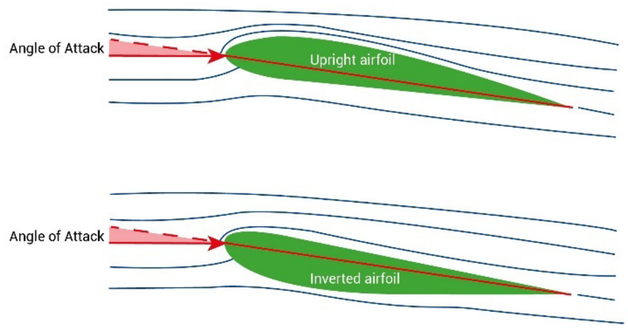

Figure A4 - Lift can be achieved with an airfoil in either orientation

A.2.3 The Limit of Using Angle of Attack to Generate Lift

However, there are limits to the amount of lift any airplane can generate. For a certain thrust (size of engine), the lift generated by an airfoil will increase as the angle of attack increases. Beyond a certain angle, the smooth (laminar) flow of air above the wing breaks down and becomes **turbulent**, destroying the lift effect. This critical angle at which lift becomes poor and drag increases too much is known as the **critical angle of attack**, leading to **aerodynamic stall**. An overall measure of generated lift (the coefficient of lift, C_L) is shown for typical airfoils in Figure A5.

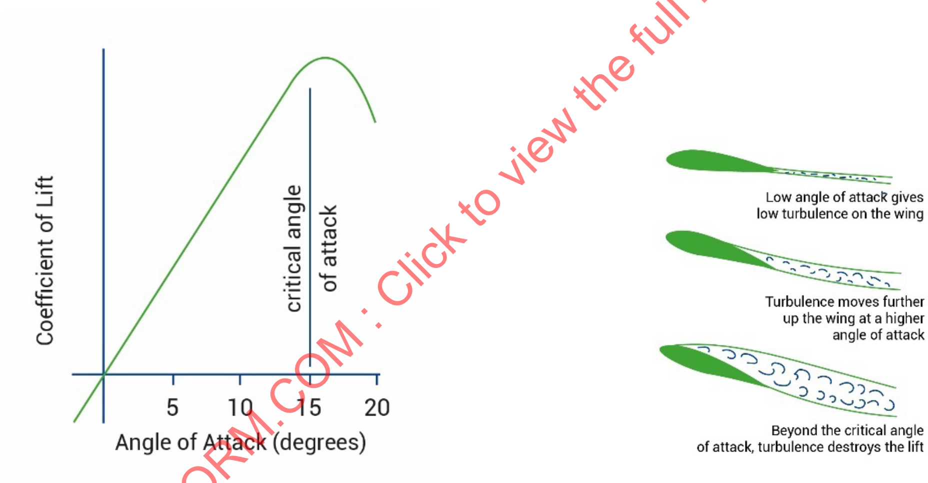

Figure A5 - Coefficient of lift and the angle of attack

There is one further important point to note from the above description of aerodynamic stall. While some air is pushed down by the higher pressure under the wing, it is the **top of the wing** that is the biggest contributor to airplane lift. Disruption of this flow of air over the top of the wing has the greatest impact in destroying lift. Referring to Figure A5, the loss of lift at an angle greater than about 16 degrees is shown only for the top surface. This is also why most additional equipment on airplane wings (engine mountings, ancillary fuel tanks) are located under the wings, rather than on top. For most airplanes, the top surface is kept smooth and uncluttered.

A.2.4 The Aerodynamic Operating Envelope

In addition to this aerodynamic Stall that happens due to a high angle of attack, the aircraft also stalls due to a low speed - this is called "**stall speed**." Essentially, the aircraft does not have enough thrust to gain lift from the wings. There is hence an **aerodynamic operating envelope,** which can be defined in terms of both aircraft speed and the angle of attack. These limits can be summarized as:

- The speed of the aircraft must be between the minimum required (**stall speed**) and the maximum at which the aircraft can safely operate, and
- The angle of attack must be between the minimum required to achieve lift and the maximum possible (limited by **aerodynamic stall**)

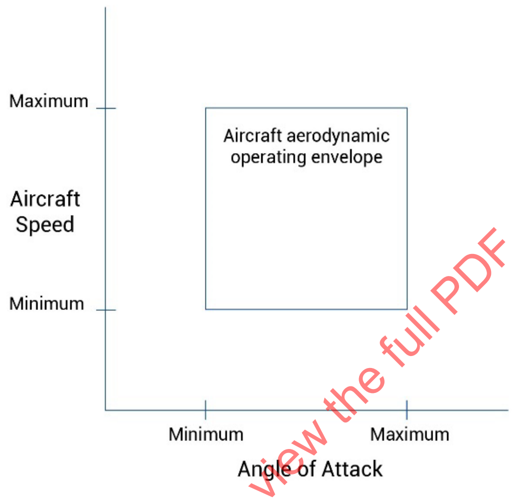

Figure A6 - Aerodynamic operating envelope

A.3 TE3: EFFECTS OF FROZEN CONTAMINATION ON AIRCRAFT PERFORMANCE

At the end of this section, the trainee should be able to describe in detail:

- The effect of frozen contamination on lift and drag of an airplane
- The effect of frozen contamination on the aerodynamic operating envelope
- The critical component areas for lift and maneuverability of an airplane
- How even a small layer of frost may affect lift, drag, and stall speed
- Other effects of frozen contamination on an airplane

A.3.1 General

This section explains how operating in winter conditions can affect aircraft performance. The basic concept will be introduced that any frozen contamination (ice, frost, slush, or snow) on aerodynamic surfaces affects the aerodynamic performance, and why the deicing ground crew should note any and all factors relating to the aerodynamic surfaces of the aircraft will be discussed. Subjects in this section are simplified to a large extent and further investigation would clarify issues in more detail, but this is not necessary for the deicing ground crew.

A.3.2 Frozen Contamination and the Effect Upon Aerodynamics

The specific performance of any aircraft is determined and certified with the assumption that all of its **aerodynamic surfaces are clean**. Any contamination will decrease this performance, and such a decrease in performance and control has not necessarily been assessed. The clean aircraft concept must be very clear for a deicing ground crew. The motto for winter operations is: “make it clean and keep it clean.”

Any ice on the wings of an airplane causes multiple detrimental effects:

- The airfoil surface becomes rougher, disrupting the smooth flow of air. This more turbulent air on top of the wing decreases lift dramatically. Just a small buildup of ice (e.g., frost) can reduce or destroy the lift.

- With the rougher surfaces of ice on the aircraft, there is also an increase in the drag forces.

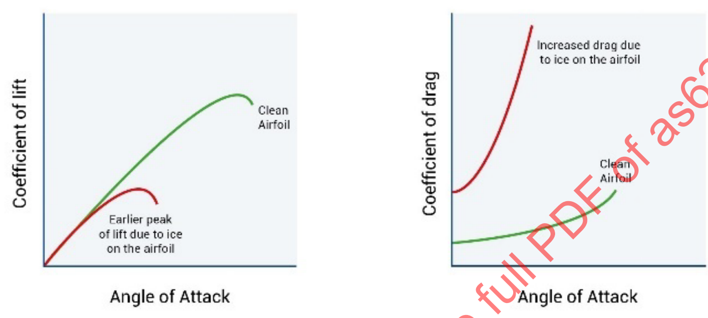

Figure A7 - Decrease in airfoil stall angle and increase in drag coefficient

The consequences of this frozen contamination on the aircraft performance are:

- Stall speed is higher, meaning that the airplane will stall at a higher speed than expected.

- Because the stall speed increases, the stall angle of attack decreases. Thus, an aircraft climbing after takeoff could unexpectedly stall at a “normal” climb angle of attack for a clean aircraft.

- Hence, the aerodynamic operating envelope is much smaller, leaving the pilot with fewer options for airplane performance and control.

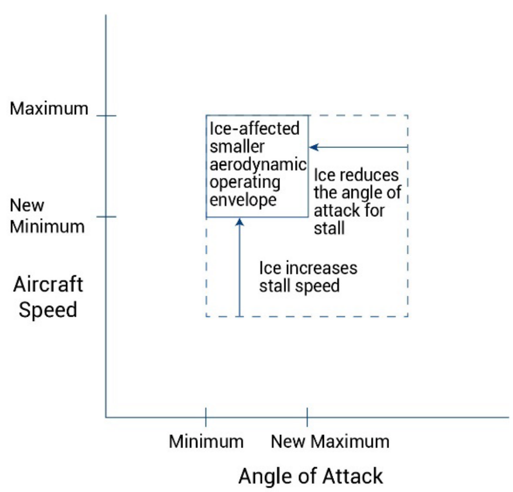

Figure A8 - The smaller aerodynamic operating envelope due to frozen contamination on the wings

A.3.3 Aircraft Icing

A.3.3.1 Ground Icing and Deicing/Anti-Icing

Icing of aircraft outer components on the ground is normally very obvious to observe due to the presence of snow, ice, slush, or frost. The way in which most aircraft are treated to remove and prevent frozen contamination on the ground is with deicing/anti-icing fluids to ensure that the aircraft is free of contamination at the point of takeoff.

A.3.3.2 In-Flight Icing

In-flight icing occurs when an aircraft flies through a cloud of supercooled droplets (not ice-particles), which then freeze onto the aircraft surface. This buildup of ice on the aircraft during flight can be quick or may be insidious, as the speed will bleed off as drag increases. Pilots need to be aware that they may be in a cloud of supercooled droplets which may cause ice accretion. In-flight icing is typically managed with onboard deicing/anti-icing systems, which are entirely different from deicing/anti-icing treatment for ground icing. Deicing/anti-icing treatment for ground icing does not protect against ice accumulation in flight. In-flight icing is not addressed further in this standard.

A.3.3.4 Frozen Contamination and Aircraft Components

The critical effects of frozen contamination are the resulting decrease in lift, increase in drag, and potentially limited maneuverability. The **leading edges of the wing and of the vertical and horizontal stabilizers** are the most critical areas with regard to the airflow around the aircraft. The leading edges are where the airflow becomes divided evenly around the wing surface (or tail surfaces). As the angle of a wing to the airflow (the angle of attack) is increased, the air flows smoothly along the surfaces at first (called laminar flow), but then after a certain point starts to break away (called turbulent flow), depending on the angle of attack for the specific wing design. Any contamination at the leading edge will upset the air flow, and it will become turbulent earlier than intended, reducing lift and increasing drag.

The aircraft moves around three axes: longitudinal, horizontal, and vertical. The flightcrew controls this movement by changing the position of the primary flight controls: ailerons, spoilers, rudder, and the elevator and horizontal tail, depending on the particular flight situation. Any frozen contamination on these control surfaces may restrict their movement or cause them to be less effective, and in worst case, can cause a loss of control of the aircraft.

Different aircraft are designed in different ways, but the basic lifting physics remain the same. Any part on the aircraft that changes the airflow is there for a reason, and the deicing ground crew must assure that these areas are free of contamination, whether they are identified as a critical lifting surface or not. Such other aerodynamic parts on an aircraft can be trailing-edge flaps, strakes, vortilons, winglets, pylons, stall strips or vanes, vortex generators, etc. However, it is crucially important to also make and keep clean the in-spar and aft regions of wings and tails (aft of the leading edges). Lowering leading-edge slats and trailing-edge flaps, for example, exposes different surfaces that were nested before and where contamination can also adhere. If slats and flaps are in a lowered position while the aircraft is on the ground, such areas shall be checked and cleaned, as necessary. Contamination on these parts will cause irregular airflow, which can cause performance or maneuverability problems when they are lowered in flight. In addition, stowing contaminated flaps and slats can cause structural damage to the surfaces.

The fuselage is not a critical lifting surface, but contamination shall be removed in the same manner as other surfaces. The main concern is that snow, slush, or ice will break off and damage the engine or aircraft surfaces that can cause a dangerous situation during takeoff. Another concern can be the additional weight of the contamination, which could affect takeoff performance such as field length. Light frost may be allowed on the fuselage in certain circumstances (must be able to read lettering, etc.), depending on the aircraft manufacturer's requirements, company procedures, and regulatory requirements.

The upper surfaces of the wings and tail are not the only areas to check and treat. The lower surfaces are also highly important. The wing lower surfaces shall be free of ice and snow, but frost may be allowed in some areas (typically the fuel-tank area), depending on the aircraft manufacturer's requirements, company procedures, and regulatory requirements. However, the horizontal stabilizer's lower surface shall be clean in all cases. The horizontal stabilizer is an inverted airfoil, so the lower surface is the lifting surface. It creates a lifting force either up or down depending on how the elevator (and tabs) is positioned. A tail "down force" is pronounced and essential for takeoff, and the horizontal tail shall therefore be verified as clean on both sides.

It is obvious that if an aircraft is covered with large amounts of snow, slush, or ice, it will affect lift and performance, but even "lighter" contamination that seems minor or insignificant to the eye, such as frost, can have a considerable negative effect. Even if the loss of performance is not enough on its own to cause an accident, safety margins can be reduced, so that if another problem arises, such as an engine failure, the combination of problems may be enough to transform an incident into a major accident. Any loss of performance will also cause the aircraft to use more fuel, but the main focus of this guide is on the flight safety consequences of contaminated aircraft surfaces, rather than other impacts.

A.3.4 The Effect of Frost on Lift

Tests have been performed on some aircraft of how different thicknesses of frost affect the lifting performance. The effect on other types of aircraft may be similar, but this particular example was studied to assess the performance of a narrow-body jet aircraft. Three configurations were compared: clean wing, a thin layer of frost (e.g., 1 mm or less), and a thick layer of frost (e.g., 1 to 2.5 mm). First, normal takeoffs with these configurations were compared, then takeoffs with an engine-out (loss of one of the main engines). Commercial jet airliners are fitted with powerful engines that in normal cases produce a certain amount of excess thrust. A thick layer of frost always has some effect on normal lifting performance. However, when there is an engine-out situation, even a thin layer of frost may have a notable effect on lift compared to a clean wing under these conditions. When there is a thick layer of frost during an engine-out on takeoff, lifting capabilities may be dramatically reduced. It must be noted that these situations may differ greatly between different aircraft, and in some cases, frost may even be allowed to some extent. Aircraft manufacturer limitations shall be noted in all cases.

