Training Recommendations and Background Information for De-Icing /Anti-Icing of Aircraft on the Ground

5th Edition

September 2008

Association of European Airlines

AEA DE-ICING / ANTI-ICING TRAINING WORKING GROUP

The AEA De-icing/Anti-icing Training Working Group consists of dedicated member airline specialists in the field of de-icing/anti-icing of aircraft on the ground.

MISSION STATEMENT

The AEA De-icing/Anti-icing Training Working Group is the European focal point for the continuous development of safe, economical and universal training standards and procedures for the de-icing/anti-icing of aircraft on the ground in conjunction with related international standards organizations.

TERMS OF REFERENCE

Promote and develop safe practices, effective procedures and improved technology related to training of aircraft ground operations in winter conditions to ensure the highest possible levels of safety for passengers, flight crew and ground personnel.

Develop a set of commonly agreed recommended training practices and procedures for the de-icing/anti-icing of aircraft on the ground, to reflect current industry best practice. Publish these recommendations as the document 'AEA Training Recommendations and Background Information for De-Icing / Anti-Icing of Aircraft on the Ground'.

Update the document 'AEA Training Recommendations and Background Information for De-Icing / Anti-Icing of Aircraft on the Ground', as required, to ensure continued compliance with all relevant standards and regulatory requirements, and to ensure that it continues to reflect current industry best practice.

Develop training standards and specifications related to the de-icing/anti-icing of aircraft on the ground in conjunction with international standards organizations.

Prepare training material for aircraft ground de-icing/anti-icing purposes.

Harmonize with other organisations in the aircraft ground de-icing/anti-icing field (for example SAE, ISO, IATA, ICAO and regulatory authorities).

September, 2008

TRAINING RECOMMENDATIONS AND BACKGROUND INFORMATION FOR DE-ICING/ANTI-ICING OF AIRCRAFT ON THE GROUND – 5th EDITION

***This document has been prepared by the Training sub-working group, reviewed by the AEA's De-icing/Anti-icing Working Group* and approved by the AEA's Technical & Operations Committee (TOC).**

The De-icing/Anti-icing Training sub-working group consists of the following AEA member airlines:

Finnair, Chairman
SAS
Lufthansa
BMI
British Airways, Secretary

This document has been drafted according to the best knowledge of the author on the standard procedures for de-icing/anti-icing of commercial transport aeroplanes. However, it reflects general recommendations only and local airworthiness agencies' rulemaking and guidance as well as airframe manufacturers' manuals must always be followed. As individual icing situations or aircraft types/models may require special procedures, this document can never replace the responsibility of the operator's judgement. The responsibility for the correct de-icing/anti-icing of aeroplanes always stays with the operator of the aeroplane.

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PREFACE

This edition 5 completely replaces the previous edition. This manual has been updated with editorial changes and changes according to the AEA recommendations edition 23.

This manual undergoes substantial revision work and therefore it is visible as many marked changes although the operational procedures are not affected in the same extent. The main changes in this year's update are:

- Revisions from the AEA Recommendations, edition 23 have been noted
- Editorial changes
- Mission statement and terms of reference edited
- Rewording the 'de-icer' to 'de-icing operator'
- Adding a new qualification for cabin crew, DI-L80B
- Clarifying the coordinator qualification and operational duty
- Specifying the fluid delivery acceptance check
- Editing and clarifying the check procedures and communication procedures
- Adding reference indication to the training syllabus
- Adding an example of a typical closed cabin de-icing vehicle to the practical training syllabus part
- Including fuselage surface area as a reference in A/C specific information in Annex A
- Removing the index part in the manual and the Annex A
- Index removed from manual and annex

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Training Recommendations for De-Icing /Anti-Icing of Aircraft on the Ground

1 FOREWORD

This manual is intended to provide a common basis for de-icing/anti-icing training and qualification for de-icing providers and airlines. Each organisation involved is responsible for complying with local regulations and requirements imposed by manufacturers of aircraft, equipment, and fluids, by regulatory and environmental authorities.
This manual is divided in two parts:
- training and qualification recommendations, including the scope of training and
- overview and background information about de-icing/anti-icing procedures and related subjects.

It is up to each individual qualified instructor to explain these subjects to the personnel in an understandable way.

Reference material used in this manual includes common industry standards and recommendations, regulatory requirements and advisories. In particular, the AEA Recommendations for the De-icing/anti-icing of Aircraft on the Ground are used as a reference for recommended de-icing procedures. No reference is made to any specific instruction or recommendations given by manufacturers of aircraft, equipment, or fluids. These must also be taken into account. This manual contains a summary of operational procedures. Because of the large variety of procedures, standards and recommendations, it is impossible to include each element and cover all aspects. The main approach has been towards commercial airliners and relating ground service rather than helicopters, general aviation and similar operations. Internet links and a bibliography are included for further study and information at the end of this manual (Annex). Whenever the words “he”, “his” or “him” appears in this document, or any other words indicating the male gender alone, they shall also mean the female gender.

1.1 Introduction

This manual covers the recommendations for qualifying staff, contents of training, basic aerodynamics and meteorology related to de-icing/anti-icing operations, general health and safety information, different aspects of de-icing/anti-icing operations and aircraft types, operation of de-icing/anti-icing equipment, environmental issues and the coordination of de-icing/anti-icing operations.

The history of winter operations clearly shows that de-icing/anti-icing plays a vital role in flight safety. Regrettably even within the past few years incidents and accidents have happened due to improper winter operation procedures. Investigation has shown the causes to be deficiencies such as inspection or the determination for the need of de-icing/anti-icing, the de-icing/anti-icing procedure itself and the negligence/misinterpretation of holdover time. Factors leading to these errors are e.g. poor training, miscommunication, improper de-icing/anti-icing, fluid degradation, misinterpretation of tables and manuals etc. De-icing/anti-icing procedures are not just the concern of northern countries. Even in warm countries, frost and ice can build up on aircraft wings after a long flight at altitude. De-icing is a worldwide issue. Many organisations, companies and individuals have performed valuable research and contributed to the safety of icing related issues. Further work is needed to establish universal and comprehensive standards for all aspects of de-icing/anti-icing. Organisations that continue to be involved include are AEA, SAE, ISO, JAA, FAA, ICAO, TC and NASA.

A list of abbreviations of common terms relating to winter operations and de-icing/anti-icing can be found at the back of this manual. De-icing is a term that is often used when talking about general winter operational procedures. It does not mean that anti-icing or any other relating issues are less important or not related to the issue discussed.

1.2 Responsibilities

Everyone involved in each step of the de-icing/anti-icing process must be trained and qualified. This includes de-icing crews, release persons, de-icing managers and supervisors, quality assurance personnel, and flight crews. There are operational differences regarding who is performing each individual task, but the need for proper training and qualification is the same. The person communicating with the flight crew shall have a basic knowledge of the English language in order to communicate properly (refer to Annex D, ICAO language levels, operational level 4 is the preferred minimum).

The responsibility to determine the need for de-icing/anti-icing before dispatch lies either with the trained and qualified person who performs the departure duties on ground, or with the flight crew, who must be suitably trained and qualified for winter operations. The flight crew must then make sure that they receive the correct treatment. The trained and qualified de-icing operator is responsible for performing the correct de-icing/anti-icing procedure. The inspection after de-icing/anti-icing must be made by a trained and qualified person (e.g. the flight crew, release person or the de-icing operator).

A de-icing program should be established for each airline and/or operator/service provider to make sure that proper training, qualification and operation are performed. The importance of the “clean aircraft concept” must be made clear to everyone involved. The infrastructure must enable and support de-icing operations. All stakeholders must be aware of their responsibilities and duties. Aircraft operators and de-icing providers should have suitable ground handling agreements in place, at each airfield, which detail the rules and procedures. A quality program should be implemented to assure proper and safe operational procedures.

2 TRAINING

2.1 Training recommendations

The area of de-icing training shall be divided into the following parts: theoretical, practical and recurrent. Each part shall have a test to verify the correct procedures. The theoretical parts shall have a written examination with a passing rate of min. 75% and the practical part should have a demonstration of skill. The training shall be divided into different groups according to levels of qualification/operation.

A de-icing training program should be introduced. This training program should include all elements of training, levels of qualifications, verification of success, functions, duties, responsibilities, quality control, regular overview of instructing and records kept. The program should be under constant review to make sure it covers all new aspects of operation. The head of de-icing training is responsible to build up such a program. Up to date standards and recommendations shall be referred to.

Training sessions shall be recorded and kept for verification of qualifications. Records of theoretical sessions and exams as well as on-job-training records (where applicable) must be retained for each person qualified. The record shall clearly show that instruction has been given and received (signed documents are preferred). The same procedure shall be followed where contract de-icing is used. Names, dates and the scope of training must be clearly stated. A training schedule for each qualified person shall be maintained.

2.1.1 Scope of training

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 de-icing operators and the level and length of training should therefore be adjusted accordingly. However, the minimum level of training should be covered in all cases. As a rule of thumb, each hour of classroom training should at least equal the same amount (or include more) of practical training wherever this is relevant. Even if recurrent training does not include recurrent practical training, it is recommended that appropriate on-job-training be held periodically, or when new procedures/equipment have been introduced.

2.1.1.1 Training sessions

The content and length of theoretical and practical training depends on the level of qualification. The most in depth training is performed for the de-icing crew and de-icing instructors. Others receive a basic knowledge of de-icing/anti-icing and relevant subjects concerning their particular area of operation. Subjects mentioned below are headlines only and a more detailed content should be included for the instruction of each particular task. Both initial and recurrent training should include these subjects.

The content of de-icing training shall cover the following (but are not limited to these):

a) Common standards, regulations and recommendations
b) Basic knowledge of aircraft performance
c) Effects of frost, ice, snow, slush and fluids on aircraft performance
d) Meteorological considerations on ice formation
e) Basic characteristics of aircraft de-icing/anti-icing fluids, including causes and consequencses of fluid degradation and residues
f) General techniques for removing deposits of frost, ice, slush and snow from aircraft surfaces and for anti-icing
g) De-icing/anti-icing procedures in general and specific measures to be performed on different aircraft types
h) Aircraft in general and common critical areas
i) Types of checks required
j) De-icing/anti-icing equipment and facilities operating procedures including actual operation
k) Safety precautions and human factors
l) Emergency procedures
m) Fluid application and limitations of holdover time tables
n) De-icing/anti-icing codes and communication procedures (RT/E), knowledge of the English language
o) Special provisions and procedures for contract de-icing/anti-icing
p) Environmental considerations (e.g. where to de-ice, spill reporting, hazardous waste control etc.)
q) New procedures, new development and alternative technology, lessons learned from previous winters
r) Conditions which can lead to the formation of ice on the aircraft
s) Local rules and restrictions
t) Airport operational procedures and ATC
u) Quality control
v) Company and customer procedures
w) De-icing coordination procedures in general
x) Instructional procedures in general

When considering the length of theoretical training to cover all of these subjects, it is recommended that it be performed in about 14 hours, e.g. two days, of training. The practical parts should cover the relevant operational procedures and considerations and be performed preferably in about 21 hours, e.g. three days. The length and scope for different levels is explained in 2.1.2. Initial training is recommended to be held as classroom training. Recurrent training can be performed either in the classroom or as a “distance learning”, e.g. computer based training. All training shall include an examination that covers all relevant subjects.

2.1.2 Levels of qualification

The qualification level should be clearly defined. Each qualified person shall be fully aware of their approved functions. A suggested structure for levels of qualifications is listed below. A person may hold several approvals depending on the job function. Levels are divided into the following groups:

DI-L10 De-icing operator
DI-L20 De-icing vehicle driver
DI-L30 Supervision of de-icing/anti-icing
DI-L30B Pre-/Post de-icing/anti-icing inspector
DI-L40 De-icing instructor
DI-L50 De-icing coordinator
DI-L60 Fluid Quality Inspector (Laboratory staff)
DI-L70 Head of de-icing training
DI-L80 Flight Crew - winter operations (basics of de-icing/anti-icing)
DI-L80B Cabin Crew (icing awareness)

Initial qualification is performed after a successful theoretical part including exam and a practical training including assessment where relevant. Each qualification shall be renewed annually with a theoretical part including a written examination. The training subjects do not need to be covered repeatedly for each initial level of qualification if the same person is performing several duties.

2.1.3 Training subjects

These subjects are as a reference only. It is up to the instructors to give each and everyone of the de-icing operation the relevant instruction that can be based on the following subjects. These subjects should 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 notices local requirements and selects the direction of instruction accordingly. The noted subjects are intended to be introduced during training and not necessary mastered as some elements can be for general knowledge. Here is the selection of elements to include in instruction and subjects referred to in the manual.