A.3.5 Effects of Frost on Stall

Tests have also been performed on how different thicknesses of frost affect stall performance. This particular example was to assess the performance of a narrow-body jet aircraft. Each aircraft has a particular critical angle of attack when the wing stops lifting. This is called a stall. Below the stall angle of attack, higher angles of attack produce more lift, which is a phenomenon needed especially during takeoff and landing. When a thin layer of frost is on the wing, it reduces the maximum angle of attack by a certain amount, and the wing stalls earlier than anticipated, perhaps even without any stall warning. This scenario will also increase the drag of the wing, causing it to stall somewhat earlier than anticipated with the same takeoff angle. The same scenario can be seen with a thicker layer of frost, but in this case, the effect is even more dramatic. Due to these effects, usually no amount of frost is permitted on the wing upper surface for takeoff. Certain frost configurations may have been tested by the aircraft manufacturer and certified or otherwise approved by the regulatory authority as safe for flight. This atypical information should be in the aircraft flight manual.

A.3.6 Other Effects on Performance

As discussed above, contamination will affect the amount of drag of an aircraft, as well as lift. The more contamination there is on an aircraft, the more drag is produced, and thus the aircraft will have less performance than a clean aircraft. The contamination does not have to be on aerodynamic lifting surfaces (which must be cleaned anyway) to create drag, it can be on anything - the landing gear, fuselage, etc. These areas must be cleaned as well. If contamination exists on these components, thrust must be added (if excess thrust is available) to compensate for the reduced performance. This is perhaps most notable for propeller aircraft, which often do not have much excess thrust available for takeoff. The propeller is itself a lifting device, and its surface must be clean using the proper cleaning procedures according to the aircraft manufacturer's requirements. Any contamination of the blade surface can reduce the pulling force effectiveness of the propeller. Vibration of the propellers due to contamination may also be a factor. The same applies for jet aircraft - fan blades must be clean. A visual check of the fan blades, and especially on their rear side, is necessary to detect frozen contamination adhering to them. The presence of ice on fan blades can lead to vibration, performance loss, and even engine damage.

A.4 TE4: THE CLEAN AIRCRAFT CONCEPT, REGULATORY BODIES, AND RECOMMENDATIONS

At the end of this section, the trainee should be able to describe in detail:

- The "clean aircraft" concept
- The regulatory requirements of various regional authorities
- The role of SAE International and the key global aircraft ground deicing standards
- The main purpose of aircraft deicing and anti-icing

A.4.1 The Clean Aircraft Concept

Regulations governing aircraft operations in ground icing conditions shall be followed. The International Civil Aviation Organization (ICAO) Annex 6, Part I, mandates specific rules for the safe operation of aircraft during ground icing conditions, and all member states subsequently are required to have regulations in place to ensure this. In part, these state:

> *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 aircraft has been inspected for icing and, if necessary, has been given appropriate deicing/anti-icing treatment. Accumulation of ice or other naturally occurring contaminants shall be removed so that the aircraft is kept in an airworthy condition prior to takeoff.*

Paraphrased, these rules specify that no one may dispatch or take off an aircraft with frozen deposits on components of the aircraft that are critical to safe flight. A critical surface or 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. This is known as the "**clean aircraft**" **concept**.

A.4.2 Regulatory Requirements

The requirement to ensure that all aircraft are free of all frozen contamination at takeoff is enforced by the aviation authorities, including:

- The U.S. Federal Aviation Administration (FAA)
- Transport Canada (TC)
- The European Aviation Safety Agency (EASA)
- The Civil Aviation Administration of China (CAAC)

Guidance and advisory material are made available by the International Civil Aviation Organization (ICAO), the International Air Transport Association (IATA), and aircraft manufacturers such as Boeing and Airbus.

A.4.3 The SAE Aircraft Global Deicing Standards

SAE International publishes standards for the aviation industry. For aircraft ground deicing/anti-icing, the group that specifically deals with this area within SAE is the G-12 group. This group is composed of representatives from many different areas concerned with aircraft ground deicing, including:

- Aircraft manufacturers
- Air operators
- Air operator pilots

- Ground equipment manufacturers and operators
- Ground service providers
- Deicing/anti-icing fluid manufacturers
- Regulators
- Researchers
- Other interested parties

This group has developed and maintains documentation to provide advice on best practices, equipment, materials specifications, and fluid qualification test requirements for aircraft deicing/anti-icing. ICAO, SAE, and IATA worked together to simplify the many different sets of documents to be used within the industry and produce a series of guidance known as the Global Aircraft Ground Deicing Standards. While the total number of G-12 standards is around 25, the key documents that mainly apply to the practical aspects of aircraft ground deicing of are far fewer. These most important documents are shown in Figure A9.

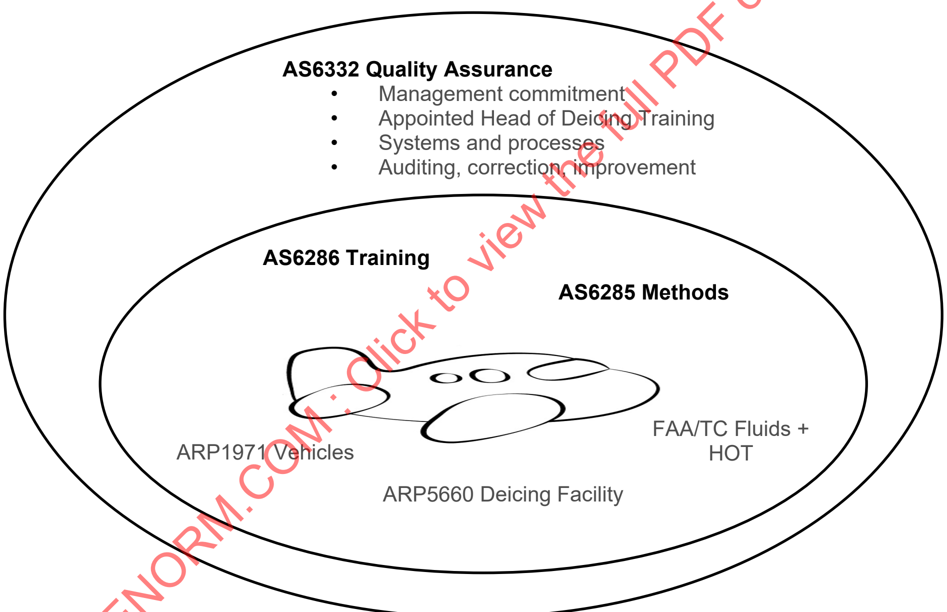

Figure A9 - The global aircraft ground deicing standards (shown in bold)

A.4.4 SAE Global Aircraft Ground Deicing Standards

There are three major SAE global aircraft ground deicing standards which are the result of a collaborative effort between the SAE, ICAO, IATA, and regulators. The three standards (identified here by their shortened titles) are:

- **AS6285: Methods**. This standard specifies the methods and processes to be used to ensure that aircraft are deiced and anti-iced effectively. This includes ensuring the quality of the deicing and anti-icing fluids to be used, the communications procedures between ground crew and flightcrew, the critical external components of the aircraft that must be deiced, the checks necessary to ensure deicing has been carried out effectively, the ground equipment to be used, the detailed methods and best practices for carrying out the deicing/anti-icing treatment, and the requirement for all deicing staff personnel to be suitably qualified for the position.

- **AS6286: Training**. This standard specifies the way in which staff is to be trained and qualified as competent to carry out deicing and anti-icing of aircraft. Appendix A describes more supplementary material to provide a context for the necessity to carry out deicing safely and effectively, and AS6286B (Revision B, dated 2016-11) includes a guide to deicing/anti-icing treatment for almost all aircraft types currently in commercial operation, as well as where spraying with deicing or anti-icing fluid should not be done ("No Spray Diagrams").

- **AS6332: Quality**. This document specifies the necessary commitment of senior staff to ensuring that deicing and anti-icing are effectively carried out, that all staff are suitably trained, that all procedures are documented and all results are recorded, and that learning from incidents and events is captured, analyzed, and used to provide continual improvement of all of the deicing/anti-icing processes and methods. As such, this standard applies to how well the deicing and anti-icing of aircraft is carried out and how it can be improved further.

A.4.5 Other Related SAE Standards and Documents

Although the four SAE global standards above contain most of the information and best practices necessary to carry out deicing/anti-icing of aircraft, there are a few other documents that provide additional guidance.

a. **ARP1971: Vehicles**. This standard concerns the main features and operability of vehicles designed to use deicing and anti-icing fluids to treat aircraft. Although **TE10** of this document also describes these, ARP1971 remains an additional source of information and instruction for vehicles.

b. **ARP5660: Deicing Facility**. The purpose of this document is to provide guidelines for the standardization of safe operating procedures to be used in performing the services and maintenance at Designated Deicing Facilities (central or remote deicing facilities) that are necessary for proper deicing/anti-icing of aircraft on the ground.

c. **FAA/TC Holdover Time Guidelines and List of Fluids**: This documentation provides current lists of fluids that have been tested and accepted as suitable for the effective deicing and anti-icing treatment of aircraft, as well as some of their properties. In addition, holdover time tables are published, which are guidelines on the amount of time any particular fluid can be expected to prevent the adherence of frozen contamination on treated surfaces under various specific conditions of freezing precipitation (snow, freezing rain, etc.) and temperature. FAA and Transport Canada also publish supplemental information that is meant to be used with the holdover times guidelines, namely, the Revised FAA-Approved Deicing Program Updates, Winter 20xx-20yy (latest version) and Transport Canada Guidelines for Aircraft Ground Icing Operations TP 14052 (latest edition).

d. **Other SAE Fluid Standards and the Qualification Process**: While there are numerous SAE Standards which refer to the way in which deicing/anti-icing fluids are tested for their performance and materials compatibility, these are not of direct relevance to an airport ground crew. The important outcome of these processes is that when qualified to these standards, the fluids are then listed in the FAA/TC publications and holdover time guidelines are provided for them. The common types of fluids and their performance properties are described in **TE8** of this standard.

A.4.6 The Main Purpose of Aircraft Deicing and Anti-Icing

Frozen contamination on the surface of an aircraft can have far-reaching safety implications, and no national aviation authorities allow the dispatch of aircraft that have not been suitably deiced/anti-iced before takeoff. The purpose of deicing/anti-icing treatment can be summarized as:

"To result in a performance as close to the original aerodynamics of the ice-free aircraft as the deicing/anti-icing techniques will permit."

In Figure A10, the frozen contamination on the aircraft surfaces must be removed such that the decreased operating envelope caused by the contamination is expanded to be as close to the original certified performance of the aircraft.

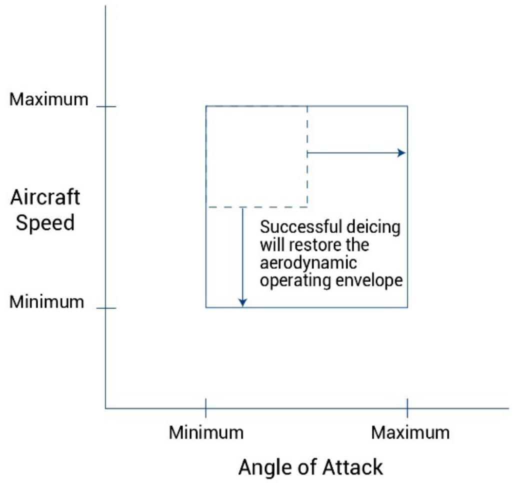

Figure A10 - Restoration of aerodynamic performance by deicing and anti-icing of the aircraft

A.5 TE5: METEOROLOGICAL CONSIDERATIONS FOR ICE FORMATION

At the end of this section, the trainee should be able to describe in detail:

- General weather conditions and ice formation
- Typical weather conditions that can lead to frozen contamination on an aircraft
- Weather conditions or situations that may need special attention
- Recognition that some weather conditions are included in holdover time guidelines, and some are not
- Some forms of weather reporting common to airports
- Potential weather effects on airport operations

A.5.1 General Weather Conditions and Aircraft Ground Icing

A.5.1.1 General Considerations of Aircraft Ground Icing

Aircraft ground icing (the accumulation of frozen contamination on aircraft) may occur during any season of the year, but in temperate climates, icing is more frequent in winter. Polar regions have the most notable ground icing weather in spring and fall. During the winter, the air is normally too cold in the polar regions to contain heavy concentrations of moisture necessary for aircraft ground icing. This does not, however, rule out the possibility of such events in these areas. Arctic regions, as could be expected, are very cold in winter, but due to local terrain and the movement of pressure systems, occasionally some areas are surprisingly warm.

Ice, snow, frost, and slush have a direct impact on the safety of flight. They degrade lift and takeoff performance or maneuverability, and they can also cause engine failures and structural damage. Fuselage-mounted engines are the most susceptible to this “foreign object damage” phenomenon caused by winter operations, but wing-mounted engines can also experience this damage. The worst case is when ice on the wing breaks off during takeoff due to the flexing off the wing and goes directly into an engine leading to surge, vibration, and possible complete loss of thrust. Snow, even light snow, which comes off of the surfaces or the fuselage can also cause engine damage leading to surge, vibration, and thrust loss. Leakage of the water and waste panels can cause ice buildup, which can also break off, causing damage and hazardous situations. Even if ice does not go into an engine, it can severely damage, for example, the tail surfaces (mainly leading edges), causing performance issues or even vibration problems. It should also be noted that ice could fall onto the ground during takeoff and flight, causing dangerous situations for anyone or anything that might be struck by it.

A.5.1.2 Frost Formation

Frost can form due to many reasons. Frost forms near the surface primarily in clear, stable air with light winds. Thin metal airfoils are especially vulnerable surfaces on which frost will form. Frost does not change the basic aerodynamic shape of the wing, but the roughness of its surface spoils the smooth flow of air, increasing the drag and thus causing a slowing of the airflow. This slowing of the air causes early flow separation over the affected airfoil, resulting in a lift loss. In coastal areas during spring, fall, and winter, heavy frost and rime ice may form on aircraft parked outside, especially when fog or ice fog is present.

Wing surface temperatures can be considerably below ambient temperature due to contact with cold fuel and/or close proximity to large masses of cold-soaked metal. In these areas, frost can build up on wing surfaces and may result in the entire wing requiring deicing/anti-icing prior to the subsequent departure. A special procedure provides recommendations for the prevention of local frost formation in cold-soaked wing tank areas during transit stops in order to make deicing/anti-icing of the entire wings unnecessary under such circumstances. This procedure does not, however, supersede standard deicing/anti-icing procedures and has to fulfill the proper requirements. This procedure also does not provide relief from any requirements for treatment and checks in accordance with aircraft manufacturer manuals.

Hoarfrost may be allowed on the fuselage if the markings are still readable. A layer of frost due to cold fuel may be allowed on the underwing surfaces. No frost is allowed outside the fuel tank area on the underwing surfaces. The flightcrew shall be informed of any existing frost remaining on the aircraft so that they can make the possible recalculations concerning the takeoff. The lower surfaces of the horizontal stabilizer shall be clear of frost and ice. Air operator and aircraft manufacturer limits for allowing a certain amount of frost (and areas where allowed) should be noted.

A.5.2 Definitions of Freezing Weather Conditions

This section lists the generally accepted definitions of weather types that may lead to the buildup of frozen contamination on an aircraft. The general terms are standardized, and they are understood in the same way everywhere. Weather information is essential for the deicing crew as official temperature and weather characteristics must be obtained for proper analysis of deicing, anti-icing, fluid mixture requirements, and holdover time procedures.

a. Active frost

Active frost is a condition when frost is forming. Active frost occurs when:

1. The aircraft surface temperature is at or below the frost point

OR

2. There is water in liquid form (e.g., dew) on the aircraft surface and the surface falls to/or below 0 °C (frozen dew).

b. Dewpoint and frost point

DEWPOINT: Temperature at which unsaturated air must be cooled to cause saturation with respect to liquid water. The moisture condenses to liquid water either on surfaces as dew or as tiny liquid droplets suspended in air.

FROST POINT: Temperature, at or below 0 °C, at which air undersaturated with moisture must be cooled (at constant pressure) to cause saturation with respect to ice. The moisture directly deposits, without going through the liquid phase, as frost on exposed surfaces providing nucleation sites. The frost point is higher (warmer) than the dewpoint by about 10% at a given humidity level in air. Air temperature readings given by a thermometer are applicable to the height above ground of the thermometer itself. Because cool air sinks and the ground often cools very quickly, especially on clear nights, the ground temperature on clear, still nights is invariably lower than the temperature only a few feet higher. Thus, frost can form even when a thermometer gives a reading above freezing. The same happens with aircraft - frost can form on aircraft when the thermometer air temperature reading is above 0 °C.

c. Freezing drizzle

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

d. Freezing fog

A suspension of numerous tiny water droplets that freeze 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).

e. Frost/hoar frost

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

f. Hail

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

g. Ice pellets/small hail

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 inch) or less. The pellets of ice usually bounce when hitting hard ground.

h. Light freezing rain

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

i. Moderate and heavy freezing rain

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

j. 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.

k. Snow grains

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 inch). When snow grains hit hard ground, they do not bounce or shatter.

l. Snow pellets

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

A.5.3 Weather Conditions or Situations That May Also Lead to the Buildup of Frozen Contamination on an Aircraft

A.5.3.1 Clear Ice

Clear ice refers to the formation of a layer or mass of ice which is relatively transparent because of its homogeneous structure and small number and size of air spaces. During winter months, aircraft surfaces are regularly wet and appear shiny. However, as clear ice has the same appearance, the possibility that icing may be occurring must always be considered. Factors which favor clear icing are large drop size, rapid accretion of super-cooled water, and slow dissipation of latent heat of fusion. Aircraft are most vulnerable to this type of buildup when:

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

b. Ambient temperatures between -2 and +15 °C (28 and 59 °F) are experienced

c. Precipitation occurs while the aircraft is on the ground and/or

d. Frost or ice is present on the lower surface of either wing

NOTE: Clear ice can form at other temperatures if conditions (a), (c), and (d) exist.

A.5.3.2 Cold-Soak Effect and Clear Ice

The wings of aircraft 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 re-fueled with very cold fuel. Other aircraft structural components are also considered cold-soaked following flight at high altitude, due to the extremely cold temperature of the structural material after landing. Whenever precipitation falls on a cold-soaked aircraft when on the ground, clear icing may occur. Even in ambient temperatures between -2 and +15 °C (28 and 59 °F), ice or frost can form in the presence of visible moisture or high humidity if the aircraft structure remains at 0 °C (32 °F) or below. This cold-soak effect may lead to the presence of clear ice. Clear ice is very difficult to detect visually and may break loose during or after takeoff. The following factors contribute to cold-soaking: length of flight time at high altitude, temperature, and quantity of fuel in fuel tanks, type and location of fuel tanks, temperature of re-fueled fuel, and time since re-fueling.

A.5.3.3 Incidental Water Spray

Water blown by propellers or jet engines or splashed by wheels of an aircraft as it taxis or runs through pools of water or slush, may result in serious aircraft icing. Ice may form in wheel wells, brake mechanisms, flap hinges, antennas, etc., and prevent the proper operation of these parts. Water may freeze in cavities, and it is very hard to note without a closer examination. Fan blades of a jet engine can be susceptible to icing if conditions are right. Ice fog and high humidity in general may be major factors contributing to fan blade icing. Aircraft may experience icing while flying through clouds for landing, in which case ice can be found on all leading-edge and frontal areas after landing. The heated aircraft cabin may melt any ice and/or snow from the top of the fuselage, and the melt water may drain downward and freeze on the wings and underneath the fuselage. All of these areas must be checked, and proper treatment performed if necessary.

A.5.4 Weather Conditions Assessed for Holdover Time Tables

Holdover time tables (see **TE11**) are guidelines for the use of aircraft deicing and anti-icing fluids in certain weather conditions. The two required functions of these fluids (**TE8**) are:

- To allow the cleaning of frozen precipitation from the aircraft (deicing)

- To prevent the aircraft surfaces from refreezing (after deicing) or to prevent the accumulation of frozen precipitation on the aircraft surfaces (after anti-icing) for a limited amount of time

The holdover time tables are guidelines of how long, after the start of application, anti-icing fluids can be expected to provide protection and how long an aircraft might reasonably be expected to remain clean if the weather conditions remain fairly constant. Holdover times are subject to the variability of the weather conditions at the time. Other variables include fluid concentrations and jet blast.

The holdover time tables include established times for the following weather conditions:

- Freezing drizzle
- Freezing fog
- Frost
- Light freezing rain
- Light snow, snow grains, or snow pellets
- Moderate snow, snow grains, or snow pellets
- Rain on a cold soaked wing

The holdover time tables do not include times for the following conditions (meaning that takeoff is not permitted, except for certain ice pellet conditions that have allowance times permitting takeoff):

- Hail or small hail
- Heavy freezing rain
- Heavy snow
- Ice pellets
- Moderate freezing rain

A.5.5 Airport Weather Reporting

A.5.5.1 Interpreting Weather Data

Weather information can be gathered from various sources. Some of this written information can be difficult to understand at times, but it all follows the same logic. For the deicing crew, temperature, dewpoint, precipitation, intensity, and forecast information are elements that affect their operations. Some of these terms are explained below, as well as an example of a local meteorological report.

A.5.5.2 METAR

A METAR is a Meteorological Report (local) of the current weather situation, also known as METREP, SPECI, AUTO-METAR. These are normally reported every 30 minutes and can include a possible TREND-forecast. An example report:

SA EFHK 090720 26006KT -SN 5000 SCT006 BKN008 M02/M03 Q0998 NOSIG 1529//75 2229//75=

SA	= METAR report
EFHK	= ICAO Airport code, Map area E Finland Helsinki-Vantaa
090720	= Observation day (09) and time (0720), UTC
26006KT	= Wind (260º and 06 Knots)
-SN	= Light snow
5000	= Visibility (m)
SCT006	= Clouds (coverage and height) BKN008= Clouds (coverage and height)
M02/M03	= Temperature (-2 °C) and dewpoint (-3 °C)
Q0998	= Air pressure (QNH 998 hPa)
NOSIG	= TREND forecast (no significant changes)
1529//75	= SADIS-group
2229//75	= SADIS -group
=	= End of report

A.5.5.3 TAF

A TAF is a Terminal Area Forecast for the airport, including changes. It is valid for 9 to 18 hours, or as long as the airport is open. It is renewed every 3 to 6 hours. An example forecast report:

FC EFHK 090500 090615 22013KT 6000 -RASN BKN006 TEMPO 0610 2000
-DZ BKN004 BECMG 1012 33010KT 9999 SCT010 BKN030 TEMPO 1014 5000 -SNRA BKN007 =

FC	= TAF
090500	= Time when forecast prepared
090615	= Time valid, Day 09 between 06 to15 UTC
22013KT	= Wind
-RASN	= Light rain and snow (slush)
6000	= Visibility (m)
BKN/SCT	= Cloud coverage and height
TEMPO	= Temporary change (time when)
2000	= Visibility (m)
-DZ	= Light drizzle
BECMG	= Becoming (time when)
33010KT	= Wind
9999	= Visibility (not stated, better than 10 Km)
-SNRA	= Light snow and rain (slush/sleet, snow dominating)
=	= End of report

TREND	Forecast (time based on METAR report)
SIGMET	Significant Meteorological Report
SWC	Significant weather chart
AIREP SPECIAL	Pilot Report

Other usable means of determining weather conditions are the automated weather service (VHF-frequency at the airport), weather charts, weather radar, etc. Even if weather sampling is not an everyday routine for everyone, it is important that someone informs the deicing crew of the official and correct temperatures in order to use correct glycol concentration. It is also important to refer to the right weather column for holdover times. This information should be updated as weather and temperature situations change.

A.5.6 Potential Weather Effects on Aircraft Operations

Winter operation in harsh winter climates is bound to affect the punctuality of any air operator. Not only is ground operation impaired, but also snow and ice on apron, taxiway, and runway areas affect aircraft operations. However, there is **no shortcut permitted for a safe deicing/anti-icing procedure on the ground.** Flights are in some cases restricted to a certain takeoff time irrespective of season. This "window" of departure causes undue pressure for the completion of ground procedures, but this shall not cause any diversions from normal and safe deicing/anti-icing procedures. Heavy winter weather conditions occurring often make the ground deicing procedure more of a normal task than an exception to consider. Air operators that do not operate on a regular basis in these areas might not be as aware of the importance of an appropriate contamination check and treatment. Milder winter seasons in warmer regions do not rule out the importance of using the same deicing/anti-icing procedures as in other regions.

SECTION B: THE METHODS FOR CHECKING THE AIRCRAFT FOR CONTAMINATION

A.6 TE6: HOW TO CHECK THE AIRCRAFT CRITICAL SURFACES

At the end of this section, the trainee should be able to describe in detail:

- How to examine the aircraft critical flight surfaces (wings, vertical stabilizer, horizontal stabilizers), top fuselage, undercarriage, nose radome must be clean, pitot-static orifices, angle of attack devices, windscreens

A.7 TE7: POST DEICING/ANTI-ICING CHECK

At the end of this section, the trainee should be able to describe in detail:

- How to examine the aircraft to make sure that no contamination (frozen deposits) remains after deice/anti-ice, no refreezing has happened if anti-ice fluids have failed, the aircraft is clean and in proper condition for flight

SECTION C: THE METHODS FOR AIRCRAFT TREATMENT WITH DEICING/ANTI-ICING FLUIDS

A.8 TE8: GENERAL TECHNIQUES FOR REMOVING FROZEN DEPOSITS FROM AN AIRCRAFT

At the end of this section, the trainee should be able to describe in detail:

- The various ways in which deicing can be performed
- The only way in which anti-icing can be performed
- The need to prepare equipment, procedures, and people before deicing/anti-icing an aircraft
- The areas of an aircraft to inspect for frozen contamination
- The descriptions of one-step and two-step deicing and anti-icing processes

A.8.1 Deicing/Anti-Icing Operations - General Information

A.8.1.1 Deicing Operations

Deicing operations can be and have been performed in a variety of ways throughout the years. These methods may include the use of paste on leading edges; wing covers to prevent frozen contamination from adhering; ropes, brushes, or brooms to remove large accumulations of snow; and the use of a variety of deicing fluids. More recently, some newer methods have been used, such as the use of forced air or infrared technology to remove contamination. It is worth noting that there is no single correct method for performing deicing for every case. The operation must be suited for each airport, company, and local setting. Whatever method is used for deicing an aircraft, the resulting requirement is that all critical surfaces shall be clean. Brushes and forced air methods are useful when deicing areas where fluid application is limited or forbidden. Using alternate methods for cleaning the surfaces can be used to help shorten the time spent deicing/anti-icing with fluids. This, in turn, will help the departure efficiency relating to deicing operations.

A.8.1.2 Anti-Icing Operations

Anti-icing the aircraft can only be achieved by applying anti-icing fluids. Mechanical methods are not anti-icing procedures because they do not provide protection from the adherence of incoming active precipitation (e.g., such as when it is still snowing after deicing). Only qualified anti-icing fluids and industry-accepted procedures may be used. While deicing operations can be assisted by the removal of frozen contamination using alternate methods, only anti-icing fluids can protect the aircraft after that, and even then, **only for a limited time**. **For the remainder of this training document, only the use of anti-icing fluids** shall be considered. This is the method used in the vast majority of aircraft deicing/anti-icing operations.

A.8.1.3 Tasks Prior to Deicing/Anti-Icing Treatment

Before a deicing operation begins, a check of the equipment and supplies should be made. This check should include all relevant aspects for the proper functioning of the equipment, personal safety gear, and the fluids to be used. After these have been checked, a verification of the latest procedures for deicing/anti-icing should be performed. The appropriate procedures will vary according to the method of the deicing operations needed. The necessary checks and communications can be performed at the gate. However, for remote or centralized deicing operations, appropriate information must be provided to the deicing crew in another way (e.g., coordinator communication). The determination of the need for deicing/anti-icing can be made by qualified persons other than the deicing crew. Once an affirmative determination is made, a verification of the deicing/anti-icing procedures to be used must be performed with the flightcrew in order to ensure that there are no misunderstandings. The information to be verified with the flightcrew includes areas of the aircraft that will be deiced and anti-iced, the fluids and mixtures to be used, the start clearance for deicing, the results of checks, and any aircraft-specific information the crew wishes to note.

A.8.1.4 Contamination Check to Establish the Need for Deicing

Requests for deicing/anti-icing shall specify the parts of the aircraft requiring treatment. Certain questions must be considered, such as:

- Any aircraft-specific requirements and precautions
- Whether the deicing operation will be performed at the gate or a remote location
- Whether the aircraft can have the engines started and be taxied to a remote deicing location with the adhering contamination (e.g., frozen contamination on engine components may prevent this)
- Who makes the request for deicing/anti-icing
- Verification of proper procedures, with all parties involved (ground crew, flightcrew, and deicing crew)
- Whether forced air or brushes will be used before the application of fluids

The contamination check is performed by the flightcrew or ground crew prior to departure to verify the presence of adhering contamination to establish the need for deicing/anti-icing. It may be part of the flightcrew walk around before the flight. A contamination check shall visually include all critical parts of the aircraft and shall be performed from points offering sufficient visibility of those parts (e.g., from the deicing vehicle itself or any other suitable piece of equipment, including ladders, or from inside the aircraft - whatever means are necessary to perform a thorough check must be employed). Any frozen contamination found, except frost allowed in certain areas, shall be removed by a deicing treatment. This shall be followed by an anti-icing treatment if required per the weather conditions.