Recommended elements for training, Ref. 2.1.1.1	**De-icing qualification level**										**Reference subject in Training Manual or applicable source**
	DI-L10	**DI-L20**	**DI-L30**	**DI-L30B**	**DI-L40**	**DI-L50**	**DI-L60**	**DI-L70**	**DI-L80**	**DI-L80B**	
Common standards, regulations and recommendations	X	X	X	X	X	X	X	X	X		*See Annex C,* (Bibliography)
Basic knowledge of aircraft performance	X		X	X	X	X		X			*See Chapter 3,* (Aerodynamics)
Effects of frost, ice, snow, slush and fluids on aircraft performance	X		X	X	X	X		X	X		*See Chapter 3,* (Aerodynamics)
Meteorological considerations on ice formation	X		X	X	X	X		X	X		*See Chapter 4,* (Weather)
Basic characteristics of aircraft de-icing/anti-icing fluids, including causes and consequences of fluid degradation and residues	X		X		X	X	X	X	X		*See Chapter 6,* (De-icing/Anti-icing Fluids)
General techniques for removing deposits of frost, ice, slush and snow from aircraft surfaces and for anti-icing	X		X		X	X		X	X		*See Chapter 7 and 8,* (De-icing/Anti-icing Operations and Off-gate de-icing/anti-icing operation)
De-icing/anti-icing procedures in general and specific measures to be performed on different aircraft types	X	X	X	X	X	X		X	X		*See Chapter 7 and 8,* (De-icing/Anti-icing Operations and Off-gate de-icing/anti-icing operation)
Aircraft in general and common critical areas	X	X	X	X	X	X		X	X		*See Chapter 9 and Appendix A,* (Aircraft Types)
Types of checks required	X		X	X	X	X		X	X		*See Chapter 7 and 8,* (De-icing/Anti-icing Operations and Off-gate de-icing/anti-icing operation)

Recommended elements for training, Ref. 2.1.1.1	**De-icing qualification level**										**Reference subject in Training Manual or applicable source**
	DI-L10	**DI-L20**	**DI-L30**	**DI-L30B**	**DI-L40**	**DI-L50**	**DI-L60**	**DI-L70**	**DI-L80**	**DI-L80B**	
De-icing/anti-icing equipment and facilities operating procedures including actual operation	X	X			X	X		X			*See Chapter 7 and 11*, (De-icing/Anti-icing Operations and De-icing/anti-icing Equipment)
Safety precautions and Human Factors	X	X	X	X	X	X	X	X	X		*See Chapter 5*, (Health and Safety, see also 8, 9, 11 and 12
Emergency procedures	X	X	X	X	X	X		X			*See Chapter 5*, (Health and Safety, see also 11)
Fluid application and limitations of holdover time tables	X		X		X	X		X	X		*See Chapter 7*, (De-icing/Anti-icing Operations)
De-icing/anti-icing codes and communication procedures (RT/E)	X	X	X	X	X	X		X	X		*See Chapter 7*, (De-icing/Anti-icing Operations)
Special provisions and procedures for contract de-icing/anti-icing					X	X		X			*See Chapter 13,* (Quality Control)
Environmental considerations	X		X		X	X	X	X			*See Chapter 10*, (Environment)
New procedures, new development and alternative technology, lessons learned from previous winters	X		X	X	X	X		X	X		*See Chapter 7*, (De-icing/Anti-icing Operations, see also 1.2.2, Annex C Bibliography and company material/history)
Conditions which can lead to the formation of ice on the aircraft	X		X	X	X	X		X	X	X	*See Chapter 4 and 7,* (Weather, De-icing/Anti-icing Operations)
Local rules and restrictions	X	X	X	X	X	X		X	X		*See Airport AIP or local winter operations plan,* (Ref. Annex C Bibliography, also 12 and 10)
Airport operational procedures and ATC	X	X	X	X	X	X		X	X		*See Chapter 8 and Airport AIP or local winter operations plan,* (Off gate de-icing/anti-icing operation, see also 12)
Quality control	X		X		X	X	X	X			*See Chapter 13*, (Quality Control)

Recommended elements for training, Ref. 2.1.1.1	De-icing qualification level										Reference subject in Training Manual or applicable source
	DI-L10	DI-L20	DI-L30	DI-L30B	DI-L40	DI-L50	DI-L60	DI-L70	DI-L80	DI-L80B	
Company and customer procedures	X	X	X	X	X	X	X	X	X	X	*Refer to company and customer manuals*, (See also Annex C Bibliography)
De-icing coordination procedures in general			X		X	X		X	X		*See Chapter 12*, (De-icing/anti-icing coordination)
Instructional procedures in general					X			X			*See Chapter 14*, (Training Fundamentals)

2.1.3.1 De-icing operator, DI-L10

The de-icing operator qualification (DI-L10) includes the contamination check (check for the need to de-ice), performance of de-icing/anti-icing and post de-icing/anti-icing check. This level of qualification includes driving the de-icing vehicle (DI-L20) and the qualification level DI-L30. There should be a note of restriction to this qualification if some of the duties are not performed as mentioned. The de-icing operator should receive training covering all parts in detail mentioned in 2.1.1.1 (except coordination and instructional procedures). Local procedures should be taken into account and emphasised more than others where relevant (e.g. some airports perform only centralised de-icing and some perform a mix operation etc.).

The theoretical training should be considered to be covered in about 14 hours, e.g. two days, of training including a written exam. The practical part should be considered to be covered in about 21 hours, e.g. three days. 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 should assess the practical part with "a demonstration of skill" during actual operation. The qualification has to be renewed annually with a theoretical part including a written exam.

2.1.3.2 De-icing vehicle driver, DI-L20

The de-icing vehicle driver qualification (DI-L20) qualifies the person to manoeuvre the vehicle and perform the communication procedures but it does not include any other de-icing levels. There should be a note of restriction to this qualification if some of the duties are not performed as mentioned. The driver should receive training covering relevant parts mentioned in 2.1.1.1. Local procedures should be taken into account and emphasised more than others where relevant.

The theoretical and practical training should be considered to be covered in about 7 hours, e.g. one day, including a written exam. The practical part should cover all different vehicles and types of operation that can be in use and it should include an assessment. The length of training depends largely on the type of operation and amount of different vehicles but practical training should not be shorter than the theoretical part. Local settings may demand a more extensive training and these recommendations are not binding. The qualification has to be renewed annually with a theoretical part including a written exam. However, all new equipment and operational changes need a practical training as well.

2.1.3.3 Supervision of de-icing/anti-icing , DI-L30

This level of qualification includes the performance of the post de-icing/anti-icing check, driving the de-icing vehicle (DI-L20) and the de-icing operator qualification (DI-L10). There should be a note of restriction to this qualification if some of the duties are not performed as mentioned. The person supervising the de-icing/anti-icing and performing the required checks should receive training covering relevant parts mentioned in 2.1.1.1. Local procedures should be taken into account and emphasised more than others where relevant.

The theoretical training should be considered to be covered in about 14 hours, e.g. two days, of training including a written exam. The practical part should be considered to be covered in about 21 hours, e.g. three days. This training is similar to the DI-L10 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 should assess the practical part with “a demonstration of skill” during actual winter operation. The qualification has to be renewed annually with a theoretical part including a written exam.

2.1.3.3 Pre-/Post de-icing/anti-icing inspector, DI-L30B

This level of qualification includes the determination of the need for de-icing/anti-icing and the performance of the pre/post de-icing/anti-icing check. This level is more limited than the DI-L30 and is only focused on duties to determine the need for de-icing/anti-icing and for the checking procedures. There should be a note of restriction to this qualification if some of the duties are not performed as mentioned. The person determining the need for de-icing/anti-icing and performing the required checks should receive training covering relevant parts mentioned in 2.1.1.1. Local procedures should be taken into account and emphasised more than others where relevant.

The theoretical training should be considered to be covered in about 4 hours, e.g. a half day, of training including a written exam. The practical part should be considered to be covered in about 4 hours, e.g. a half day. Theoretical and practical parts can be combined where relevant. This training is similar to the DI-L30 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 should assess the practical part with “a demonstration of skill” during actual operation. The qualification has to be renewed annually with a theoretical part including a written exam.

2.1.3.4 De-icing instructor, DI-L40

Training should be conducted by personnel who have demonstrated competence in the de-/anti-icing subjects to be instructed and who have the skills to deliver the training effectively. The assumption is that the instructor has at some point received the proper training for a DI-L10 qualification that includes the performance of de-icing/anti-icing, supervision of de-icing/anti-icing (DI-L30) and driving the de-icing vehicle (DI-L20). There should be a note of restriction to this qualification if some of the duties are not performed as mentioned. The de-icing instructor should receive training covering all parts in detail mentioned in 2.1.1.1. Local procedures should be taken into account and emphasised more than others where relevant. There may be cases where specialists in their own field (e.g. a meteorologist, ATC staff, etc.) are used as instructors for a particular subject. These specialists do not need to be qualified in de-icing.

The initial theoretical training (DI-L10) should be considered to be covered in about 14 hours, e.g. two days, of training including a written exam. The practical part should be considered to be covered in about 21 hours, e.g. three days. 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 de-icing instructors should be considered to be held as a separate session where subjects are covered in an instructional way. 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 de-icing instructor is qualified to assess any demonstration of skill where needed. The qualification is renewed annually with a theoretical part including a written exam. The recurrent training will renew all previous qualifications (DI-L10-40).

2.1.3.5 De-icing coordinator, DI-L50

The de-icing coordinator qualification (DI-L50) entitles the person to coordinate and manage the de-icing operation and/or work as a team leader in de-icing. This qualification is intended for coordinating de-icing operations mainly at remote and/or centralized de-icing facility areas or for other similar de-icing coordination functions at an airport. The qualification includes the performance of de-icing/anti-icing (DI-L10), supervision of de-icing/anti-icing (DI-L30) and driving the de-icing vehicle (DI-L20). There should be a note of restriction to this qualification if some of the duties are not performed as mentioned. The de-icing coordinator should receive training covering all parts in detail mentioned in 2.1.1.1 (except part w). Local procedures should be taken into account and emphasised more than others where relevant.

The initial theoretical training should be considered to be covered in about 14 hours, e.g. two days, of training including a written exam. The practical part should be considered to be covered in about 21 hours, e.g. three days. Local settings may demand a more extensive training and these recommendations are not binding. The training for de-icing coordinators should be considered to be held as a separate session where subjects 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 de-icing training (DI-L10). The length of this training may be implemented according to local demands. The qualification is renewed annually with a theoretical part including a written exam. The recurrent training will renew all previous qualifications (DI-L10-30 and DI-L50) unless specified otherwise (e.g. limited level).

2.1.3.6 Fluid Quality Inspector (Laboratory staff), DI-L60

The fluid quality inspector – (laboratory) qualification (DI-L60) includes the performance of quality control of fluids. The qualification should include training covering related parts mentioned in 2.1.1.1. Local procedures should be taken into account. International standards and auditing requirements, regarding fluid quality, should be taken into account. Fluid specific procedures should be noted. This qualification can in some cases be included in DI-L10 if local procedures so demand. However, appropriate training for quality inspection and procedures should be performed in any case.

A theoretical and practical training should be performed. Local settings may demand a more extensive training and these recommendations are not binding. The qualification is renewed annually with a theoretical part including a written exam. Any new fluid- and/or procedural requirements need special attention.

2.1.3.7 Head of de-icing training, DI-L70

The head of de-icing training is responsible for the de-icing training program. The head of de-icing training should have sufficient knowledge in de-icing operations and training to be qualified for this position. The head of de-icing training qualification covers all other levels of qualification (DI-L10-60). The qualification is renewed annually automatically as long as the responsibilities remain with the same person. This responsibility includes keeping up-to-date with the latest recommendations and standards involving relevant de-icing/anti-icing issues.

It is the responsibility of the head of training to review all relating 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 training. All different training sessions shall receive an appropriate material content according to the appropriate qualification. Any company standard training material shall be under revision control and appropriate standards and recommendations shall be referred to.

2.1.3.8 Flight Crew - winter operations, DI-L80

The flight crew is not normally engaged in daily ground de-icing procedures but a knowledge of the process should be in place. The flight crew may have their own training regarding winter operations. This training should be implemented to cover all relevant aspects of the ground process. This is an important factor in order to be able to communicate with the ground crew about proper treatment procedures and in general have a sufficient knowledge of these subjects. Responsible for de-icing/anti-icing training for flight crews is the Postholder Training. The Postholder Training should harmonise the training with the head of de-icing training and operation. The qualification is renewed annually with a theoretical part including an examination.

2.1.3.9 Cabin Crew – icing awareness, DI-L80B

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

2.1.4 Examination process

The examination process contains a theoretical exam where a minimum pass rate of 75% is required. The practical part (where applicable) only contains a fail/approve determination. Even though 75% will approve the theoretical part, 25% was still misunderstood. This "gap" must be noted and wrong answers corrected with the student to 100% in order to secure the safe de-icing operation. The written exam can be performed as an open book exam where pertinent holdover time tables and quality indexes can be referred. Normal de-icing procedures should be common knowledge and there should not be any material available during the test explaining these subjects. Note that de-icing operations should be based on safety and not based on things remembered (regarding holdover timetables and quality).