Some areas can be cleaned manually during the check, a deicing procedure might not then be necessary, although this procedure must be confirmed with the flightcrew. The captain of the aircraft has the final authority and accountability for the aircraft, but the more conservative, safer option shall always be considered, whether it is the opinion of the flightcrew or the ground crew (specific company and aircraft limits to be noted).

During winter operations, aircraft critical surfaces and certain instrumentation must always be inspected, and this can be accomplished prior to communications with the flightcrew. These include:

- Wings (upper and lower surfaces, including control-surface gaps and deployed leading-edge/trailing-edge high-lift devices [e.g., slats and flaps])
- Horizontal tail (upper and lower surface, including control-surface gaps)
- Vertical tail and rudder (including gaps)
- Fuselage
- Any other aerodynamic surfaces
- Engine inlets and fan blades or propellers (front and back sides of blades), as applicable
- Pitot probes and static ports
- Antennas and sensors
- Landing gear and landing gear doors

For more detailed information on these checks, refer to AS6285.

After checking these areas, a decision can be made with the flightcrew regarding the deicing/anti-icing procedures. The weather elements and taxi distances will affect the choice for the Type and mixture of fluid to use. For certain aircraft types, additional requirements exist: for example, special checks for **clear ice**, such as tactile checks of the wings. These special checks are not always included in the contamination check. Air operators shall make arrangements for suitably qualified personnel to perform such checks. When an aircraft has been deiced and anti-iced sometime prior to the arrival of the flightcrew, an additional contamination check may be necessary prior to departure to establish whether further treatment is required.

A.8.2 One-Step and Two-Step Deicing/Anti-Icing

A.8.2.1 General Information

If an aircraft is contaminated with frozen precipitation of any kind (ice, snow, frost, or slush), then it must be deiced before dispatch. Even though safety is the overriding consideration, there are two recognized ways in which this can be carried out for greatest efficiency.

- When aircraft surfaces are simply contaminated by frozen precipitation, and if there is no active frost condition and no active freezing precipitation taking place, then the aircraft shall be deiced prior to dispatch.

- When aircraft surfaces are contaminated by frozen precipitation and there is active frost or freezing precipitation occurring, there is a risk of contamination of the surfaces after deicing and before the time of dispatch. In this case, aircraft surfaces shall also be anti-iced. If both deicing and anti-icing are required, the procedures may be performed in one or two steps. The selection of a one- or two-step process depends upon weather conditions, available equipment, available fluids, and the holdover time necessary before takeoff.

A.8.2.2 One-Step Deicing/Anti-Icing

Some contamination, such as frost, can be removed and the surface can be protected from recontamination at the same time using the same fluid and same mixture. This is called a one-step process. One-step deicing/anti-icing is performed with either a heated unthickened fluid (SAE Type I) or a diluted and heated thickened fluid (SAE Types II, III, and IV). When thickened fluids are used, caution must be taken for the dry-out characteristics and gel-residue problems of this particular treatment, as thickened fluids contain polymers that may remain on the aircraft after the flight. The types of fluid used for deicing/anti-icing are described in detail in **TE10**. The fluid to choose for a one-step process is the mixture that provides the needed protection. The fluid concentration shall be chosen to achieve the desired holdover time, which is dictated by the outside air temperature (OAT) and weather conditions. Wing skin temperatures may differ from and, in some cases, be lower than the OAT. A stronger mix (more glycol in the glycol-water mixture) can be used under these conditions. The stronger mix will not improve the holdover time, but it will lower the freezing point of the mixture.

A.8.2.3 Two-Step Deicing/Anti-Icing

Two-step deicing/anti-icing is performed when freezing precipitation is taking place (active frost, freezing drizzle/rain, or snow). Deicing is first carried out to remove the frozen contamination on the aircraft surfaces. After deicing, a second, separate over-spray of anti-icing fluid shall be applied to protect the relevant surfaces while the freezing precipitation continues to take place. A two-step process is common during active freezing precipitation. The correct anti-icing fluid concentration shall be chosen to achieve the desired holdover time, which is dictated by the OAT and weather conditions. The second step shall be performed before the first step fluid freezes. If necessary, the second-step fluid shall be applied area by area. The second-step fluid shall be applied in such a way that it results in complete coverage, with a sufficient and even layer of anti-icing fluid on the treated surfaces. It is the responsibility of the deicing operator to ensure that all frozen contamination has been removed from the treated surfaces before applying the second-step fluid.

NOTE 1: Anti-icing treatment protects the aircraft from recontamination for a **limited amount of time (the holdover time)**. The selection of the correct anti-icing fluid therefore strongly depends upon the likely time between deicing/anti-icing the aircraft and takeoff. If the holdover time of the anti-icing fluid is exceeded, the aircraft will need to be deiced and anti-iced again.

NOTE 2: **Under no circumstances** should an anti-icing treatment be applied to an aircraft that has already been anti-iced. It must first be deiced again to remove the original anti-icing fluid before a further anti-icing treatment is applied.

A.9 TE9: DEICING/ANTI-ICING BY FLUIDS - PROCEDURES IN GENERAL

At the end of this section, the trainee should be able to describe in detail:

- The critical aspects of the deicing process
- The general deicing process
- The special care required for deicing composite aircraft wings
- The general process for using anti-icing fluids effectively
- When Type I fluids may be used for anti-icing an aircraft
- What Type II, III, and IV fluids are designed to do
- The limitation of anti-icing fluids in terms of the time between aircraft treatment and takeoff (holdover time)

A.9.1 The Critical Aspects of the Deicing Process

Ice, snow, slush, or frost may be removed from aircraft surfaces by heated fluids, mechanical methods, alternate technologies, or combinations thereof. Heavier accumulations require the heat of the fluid to break the bond between the frozen contamination and the structure, and the hydraulic force of the fluid spray is then used to flush it off of the surface. For normal deicing of an aircraft, fluid should be sprayed heated. Fluid temperature and pressure should not exceed aircraft maintenance manual requirements. For maximum effect, fluids shall be applied close to the surface of the skin to minimize heat loss. The heat of the fluid effectively melts any frost, as well as light accumulations of snow, slush/sleet, and ice. Choosing a **correct spray method** may vary as much as the winter weather does. The procedure must be adapted according to the situation and local settings.

A.9.2 The General Deicing Process

During deicing (and anti-icing), moveable aircraft surfaces shall be in the position specified by the aircraft manufacturer. When removing frost, a nozzle setting giving a solid cone (fan) spray should be used. This ensures the **largest droplet pattern** available, thus retaining the **maximum heat** in the fluid. When the hot fluid is applied close to the aircraft skin, a minimal amount of fluid will be required to melt frozen contamination. When removing snow, a nozzle setting sufficient to flush off deposits and minimize foam production is recommended (note that foam can be confused as snow). The procedure adopted will depend on the equipment available and the depth and type of snow (e.g., light and dry or wet and heavy). In general, the heavier the accumulation, the heavier the fluid flow that will be required to remove snow effectively and efficiently from the aircraft surfaces.

For light deposits of both wet and dry snow, similar procedures as for frost removal may be used. Under certain conditions, it will be possible to use the heat of the fluid, combined with the hydraulic force of the fluid spray, to melt and subsequently flush off snow. Wet snow is more difficult to remove than dry snow, and unless the accumulation is relatively light, selection of a high fluid flow will be more effective. A heavy accumulation of snow will always be difficult to remove from aircraft surfaces and large quantities of fluid may be consumed in the attempt. Under these conditions, serious consideration should be given to manually removing the bulk of the snow before performing the fluid deicing procedure.

Heating the fluid is very important when removing ice, as is the pressure of the spray to break the ice bond. The method makes use of the high thermal conductivity of metal aircraft skin. A stream of hot fluid is directed at close range onto one spot at an angle of less than 90 degrees until the aircraft skin is exposed. The aircraft skin will then transmit the heat laterally through the metal in all directions, raising the temperature above the freezing point and thereby breaking the adhesion of the ice to the aircraft surface. By repeating this procedure, a number of times, the adhesion of a large area of ice (or snow) can be broken. The contamination can then be flushed off with either a low or high flow, depending on the amount of accumulation. **Nonmetallic surfaces (composites)** have a lower heat transfer capability than metallic surfaces. Deicing may take longer, and more fluid may be needed as heat is not as effectively transmitted through the wing surface.

A.9.2.1 Cold Dry Snow or Ice Crystals

Cold dry snow or ice crystals, in very cold conditions (generally below -10 °C [14 °F]), may not adhere to a cold dry aircraft nor its critical surfaces. Under these conditions, it may swirl as it blows across the surfaces, making it evident it is not adhering. Therefore, the critical surfaces remain free of adhering contaminants. However, if frozen contamination has accumulated on critical surfaces, it must be adequately removed. It cannot be assumed that these accumulations will blow off during takeoff.

During cold dry conditions, the air operators will need to take into consideration the following elements:

1. Refueling with fuel warmer than the wing skin temperature may create a condition whereby previously non-adhering precipitation may adhere to the wing surfaces.

2. The use of heated deicing fluids may increase the risk of cold dry snow or ice crystals to adhere to critical surfaces post application. Under such operational conditions, an anti-icing treatment might need to be considered.

   CAUTION: A close monitoring of deicing/anti-icing fluid's LOUT is required to ensure a safe operation.

3. Monitor the location of heat-releasing equipment such as ground power units or bridges that may create conditions for non-adhering precipitation to start adhering to aircraft surfaces.

4. The location where the aircraft is parked might increase the risk for non-adhering precipitation to start adhering (e.g., one wing in the sun, a building obstructing the wind, etc.).

5. Operations in close proximity to other aircraft may cause snow, ice particles, or moisture to be blown onto critical aircraft components; or can cause dry snow/ice crystals to melt and refreeze on aircraft critical surfaces. If it cannot be adequately demonstrated that cold dry snow or ice crystals are not adhering or accumulating, then it must be removed before takeoff.

   CAUTION: Aircraft with rear mounted engines are more susceptible to ingest frozen accumulation that might cause damage or engine failure.

When the presence of frost or ice is limited to localized areas on the surfaces of the aircraft and no holdover time is likely to be required, only the contaminated areas will require treatment. Deicing to remove local area contamination can only be performed when no precipitation is falling or expected. This contamination will generally be found on the wing and/or stabilizer leading edges or in patches on the wing and/or stabilizer surfaces. A heated fluid and water mixture suitable for a one-step procedure shall be used, and the treatment shall be symmetrical (e.g., both wings must receive the same treatment). The treatment and removal of contamination must be checked by a trained and qualified person, and the pilot in command must be informed of the procedure using words such as, "Wing local area deicing only; holdover times do not apply." It is the responsibility of the deicing operator to ensure that the treatment is performed symmetrically and that all frozen contamination has been removed.

A.9.3 The General Anti-Icing Fluid Application Strategy

Anti-icing fluid shall be applied to the aircraft surfaces (assuming that they have already been deiced and are clean of any ice, snow, frost, or slush) if it is anticipated that there will be active precipitation that will accumulate on the aircraft before takeoff. For effective anti-icing, **an even layer of sufficient thickness of fluid** is required over the prescribed aircraft surfaces. Two anti-icing procedures are recognized; the choice of which to use will depend on the severity of the weather conditions. The types of fluid referred to in this section are described in detail in **TE10**. All fluid types are and can be used as both deicing and anti-icing fluids. It is very common within the industry to refer to Type I fluids as deicing fluids and Types II, III, and IV as anti-icing fluids, based upon one way that they are commonly used. It is, however, not technically correct.

A.9.3.1 Use of a Type I Fluid for Anti-Icing

Type I fluids are generally designed to be used for the cost-effective deicing of aircraft. They are diluted with water to have a freezing point at least 10 °C (18 °F) lower than the outside air temperature and are applied heated 60 °C (140 °F). For Type I fluid, an additional minimum of 1 L/m^2 (0.264 gal/m^2) with a temperature of at least 60 °C (140 °F) at the nozzle shall be applied. If there is active precipitation, a Type I fluid will provide a limited holdover time, specified in the holdover time guidelines published by the FAA or Transport Canada. In conditions of active precipitation, the use of Type I fluids for anti-icing is most common when there is very little time between fluid application and takeoff ("spray and go" operations).

A.9.3.2 Use of a Type II, Type III, or Type IV Fluid for Anti-Icing

Type II, III, and IV fluids are specifically designed and manufactured to provide extended anti-icing protection time (holdover time). Under conditions of active freezing precipitation, these fluids must be used to ensure that a deiced aircraft will not become re-contaminated prior to takeoff. These fluids can be diluted with water to either a 75% or 50% concentration, but they must have a freezing point at least 7 °C (13 °F) lower than the OAT. For longer anti-icing protection, unheated Type II, III, or IV fluid should be used. The high fluid pressures and flow rates normally associated with deicing are not required for anti-icing and, where possible, pump speeds should be reduced accordingly. The nozzle of the spray gun should be adjusted to provide a medium spray.

The fluid application process should be continuous and as short as possible. Anti-icing should be carried out as near to the departure time as operationally possible in order to utilize the maximum holdover time available from the fluid. During anti-icing (and deicing), moveable aircraft surfaces shall be in the position specified by the aircraft manufacturer. For Type II, III, and IV fluids, the correct amount to use is indicated by fluid just beginning to run off of the leading and trailing edges of horizontal surfaces. The anti-icing fluid shall be distributed uniformly over all surfaces to which it is applied. In order to control the uniformity, all horizontal aircraft surfaces shall be visually checked during application of the fluid. Anti-icing fluids may not flow evenly over wing leading edges, horizontal and vertical stabilizers. These surfaces should be checked to ensure that they are properly coated with fluid.

When applying the anti-icing fluid as a second step in a two-step process, use a spraying technique which completely covers the first step fluid and provides a sufficient amount of second-step fluid. Where either recontamination of the aircraft or exceedance of the holdover time occurs following the initial treatment, both the first and second steps shall be repeated. The holdover time provided by the anti-icing fluid should be equal to or greater than the estimated time from the **start of anti-icing to the start of takeoff**. Aircraft shall be treated symmetrically; that is, the left-hand and the right-hand side shall receive the same and complete anti-icing treatment. Aerodynamic problems could result if this requirement is not met. Local area anti-icing is not permitted.

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-parked aircraft**. This will minimize the accumulation of contamination prior to departure and often makes subsequent deicing easier. This procedure has a potential risk of building fluid residues and is not recommended to be performed continuously. Upon receipt of a frost, snow, freezing drizzle, freezing rain, or freezing fog warning from the local meteorological service, anti-icing fluid may be applied to clean aircraft surfaces prior to the start of freezing precipitation. This will minimize the possibility of the precipitation bonding to the surfaces or reduce the accumulation of frozen precipitation on the surfaces and facilitate subsequent deicing. The time factor must also be taken into account when considering these procedures (e.g., it may be worthwhile for turnarounds and short stops, but overnight stops should be considered carefully).

NOTE: This short turnaround or overnight anti-icing treatment **shall not** be considered a full deicing/anti-icing treatment sufficient for aircraft departure. It is only used to help make the subsequent deicing/anti-icing treatment of the aircraft easier. Full deicing and anti-icing must take place as usual, together with appropriate use of holdover times.

A.10 TE10: BASIC CHARACTERISTICS OF AIRCRAFT DEICING/ANTI-ICING FLUIDS

At the end of this section, the trainee should be able to describe in detail:

- Why deicing/anti-icing fluids are the most common way of removing and preventing frozen contamination on an aircraft
- The three safety requirements of deicing/anti-icing fluids
- The difference between Type I fluids and Type II, III, and IV fluids
- The colors of the different deicing/anti-icing fluid types
- The unusual characteristics of anti-icing fluids, and what precautions should be taken when using them
- The two basic ways that deicing/anti-icing fluid performance is characterized

A.10.1 The Use of Aircraft Deicing/Anti-Icing Fluids

Any ice, snow, slush, or frost on aircraft wings must be removed before flight, and this is mainly achieved using deicing/anti-icing fluids. Other techniques (brooms, ropes, infra-red, etc.) can be used, but the use of aircraft deicing fluids (ADF) is the most common method. This is due to their use being:

- Widely applicable to any aircraft type
- Easy to deploy
- Good industry standard methods are available for deicing operations

While the fluid is used to remove frozen contamination, the fluid itself must not compromise the safe aerodynamics of the aircraft for takeoff. This leads to the **three safety aspects of ADF**:

- ADF must be able to remove frozen contamination from an aircraft (**deice**).
- ADF must be able to keep an aircraft free of frozen contamination until the aircraft takes off (**anti-ice**).
- ADF **must not compromise the aerodynamics** of an aircraft during takeoff. This means that the fluid must be proven to have an acceptably low impact on the aerodynamics of the wing, in strict conformance with industry standards. Most of the fluid should shear off of the wing during the takeoff roll and rotation.

A.10.2 Deicing/Anti-Icing Fluid Information and Fluid Types

- Type I fluids are “unthickened” and orange in color.
- Types II and IV fluids are “thickened” using polymers. This results in these fluids staying on the surfaces until takeoff. They absorb incoming precipitation within the holdover time for the weather condition, keeping the aircraft free from frozen contamination. Type II fluids are yellow, and Type IV fluids are green. Fluids containing polymers may result in dried-fluid gel residues if the aircraft is not regularly cleaned, or if a two-step process (with the first step being deicing with a Type I fluid) is not carried out thoroughly. This is most susceptible to occurring when these fluids are used in a one-step process.
- Types I, II, and IV are the most common fluids. There is also a Type III fluid which contains less thickener than Types II and IV and thus provides less holdover time. They are bright yellow in color and are rarely used.

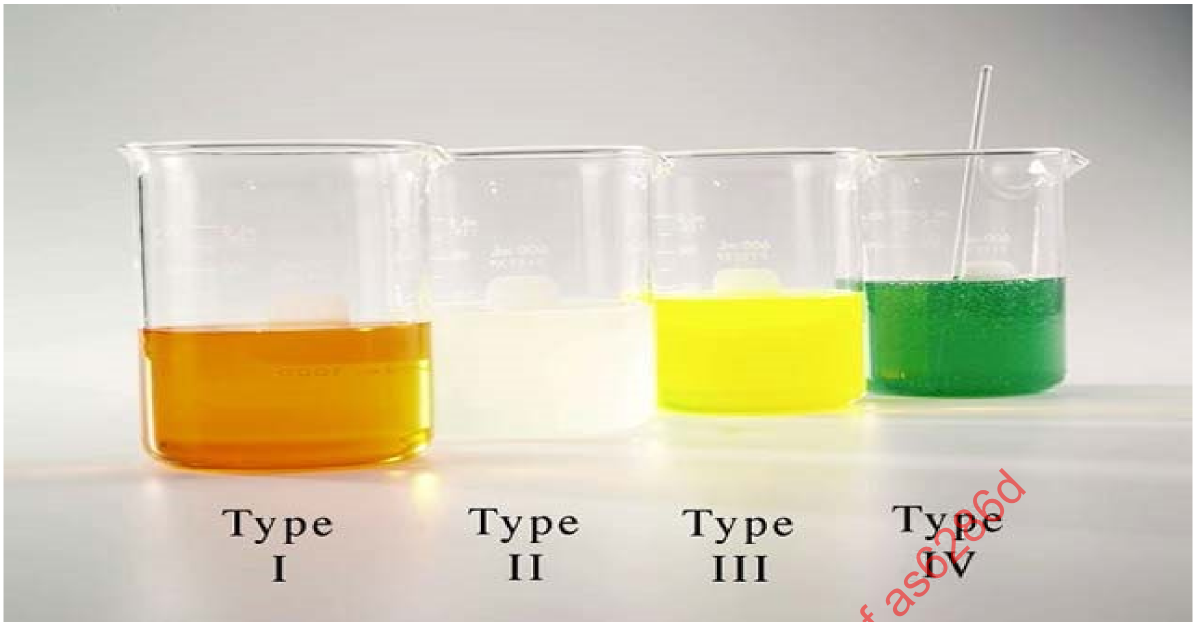

Figure A11 - The colors of the four most common types (I, II, and IV left to right, respectively) of aircraft deicing/anti-icing fluids

For thickened fluids, the holdover time (HOT) is an estimate of the maximum time that the fluid will protect the aircraft before takeoff. If the HOT is exceeded before takeoff, the aircraft must undergo the whole procedure of deicing and anti-icing again. Current standards state that if anti-icing has been carried out and the HOT is exceeded, the aircraft cannot be treated with a second layer of anti-icing fluid and be deemed safe. It must first be decided before another treatment with an anti-icing fluid. While HOT guidelines/tables provide information over a wide range of conditions (**see TE11**), the categorization of ADF is done using water spray endurance time (WSET) values obtained under carefully controlled laboratory conditions, as shown in Table A1. The WSET process is described in more detail in A.10.6.

Table A1 - Aircraft deicing fluid (ADF) categorization

SAE Fluid Type Designation	Primary Performance Criteria	Laboratory Endurance Times, Minutes	
		WSET Endurance	HHET Endurance
Type I (orange)	Efficient deicing	More than 3	More than 20
Type II (yellow)	Anti-icing	More than 30	More than 240
Type III (bright yellow)	Anti-icing	More than 20	More than 120
Type IV (green)	Anti-icing	More than 80	More than 480

Note: Water spray endurance time (WSET) and high humidity endurance time (HHET) test results are determined in a laboratory under closely controlled conditions using test methods as described in AMS1424 and AMS1428 and standards mentioned therein.

A.10.3 The Typical Process for Deicing and Anti-Icing of Aircraft

A generally applicable method for ensuring the safe takeoff of aircraft during very snowy or icy conditions is to perform a two-step procedure:

- Step 1: Deicing - This removes the frozen contamination from the aircraft. Deicing is commonly carried out with a Type I fluid, diluted to a freezing point of OAT (or below), and applied hot at the nozzle of the spray head. The second step shall be performed before the first step fluid freezes, if necessary, area by area.

- Step 2: Anti-Icing - Anti-icing fluid is then applied to a contamination-free aircraft to “keep it clean” during the HOT of the fluid.

A simple flow diagram of a two-step process is shown in Figure A12.

Ice contaminated aircraft

↓

Deicing (e.g., Type I)

↓

Anti-icing (e.g., Type II, III or IV)

↓

Takeoff within fluid HOT, fluid shears off the wing

Figure A12 - Example of fluid application

A.10.4 Understanding the Technology of Deicing and Anti-Icing Fluids

A.10.4.1 The Simple Concepts

Deicing and anti-icing fluids are similar in that the major component of these products is a chemical that lowers the melting point of ice or snow. The usual chemicals used for these products are propylene glycol and ethylene glycol. Both have excellent freezing point depressant properties and good environmental profiles. However, ethylene glycol is toxic to mammals and must be used with caution. To melt and remove frozen contamination already settled on the aircraft, it is also necessary to heat these fluids if used for deicing. Anti-icing fluids are normally applied neat (or diluted as per temperature requirements) and unheated once the aircraft is clean of contamination.

The two fluid categories, unthickened (Type I) and thickened (Types II, III, and IV) can be contrasted as follows:

- Type I: These are **unthickened glycol-based fluids**, diluted with water before use, which allows an efficient balance of the need to melt ice and snow with enough glycol, and the cost effectiveness of the operation. Type I fluids are usually supplied as concentrates containing 80 to 92% glycol with around 8 to 20% water and other additives. Diluted Type I mixtures are normally sprayed, heated, on the aircraft by deicing trucks. While this is an efficient way to remove frozen contamination from the aircraft, these heated Type I dilutions do not give much anti-icing protection in **active icing conditions**.

- Types II, III, and IV: These fluids are also glycol-based and are usually supplied as products with 50% glycol, and 50% water plus other additives. The key additional ingredient in these formulations is **a polymer thickener**. This material not only makes the product more viscous in nature but also maintains a fluid layer on the aircraft. This thick layer of fluid is then capable of absorbing more freezing precipitation for a length of time before (by being diluted) it eventually reaches a point where it may also freeze. **The time between the fluid being applied and its eventual failure to prevent icing is known as the holdover time (HOT)**.

A.10.5 The Properties of Anti-Icing Thickened Fluids - Newtonian Versus Non-Newtonian Flow

Newtonian fluids are liquids that behave in fairly predictable ways. Water and oil show patterns of flow and response to pumping that are easy to understand. The more force used to push them, the more resistance is encountered. The same is true of certain paints. Once applied to a vertical surface, they continue to flow and can form a pattern of drips below the brushstroke.

In contrast, there are also non-drip paints. When this material is pushed with a brush, it changes from being very stiff in its structure, to being able to flow and cover surfaces. However, once the paint is no longer being worked with the brush, it becomes stiffer in structure and does not drip as readily. This ability to flow under a shear force but to regain structure after the shear is removed is an example of a fluid that is non-Newtonian. It is also called shear-thinning or pseudo-plastic - it becomes **thinner** (less viscous) **under shear stress**. The application of these principles to aircraft deicing and anti-icing fluids now becomes clear.

- Type I fluids: As unthickened fluids, they are Newtonian, and can be pumped and sheared with no deleterious effect on their performance.

- Type II, III, and IV fluids: The ability of thickened fluids to be sprayed and to regain their structure when on the aircraft is obviously an advantageous property, regaining viscosity ensures a good thickness of the fluid layer, giving it the ability to protect the aircraft during the holdover time (HOT). However, **precautions must be used** in the handling of these fluids. If too much shear is applied to thickened fluids during offloading of tankers, transferring between tanks, truck filling and finally aircraft spraying, then the polymers may be degraded and HOT substantially lost. In addition, heating them for a long time or contaminating them with other chemicals or rust may also lead to degraded performance. Always follow the fluid manufacturer's recommendations.

A.10.6 Characterizing Deicing and Anti-Icing Fluids

It is clear from the foregoing discussion that the deicing and anti-icing fluids are a critical part of the ability to ensure a "clean aircraft" on takeoff. It is therefore unsurprising that much effort has gone into methods to characterize the performance aspects of these fluids.

Fluid users should make sure that the fluids meet all the requirements of AMS1424 and AMS1428 (see 4.5 c).

While most tests in the two standards AMS1424 and AMS1428 are similar in nature (corrosion, stability, compatibility effects), the thickened fluids undergo more testing due to the complex nature of non-Newtonian fluids. As each fluid manufacturer can use different chemistry and formulation methods to achieve the desired properties, the testing is primarily performance related rather than chemistry related. The two key performance tests that are applied to the thickened fluids are:

a. Fluid characterization by the Water Spray Endurance Time (WSET) Test

   A Type II fluid must have a minimum endurance of 30 minutes in a WSET measurement by definition. Type IV fluids must have a minimum of 80 minutes in a WSET test (see Table A1). The WSET process consists of covering with fluid an aluminum plate at an angle of 10 degrees, spraying a controlled amount of water onto the surface of the fluid at -5 °C, and measuring the time taken for the advancing front of frost on the plate to move past a line drawn 2.4 cm down the plate. As this procedure is well controlled, the repeatability and reproducibility of this method are very good, allowing accurate characterization of the endurance time of fluid and hence its classification.

b. Aerodynamic acceptance by fluid elimination

   The balance of properties that is needed for thickened Type II, III, and IV fluids is that they must endure (give a defined WSET) and that **a specified amount must also be eliminated from the wing of the treated aircraft at the point of rotation (VR, see Figure A13)**. The maximum amount of residual fluid that can remain on the aircraft is established. As the fluid flows off, there is a direct correlation between what is known in aerodynamics as the Boundary Layer Displacement Thickness (BLDT) and the lift loss caused by the presence of the fluid. Each fluid is tested to ensure that its use will not result in a greater lift loss (in terms of measured BLDT) than the accepted standard. This is known as the **Aerodynamic Acceptance Test, AS5900**, also often called the flat-plate fluid elimination test.

These two key performance measures ensure that both lifetime of the fluid before freezing and the ability not to interfere with aircraft aerodynamics are well defined for all qualified fluids.

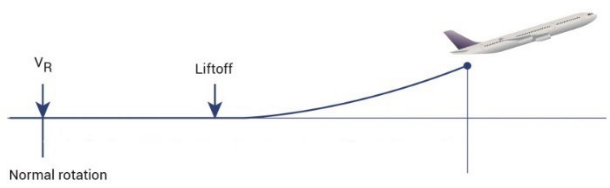

Figure A13 - Aircraft takeoff profile

A.11 TE11: TYPES OF FLUID CHECKS REQUIRED AND THE EQUIPMENT FOR DOING THIS

At the end of this section, the trainee should be able to describe in detail:

- The general handling and storage requirements of deicing/anti-icing fluids
- The quality control checks to be performed on deicing/anti-icing fluids
- Pumping and heating plus storage tank requirements

A.11.1 General Fluid Handling and Storage Notes

Fluid handling is an important part of the deicing operational process. The fluid must be received, stored, pumped, heated, and used with the same level of quality and care throughout all processes. Fluids are designed to do the right job at the right time. They need to deice and anti-ice effectively, and then to shear off the aircraft at the point of rotation. This requires a balance of properties that such fluids are designed to provide if they are handled and treated in accordance with manufacturer's instructions. Failure to handle these complex fluids with care may result in damage to the fluids and a drop in expected performance.