The examination for any particular course should be build 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 amount 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 EASA Part-66 or any equivalent requirement. The questions should be multiple choice questions containing a minimum of three possible answers per question. If there are clearly differing procedures from normal de-icing operation then written answers can be used to explain this.

It is up to the head of de-icing training to include these elements in the training program. The questions shall always be based on facts and not perceptions. The question shall not be misleading or be possible to be interpreted wrongly. This misconception may lead to remembering the subject in a false way. The question series should cover all aspects of operation and include the local arrangements (if any). Practical evaluation should include an oral quizzing where practical items are covered (e.g. reading holdover timetables and/or refractive index limits etc.).

Records shall be kept of all tests and scores, both theoretical exam and practical assessment. The record must indicate what the qualification is going to be, who is doing the test, who is the evaluating instructor, the score and the date. A failed examination can be retaken but this must be noted for future reference. If a person does not pass the examination a re-evaluation should be made and additional training considered if necessary. The evaluation process must lead to a qualification. Any restriction to the qualification shall be documented. A certificate should be given to the person for verification of the successful training. A copy of the certificate should be kept. Any documentation should be easily at hand for verification of approved de-icing staff.

2.1.5 Training system and renewal

All training should be performed according to a preassigned training program. This program should include all levels of training and their relevant requirements. The theoretical part should be assorted according to the qualification and thus divide the training sessions from each other. This training system will easily identify what course is leading to which qualification. A recurrent course should be presented as a training session that renews previous qualifications. This numbering system does not need to be the same for every company but a logical sequence to follow is desired. When qualified to perform certain de-icing duties an annual recurrent training is demanded. This recurrent training does not have to be performed exactly or before the date of the previous qualification. This would lead to a never-ending advancement of training which is not possible. The qualification will stay valid for the beginning of the season but needs to be renewed before the years end. As an example: if qualified on November 1st 2007 a renewal is forthcoming in November 2008 but at latest by 31st December. This flexibility eases the burden of training large groups in the beginning of the season. However, it is highly recommended that the training be performed as early in the season (or before the beginning of the season) as practicable.

Background Information for De-Icing /Anti-Icing of Aircraft on the Ground

3 AERODYNAMICS

3.1 General

This section explains how operating in winter conditions can affect aircraft performance. The basic concept will be introduced of how any contamination affects the performance and why the de-icing ground crew should note any and all factors relating to the aerodynamic surfaces of the aircraft. 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 de-icing ground crew.

The specific performance of any aircraft is calculated and tested with the assumption that all of its aerodynamic surfaces are clean. Any contamination will affect 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 de-icing ground crew. As a rule of thumb “make it clean and keep it clean”.

3.1.1 Forces involved

An aircraft is subjected to four forces, Lift, Drag, Thrust and Weight. For an aircraft to fly straight and level, all these forces must be balanced. A change in any one of these forces will affect this balance. This change can be either intended or unintended (e.g. icing). Frost, snow, slush or ice accretion has a negative effect on all these forces. Lift lessens, drag increases, weight increases and available excess thrust decreases. Contamination also affects the stall angle of attack by decreasing it, which could be very harmful at takeoff. It is up to the de-icing crew to clean the aircraft and protect it so it is aerodynamically “clean” until takeoff after which the flight crew can operate the aircraft’s own de-icing/anti-icing systems to protect the critical parts of the aircraft.

3.1.1.1 Basic aerodynamics

The critical effects of contamination are the resulting decrease in lift and manoeuvrability. 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. This part is where the airflow is 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 evenly along the surfaces at first (called laminar), but then after a certain point starts to break away (called turbulent) depending on the angle of attack. Any contamination at the leading edge will upset this flow and it will break off earlier than intended causing a loss of lift.

The aircraft moves around three axes, Longitudinal, Horizontal and Vertical. The flight crew controls this movement by changing the position of the ailerons, rudder and/or the elevator depending on the particular flight situation. Any contamination on these control surfaces may restrict their movement or cause them to be ineffective (because of incorrect airflow) and in worst case cause a loss of control.

3.1.2 Aerodynamic areas

Basically the entire aircraft is designed to divide the airflow in a particular way and any contamination will disturb this flow. The wings and the tail are the main concern but also secondary parts such as slats, flaps, ailerons, rudder, elevator and tabs are critical for the correct airflow, especially the leading edges where the airflow is divided. It is important that the de-icing crew can identify these parts because the success of removal of contamination and protection from icing has a direct impact on lifting and manoeuvrability.

Many 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 de-icing ground crew must assure that these areas are free of contamination whether they are considered a critical lifting surface or not. Such other aerodynamic parts on an aircraft can be strakes, vortilons, winglets, pylons, stall strips/vanes, vortex generators etc.

3.1.3 Aircraft surfaces

The importance of cleaning the leading edges of the wings and tail was mentioned earlier. However, lowering slats and flaps exposes new surfaces and leading edges where contamination can adhere. If slats and flaps are in a lowered position while the aircraft is on the ground such areas shall be checked and cleaned/protected if necessary. Contamination on these parts will cause irregular airflow and manoeuvrability problems when they are lowered in flight.

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. Frost may be allowed to a certain extent depending on aircraft manufacturer's requirements and company procedures.

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

3.1.4 How contamination affects lift and performance

It is obvious that if the aircraft is covered with large amounts of snow, sleet/slush or ice, that it will affect lift and performance, but even "lighter" contamination such as frost can still have a considerable negative effect. Even if the loss of performance is not enough on it's 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 this manual's main focus is on the flight safety consequences of contaminated aircraft surfaces, rather than the financial impact.

3.1.4.1 Frost affecting lift

Tests have been performed on how a different thickness of frost effects the lifting performance. The effect on other types of aircraft may be similar, this particular example happens to compare the performance of a narrow body jet aircraft. Three scenarios where compared, clean wing, a thin layer of frost (e.g. 1 mm or less) and a thick layer of frost (e.g. 1-2,5 mm). First normal takeoffs with these layers where compared then takeoffs with an engine-out situation with the same layers. Commercial airliners are fitted with powerful engines that in normal cases produce a certain amount of excess thrust. This is seen as only a marginal lift loss in normal takeoff situations. A thick layer of frost has some effect on normal lifting performance but it is not dramatic. However, when there is an engine-out situation with these contamination layers, it can be seen that 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.

3.1.4.2 Frost affecting stall

Tests have also been performed of how different thickness of frost affect the stall performance/speed with a certain angle of attack. This particular example compares a narrow body jet aircraft. Each aircraft has a particular angle of attack when lift is reduced and it is said to stall. The higher the angle of attack the more lift is produced, this is a phenomenon needed particularly during takeoff (and landing). When a thin layer of frost is on the wing, it reduces the maximum angle of attack (CL-max) by a certain amount and the wing stalls earlier than anticipated/calculated even without any stall warning. This scenario can be put into a certain velocity and in this case it stalls 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 more dramatic. Putting into a velocity, it stalls notably earlier than anticipated.

3.1.4.3 Other effects on performance

It is clear that contamination will affect the amount of drag on an aircraft. The more contamination located on an aircraft the more drag and thus less performance. This contamination does not have to be on aerodynamic surfaces (which must be cleaned anyway) to create drag, it can be on the landing gear, fuselage etc. These areas must be cleaned but as an example it can produce drag even if it does not directly affect lift. Thrust must always be added (if excess thrust is available) to compensate for the reduced performance. This is perhaps even more notable on propeller aircraft. The propeller is in itself a lifting device and its surface must be clean (the proper cleaning procedures according to A/C manufacturer's requirements). Any contamination of the blade surface can reduce the pulling force effectiveness of the propeller. Vibration of the propeller(s) due to contamination may also be a factor to note. The same applies for jet driven aircraft. A visual check of the fan blades and especially on the rear side of the fan blades is necessary to detect frozen contamination adhering to them. This can lead to vibration, performance loss and even engine damage.

3.1.5 Fluid behaviour on aircraft surfaces

De-icing/anti-icing fluids can be misunderstood to be an equal contaminant on the wing as for example slush/sleet. Fluids have been tested and manufactured to perform in a certain way. This has been aerodynamically tested and it is evident that the fluid is sheared from the wing at takeoff leaving only a marginal film of fluid that does not constitute a notable aerodynamic effect. Different fluids are thicker than others are (Type-I vs. Type-II/III/IV) and less viscous fluid drain off easier than thicker fluid.

Failed fluid no longer performs aerodynamically as expected. At this point the fluid is comparable to any other contamination. Also old fluid (e.g. after a flight) sticking to the surface should be removed because it neither performs correctly. Tests have been made on how the fluid effects lifting performance at certain rotational speed, rate and angle of attack etc. This data is still under study. Certain aircraft types and airlines need to know the fluid (and coverage) on the surface in order to correct thrust settings, V-speeds etc. Restrictions also apply for certain aircraft types and airline procedures on the flight performance. Additional rotation speed, airspeed in general, runway length and added weight are examples of how de-icing/anti-icing fluids can set restrictions or add procedures for the flight.

4 WEATHER

4.1 Relevant weather aspects

Weather is complex and at times difficult to understand. Our restless atmosphere is almost constantly in motion as it strives to reach equilibrium. These never-ending air movements set up chain reactions, which culminate in a continuing variety of weather. The climate of any particular region is largely determined by the amount of energy received from the sun, but the local geography of the area also influences the climate. We are prepared to face "problems" in areas where winter is unavoidable but there can be a hidden danger at regions where winter weather aspects are not so obvious. The main point is to be aware of how, where and why ice, in its different forms (and relating forms of frost and snow), can build up.

4.1.1 Weather terminology

Weather terminology can be seen and heard from various weather information sources. The general terms are standardised and they are adapted in the same way everywhere. Weather information is essential for the de-icing crew in the sense that official temperature and weather characters must be obtained for proper analysis of de-icing, anti-icing, mixture and holdover time procedures. Weather abbreviations can be found in Annex B.

The intensity can be marked as light (-) or heavy (+), otherwise it is considered moderate intensity (no marking). Note: intensity in MET reports is defined according to horizontal visibility. The actual accumulation of precipitation and horizontal visibility may in some cases not be comparable and therefore caution must be taken when interpreting the intensity.

4.1.2 Explanation of weather terms

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

Change of state:
The transformation of water from one form (e.g. solid (ice), liquid, or gaseous (water vapour), to any other form).

(a) Condensation: the change of water vapour to liquid
(b) Evaporation: the change of liquid water to water vapour
(c) Freezing: the change of liquid water to ice
(d) Melting: the change of ice to liquid water
(e) Sublimation: the change of (1) ice to water vapour or (2) water vapour to ice (also called deposition)

Clear ice:
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. Factors, which favour 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 build-up, when:

(a) Wing temperatures remain well below 0°C during the turnaround/transit
(b) Ambient temperatures between -2°C and +15°C are experienced (note: Clear ice can form at other temperatures if conditions (a), (c) and (d) exist)
(c) Precipitation occurs while aircraft is on the ground and/or
(d) Frost or ice is present on lower surface of either wing.

Cold-soak effect:
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-fuelled with very cold fuel. Whenever precipitation falls on a cold-soaked aircraft when on the ground, clear icing may occur. Even in ambient temperatures between -2°C and +15°C, ice or frost can form in the presence of visible moisture or high humidity if the aircraft structure remains at 0°C or below. Clear ice is very difficult to be detected visually and may break loose during or after takeoff. The following factors contribute to cold-soaking: temperature and quantity of fuel in fuel cells, type and location of fuel cells, length of time at high altitude flights, temperature of re-fuelled fuel and time since re-fuelling.

Cold front:
Any non-occluded front, which moves in such a way that colder air, replaces warmer air.

Dew point:
The temperature to which a sample of air must be cooled, while the amount of moisture and barometric pressure remain constant, in order to attain saturation with respect to water.

Drizzle:
A form of precipitation. Very small water droplets (diameter less than 0,5mm) that appear to float with the air currents while falling in an irregular path (unlike rain, which fall in a comparatively straight path and unlike fog droplets which remain suspended in the air).

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

Freezing fog:
A suspension of numerous minute water droplets which 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).

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

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

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

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/hour (0.10 inch/hour) or 25 grams/dm^2/hour with a maximum of 0.25-mm (0.01 inch) in 6 minutes.

Lowest operational use temperature (LOUT):

The lowest operational use temperature (LOUT) is the higher (warmer) of
a)The lowest temperature at which the fluid meets the aerodynamic acceptance test (according to AS5900) for a given type (high speed or low speed) of aircraft
or
b)The freezing point of the fluid plus the freezing point buffer of 10°C for Type I fluid and 7°C for Type II, III or IV fluids.
For applicable values refer to the fluid manufacturer's documentation

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/hour (0.10 inch/hour) or 25 grams/dm^2/hour.

Rain or high humidity (on cold soaked wing):
Water, visible moisture, or humidity forming ice or frost on the wing surface, when the temperature of the aircraft wing surface is at or below 0°C (32°F).

Rain and snow:
Precipitation in the form of a mixture of rain and snow.

Relative humidity:

The ratio of the existing amount of water vapour in the air at a given temperature to the maximum amount that could exist at that temperature (usually expressed in percent).

Saturation:

The condition of the atmosphere when actual water vapour present is the maximum possible at existing temperatures.

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.

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 in.). When snow grains hit hard ground, they do not bounce or shatter.
Snow pellets:
Precipitation of white, opaque particles of ice. The particles are round or sometimes conical; their diameter range from about 2-5 mm (0.08-0.2 in.). Snow pellets are brittle, easily crushed; they do bounce and may break on hard ground.

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

Super cooled water:
Liquid water at temperatures colder than freezing.

Warm front:
Any non-occluded front, which moves in such a way that warmer air, replaces colder air.

Water vapour:
Water in the invisible gaseous form.

* Note: intensity in MET reports is defined according to horizontal visibility.

4.1.3 Interpreting weather data

Weather information can be gathered from various sources. Some of this written information can be difficult to understand at times but they all follow the same logic. As for the de-icing crew, temperature, dew point, precipitation, intensity and forecast information are elements that affect the operation. Some of these terms are explained below as well as an example of a local meteorological report.

METAR — Meteorological Report (local), also METREP, SPECI, AUTO-METAR. Reported normally every 30 min. Includes a possible TREND-forecast. Informs of the current weather situation. 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 (260 º and 06 Knots)
-SN	= Light snow
5000	= Visibility (m)
SCT006	= Clouds (coverage and height)
BKN008	= Clouds (coverage and height)
M02/M03	= Temperature (-2 ºC) and dewpoint (-3 ºC)
Q0998	= Air pressure (QNH 998 hPa)
NOSIG	= TREND forecast (no significant changes)
1529//75	= SADIS-group
2229//75	= SADIS -group
=	= End of report

TAF — Terminal Area Forecast for the airport (including changes). Valid for 9H/18H or as long as the airport is open. Renewed every 3/6 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 06-15 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 are the automated weather service (VHF-frequency at the airport), weather charts, weather radar etc. Even if this weather sampling is not an everyday routine for everyone it is important that someone informs the de-icing crew of the official and correct temperatures in order to use correct glycol mixtures. 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.

4.1.4 Ice formation

Water can have many forms; vapour, liquid, snow or ice. Water can be visible (fog, mist, drizzle, rain etc.) or invisible but evident (high humidity). Excluding the obvious ice and snow, water can form into ice with the appropriate temperature and surface settings. Traditionally, two common temperature references are the melting point of pure ice (±0 ºC) and the boiling point of pure water (+100 ºC) at sea level. However, ice can form when the difference between the air temperature and dew point is small (indicating a high humidity) and when surface temperature (e.g. wing) is close to ±0 ºC even if the outside air temperature is well above freezing. This phenomenon can happen whenever the wing tank contains cold fuel and conditions are right. Icing is perhaps more of a problem for the flight crew in flight but whenever the right conditions exist on ground each trained and qualified de-icing ground crew should be aware of the event.

4.1.4.1 Areas of ice build-up

There is no one single rule of where ice can be found. It may be local in extent and different in character. A big concern is whenever a temperature close to ±0 ºC exist and there has been some rain or snowfall after which the temperature drops below freezing and all the rain or melted snow freezes. In worst cases it can be hidden underneath a layer of snow. Clear ice is like it sounds, clear and difficult (if not impossible) to see. A normal area of ice build up on an aircraft is the tank area. The cold fuel causes the aircraft surface (tank area) to drop close to or below ±0 ºC, which in turn reacts with the moist air and freezes. A hand feel check is the best way to verify the presence (or removal) of ice. Tank areas are not only located at the wing root, they can also be located at the wingtip and in the tail section.

Water blown by propellers or jet engines, 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 inspection. Fan blades of a jet engine can be susceptible for icing if conditions are right. Ice fog and high humidity in general may be a major factor contributing to fan blade icing. Aircraft may experience icing while flying through clouds for landing. Icing can be found on all leading edge and frontal areas after landing. The heated aircraft cabin will melt any ice and/or snow from top of the fuselage and the melted water will drain downwards and freeze on the wings and underneath the fuselage. All these areas must be checked and proper treatment performed if necessary.

Super cooled water increases the rate of icing and is essential to rapid accretion. A condition favourable for rapid accumulation of clear icing is freezing rain below a frontal surface. Rain forms above the frontal surface at temperatures warmer than freezing. Subsequently, it falls through air at temperatures below freezing and becomes super cooled. The super cooled drops freeze on impact with an aircraft surface. It may occur with either a warm front or a cold front. The rain does not necessarily need to be super cooled to freeze. As mentioned earlier, if the aircraft surface area is very cold then rain can freeze as well. Freezing fog is relatively same in character as supercooled rain; it tends to freeze on impact. Fog can also cause frost and it may well cover the whole aircraft. The difference of ice creation caused by FZFG and FZRA differs by droplet size and humidity also differs depending on the air mass, cold air is dryer than warm air.

Icing may occur during any season of the year but in temperate climates, icing is more frequent in winter. Polar Regions have the most notable icing 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 icing. This does not, however, rule out the possibility of icing in these areas. Arctic areas, as could be expected, is very cold in winter but due to local terrain and the movement of pressure systems, occasionally some areas are surprisingly warm.

4.1.4.2 Hazards of ice on aircraft

Ice, snow and slush have a direct impact on the safety of flight. Not only because it degrades lift and takeoff performance/manoeuvrability but it can also cause engine failures and structural damage. Mainly fuselage aft-mounted engines are susceptible for this FOD (Foreign Object Damage) phenomenon caused by winter operations. But it does not exclude wing-mounted engines. Ice can be present on any part of the aircraft and when it breaks off there is some probability that it could go into the engine.

The worst case is that ice on the wing breaks off during takeoff due to the flexing off the wing and goes directly into the engine (or both) leading to surge, vibration and complete thrust loss. Snow, even light snow, which is loose on the surfaces and the fuselage, can also cause engine damage leading to surge, vibration and thrust loss. Leakage of the water and waste panels can cause ice build-up, which will break off causing damage and hazardous situations. Even if the ice does not go into an engine it can severely damage the structure of e.g. the tail surfaces (mainly leading edges) causing unbalanced airflow or even vibration problems. It should also be noted that ice could fall down on the ground during takeoff and flight causing dangerous situations for anyone or anything.

Ice damage is not only a safety related issue (even if it is the most important one) but it is also a financial burden for airlines. All damages have a price tag and an engine overhaul is not cheap. This economical burden will ultimately affect the passengers as a side effect. FOD-problems due to icing on ground are preventable and here is where the de-icing crew have an important role.

4.1.5 Frost formation

Frost can form because of many reasons. Frost forms near the surface primarily in clear, stable air and 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 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 (explained in 3.1.4.1). In coastal areas during spring, fall and winter, heavy frost and rime 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 being de-iced/anti-iced 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 de-icing/anti-icing of the entire wings unnecessary under such circumstances. This procedure does, however, not supersede standard de-icing/anti-icing procedures and has to fulfil the proper requirements. This procedure also does not relieve from any requirements for treatment and inspections in accordance with aircraft manufacturer manuals.

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

4.1.6 Weather effects on aircraft operations

Winter operation in harsh climates is bound to affect the punctuality of any airline. Not only is ground operations impaired but also snow and ice on apron, taxiway and runway areas affect aircraft operations as well. However, there is no short cut to a safe de-icing/anti-icing procedure on ground. Flights are, irrespective of season, in some cases restricted with a certain take-off time (CTOT). This “window” of departure causes undue pressure for the completion of ground procedures but this shall not cause any diversions in normal and safe de-icing/anti-icing procedures. Heavy winter weather conditions make the de-icing ground procedure to be more a normal task than an exception to consider. Airlines that do not operate on a regular basis to these areas might not be as aware of the importance for an appropriate inspection and treatment. Milder winter seasons in warmer regions do not rule out the importance of an equal de-icing/anti-icing performance as in other regions.

4.1.7 Weather categories

De-icing/anti-icing procedures and their respective holdover timetables are set according to some weather elements. These tables do not necessarily cover all the phenomena that can be experienced during a winter season but they give a compromise of choices where different elements can be included. Some weather elements do not include tested holdover times and caution should be used if any particular weather is in this category. Each weather category has its relevant temperature indication range. These weather categories include:

(a) Active frost
(b) Freezing fog
(c) Snow/Snow grains
(d) Freezing drizzle
(e) Light freezing rain
(f) Rain on cold soaked wing
(g) Other*

* Other conditions are: Heavy snows, snow pellets, ice pellets, hail, moderate freezing rain and heavy freezing rain

Each box in the table contains an estimated time window for that particular holdover time. This range of time depends on the intensity and the decision of choice rests with the flight crew according to their estimate. In some cases the Snow/snow grains-column is divided into two additional parts, light snow and very light snow. The decision of what category to use lies with the pilot in command, unless the airport is equipped with such instrumentation that can make a correct and accurate report on each weather element and its intensity covering the whole area.

Other elements, such as wind, jetblast etc. will affect each respective weather category and its relevant holdover time. These conditions should be taken into account when looking into a particular table. Each holdover timetable should be reviewed recurrently and verified that the latest revision is used (these examples are only for reference).

4.1.8 Weather effects on fluid behaviour

Weather not only causes the need for de-icing and anti-icing it will also affect the performance of the fluids. Each fluid has a particular holdover time. This holdover time is dependent on different weather factors. The fluid can withstand a certain amount of water (in forms of snow, slush, rain etc.) until it becomes so diluted (or saturated) that it no longer gives protection against freezing or fulfils aerodynamic criteria. Further, wind has its own affect on how even the fluid layer is on the surface and can also lower the actual outside air temperature. Very cold temperatures also limit the use of glycol (variable with different compounds) both for anti-icing and de-icing. The viscosity of glycol also changes with temperature (variable for different fluids) and it in turn affects how the fluid is sprayed and how it drains off the surfaces.

5 HEALTH AND SAFETY

5.1 General

Safety is an issue concerning everyone involved. Operational safety, equipment safety, flight safety, personal safety and health etc. are elements that need to be checked and verified for proper procedures. Many companies and airlines have their own manuals regarding the subject and they should be followed. The airport may dictate general rules of conduct in emergency situations (and special cases) from an airport operations point of view and by the operators from a company point of view. Airport equipment need to be qualified for every specific task accordingly and the personnel using them shall have the proper training and qualification for its use. The airport is planned for aircraft operations but there has to be a large amount of ground service equipment to fulfil all the tasks needed for an efficient and safe departure. All this “action” on the ground can lead to many “close encounters” and procedural training should be performed for the whole ground staff for each particular task and for the apron operation in general.

5.1.1 De-icing fluids

Many different de-icing/anti-icing fluids are in use all around the world. There are several fluid manufacturers that can provide certified fluids for the market. The composition of the fluid varies by region and by manufacturer and also depending on the use of the glycol (aircraft de-icing/anti-icing or apron, taxiway and runway de-icers). Some compounds that can be found in use at airports and operators are propylene-, ethylene- and di-ethylene glycol, urea, potassium acetate, calcium magnesium acetate, sodium acetate, sodium formate, chlorides and isopropyl alcohol. Propylene- and ethylene glycol are perhaps the most common in use and known for aircraft de-icing/anti-icing.

For aircraft de-icing/anti-icing operations, Type-I, Type-II; Type-III and Type-IV are used to identify different glycol and their specific application. These fluids are diluted to some extent with water. Additives are used in the fluid to make it serve a specific task. These additives can be as an example:

(a) Surfactants (wetting agents)
(b) Corrosion inhibitors
(c) Flame-retardant
(d) pH buffers
(e) Dyes
(f) Complex polymers (thickening agents)

The major components are glycol and water. Additives comprise approximately 1% - 2% (Type-I and Type-II/III//IV respectively) of the fluids. All fluids are required to meet certain standards (SAE AMS1424 and AMS1428). These fluids would be unable (or restrictively) to meet SAE standards without additives.

Glycols are tested for environmental impact and for operational use. Some of these tests may include:

(a) Mammal toxicity
(b) Aquatic Toxicity
(c) Acute oral toxicity
(d) Acute inhalation toxicity
(e) Acute dermal toxicity
(f) Irritant effect on skin
(g) Irritant effect on eyes
(h) Sensitization
(i) Mutagenicity

Even if glycols are found to have low toxicity proper precautions should be taken. Pure glycols have been tested and results concluded but additives are considered a trade secret so all aspects have not been tested when it comes to aircraft de-icing/anti-icing fluids. Ethylene- and propylene- glycol compounds are found/used among others in food, make-up products, paint, lacquer, automotive antifreeze etc. Irritation and vapours etc. has not been found to be toxic. Oral ingestion is in general toxic for ethylene glycol but propylene glycol has not been found to be toxic, but with large quantities it can reach a dangerous level. In normal operational use, ingesting glycol orally should not be possible (excluding some drops from splashing). Consult the specific material safety data sheet received from the fluid manufacturer for proper safety procedures.