As these formulations of deicing/anti-icing fluid are unique to each manufacturer, it is recommended that they are not mixed in storage or vehicle tanks, as the fluid chemistries may not be compatible. For fluid acceptance at delivery, it is necessary to check that the fluid delivered corresponds to the fluid ordered. Make sure that the brand name and concentration of the product specified in the delivery documents corresponds to the delivered fluid. Each container or road tanker shall be checked. Make sure that the brand name and the concentration of the delivered fluid corresponds to the brand name and the concentration of the storage or vehicle tanks. Before filling a storage tank or vehicle tank, take a sample from the delivered container or road tanker (each separate compartment, if applicable) and perform the usual quality control checks for each fluid.

Verify each delivery (container/tank truck) has an associated fluid certificate of analysis (C of A). The C of A, at a minimum, shall include test results conforming to the three (four for thickened fluids) items listed directly below. Additionally, the fluid manufacturer shall give assurances on the condition of each container and/or bulk loaded delivery tanker trailer (container/trailer status). This should be through cleaning certification documentation or previous load documentation.

A.11.2 Quality Control Checks to be Performed

Refer to AS6285, 4.3.1, for all required fluid checks and documentation requirements.

A.11.3 Pumping and Heating, Storage Tanks

Deicing/anti-icing fluids can degrade when exposed to excessive mechanical shearing. Therefore, only compatible pumps and spraying nozzles shall be used. The design of the pumping systems shall be in accordance with the fluid manufacturer's recommendations. Dedicated transfer lines shall be conspicuously labeled to prevent contamination and shall be compatible with the deicing/anti-icing fluids to be transferred.

Deicing/anti-icing fluids shall be heated according to the fluid manufacturer's guidelines. For Type I fluids, water loss may cause undesirable aerodynamic effects. For Type II, III, and IV fluids, thermal exposure and/or water loss may cause a reduction or increase in fluid viscosity, leading to lower holdover times or poorer aerodynamics.

Types II, III, and IV are only required to be heated when used for deicing or for "spot" (or local) anti-icing on cold-soaked areas of the aircraft. When used for anti-icing, they are normally applied unheated, either on deiced surfaces or to prevent the formation of ice.

The fluids shall be checked periodically. Caution must be taken to avoid unnecessary heating of fluid in vehicle tanks. Prolonged or repeated heating of fluids (directly or indirectly) may result in loss of water, which can lead to a performance degradation of the fluid.

Any of the following situations, or a combination of them, can accelerate the fluid performance degradation:

- Low fluid consumption
- Trucks being in standby mode with heating systems on for extended periods of time
- High temperatures in fluid tanks
- High temperatures in water tanks, which are in direct contact with the fluid tank (no insulation between tanks)

The storage of fluids can be done in a variety of ways, large stainless steel (acid-proof or plain steel) containers, 1 m^3 containers, barrels, drums etc. The storage procedure should be chosen according to the scope and amount needed for the operation. Heating of the fluid in the storage tanks depends on the equipment in use. If the equipment directly heats the fluid before spraying, then heating the fluid in the tanks may be unnecessary. The heating must fulfill any other requirements set for the fluid. Annual visual examination of all tanks must be performed. Stainless steel (or acid-proof) tanks must be visually examined annually, but more in-depth checks and tests, such as non-destructive testing (NDT), may not be necessary on an annual basis. The testing periods should be conducted according to the container manufacturer recommendations or standards set for the deicing operation (reference SAE). Records must be kept for all examination/inspection/checks/tests of tanks and stations.

A.12 TE12: DEICING/ANTI-ICING EQUIPMENT OPERATING PROCEDURES

At the end of this section, the trainee should be able to describe in detail:

- That deicing vehicles come in many different variations and must be understood in great detail
- The types of safety and emergency precautions that must be taken with deicing vehicles
- The operation of filling stations
- The need to be clear in communications with the flightcrew
- Equipment use and spray alternatives
- The possible need to collect data on spraying operations
- The basic vehicle components
- Typical safety equipment and "before-use checks"

A.12.1 Variations of Deicing/Anti-Icing Vehicles

The primary function of the vehicle is to apply deicing/anti-icing fluid from variable heights to the surfaces of aircraft while driving around the perimeter of the aircraft. There are many different vehicles on the market. These vehicles range from small to large, from open basket to closed cabin, from fixed spray nozzles to extended-boom nozzles, from movable units to fixed units, either one- or two-person operated, etc. The vehicles have been developed for specific tasks in specific regions. Some airports only serve smaller aircraft and do not need the large-capacity vehicles, and vice versa. The vehicles have variations in fluid use as well. Some have electrical heating, and some have combustion burners that heat the fluid just before spraying. Some vehicles have a three-tank version, with Type I, Type II/III/IV, and water stored separately, whereas others have only one or two tanks with pre-mixed fluid. The vehicles' design concept has been to fulfill the requirements of one particular operator and operation. One aspect that is the same for all vehicles is that **lifting devices require specific training before use**. Certain manufacturers provide special equipment for underwing spraying. Even if this is not a man-lift device, the vehicle cannot be operated without proper training.

A.12.2 Equipment Safety Precautions

Deicing vehicle operation involves many aspects where safety precautions must be noted. Some of these aspects are the use of hot fluids, the high pressure of the spray, large and heavy vehicles moving around aircraft, when filling the vehicle, when using the boom and maneuvering, communication between the sprayer and the driver (where applicable), the sometimes poor visibility while spraying, and the use of safety harnesses, among other things. The use of the vehicle should be performed in a manner that the next user of the vehicle can continue without any doubts about the safe performance of the vehicle. Any discrepancies shall be noted and communicated, and measures shall be taken to indicate to other users that the vehicle may not be usable or that its use is limited.

The vehicle should be checked for proper operation before use. The basic operation shall be verified, and discrepancies noted. The different systems used on the vehicle should be checked for proper performance, e.g., fluid quantity indication, burner for fluid heating, and other similar elements that have to do with the proper operation of the vehicle. Additional equipment shall be checked and located (e.g., safety harnesses, hearing protectors, fire extinguisher). The vehicle should be checked for all fluids needed when in use (e.g., windshield washing fluid, fuel, etc.). Note that the vehicle is usually used in areas where space is limited, where visibility can be limited, and where the surface is slippery due to ice or the mix of fluid and water on the ground. It is recommended to test the brakes before approaching the aircraft to verify how slippery the surface is and, in general, to test the performance of the brakes.

A.12.3 Emergency Requirements

A certain amount of emergency equipment is mandatory for a deicing vehicle to make sure that some particular situations can be solved or prevented. The emergency system must contain an emergency stop/emergency shut-off system at key points around or in the vehicle, an emergency lowering system for the boom, a fire extinguisher, and systems to prevent any overheating, overfilling, or overpressure in the deicing fluid system. A way of communicating must be in place in order to be able to resolve situations with the person in the basket or cabin. The operation and monitoring of these systems shall be included in the training, and each different vehicle requires similar comprehensive types of training.

A.12.4 Operational Use of Equipment and Quality Control

There are some limitations on the use of deicing vehicles. These limitations refer, among other things, to the maximum wind velocity with the boom elevated, operational speed during deicing/anti-icing, movement velocity of the boom, load capacity of the basket/cabin, spray pressure, and heat of fluids. The vehicle boom extension must be in proportion to the average aircraft serviced at the airport. Some aircraft have a height of up to 25 m, but an average height is between 13 and 15 m for large transports and under 10 m for small transports. The boom (basket/cabin) in itself may not always extend to the particular height required, but there may be an extending nozzle boom that covers the remaining distance. It must be noted that the farther away the spraying is performed, the less heat and pressure is transferred to the aircraft surface. Note that the area sprayed shall also be visually checked. Any particular limitations or requirements shall be referred to in the current deicing vehicle standards and manufacturers' publications.

Some requirements need to be tested and verified for use, such as the spray system, emergency system, visibility during operation, controls, monitoring devices and displays, lights, speeds, warning devices, braking, and steering. The vehicles also need labeling at all appropriate areas, such as hoses, fluids, filling ports, instructional plates, etc. Labeling of different hoses and filling ports is important so that no confusion can exist when performing deicing and anti-icing separately. Since some operators use uncolored deicing/anti-icing fluids, this aspect is even more important. Spray tests must be performed periodically for thickened fluid to verify that the vehicle (pumps, nozzles, etc.) do not degrade the viscosity of the fluid when sprayed. There are many variables to consider and to note when using the vehicle. It is up to **each operator** to make sure that all functions are working and that they have been appropriately maintained. A **maintenance schedule** shall be developed, and maintenance recorded by the company performing such service. If the operator has leased this service, then a verification of the performance should be recorded. The quality control also includes a verification of the fluid used (visual and refractive index/freezing point) and a verification of the fluid temperature.

Many vehicles have temperature measurements from the tank but temperature at the nozzle shall also be verified. A minimum temperature of 60 °C (140 °F) must be maintained for Type I/water mix used for anti-icing. The vehicle may also be able to provide data for the customer after each deicing event. Minimum parameters shall be recorded, such as the date, aircraft deiced/anti-iced, fluid used, any dilutions used, and holdover time started. Additional data is usually collected and thus also provided.

Filling Stations

Each filling station is designed to serve the particular vehicles in use. The filling of fluid can be performed by an automated system that controls the level of fluid in the vehicle tank or manually, either with separate containers or by filling through manholes. It must be noted that all hoses, containers, and filling ports (including manholes) shall be marked with the appropriate label of fluid contained. Care should be taken to prevent fluids being mixed together. Application equipment shall be cleaned thoroughly before initially being filled with deicing/anti-icing fluid in order to prevent fluid contamination. Deicing/anti-icing fluid in trucks shall not be heated with a combustion burner in confined or poorly ventilated areas. The heating of fluids in containers/tanks may be performed electrically, or they may not be heated at all (anti-icing fluid is generally not heated). Unheated fluid can be filled in the tanks if the vehicle is equipped with a burner that heats the fluid before spraying. Thickened fluid is not heated in either the vehicle or at the filling station unless used diluted as a deicing fluid.

The amount of fluid and the fluid temperatures both for the filling station and vehicles should be monitored in order to secure a sufficient amount of and sufficiently heated fluid when needed. The operation of the filling station shall be included in the training, and all necessary precautions shall be noted.

A.12.5 Equipment Communication Requirements

The deicing vehicle needs to have an appropriate communication system that is suited for the operation in use, e.g., VHF, UHF, mobile phone, etc. A two-way communication needs to be established between the vehicle and the aircraft (or the coordinator). This communication needs to be performed via VHF-radio. The radio needs to be approved for use for aviation frequencies. An intercom communication (or similar) needs to be established when two persons are operating the vehicle. The external noise should be noted (e.g., aircraft engines) when using a headset type communication in open basket vehicles. External noise can disrupt the communication, and care should be taken to avoid the deicing operation continuing with misleading or no communication at all. When two or more vehicles are deicing an aircraft, other communication possibilities may be considered between these vehicles. Communication between vehicles is needed in order to verify proper treatment and procedures. The chain of communication depends on how the particular winter operation is planned and performed. Some use a coordinator (or team leader) for all the communication between the aircraft while others perform the communication from each vehicle. In some situations, a hardwire headset can be plugged into the aircraft for direct communication with the aircrews. Certain airports have separate frequencies for different areas of deicing operation. The communication equipment must be suited for the local setting and the personnel trained accordingly.

A.12.6 Equipment Fluid Use and Spray Alternatives

There are many variations in equipment design, capability, and operability. The variations impact how the deicing/anti-icing fluids are stored in the vehicle and how they are sprayed. Basically, either the fluids can be pre-mixed before use, or a proportional mixing system will mix the appropriate solution of product fluid and water according to selection. Thickened anti-icing fluids are not generally mixed with water, but some operators do use these fluids diluted as deicing fluid. These differences are mainly dependent on what particular need each operator has and how local operations are set up. Vehicles using pre-heated fluid should monitor the temperature. Vehicles using burners should verify the correct temperature while spraying. Note that when the vehicle has not been in use for some time, it may take longer to achieve the proper temperature at the nozzle.

Where fluid tanks are heated, there is normally a need for insulation, as the heat loss from a full tank should not exceed 1 °C/h. The heating of diluted Type I mixture can also generate heat that can be absorbed by the thickened fluid. This should be monitored so that the temperature does not rise too high.

The fluid flow depends on the particular fluid used and the equipment in use. Generally, a flow rate of 20 to 100 L/min may be used for thickened fluids. The requirement is that the viscosity loss is minimal after pumping and spraying to avoid degrading the fluid below the minimum viscosity. The pumps, lines, and nozzles should be such that minimum viscosity loss is achieved after spraying. The appropriate spray pressure and flow rate depends largely on elements such as the type and amount of contamination on the aircraft surfaces, wind conditions, temperature of the fluid, spraying distance, etc. Generally, a 50 to 275 L/min flow rate at a pre-nozzle discharge pressure of 650 kPa with the boom fully elevated will be suitable for any deicing task. However, guidance on pressures and flow rates should also be confirmed with the fluid manufacturer for best results.

To perform an effective deicing operation, the deicer should have full control over the movement of the nozzle. It is necessary for the nozzle to be able to vary the pattern between a cone shape and a solid stream, and the flow rate from minimum to maximum. The system should be able to indicate any mixing problems or be designed so that the mixture will become stronger instead of leaner if something fails (the mixture “fails in a safe manner”). It is the responsibility of the operator to make periodic and daily checks of the fluids, as well as visual checks according to current standards and recommendations, to make sure that correct mixtures are used. The deicing fluid and water in the lines may freeze in cold temperatures. Purging the lines and filling them with a high concentration of glycol should eliminate this. In turn, when deicing the aircraft after purging the lines, it must be noted that a certain amount of fluid needs to be sprayed before the correct mixture is reached at the nozzle.

A.12.7 Data Collection

To enable useful evaluation and follow-up of operator performance, a system for recording and controlling operations should be established. The data encompasses general customer needs, and regulations require a record keeping of this data. The data is usually computerized, and the system automatically records some parameters (e.g., mixtures, time of deicing, and time of anti-icing, etc.), but these can also be recorded manually. Other details supplied to the system (e.g., flight number, aircraft type, areas treated, duration of operation, volume and type of fluid used, temperature, etc.) will depend on the particular setting and vehicle system.