5.1.2 Personal health and safety

De-icing operations is many times subjected to harsh elements. There are cold temperatures, wind, some sort of precipitation, loud noises from aircraft engines/APU, jet blast, marginal sunlight/airport lighting at wintertime, manoeuvring a large de-icing vehicle in narrow areas between aircraft and the de-icing spraying itself. Despite all of these items (and others) the de-icing operation can be performed safely and efficiently with the proper training, equipment and safety gear. De-icing vehicles are basically divided into open-basket and closed-basket de-icers. A closed-basket protects the de-icing operator from many of the mentioned elements but if there are procedures performed outside the vehicle, proper safety gear should be used.

When de-icing from an open-basket the de-icing operator is also subjected to glycol mist (among the rest mentioned earlier) while spraying and proper protective clothes and gear should be used. Rubber gloves, water proof clothing, water proof shoes (proper footwear), hearing protector and safety harness are items that should be used for sufficient protection under such conditions. Sufficient washing of hands, neck and face (any areas subjected to outside elements) should be remembered in order to minimise any possible skin irritation caused by glycols. Hearing protectors are very important because of the high amount of noise at the apron. Noises between 80-100 decibel are quite ordinary but even 120 decibel can be experienced at times. The noise experienced over time (work period) should also be considered.

5.1.3 Operational safety

Operational safety includes the proper performance of de-icing operations around/close to aircraft, equipment and de-icing fluid filling station procedures, airport operations in general, knowledge of aircraft movements at the apron, danger of jet blast etc. These subjects should be covered during training and there should be a clear procedure of operation relating to these items. The de-icing vehicle should be checked for proper condition before use. Items such as fire extinguisher, boom emergency lowering, emergency stop buttons, work lights, the chassis in general, fluid filling ports, engine area, manuals, communication equipment, safety gear and fluids (among others) should be in correct condition and available. Slippery conditions can exist on the ground and on the equipment surface following the de-icing/anti-icing procedure. Caution should be exercised, particularly under low humidity or non-precipitating weather conditions due to increased slipperiness following the use of glycol that is not diluted by the weather element.

The operation around aircraft can be subjected to many dangerous elements such as noise, jet blast (and suction), turning propellers, moving aircraft, low visibility etc. The procedure for each situation must be clear and proper training should be received. The de-icing operation can be performed at gate (or after pushback) at some airports and this limits the danger caused by running engines and moving aircraft. Centralised/remote de-icing has its own procedure and the proper operation must be clear for all involved (flight crew and ground crew). Jet blast is very dangerous if subjected to it at close range ("close range" can be a relative term, but the distance should refer to idle and brake-off thrust). Not only the main engines but also the blast from the APU can be dangerous when operating in an open-basket. Driving behind jetblast should be avoided at all times and the de-icing procedure around the aircraft should be planned accordingly. The engine inlet also causes a threat due to the suction force and this area should be avoided as well.

Communication is an important part of the procedure (especially during centralised/remote operation) to verify a safe and correct operation. No misleading comments shall be spoken and unclear issues shall be verified. The airport usually gives out the limitations and requirements of how and where de-icing procedures can be performed. These directions should be taken into account and any special issues should be noted. The safety harness should be worn at all times when operating from an open-basket. Whenever there is a need to verify the aircraft surface by hand feel or if brushing the surfaces, safety harnesses or equal safety ropes should be used. When filling de-icing vehicles with heated fluids (water and glycol) caution should be taken because of high temperatures as the fluid can be up to 80-90 ºC.

5.1.4 Human factors

The de-icing/anti-icing process is constantly subjected to a hidden danger of human error. Proper training and qualification are not an automatic indication of professionalism if the attitude towards the de-icing operation is not in place. This phenomenon is evident both for flight crew and ground crew. Too many statistics are available because of crews improvising or neglecting the correct procedure. The de-icing process is the last process before the departure and all elements must be considered. Incidents and accidents have happened not only for aircraft but also for ground equipment because of neglect. De-icing vehicles can raise the boom as high as 14-25 meters and this configuration sets certain conditions for the operation. There should be a clear procedure of conduct in case of incidents/accidents for any scenario. Records should be kept even for small incidents so they could be analysed and learned from. A professional attitude in all conditions, operation and weather elements is the key to complement proper training.

6 DE-ICING/ANTI-ICING FLUIDS

6.1 De-icing fluids

There are currently four different fluid types. These fluids are called Type-I, -II, -III and –IV. The compound of each individual certified fluid varies but the types are known and accepted all over the world. The qualification is performed according to SAE-standards and SMI, APS and AMIL perform them for different tasks. All tests are currently performed in North America to qualify the fluids. SMI, Scientific Material International, located in Miami, Florida in the USA. SMI's role is to conduct AMS Specifications (Aerospace Material Specifications) aircraft materials compatibility testing. These are standards developed by the Aerospace Materials Division under the direction of the SAE Aerospace Council. APS Aviation Inc. is a company part of the ADGA group. APS is located in Montreal, Quebec in Canada. APS's role is to manage, conduct and analyse testing related to the effectiveness of commercially produced de/anti-icing fluids, methodologies and technologies associated with operations under icing conditions and conduct endurance time (hold over time) testing. AMIL is an icing research laboratory attached to Université du Québec à Chicoutimi (UQAC) in Canada. The main expertise at AMIL lies in the performance evaluation of anti-icing fluids used on ground aircraft.

The fluid must be accepted (among others) according to its type for holdover times, aerodynamic performance and material compatibility. The colouring of these fluids is also standardised. Glycol in general is colourless; as can be seen with older certified fluids when colouring was not standardised (older generation Type-I and Type-II). Currently orange is the colour for Type-I fluids, water white/pale straw (yellowish) is the colour for type-II fluids and green is the colour for Type-IV fluids. The colour for Type-III fluid has not yet been determined. In general de-icing/anti-icing fluid may be uncoloured if so requested. Fluid tests are performed in laboratory conditions as the environment can be controlled. These tests include a variety of material compatibility tests, aerodynamic performance in wind tunnel tests and holdover time tests according to the set weather conditions in the holdover timetables. Other tests are also conducted that are not mentioned in detail here.

6.1.1 WSET/HHET/Holdover time

Each fluid is tested in a climatic chamber relevant to the test performed and according to the type category (Type-I, -II, -III, -IV) and its related weather and temperature columns. Laboratory testing for qualification of a fluid requires a so called Water Spray Endurance Test (WSET) and a High Humidity Endurance Test (HHET).The laboratory test includes test plates where the fluid is poured, and also clean plates for reference. The plates are set in a 10º angle to simulate the angle of the wing. The precipitation is then set according to what is to be tested. The plates have a line at a 2,5 cm (1 inch) level. The fluid can be interpreted as “failed” when the ice has reached this line (fluid failure is also depending on other criteria, e.g. ice on the side of the plate). A more detailed and up-to-date description of the test procedures are found in relevant SAE standards.

WSET test involves pouring the fluid at 20 °C ± 5 onto an inclined test plate at -5 °C ± 0.5 and applying a cooled water spray in air at -5 °C ± 0.5. The water spray endurance is recorded as the time for ice formation to reach the failure zone, when the following test conditions are used: water spray intensity is set to 5 g/dm2 ± 0.2 g per hour. This is equivalent to an average precipitation rate of 0.5 mm per hour. The water spray endurance time test gives minimum times to endure before freezing depending on the fluid type, e.g. 30 min. or 80 min. It is a fundamental requirement of this test that the spray impinges onto the surface of the test plate as water droplets which freeze on impact. This is verified by observation of the untreated or ice catch plate.

HHET involves pouring the fluid at 20 °C ± 5 onto an inclined test plate at -5 °C ± 0.5, when the air temperature is 0 °C ± 0.5 and the Relative Humidity (RH) is 96% ± 2. The high humidity endurance is recorded as the time for ice formation to reach the failure zone under these conditions, when the ice formation corresponds to 0.3 g/dm2/hour, this is equivalent to a water accumulation rate (in the form of frost) of 0.03 mm per hour. It is a fundamental requirement of this test that the RH value is maintained to an accuracy of ±2% RH in the absence of any visible precipitation (such as mist, fog, or drizzle). The duration of the test depends on the fluid tested, e.g. two hours for Type I and eight hours for Type IV.

All fluids receive a particular holdover time. The fluid holdover time is given for each scenario according to tests made. This time is fluid brand specific. The manufacturer can publish their fluid with a brand name holdover timetable but this table does not cover other fluids’ holdover times. AEA publishes a so-called generic holdover timetable. This table includes the lowest time received in the tests for any fluid in any particular box included in the holdover timetable. However, this table is not brand specific and can then be used anywhere where SAE certified fluids are available. The holdover timetable includes boxes with two indicated times. These times simulate the intensity of precipitation, e.g. moderate – light. Holdover timetables are currently available for Type-I, Type-II, Type-III and Type-IV fluids.

6.1.2 Aerodynamic acceptance

De-icing/anti-icing fluids need to be approved aerodynamically. The intent is that any approved fluid sprayed on the aircraft surface will get off during the take-off roll leaving only an acceptable wet film on the surface (if any). The velocity of shearing depends on the type of fluid used (thickened or unthickened). The test for this performance is made in a wind tunnel. Boundary layer displacement thickness (BLDT) measurements is made of the test fluid. Each fluid is tested at selected fluid temperature, e.g. including 0 to -20 °C, or to the coldest usable test fluid temperature identified by the fluid manufacturer. Many consecutive test runs are conducted for the BLDT measurement. A more detailed and up-to-date description of the test procedures are found in relevant SAE standards.

A typical test run consists of pouring 1 litre of fluid onto the test duct floor of the wind tunnel to obtain an even 2-mm of fluid. After 5 minutes of wind at 5 m/s to equilibrate the fluid to the air temperature, an acceleration to 65 m/s over 30 s is achieved with an acceleration of 2.6 m/s², then the 65 m/s speed is maintained for 30 s. There can be only a trace of fluid left on the surface after the test to be acceptable (the acceptable amount is found in detail in the SAE standards). This test simulates an average take-off speed when the fluid is sheared from the aircraft surfaces. The velocity increase for Type-II and IV is 0-65 m/s while Type-III is 0-35 m/s. This result will give a temperature limit for the use of thickened fluid and when used as recommended will guarantee a proper flow-off behaviour. Since the acceptance criteria can vary slightly from one test series to another, due to differences in atmospheric pressure, humidity, temperature uniformity etc., fluid data is always compared to this limit.

6.1.3 Material compatibility and other tests

Since aircraft are constructed of complex materials and are sensitive to any foreign substances not encountered in normal flight, all chemical products have to be tested for compatibility when in contact with these materials. These tests include several scenarios relating to fluid compatibility such as corrosion, dissolvent, flammability, embrittlement, stability etc. As glycol additives are considered a trade secret it is not known to the public what compounds in the fluid are involved in the test. However, the fluids are tested with aircraft materials and these results are considered sufficient. Other tests include such items as how the fluid reacts with cold and warm temperatures for certain periods of time. It is also common that operators and airlines evaluate the fluids before use. These tests are specific for each airline/operator demand. Such tests can include items as flight tests, gel-residue tests, field-tests and shear-tests (viscosity). However, these tests are not for the qualification of fluid, merely for choice of brand. Each manufacturer has a brand specific data sheet and qualification document containing all pertinent information of the fluid.

6.1.4 Non-thickened fluids

Type-I fluids (so called Newtonian fluids) are without any thickener and thus suits best for de-icing operations. Newtonian refers to how the fluid is sheared (viscosity) over time/velocity. Type-I fluid is linear in this regard and does not change character by shear rate. Type-I fluid contains min. 80% glycol (w/w) and 18-19% water and the remaining part additives. Type-I fluid is used with an orange colour (unless uncoloured). Type-I fluids can also be used as an anti-icing fluid but the holdover time is limited. Type-I fluid is generally mixed with water either as a premix or proportional mix. The mixture depends on outside air temperatures. Propylene based Type-I fluids do not have as low a usable outside air temperature (around –30 ºC) as ethylene based Type-I fluids have (around –50 ºC), these limits depend on the mixture.

Since the Type-I fluid is more flowing than thickened fluid it will run of the wing surfaces after a certain time leaving only a marginal protective layer. This layer is seldom sufficient for prolonged protection. It is the heated mixture and the spray pressure rather than any chemical reaction that makes the fluid suitable as a de-icing fluid. Type-I fluids can be sprayed with a higher pressure since they do not consider the viscosity of the fluid as a criterion. The fluid must be heated so that a minimum temperature of +60 ºC is reached at the nozzle when used as an anti-icing fluid. The same temperature is desirable when used as a de-icing fluid. Check the current data for the fluid in use to verify correct procedures.

The freezing point of the type I fluid mixture used for either one-step de-icing/anti-icing or as a second step in the two-step operation shall be at least 10 °C below the ambient temperature. The buffer may be 3 °C (above OAT) when used as a de-icing fluid. Type I fluids supplied, as concentrates for dilution with water prior to use shall not be used undiluted. For exceptions refer to fluid manufacturers documentation.

6.1.5 Thickened fluids

Type-II/III/IV fluids (so called non-Newtonian fluids) are fluids with thickener and thus suits best for anti-icing operations (also de-icing when diluted). Non-Newtonian refers to how the fluid is sheared (viscosity) over time/velocity. Type-II/III/IV fluid is not linear in this regard and does change character by shear rate (which is the purpose of the fluid to run of the wing at takeoff). Type-II/III/IV fluids contain min. 50% glycol (w/w) and 48-49% water and the remaining part additives. Type-II fluid is used with a water white/pale straw (yellowish) colour (unless uncoloured) and Type-IV fluid is used with a green colour. The colour of type-III fluid is to be determined. The purpose of this fluid is to give a reasonable protection, compared to Type-I, from re-freezing. With the lower viscosity of this fluid, compared to Type-II and –IV, it is better suited for regional aircraft with lower takeoff speeds (<85 knots) or for aircraft with other restrictions on thickened fluids, e.g. such A/C as Dash 8 or ATR-72.

Thickened fluids are available as so-called old-generation fluids and new generation fluids. The difference is mainly in that the older fluids only offer a generic holdover timetable while the new fluids have available brand-name holdover times. Other than that there is a difference in colouring, older certified fluids used no colouring while the new have different colours according to type. Type-IV fluids in general where introduced to the market well after Type-II fluids. Temperature limits the use of thickened fluids more than it does Type-I fluids. Lowest usable outside air temperatures are in the range down to -25 ºC. Type-III fluid may have a different lowest usable outside air temperature. The application limit may be lower, provided a 7°C buffer is maintained between the freezing point of the neat fluid and outside air temperature. In no case shall this temperature be lower than the lowest operational use temperature as defined by the aerodynamic acceptance test. Thickened fluids are in general not heated when used as anti-icing fluids. The viscosity will change (lower) if heated. Thickened fluids can be used for anti-icing, as a rule, with a 100/0%, 75/25% and 50/50% mixtures. There are exceptions for using thickened fluids as a de-icing fluid. In this case the fluid is diluted below the normal anti-icing mixtures but w.henever possible, Type-I fluid should be used for de-icing to minimize the possibility of residue problems.

6.1.6 Fluid handling and storage

Fluid handling is an important part of the de-icing operational process. The fluid must be received, stored, pumped and used with the same level of quality throughout all processes. If the batch received is poor or the storage degrades the fluid, then no de-icing/anti-icing can be performed with that particular batch. As an example, there is a problem if there is only one storage tank where all received fluids are stored and if the received batch is degraded, then all stored fluid will be degraded. The acceptance of fluids shall include such items as the fluid quality testing, certificates of conformity, batch and shipment documents etc. (ref. quality procedures).

For fluid acceptance at delivery it is needed to check that the fluid delivered corresponds to the fluid ordered. Make sure the brand name and concentration of the product specified in the delivery documents corresponds to the delivered fluid. Each container/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 container/road tanker (each separate compartment if applicable) and perform the following checks (ref. quality testing):

Type I fluid:

a) Perform a visual contamination check
b) Perform a refractive index check
c) Perform a pH-value check*

Type II, III and type IV fluids:

a) Perform a visual contamination check
b) Perform a refractive index check
c) Perform a pH-value check*
d) Perform a field viscosity check

*) Perform this check if it is suitable to identify contaminants in the fluid and/or detect degradation of the fluid used.

The delivery acceptance is intended as a initial check when no filling of storage tank(s) or vehicle tank(s) is immediately performed. This may be due to the reason that the fluid usage is minimal and also that there is no need to open any seals from the tank(s) at delivery. The quality check is performed whenever the seals are opened and before filling occurs.

The idea of the visual check is to identify the correct colouring and look for any particles of dirt, rust or other substances that should not be in the fluid. It is also a good indication to note the colour of the mixture if it looks as lean or strong as the selected mixture rate should approximately be.

The refractive index check is a check to identify the correct mixture rate as to have a correct freezing point for the fluid. This can also be directly identified with a freezing point check of the fluid. The other point is to have the correct fluid mix as freezing point and aerodynamic problems may appear if the fluid is too lean or strong respectively.

The pH-check only identifies if the fluid is a neutral fluid as glycol should be. As this is very difficult to identify precisely with pH-paper a laboratory test sample may be more representative. This is not always possible to do in a laboratory and the main point is to identify that the fluid is not contaminated with e.g. an acid substance that may change the correct performance of the fluid when mixed with the glycol in great amounts. Another possibility is to identify aircraft glycol from runway glycol when they are not coloured. This can be noted with visibly different pH-values, even with a paper test.

The field viscosity test is a test to identify if the viscosity of the delivered fluid is within tolerances. This may be performed with e.g. a "falling ball" test that may have minimum and maximum sample fluids as reference or by timing the falling ball. The fluid temperature of the sample taken should be as close as possible to the reference fluid and air bubbles should not be present as these elements change the result of the test. Always conduct a laboratory test if the field test is not reliable.

Apart from quality testing, there are some basic rules to follow with the storage of fluids:

a) Different products shall not be mixed without additional qualification testing.
b) Tanks dedicated to the storage of de-icing/anti-icing fluids shall be used.
c) Storage tanks shall be of a material of construction compatible with the de-icing/anti-icing fluid, as specified by the fluid manufacturer.
d) Care should be taken to avoid using dissimilar metals in contact with each other, as galvanic couples may form and degrade thickened fluids.
e) Tanks shall be conspicuously labelled to avoid contamination.
f) Tanks shall be inspected annually for corrosion and/or contamination. If corrosion or contamination is evident, tanks shall be maintained to standard or replaced.
g) To prevent corrosion at the liquid/vapour interface and in the vapour space, a high liquid level in the tanks is recommended.
h) The storage temperature limits shall comply with the manufacturer's guidelines.
i) The stored fluid shall be checked routinely to insure that no degradation/contamination has occurred.

6.1.6.1 Pumping and heating

De-icing/anti-icing fluids can show degradation caused by 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 labelled to prevent contamination and shall be compatible with the de-icing/anti-icing fluids to be transferred. De-icing/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/IV fluids thermal exposure and/or water loss may cause a reduction in fluid viscosity leading to lower holdover times. 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 performance degradation of the fluid. Any of the following situations or a combination of them can accelerate the fluid performance degradation:

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

6.1.6.2 Storage 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 etc. The storage procedure should be chosen according to the scope and amount of operation. Heating of the fluid in the storage tanks depends on the equipment in use. If the equipment 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 inspections of all tanks must be performed. Stainless steel (or acid-proof) tanks must be visually inspected annually (as other tanks) but a more in-depth inspection, such as NDT-testing made for e.g. steel tanks, may not be necessary on an annual basis. The testing periods should be conducted according to the container manufacturer recommendations and/or standards set for the de-icing operation (ref. AEA, ISO and SAE). Records must be kept for any and all inspections of tanks and station.

6.1.6.3 Field/periodical quality testing of fluids

The quality of fluids (visual check and refractive index check for Type-I, -II, -III and –IV) sprayed must be checked each time the equipment is in use and from each mixture of fluid used. This is to verify that the quality of the fluid, freezing point and mixture are correct. The refractive index test and the result must be conducted and compared according to given tables and instructions for each particular fluid. A temperature measurement should be conducted on a periodical basis in realistic conditions, relating to Type-I heating requirements, for verification of temperature in the tank (as a comparison vs. nozzle temperature if applicable) and at the nozzle. Note that a heated thickened fluid (+50 °C) shall be used for preventive procedures for frost building up on wing tank areas. This temperature shall also be verified. A sampling procedure for thickened fluids shall be performed according to a periodical system during the season (ref. quality and sampling procedures). The delivery of fluids to the storage facility also requires a field viscosity check of the fluid to be made, e.g. a so-called “falling ball” test (thickened fluid). If there are found any deviations outside the limits of the fluids, a corrective measure must be taken immediately to correct the fluid, equipment or procedures.

7 DE-ICING/ANTI-ICING OPERATIONS

7.1 General

De-icing/anti-icing operations have been performed in a variety of ways throughout the years. These procedures have included (in cases still do) elements such as the use of paste on leading edges, wing covers, ropes, brushes/brooms and a variety of fluids. Nowadays there are some new elements introduced such as forced air and infrared technology. There is, however, no single correct way of performing each and every de-icing/anti-icing. The operation must be suited for each airport, company and local setting. However, airworthiness and operational regulations state that no one can take-off in an aircraft that has any contamination on critical surfaces. Even if the procedure of de-icing the aircraft varies, all critical surfaces shall be clean. Anti-icing the aircraft sets its own requirements of fluid to be used. Mechanical ways cannot be seen as an anti-icing procedure, the surfaces shall be protected from refreezing. Only certified fluids and accepted procedures are to be used. De-icing operations are performed for many airlines at certain airports and the assumption is that the operator is using accepted procedures and fluids. The clean aircraft concept shall be set as the only way of operating for any airline or ground operator.

7.2 Preliminary work for the start of de-icing/anti-icing

Before the de-icing operation can begin, an inspection of the equipment should be made. This inspection should include all relevant aspects for the proper functioning of the equipment, personal gear and the fluids. After the necessary checks to the personal gear, equipment and fluids have been made; a verification of procedures for de-icing/anti-icing should be made. The procedures vary according to the way of de-icing operations performed. The necessary inspections and communications can be made beforehand at the gate whereas at remote/centralised de-icing, necessary information must be informed to the de-icing crew in another way (e.g. coordinator communication). The determining of the need for de-icing/anti-icing can be made by other qualified persons, not necessary the de-icing crew. After that, a verification of the de-icing/anti-icing procedures must be performed with the flight crew in order to make sure no misunderstandings prevail. This information includes (among other) areas to de-ice/anti-ice, fluids and mixtures to use, start clearance for de-icing, critical surfaces, checks and any other A/C specific information the crew wishes to be noted. In some cases, required paperwork/data of the de-icing operation can be recorded beforehand to speed up the process.

7.2.1 Determining the need for de-icing/anti-icing

The need for de-icing/anti-icing is usually determined well beforehand by the trained and qualified ground crew or flight crew. Requests for de-icing/anti-icing shall specify the parts of the aircraft requiring treatment. Certain aspects must be considered, such as, what are the A/C specific requirements and precautions, is the de-icing operation performed at gate or remote, can the aircraft start the engines and taxi to a remote de-icing fully contaminated, who makes the request for the de-icing, verification of proper procedure with all parties involved (ground crew / flight crew / de-icing), should air-blower/brushes be used beforehand etc. The contamination check shall visually cover all critical parts of the aircraft and shall be performed from points offering sufficient visibility of these parts (e.g. from the de-icing vehicle itself or any other suitable piece of equipment). Any contamination found, except frost allowed in certain areas, shall be removed by a de-icing treatment followed by an anti-icing treatment if required.

Some inspected areas can be cleaned manually during the inspection and a de-icing procedure is not necessary. This procedure must be confirmed with the flight crew. The captain has the final authority of the procedure but the safer option should always be considered, whether it is the opinion of the flight crew or ground crew (company and A/C limits to be noted). There are some areas to include in the inspection while waiting for instructions from the flight crew. Areas to check include:

a) Wings (upper and lower)
b) Vertical and horizontal tail surfaces (upper and lower horizontal surfaces)
c) Fuselage
d) Engine inlets and fan blades (front and back side of fan blades)
e) Control surfaces and gaps
f) Pitot heads and static ports
g) Landing gear and landing gear doors
h) Antennas and sensors
i) All other aerodynamic surfaces
j) Propellers

After checking these areas, a decision with the flight crew of de-icing procedures can be made accordingly. The weather elements and taxi distances will affect the choice for type and mixture of fluid to use.

For specific aircraft types, additional requirements exist e.g. special clear ice checks, such as tactile checks on wings. These special checks are not covered by the contamination check. Aircraft operators shall make arrangements for suitably qualified personnel to meet these requirements.

7.2.1.1 One-step/two-step de-icing/anti-icing

When aircraft surfaces are contaminated by frozen moisture, they shall be de-iced prior to dispatch. When freezing precipitation exists and there is a risk of contamination of the surface at the time of dispatch, aircraft surfaces shall be anti-iced. If both de-icing and anti-icing are required, the procedure 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 to be achieved.