The data should be at hand, to be presented to the customer when requested. The data is also an invoicing requirement unless otherwise settled between ground operators/service providers and air operators. There are different ways of providing and recording this data, such as instant invoice capability or remotely via the coordinator or as a handmade receipt. Some airports also need verification of where and how much deicing fluid has been used. This data should be recorded as seasonal information and should not be needed on a daily basis. Some companies also require internet-based recordkeeping for all deicing events in order to fulfill certain aircraft-specific data analysis and reporting, as well as the generally required event information.

A.12.8 Basic Vehicle Components

NOTE: The items listed are typically found on a deicing vehicle but may vary depending on model and manufacturer. For further details, refer to the manufacturer's documentation.

- Operator's basket (containing spray guns, communication connections, basket controls, harness point, and lights) or
- Operator's enclosed cabin (containing nozzle and boom controls, communication equipment, cabin movement controls, optional truck movement controls) (one-person operation)
- Hydraulic boom
- Compartment (containing Donkey Engine, heater, and hydraulics)
- Fluid pump
- Side gun (under-wing nozzle)
- Emergency boom controls
- Deicing fluid refill point
- Truck cab (containing heater controls, gauges, communication connections, and driving controls, etc.)
- Roof window
- Truck fuel tank
- Deicing fuel tank
- Boom locating point
- Inspection hatches
- Beacon light
- Fluid type (mix)
- Fire control
- Fire access point
- Fluid level gauges
- Heater exhaust outlet
- Ladder

A.12.9 Typical Deicing/Anti-Icing Vehicle Layout

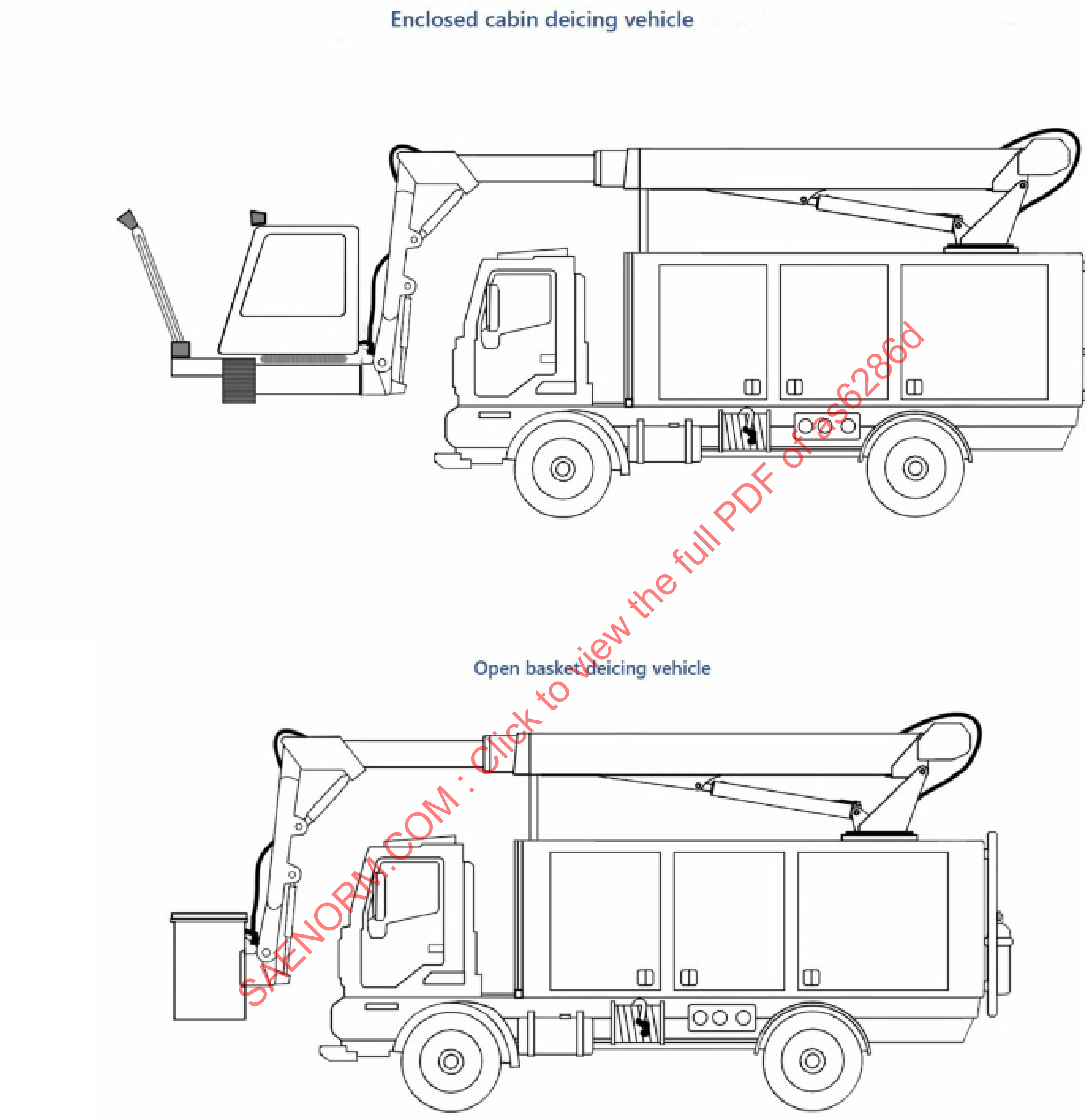

Figure A14 - Typical deicing/anti-icing vehicles

A.12.10 Safety Equipment

- Seat belt and/or fall protection equipment (e.g., lanyard and harness)
- Eye/face protection
- Respiratory protection (where required)
- Weatherproof clothing
- Gloves
- Hearing protection
- Safety footwear
- Any additional equipment identified by regulations or carrier

A.12.11 Before-Use Checks

Before operating the deicer, a walk-around check must be performed. Each of these items must be operated and checked:

- Engine(s)
- Boom and basket/cabin operation
- Heater and pump operation
- Nozzle and spray gun operation
- Emergency and safety equipment

NOTE: Perform a manufacturer recommended pre-operation user's check before operating the unit.

A.13 TE13: FLUID APPLICATION AND THE USE PLUS LIMITATIONS OF THE HOLDOVER TIME (HOT) TABLES

At the end of this section, the trainee should be able to describe in detail:

- Details of the clean aircraft concept
- The main areas of the aircraft to spray, and the general method of doing this
- The key aircraft areas to anti-ice and the other important areas to deice/anti-ice
- The general purpose of holdover time table guidelines and how to read them
- The difference between generic and fluid brand holdover time tables
- The importance of using the correct dilution of anti-icing fluids when reading the appropriate holdover time table

A.13.1 The Clean Aircraft Concept and Fluid Use

The clean aircraft concept must be understood as an important and fundamental foundation for the safety of the flight. A “clean aircraft” is considered to be one that is either totally clean or that has been cleaned of frozen contamination and protected with qualified deicing/anti-icing fluids (which still protect the surface and are able to provide the necessary aerodynamic performance). In addition, if there is any contaminated fluid on the surface, the aircraft must not be misunderstood to be clean; the contaminated fluid must also be removed. Under no circumstances shall an aircraft that has been anti-iced receive an additional coating of anti-icing fluid directly on top of the previous, contaminated fluid. If an additional treatment is required before flight, a complete deicing/anti-icing process shall be performed. Subsequent anti-icing only without the deicing step is not permitted. To be clear, any residues from a previous treatment that have “failed” (that is, fluid protection failure) must be flushed off before anti-icing re-treatment begins.

A.13.2 Spray Areas

Areas to spray on aircraft are, in most cases, the upper surfaces. However, underwing deicing may be very common for some aircraft types. The upper surfaces mainly refer to the wings, tails (including both sides of the vertical stabilizer), and fuselage. As a general rule, the deicing/anti-icing procedure should be performed from the top downward, from the leading edge toward the trailing edge, and from the aircraft front to the back. On most aircraft, it is usual to start at the wing tip and work toward the wing root. Specific areas to protect from recontamination depend on the aircraft limitations and company procedures, but at a minimum, the upper surfaces of the wings and the tail section shall be anti-iced. The fuselage may also need anti-icing. The lower sides of the wings are not generally anti-iced with thickened fluid, and using a deicing fluid with sufficient freezing point buffer is recommended.

A.13.3 Aircraft Surfaces

When using Type I for deicing, it will be applied heated. If the wing area is large and the active precipitation is heavy, previously deiced surfaces should be checked and if necessary, deiced again before anti-icing. Anti-icing fluid must be applied before the first-step deicing fluid freezes.

There is no single rule for the order in which aircraft surfaces should be sprayed that can be applied to all aircraft types. It is, however, generally recommended to start with the forward fuselage whenever it needs treatment. Following the standard process of spraying the aircraft starting from the top to the bottom, etc., it is usual to spray along the top centerline and then outward from there.

After the fuselage is deiced, it is typical to treat the wings. The way to treat the wings depends on the aircraft type and the place where deicing is performed (gate versus a remote station). Regardless, the wing should always be treated from the leading edge to the trailing edge (forward to aft). Mistakenly spraying from back to front can force fluid and contamination into gaps and balanced surfaces, cause gel residues to collect in gaps and on controls, and there is also the danger of removing grease from hinges and other parts. Most wings are to be sprayed from the wing tip inward. However, some aircraft have wing tips lower than the wing root, and in that case, deicing should be performed from the wing root outward.

The tail should be deiced from the top of the vertical stabilizer downward, including the aft fuselage/empennage area, before spraying the horizontal stabilizer (note that this does not apply to high-mounted horizontal tail, “T-tail,” aircraft). The tails must also be sprayed from leading edge to trailing edge (forward to aft).

If there is active precipitation, at a minimum, the following surfaces shall be protected by anti-icing:

- Wing upper surfaces, including leading edges and all control surfaces
- Wing tip devices
- Both sides of vertical stabilizer and rudder to receive anti-ice protection when freezing precipitation conditions exist
- Horizontal stabilizer upper surfaces including leading edges and elevator upper surfaces
- Vertical stabilizer surfaces, including the rudder (both sides)

CAUTION: Anti-icing fluids may not flow evenly over wing leading edges, horizontal, and vertical stabilizers. These surfaces should be checked to ensure that they are properly coated with fluid.

It is the responsibility of the deicing service provider to ensure that the surfaces mentioned above are free of frost, snow, slush, or ice prior to the start of the anti-icing treatment, and that on completion of the treatment, these surfaces are fully covered with an adequate layer of anti-icing fluid.

The lower surfaces of the wings do not usually need anti-icing since the precipitation cannot fall onto this surface and limited frost in the area of the fuel tanks is usually acceptable for takeoff. A sufficiently high concentration of glycol in the fluid mixture (freezing point buffer) must be used to ensure that there is no recontamination within the holdover time after treatment.

NOTE: SAE Type II, III, and IV fluids used for anti-icing purposes are normally applied unheated on clean aircraft surfaces, but they may be applied heated and diluted for a one-step procedure. Refer to the fluid manufacturer's recommendation.

Gate deicing is somewhat different than remote/centralized deicing, and local settings and precautions should be noted. Using multiple deicing vehicles for one aircraft may change the spray order, but the same concept (**high to low, front to back**) should be applied. Different vehicles may also be needed for different applications (e.g., underwing or two-step area-by-area treatment). In such cases, the procedure should be written and verified accordingly.

NOTE: The repeated application of Type II, III, or IV fluid may cause **polymer residues** to collect in aerodynamically quiet areas, cavities, and gaps. The application of hot water or heated Type I fluid as the first step of a two-step deicing/anti-icing process may minimize the buildup of these residues. Residues may rehydrate and freeze at low (such as in-flight) temperatures and can block or impede critical flight control systems. Periodic inspection for accumulated residues may be necessary. Misting the aircraft with water may facilitate their visibility, as they will generally turn white and swell into a gel-like substance. Residue accumulations require removal.

A.13.4 Other Areas to Deice/Anti-Ice

Other areas on the aircraft need special attention or procedures for cleaning. Aircraft manufacturer recommendations and company procedures should be noted.

Windows need deicing but not anti-icing, and fluid shall never be directly sprayed onto windows as this can damage them. Spray above the windows so that the fluid flows down onto them. Some aircraft have limitations on how to clean them (again, manufacturer and company procedures should be noted); in some cases, a brush or cloth may be sufficient. If hot water is used for deicing (for example, on flightdeck windows), it should be noted that water draining down from higher areas may freeze elsewhere on the fuselage. Other than this, there is no precaution for using hot water to deice windows.

The radome needs deicing and, in many cases, anti-icing. If the radome has been treated, caution must be taken so that large quantities of fluid cannot flow toward and up onto the flightdeck windows during takeoff, reducing pilot visibility. Thickened fluid should be removed before departure if necessary. Static ports and pitot tubes need to be inspected. Any contamination, including fluid flowing from above, that exists on or forward of these safety-essential gauges shall be removed.

NOTE: Ice ridges can form on the nose of the fuselage while on the ground. These ridges will disrupt air flow into the pitot tubes, which can result in false measurements. All contamination shall be removed from this area.

Engine inlets and fan blades must be deiced in some cases, based on the engine or aircraft manufacturer and aircraft operator's instructions. Engine inlets can generally be cleaned with a brush or manually. Engine covers may be installed after engine shut down in order to minimize engine ice buildup (refer to air operator and engine manufacturer instructions). The engine fan blades and the bottom of the engine air inlet should be deiced with hot air (noting manufacturer recommended temperature limits), or other means recommended by the engine manufacturer. **No deicing/anti-icing fluid is to be sprayed into the engines**. Propellers may have ice along the leading edges and/or may collect snow/slush along the sides during a ground stop. This contamination can be removed manually with a soft cloth or by hand. Some manufacturers allow the propellers to be sprayed, but some forbid the use of glycol-based fluids. Hot air, or any other means recommended by the engine manufacturer, can be used for the deicing of propellers. However, composite propellers may have temperature limits that must be noted and followed.

Aircraft external instruments, probes, and sensors may need deicing, and this should be performed using the aircraft manufacturer and operator procedures. This task shall only be performed and supervised by properly trained and qualified personnel.

For landing gear, do not spray deicing/anti-icing fluid directly onto wheels and brakes. Ice and snow must be removed from the landing gear, paying particular attention to uplocks, downlocks, sensors, door mechanisms, and steering systems.

NOTE: It may be possible to mechanically remove certain accumulations, such as blown snow. However, if frozen contamination has bonded to the surfaces, they can be removed by the application of hot air.

Underwing deicing treatments must be symmetrical and include flap lower surfaces, if contaminated. Both wings must be treated identically (same areas, same amount and type of fluid, same mixture strength), even if the frozen contamination is only present on one wing. Underwing frost is usually caused by very cold fuel in the wing tanks, a condition known as **cold-soak frost**. Use a fluid/water mix with a higher concentration of glycol than is usually required by the outside air temperature to prevent recontamination.