Some contamination, such as frost, can be removed and the surface protected from refreezing, all at the same time using the same fluid and same mixture. This is called a one-step procedure. One-step de-icing/anti-icing is generally performed with a heated unthickened fluid. Thickened fluid can and is in some cases used for this one-step process. Caution must be taken for the dry-out characteristics and gel residue problems of this particular scenario, the mixture to choose for this step is the mixture that gives a protective cover; in other words, the de-icing is performed with an anti-icing mixture, which protects the surface at the same time. The correct fluid concentration shall be chosen with regard to desired holdover time and is dictated by outside air temperature and weather conditions. Wing skin temperatures may differ and, in some cases, be lower than 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.

Two-step de-icing/anti-icing (when the first step is performed with de-icing fluid) is a procedure performed whenever the contamination demands a de-icing process separately. The correct fluid(s) shall be chosen with regard to ambient temperature. After de-icing, a separate over-spray of anti-icing fluid shall be applied to protect the relevant surfaces thus providing maximum possible anti-ice capability. The second step is performed with anti-icing fluid. The correct fluid concentration shall be chosen with regard to desired holdover time and is dictated by outside air temperature and weather conditions. The second step shall be performed before first step fluid freezes (typically within 3 min), if necessary area by area. A two step procedure is common during freezing precipitation. The second step shall be applied in such a way that it gives a complete, sufficient and an even layer of anti-icing fluid on the treated surfaces.

7.2.2 Critical surfaces

Basically all surfaces that have an aerodynamic-, control-, sensing-, movement- or measuring-function must be clean. All of these surfaces can not necessarily be cleaned and protected in the same conventional de-icing/anti-icing manner as e.g. the wings. Some areas require only a cleaning operation while other need protection against freezing. The procedure of de-icing may also vary according to A/C limitations. The use of hot air may be required when de-icing e.g. landing gear or propellers.

Some critical elements and procedures to follow, common for most aircraft is:

a) De-icing/anti-icing fluids shall not be sprayed directly on wiring harnesses and electrical components (receptacles, junction boxes, etc.), onto brakes, wheels, exhausts, or thrust reversers.
b) De-icing/anti-icing fluid shall not be directed into the orifices of pitot heads, static ports or directly onto airstream direction detectors probes/angle of attack airflow sensors.
c) All reasonable precautions shall be taken to minimise fluid entry into engines, other intakes/outlets and control surface cavities.
d) Fluids shall not be directed onto flight deck or cabin windows as this can cause crazing of acrylics or penetration of the window seals.
e) Prior to the application of de-icing/anti-icing fluids all doors and windows should be closed to prevent galley floor areas being contaminated with slippery de-icing fluids and upholstery becoming soiled. Note that doors shall not be closed until all ice or snow has been removed from the surrounding area.
f) Any forward area from which fluid can blow back onto windscreens during taxi or subsequent takeoff shall be free of residues prior to departure.

g) If type II, III or type IV fluids are used, all traces of the fluid on flight deck windows should be removed prior to departure, particular attention being paid to windows fitted with wipers. Rinsing with an approved cleaner and a soft cloth may remove de-icing/anti-icing fluid.

h) Landing gear and wheel bays shall be kept free from build-up of slush, ice or accumulations of blown snow.

i) When removing ice, snow, slush or frost from aircraft surfaces care shall be taken to prevent it entering and accumulating in auxiliary intakes or control surface hinge areas, e.g. manually remove snow from wings and stabilizer surfaces forward towards the leading edge and remove from ailerons and elevators back towards the trailing edge.

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

k) Under freezing fog conditions, the rear side of the fan blades shall be checked for ice build-up prior to start-up. Any deposits discovered shall be removed by directing air from a low flow hot air source, such as a cabin heater, onto the affected areas.

l) A flight control check should be considered according to aircraft type (see relevant manuals). This check should be performed after de-icing/anti-icing. After prolonged periods of de-icing/anti-icing it is advisable to check aerodynamic quiet areas and cavities for residues of thickened de-icing/anti-icing fluid. Consult airframe manufacturers for details and procedures.

7.2.2.1 Clean aircraft concept

The clean aircraft concept must be understood as an important part for the safety of the flight. A clean aircraft is considered to be either totally clean or cleaned and protected with de-icing/anti-icing fluids that still protect the surface and are able to perform aerodynamically correct. Contaminated fluid on the surface must not be misunderstood as a clean aircraft; this contamination must be removed. Under no circumstances shall an aircraft that has been anti-iced receive a further coating of anti-icing fluid directly on top of the contaminated film. If an additional treatment is required before flight, a complete de-icing/anti-icing shall be performed. Ensure that any residues from previous treatment are flushed off. Anti-icing only is not permitted.

7.3 Spray areas

Areas to spray on any aircraft are in most cases the upper surfaces. However, underwing de-icing may for some A/C types be very common. When talking about upper surfaces, it is referred to as the wings, tail (including vertical stabilizer) and fuselage. As a rule of thumb, the de-icing/anti-icing procedure should be performed from the top-down, leading edge towards trailing edge and from the A/C front parts backwards. On most aircraft start at the wing tip and work towards the wing root. Areas to protect from refreezing depend on the aircraft limitations and company procedures but in general the upper surfaces of the wings and the tail section should be anti-iced. The fuselage may also need anti-icing but under wings are not generally anti-iced with thickened fluid.

7.3.1 Aircraft surfaces

There is no single rule of spray order that can be applied to all aircraft. It is, however, recommended to start with the fuselage (front part covering the wing area) whenever it needs treatment (spray along the top centre-line and then outboard). After the fuselage comes the wings and the way to treat the wings depends on the aircraft and the place where de-icing is performed (gate vs. remote). The wing should always be treated from the highest part towards the lowest part (generally wingtip inboard). Some aircraft have the wingtips lower than the wing root and in that case de-icing should be performed from the wing root outboard. The tail should be performed from the vertical stabilizer downward and the aft-fuselage part before the horizontal stabilizer (excluding T-tail A/C).

It is recommended that anti-icing fluid be sprayed within 3 min. after de-icing so the surface would not freeze from the low mixture of de-icing fluid. If the wing area is large and the contamination is heavy, previously de-iced parts should be considered to be de-iced again before anti-icing. The following surfaces shall be protected:

a) wing upper surfaces including leading edges and upper control surfaces;
b) horizontal stabiliser upper surfaces including leading edges and elevator upper surfaces;
c) vertical stabiliser surfaces including the rudder surfaces (both sides);
d) fuselage upper surfaces depending upon the amount and type of precipitation (especially important on centre-line engined aircraft).

Under wings do not need anti-icing since the precipitation cannot reach there. However, a sufficiently high mixture must be used so as not to cause ice formation after the de-icing. Gate de-icing is somewhat different than remote/centralised de-icing and local settings and precautions should be noted. Using multiple de-icing vehicles at one aircraft may change the spray order but the same concept (high-low, front-back) should be applied. Different vehicles may also be needed for different de-icing work (e.g. underwing) in this case the procedure should be coordinated accordingly.

7.3.1.1 Other areas

Other areas on the aircraft may need special attention or procedures to clean. Windows (cockpit windows) need de-icing but there is no need for anti-icing. Some aircraft have limitations on how to clean them (manufacturer/company procedures should be noted) but in general a brush or cloth is sufficient. It should be noted that drain off water may freeze elsewhere on the fuselage if using water for de-icing cockpit windows, there is otherwise no limitation on using water on windows than freezing. The radome needs de-icing in many cases and also anti-icing. Caution must be taken so that fluids would not flow in large quantities on the cockpit windows during takeoff (if the radome has been treated). Static ports and pitot tubes may need inspection. Any contamination like, e.g. ice and drain off fluid, shall be removed from these areas.

The repeated application of type II, III or IV fluid may cause residues to collect in aerodynamically quiet areas, cavities and gaps. The Application of hot water or heated type I fluid in the first step of the de-icing/anti-icing process may minimise the formation of residues. Residues may re-hydrate and freeze under certain temperature, high humidity and/or rain conditions and may block or impede critical flight control systems. These residues may require removal. When checking for residues, misting with water may facilitate their visibility. It must be clear that de-icing or anti-icing should not be performed (sprayed) from the trailing edge forward. This can cause even more residue to collect and there is also the danger of removing grease from hinges and other parts.

Engine inlets and fan blades need de-icing in some cases. Inlets can generally be cleaned with a brush or manually by hand. Fan blades and the bottom of the engine air inlet needs to be de-iced with hot air (noting manufacturer recommended temperature limits), or other means recommended by the engine manufacturer. No de-icing fluid is to be sprayed into engines. Propellers may have ice along the leading edges and/or may collect snow/slush along the side 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. Hot air, or other means recommended by the engine manufacturer, can be used for de-icing propellers (composite propellers have temperature limits that must be noted).

The application of de-icing fluid in landing gear and wheel bay areas shall be kept to a minimum. De-icing fluid shall not be sprayed directly onto brakes and wheels. Accumulations such as blown snow may be removed by other means than fluid (mechanically, air blast, heat etc). However, where deposits have bonded to surfaces, they can be removed by the application of hot air or by spraying with hot de-icing fluids by using a low-pressure spray.

7.3.2 Spray methods, fluid application and alternate methods

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. Ice, snow, slush or frost may be removed from aircraft surfaces by heated fluids, mechanical methods, alternate technologies or combinations thereof. For maximum effect, fluids shall be applied close to the surface of the skin to minimise heat loss. The heat in the fluid effectively melts any frost, as well as light deposits of snow, slush/sleet and ice. Heavier accumulations require the heat to break the bond between the frozen deposits and the structure; the hydraulic force of the fluid spray is then used to flush off the residue.

7.3.2.1 Removal of contamination

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. Providing the hot fluid is applied close to the aircraft skin, a minimal amount of fluid will be required to melt the deposit. When removing snow a nozzle setting sufficient to flush off deposits and minimise foam production is recommended. Note that foam could 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 deposits 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 adopted. Wet snow is more difficult to remove than dry snow and unless deposits are relatively light, selection of high fluid flow will be found to be more effective. Under certain conditions it will be possible to use the heat, combined with the hydraulic force of the fluid spray to melt and subsequently flush off frozen deposits. Heavy accumulation of snow will always be difficult to remove from aircraft surfaces and vast quantities of fluid will invariably be consumed in the attempt. Under these conditions, serious consideration should be given to removing the worst of the snow manually before attempting a normal de-icing procedure.

Heated fluid is very important when removing ice as well as the pressure of the spray to break the ice bond. The method makes use of the high thermal conductivity of the metal skin. A stream of hot fluid is directed at close range onto one spot at an angle of less than 90°, until the aircraft skin is exposed. The aircraft skin will then transmit the heat laterally in all directions raising the temperature above the freezing point thereby breaking the adhesion of the frozen mass to the aircraft surface. By repeating this procedure a number of times, the adhesion of a large area of frozen snow or glazed ice can be broken. The deposits can then be flushed off with either a low or high flow, depending on the amount of the deposit.

7.3.2.2 General fluid application strategy.

For effective removal and protection of snow and ice, the following techniques shall be adopted. Certain aircraft can require unique procedures to accommodate design differences, see manufacturers instructions. When choosing a mixture and spraying method, note that ice, snow or frost dilutes the fluid. Apply enough hot de-icing fluid to ensure that re-freezing does not occur and all contaminated fluid is driven off. Symmetrical treatment is essential but does not mean that the whole surface has to be treated (ref. preventive tank area procedure).

Anti-icing fluid shall be applied to the aircraft surfaces (assuming that they are clean) if anticipated that precipitation may appear and adhere to the aircraft at the time of aircraft dispatch. 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 minimise ice accumulation prior to departure and often makes subsequent de-icing easier. This procedure has a potential risk of building residues and is not recommended if performed continuously. On 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 minimise the possibility of snow and ice bonding or reduce the accumulation of frozen precipitation on aircraft surfaces and facilitate subsequent de-icing. The time-factor must be taken into account when proceeding with these procedures (e.g. turn-arounds and short stops in general may be worthwhile but overnight stops should be thought out well).

For effective anti-icing, an even layer of sufficient thickness of fluid is required over the prescribed aircraft surfaces, which are clean (free of frozen deposits). For longer anti-icing protection, undiluted, unheated type II, III or type IV fluid should be used. The high fluid pressures and flow rates normally associated with de-icing are not required for this operation and, where possible, pump speeds should be reduced accordingly.

The nozzle of the spray gun should be adjusted to provide a medium spray. The 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 utilise maximum holdover time. 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 second step fluid, use a spraying technique, which completely covers the first step fluid and provides a sufficient amount of second step fluid. Where re-freezing occurs following the initial treatment, both first and second step shall be repeated. With regard to holdover time provided by the applied fluid, the objective is that it be equal to or greater than the estimated time from start of anti-icing to start of takeoff based on existing weather conditions. Aircraft shall be treated symmetrically, that is, left-hand and right-hand side shall receive the same and complete treatment when anti-icing. De-icing only may be local but still symmetrical. Aerodynamic problems could result if this requirement is not met. During anti-icing and de-icing, the moveable surfaces shall be in a position as specified by the aircraft manufacturer.