A.13.5 Interpreting Deicing/Anti-Icing Fluid and Holdover Time (HOT) Tables

A.13.5.1 The Purpose of a Holdover Time (HOT) Table

In A.10.2, the classification of anti-icing fluids was explained: Classifications are based on the water spray endurance time (WSET) test. Under laboratory conditions of freezing precipitation at -5 °C (23 °F), fluids will prevent freezing precipitation from accumulating beyond a standard level for a particular amount of time. While this is useful to evaluate a minimum amount of expected anti-icing protection time under these limited and very controlled conditions, there are many other forms of freezing precipitation (frost, snow, freezing drizzle, etc.), temperatures, and fluid dilutions that for which flightcrews need protection-time guidance.

The holdover time (HOT) tables are guidelines of anti-icing protection times that have been obtained by performing a series of "endurance time" tests for each thickened fluid (including dilutions) in natural freezing precipitation conditions at a variety of temperatures. As there are a variety of precipitation conditions, and ranges of precipitation intensities and temperatures, the results of endurance time testing are presented as a table of "holdover times." Flightcrews must use HOT guidelines to estimate the amount of time during which the aircraft should be free of frozen contamination ("clean") for takeoff. If the HOT for the prevailing weather condition is exceeded, the aircraft will need to be deiced and anti-iced again.

In this section, Tables A2, A3, and A4 show the typical format of a HOT table. The various freezing precipitation types are displayed along the top, and the range of outside air temperatures is displayed down the sides. For each cell in the table, a range of HOT is given.

Precipitation Intensity:

The HOT tables cells have a range of times published; the lower time value corresponds to more intense precipitation, while the longer time corresponds to lighter precipitation intensity.

Except for freezing drizzle, heavy precipitation intensities are not provided in any HOT guidelines.

As an example, in Table A2, in freezing fog conditions at -2 °C, the holdover time range is 11 to 17 minutes. The lower time (11 minutes) corresponds to a more intense precipitation, while the longer time (17 minutes) corresponds to a lighter precipitation intensity.

If the deicing crew is asked to give this information to the flightcrew, it is essential to give the time span. In the above case, it would be 11 to 17 minutes.

Snowfall intensity rates in grams per decimeter square per hour (g/dm^2/h) and their liquid water equivalent (LWE) rates (generated by purpose-built systems) are as follows:

- Moderate snow: 10 to 25 g/dm^2/h and 1.0 to 2.5 mm/h
- Light snow: 4 to 10 g/dm^2/h and 0.4 to 1.0 mm/h
- Very light snow: 3 to 4 g/dm^2/h and 0.3 to 0.4 mm/h

If the precise rate cannot be determined, it is recommended to use the shorter time of the given cell.

For freezing rain, the range is confined to light freezing rain which can be up to 25 g/dm^2/h.

It is the responsibility of the pilot in command to determine which time is to be used.

Appropriate use of the HOT tables relies upon the reader being able to determine which precipitation condition is applicable (plus the outside air temperature).

Alternatively, an automated system can be used, called a holdover time determination system (HOTDS) that identifies the precipitation type and intensity and displays the appropriate HOT for the crew.

The differences in the HOT values for the various precipitation conditions can also provide an indication of which types of precipitation present a greater or lesser threat of contaminating the aircraft prior to takeoff.

The above values are given for training purposes only. HOT tables are updated by the regulators every year, and the trainee should understand that only values from current, official HOT tables can be used in real-time operations.

The HOT tables represent a wide range of precipitation types and rates, and they must be interpreted by suitably trained personnel.

The Two Main Types of Holdover Time Tables and When the Holdover Time Starts and Ends

There are two different categories of holdover time tables in use: generic and fluid brand. The generic tables are developed using the lowest HOT for each cell of the table from those of all of the qualified fluids. For this reason, the generic tables may provide lower HOT values than the HOT table does for any one particular fluid.

The purpose of a generic table is that it can be safely used for **any qualified fluid of that type**, regardless of brand.

On the other hand, the **fluid brand HOT tables are** applicable to only that one particular fluid and cannot be used for any other fluid.

If the specific holdover time information for the fluid brand provided is unknown, the generic table shall be used. The HOT tables used by the various operators may vary a bit in content from the example. There may be differences in the precipitation categories (most commonly, those for snow, light snow, very light snow) and differences depending upon the authority or organization that published the tables or country (e.g., FAA, TC).

Appropriately applied anti-icing fluids are expected to provide the appropriate published HOT. For a one-step deicing/anti-icing process, the HOT begins at the **start of fluid application,** and for a two-step process, at **the start of the final (anti-icing) step.** Holdover time ends either when the aircraft takes off, or when the fluid "fails." There are two types of fluid failure. The most commonly known type of fluid failure is due to freezing precipitation. This type of failure is visually identified by seeing either undissolved frozen precipitation in the fluid or frozen contamination starting to form or accumulate on treated aircraft surfaces (usually the wings). The second type of fluid failure is when the fluid fails to wet the surface upon application. This can be caused by contact with other materials, such as silicones. A fluid that does not wet the surface (spread evenly) is also a failed fluid.

Due to their properties, Type I fluids form a thin liquid wetting film, which provides a very short HOT time, especially in conditions of freezing precipitation. Most of the HOT comes from the heat of the applied fluid. With this type of fluid, no additional HOT can be obtained by increasing the concentration of the fluid in the fluid/water mix.

Types II, III, and IV fluids contain thickening agents, which enable the fluids to form a thick liquid wetting film on the aircraft surfaces. This thick layer of fluid provides significantly longer HOTs than Type I fluids.

A.13.5.2 Type I Fluid HOT Table Example (Table A2)

Table A2 shows **a Type I HOT table**. The table provides times that can be used for all qualified Type I fluids. The lower value of the time span indicates the estimated time of protection during moderate precipitation, and the higher value indicates the estimated time of protection during light precipitation.

The table is read by first verifying the OAT and the form of precipitation. The HOT cell to use is where these two parameters cross. As an example: At a temperature between -3 and -6 °C (27 and 21 °F), in **moderate** snow conditions, a Type I fluid is expected to provide, **on an aircraft composed predominantly of aluminum**, a HOT between **0:05** and **0:08** minutes.

It is the responsibility of the pilot-in-command to determine which time is to be used based upon the intensity or rate of snowfall (if not provided with this information by other means). If the deicing crew is asked to give this information to the flightcrew, it is essential to give the time span (e.g., 5 to 8 minutes).

All HOT tables contain several notes. The notes shall be observed accordingly. For Type I fluids, there are separate HOT tables for composite and metallic aircraft surfaces: which to use for which aircraft type is recommended by the aircraft manufacturer.

Table A2 - Type I holdover time table

HOLDOVER TIMES FOR SAE TYPE I FLUID ON CRITICAL AIRCRAFT SURFACES COMPOSED PREDOMINANTLY OF ALUMINUM

Outside Air Temperature[1,2]	Freezing Fog, Freezing Mist[3], or Ice Crystals	Very Light Snow, Snow Grains or Snow Pellets[4,5]	Light Snow, Snow Grains or Snow Pellets[4,5]	Moderate Snow, Snow Grains or Snow Pellets[4]	Freezing Drizzle[6]	Light Freezing Rain	Rain on Cold-Soaked Wing[7]	Other[8]
-3 °C and above (27 °F and above)	0:11 - 0:17	0:18 - 0:22	0:11 - 0:18	0:06 - 0:11	0:09 - 0:13	0:02 - 0:05	0:02 - 0:05	CAUTION: No holdover time guidelines exist
below -3 to -6 °C (below 27 to 21 °F)	0:08 - 0:13	0:14 - 0:17	0:08 - 0:14	0:05 - 0:08	0:05 - 0:09	0:02 - 0:05	CAUTION: No holdover time guidelines exist	CAUTION: No holdover time guidelines exist
below -6 to -10 °C (below 21 to 14 °F)	0:06 - 0:10	0:11 - 0:13	0:06 - 0:11	0:04 - 0:06	0:04 - 0:07	0:02 - 0:05	CAUTION: No holdover time guidelines exist	CAUTION: No holdover time guidelines exist
below -10 °C (below 14 °F)	0:05 - 0:09	0:07 - 0:08	0:04 - 0:07	0:02 - 0:04	CAUTION: No holdover time guidelines exist	CAUTION: No holdover time guidelines exist	CAUTION: No holdover time guidelines exist	CAUTION: No holdover time guidelines exist

NOTE: This table is intended for training only and shall not be used for actual operations.

A.13.5.3 Type II/IV Fluid Generic Holdover Time Table Example (Tables A3.1 and A3.2)

Tables A3.1 and A3.2 show **generic Type II/IV HOT tables**. The tables provide the expected range of protection times that can be used for all qualified Type II/IV fluids. As for a Type I table, the lesser time value is the estimated time of protection during moderate precipitation, and the greater time value is the estimated time of protection during light precipitation.

The table is read by verifying the outside air temperature, the form of precipitation, and the concentration of the fluid. (Alternatively, the fluid concentration can be selected based upon the amount of HOT desired.) The applicable HOT cell is where these parameters cross. As an example, for a temperature between -3 °C (27 °F) and **-8** °C (**18** °F), for a fluid concentration of 100/0 and snow conditions, the appropriate HOT range for Type II is 20 to **35** minutes, but for Type IV, the appropriate HOT range for light snow is 55 to 105 minutes, and for moderate snow, the appropriate HOT range is 25 to 55 minutes.

It is **very important to use the HOT for the correct concentration of fluid because using an incorrect one can result in using a dramatically incorrect HOT, thus compromising the safety of the takeoff.**

It is the responsibility of the pilot in command to decide on which time is appropriate based upon the rate of the snowfall (if not provided with this information by other means). If the deicing crew is asked to give this information to the flightcrew, it is essential to give the time span (e.g., 20 to 35 minutes).

The fluid mixture concentration may depend upon the procedures used by the deicing service provider. Some providers only offer one concentration (e.g., 100/0), while others offer all standard dilutions (e.g., 75/25, 50/50).

All HOT tables contain several notes. The notes shall be observed accordingly. For thickened fluids, the generic HOT table provides times that are valid for **both composite and metallic aircraft surfaces** (the difference between Type I and the thickened fluids is the heat conduction properties afforded by the heated Type I fluid).

Table A3.1 - Typical Type II generic holdover time table

GENERIC HOLDOVER TIMES FOR SAE TYPE II FLUIDS

Outside Air Temperature[1]	Fluid Concentration Fluid/Water By % Volume	Freezing Fog, Freezing Mist[2], or Ice Crystals	Snow, Snow Grains or Snow Pellets[3,4]	Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold-Soaked Wing[6]	Other[7]
-3 °C and above (27 °F and above)	100/0	0:55 - 1:50	0:25 - 0:50	0:30 - 1:00	0:20 - 0:35	0:07 - 0:45	CAUTION: No holdover time guidelines exist
	75/25	0:25 - 0:55	0:15 - 0:25	0:15 - 0:40	0:10 - 0:20	0:04 - 0:25	
	50/50	0:15 - 0:25	0:05 - 0:10	0:08 - 0:15	0:06 - 0:09		
below -3 to -8 °C (below 27 to 18 °F)	100/0	0:30 - 0:45	0:20 - 0:35	0:20 - 0:45	0:15 - 0:20		
	75/25	0:25 - 0:50	0:10 - 0:20	0:15 - 0:25	0:08 - 0:15		
below -8 to -14 °C (below 18 to 7 °F)	100/0	0:30 - 0:45	0:15 - 0:30	0:20 - 0:45[8]	0:15 - 0:20[8]		
	75/25	0:25 - 0:50	0:08 - 0:20	0:15 - 0:25[8]	0:08 - 0:15[8]		
below -14 to -18 °C (below 7 to 0 °F)	100/0	0:15 - 0:20	0:02 - 0:07				
below -18 to -25 °C[9] (below 0 to -13 °F)	100/0	0:15 - 0:20	0:01 - 0:03				
below -25 °C to LOUT[9] (below -13 °F to LOUT)	100/0	0:15 - 0:20	0:00 - 0:01				

NOTE: This table is intended for training only and shall not be used for actual operations.

Table A3.2 - Typical Type IV generic holdover time table

GENERIC HOLDOVER TIMES FOR SAE TYPE IV FLUIDS

Outside Air Temperature[1]	Fluid Concentration Fluid/Water By % Volume	Freezing Fog, Freezing Mist[2] or Ice Crystals	Very Light Snow, Snow Grains or Snow Pellets[3,4]	Light Snow, Snow Grains or Snow Pellets[3,4]	Moderate Snow, Snow Grains or Snow Pellets[3]	Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold-Soaked Wing[6]	Other[7]
-3 °C and above (27 °F and above)	100/0	1:15 - 2:40	1:55 - 2:20	1:00 - 1:55	0:30 - 1:00	0:40 - 1:10	0:20 - 0:35	0:08 - 1:05	CAUTION: No holdover time guidelines exist
	75/25	1:25 - 2:40	2:05 - 2:25	1:15 - 2:05	0:40 - 1:15	0:50 - 1:20	0:30 - 0:45	0:09 - 1:15	
	50/50	0:30 - 0:55	1:00 - 1:10	0:25 - 1:00	0:10 - 0:25	0:15 - 0:40	0:09 - 0:20		
below -3 to -8 °C (below 27 to 18 °F)	100/0	0:20 - 1:35	1:45 - 2:05	0:55 - 1:45	0:25 - 0:55	0:25 - 1:10	0:20 - 0:25		
	75/25	0:30 - 1:20	1:50 - 2:10	1:00 - 1:50	0:30 - 1:00	0:20 - 1:05	0:15 - 0:25		
below -8 to -14 °C (below 18 to 7 °F)	100/0	0:20 - 1:35	1:20 - 1:40	0:45 - 1:20	0:25 - 0:45	0:25 - 1:10[8]	0:20 - 0:25[8]		
	75/25	0:30 - 1:20	1:40 - 2:00	0:45 - 1:40	0:20 - 0:45	0:20 - 1:05[8]	0:15 - 0:25[8]		
below -14 to -18 °C (below 7 to 0 °F)	100/0	0:20 - 0:35	0:30 - 0:45	0:09 - 0:30	0:02 - 0:09				
below -18 to -25 °C[9] (below 0 to -13 °F)	100/0	0:20 - 0:35	0:10 - 0:20	0:03 - 0:10	0:01 - 0:03				
below -25 °C to LOUT[9] (below -13 °F to LOUT)	100/0	0:20 - 0:35	0:07 - 0:10	0:02 - 0:07	0:00 - 0:02				

NOTE: This table is intended for training only and shall not be used for actual operations.