7.3.2.3 Alternate methods

Alternate technology may be used to accomplish the de-icing process, provided that the requirements are accomplished. Such procedures may be brooms/brushes, air blowers, infrared technology etc. Mechanical methods may be helpful for removing contamination but it shall not be considered clean and protected as to de-icing/anti-icing. Aircraft manufacturer requirements and airline limitations shall be noted when using infrared technology for de-icing. Brushes and air is useful when de-icing areas where fluid application is limited or forbidden. The flight crew shall always be notified of the procedure used and to be consulted for further actions. Using alternate methods for cleaning the surfaces will always shorten the time spent for normal de-icing/anti-icing. This in turn will help the departure efficiency relating to de-icing operations.

7.3.3 Post de-/anti-icing check

A verification of clean surfaces (regarding contamination) shall always be made after the de-icing/anti-icing. This check shall cover wings, horizontal stabilizer, vertical stabilizer, fuselage, and all other parts of the aircraft on which the de-icing/anti-icing treatment was performed, according to the requirements identified during the contamination check. This verification can be either visual or tactile (depending on aircraft and company limitations/requirements). Note that any visual check may not be sufficient in certain situations (like clear ice). A tactile check (hands-on) is the best choice whenever there is a doubt. There are technology available (cameras/Ground Ice Detection Systems) for checking the surfaces but this must be approved both locally and by the airlines using the service. Some aircraft require a tactile check to verify the surface is clean. These inspections should be made both before and after de-icing/anti-icing.

Note that a trained and qualified person shall not dispatch an aircraft after a de-icing/anti-icing operation until the aircraft has received a final check. If the check is not to be performed by the flight crew then the commander must ensure that he has received confirmation that it has been accomplished before take off. Inspections should visually cover all critical parts of the aircraft and be performed from points offering sufficient visibility of these parts (e.g. from the de-icer itself or another elevated piece of equipment). Any contamination found, shall be removed by further de-icing/anti-icing treatment and the check repeated.

If a pre-de-icing/anti-icing procedure or a local frost prevention procedure has been performed a tactile check of the treated areas and a visual check of the untreated areas of both wings shall be performed immediately before the aircraft leaves the parking position. These checks are conducted to insure that both wings are clean and free of frost and ice. The applied de-icing/anti-icing fluid shall still be liquid and shall show no indication of failure, such as colour turning to white, loss of gloss, getting viscous, showing ice crystals etc. The Anti-Icing Code shall not be transmitted before the post de-icing/anti-icing check is completed.

7.3.3.1 Pre takeoff check

After the proper inspections, de-icing and anti-icing procedures and verifications, the aircraft is ready to taxi. The Commander shall continually monitor the weather situation after the de-icing/anti-icing treatment has been carried out. There can, however, be delays before takeoff and the fluid may be contaminated during precipitation. In this case a pre-takeoff check should be performed. The commander shall assess, prior to takeoff, whether the applied holdover time is still appropriate and/or if untreated surfaces may have become contaminated. This check is normally performed from inside the flight deck as a visual check. If the visual check is insufficient a pre-takeoff contamination check should be performed. This check shall be performed when a pre-takeoff check or when the applied holdover time has been exceeded cannot effectively assess the condition of the critical surfaces of the aircraft. This check is normally performed from outside the aircraft. The alternate means of compliance to a pre-takeoff contamination check is a complete de-icing/anti-icing re-treatment of the aircraft.

7.3.3.2 Clear ice checks and precautions

Clear ice can form on aircraft surfaces, below a layer of snow or slush/sleet. It is therefore important that surfaces are closely examined following each de-icing operation, in order to ensure that all deposits have been removed. Significant deposits of clear ice can form, in the vicinity of the fuel tanks, on wing upper surfaces as well as under-wing. This type of ice formation is extremely difficult to detect. Therefore when the conditions prevail, or when there is otherwise any doubt whether clear ice has formed, a close examination shall be made immediately prior to departure, in order to ensure that all frozen deposits have in fact been removed. Note that this type of build-up normally occurs at low wing temperatures and when large quantities of cold fuel remain in wing tanks during the turnaround/transit and any subsequent re-fuelling is insufficient to cause a significant increase in fuel temperature. This does not rule out the possibility of ice formation in any other conditions. Finding clear ice, and removing it, should always be noted to the flight crew. Frost on the underside and humidity (or precipitation) is a good sign that there may be clear ice forming on the upper surfaces, but note that this is not the single way to determine ice formation.

7.4 De-icing/anti-icing communication

Proper communication is as important as proper de-icing/anti-icing. There cannot be any doubt of the procedure, fluid used, holdover time, areas covered etc. when communicating and verifying the process. As a rule, an aircraft shall not be dispatched for departure after a de-icing/anti-icing operation until the flight crew has been notified of the type of de-icing/anti-icing operation performed. The standardised notification performed by qualified personnel indicates that the aircraft critical parts are checked free of ice, frost, snow, and slush, and in addition includes the necessary anti-icing code, as specified, to allow the flight crew to estimate the holdover time to be expected under the prevailing weather conditions. The person communicating with the flight crew shall have a basic knowledge of the English language in order to communicate properly (refer to Annex D, ICAO language levels, operational level 4 is the preferred minimum).

As important as the communication between the flight crew and the de-icing crew so is the communication between the de-icing crews themselves and the de-icing coordinator. No misconception can be allowed when deciding on treatment and verifying operational procedures. If several de-icing vehicles are performing the de-icing/anti-icing simultaneously on an aircraft, a lead vehicle/person should be decided. This team leader will be the person communicating with the aircraft and the vehicles at the aircraft. The procedures and the areas to be treated are divided and settled according to the team leader instructions. This procedure will increase the safety of proper communication and operations. The team leader will give instructions on fluids and mixtures to use, areas to be treated and by whom etc. After the procedure is done, all vehicles report to the team leader their particular information.. The team leader will conclude which area was treated first with anti-icing fluid and report this time to the flight crew along with the rest of the required information (anti-icing code). At the time of final report, all vehicles shall be in a safety area or in a position well clear of the aircraft. The procedure should reflect the local demands.

Communication between the Commander and the de-icing crew will usually be achieved using a combination of printed forms and verbal communication. For treatments carried out after aircraft doors are closed, use of flight interphone (headset) or VHF radio will usually be required. Electronic message boards may also be used in 'off stand' situations. Use of hand signals is not recommended except for the final 'all clear' signal.

7.4.1 Releasing/Dispatching aircraft and final walk-around

The person releasing/dispatching the aircraft immediately before taxi and takeoff shall verify to the flight crew all relevant information regarding the de-icing/anti-icing and/or clean surfaces. This person can also verify the de-icing/anti-icing process and communicate on any relevant issues. A final check shall be made when making the final walk around (or verification of de-icing/anti-icing) before pushback or before taxi. This final inspection should also include a visual check of the engine inlets (fan blades) and/or the propellers. Any other verification or check should be made at this point. The release person can perform the de-icing/anti-icing code and other information if the de-icing crew is unable to communicate with the flight crew. Invoicing or other required information can be exchanged at this point (aircraft are in general ready to taxi and paperwork must be settled in another way).

7.4.1.1 The anti-icing code

The final communication with the flight crew is the anti-icing code. This information is very important for the flight crew when deciding on elements related to takeoff procedures. The following information shall be recorded and be communicated to the flight crew by referring to the last step of the procedure and in the sequence provided below:

a) The fluid type (e.g. Type I, II, III, IV)
b) The concentration of fluid within the fluid/water mixture, expressed as a percentage by volume. Note that this is no requirement for Type I fluid
c) The local time (hours/minutes) at the beginning of the final de-icing/anti-icing step
d) The date (written: day, month, and year). Note that this is only required for record keeping, optional for crew notification.
e) The complete name of the anti-icing fluid (so called "brand name"). Note that the name is optional and for type II, III and IV fluids only.
f) The statement "Post de-icing/anti-icing check complete".

If two different companies are involved in the de-icing/anti-icing treatment and post de-icing/anti-icing check, it shall be ensured that the anti-Icing code is not given before the post de-icing/anti-icing check is completed. As an example, a de-icing/anti-icing procedure which last step is the use of a mixture of 75% of a type II fluid and 25% water, commencing at 13:35 local time on 20 February 2008, and that the Post de-icing/anti-icing check is complete is recorded as follows: TYPE II/75 13:35 (20 FEB 2008) ("complete name of anti-icing fluid"). Post de-icing/anti-icing check complete. The Anti-icing Code shall be provided by a qualified person at the completion of the treatment indicating that the wings, horizontal stabilizer, vertical stabilizer, fuselage and all treated surfaces are free of ice, frost, snow, and slush, and in addition includes the necessary information to allow the Commander to estimate the holdover time to be expected under the prevailing weather conditions.

The anti-icing code contains the minimum information needed for communication. It is allowed, and preferred, to give other information, such as areas treated, areas checked, engines and propellers, frost thickness on under wings etc, if there is a need for it or if the crew has requested something else. The way of communicating can vary with local settings and arrangements. There can be a VHF-, UHF-, headset/intercom at the A/C, team leader communication, and de-icing vehicle or coordinator communication with the aircraft. The way of providing the information is not relevant, it is, however, important what and how communication is performed. Gate de-icing and remote de-icing can contain different communication needs.

7.4.2 Flight crew information

The flight crew shall be notified, and approve, of both the start and the finish of the de-icing/anti-icing procedures. The aircraft needs to be configured before the start of the de-icing/anti-icing and the crew must consider when they are able to depart before allowing the de-icing operation to begin. Some aircraft need to shut of the APU, air-conditioning and some need to be informed of the de-icing at certain parts of the aircraft (e.g. when de-icing the tail) before the operation can begin. The main idea is to receive the "go-ahead" from the flight crew, they will then take into account any possible procedures needed. The flight crew shall receive a confirmation from the ground crew that all de-icing/anti-icing operations are complete and that all personnel and equipment are clear before reconfiguring or moving the aircraft.

The flight crew shall also be notified of any de-icing/anti-icing procedures made beforehand (e.g. at night) or if preventive anti-icing has been performed. The pre-de-icing/anti-icing does not rule out the need for an inspection or the need for an additional treatment. This decision lies with the captain and any additional information such as if there has been any significant weather elements since the de-icing operation was performed and before the arrival of the flight crew. Other information might be areas that where not treated beforehand but may need an additional check before departure. The information shall be given either by direct communication or by written information. All events shall be recorded so further information can be provided if necessary. Following information shall be provided to the cockpit crew for a preventive procedure: "Local frost prevention was accomplished". A normal de-icing/anti-icing information (code) shall be given for pre-de-icing/anti-icing events.

7.4.2.1 Off-gate de-icing/anti-icing communication

The gate de-icing/anti-icing is quite straightforward since engines are not running and the A/C is easier to configure for de-icing (if configuring is needed at all). The remote procedures may need some extra verification before the start of the de-icing operation. Such information can be the verification of brakes set, configurations, engines shut down and start up etc. The procedure is dependent on the aircraft limitations for de-icing. Aircraft with four engines may need to shut down the outer engines to allow a safe de-icing operation. If this is not possible, the aft section and tail shall be treated in such a way that the jetblast can be avoided (e.g. approaching far behind and close to the fuselage). Added communication is needed to verify this procedure with all engines running. This procedure can be time consuming but the safety of the operation is a key element for everyone. In some cases, aircraft are unable to shut down the outer engines and If propeller aircraft are de-iced at the remote area, proper communication is essential to verify possible extra procedures, which side of A/C to treat first, propeller "brakes" etc.

An alternate means of communication may be the use of Electronic Message Boards. In the event of conflict, verbal communication shall take precedence.

Following standard communication terminology is recommended during off-gate de-icing/anti-icing procedures: (DIS = De-icing/anti-icing supervisor), (COMMANDER = Pilot in command).
DIS: "Set parking-brakes, confirm aircraft is ready for treatment, inform on any special requests."
After aircraft is configured for treatment:
COMMANDER: "Brakes are set, you may begin treatment and observe.....(any special requests like: ice under wing/flaps, clear-ice on top of wing, snow on fuselage, ice on landing gear, anti-ice with type IV fluid, etc.)".
DIS: "We begin treatment now and observe....(special request given, like "ice under wing", etc.). I will call you back when ready".
ONLY AFTER EQUIPMENT IS CLEARED FROM AIRCRAFT AND ALL CHECKS ARE MADE:
DIS: "De-icing/anti-icing completed, ANTI-ICING CODE IS:......(plus any additional info needed). I am disconnecting, standby for clear signal at right/left and/or contact ground/tower for taxi clearance."
COMMANDER: "De-icing/anti-icing completed, anti-icing code is......".

7.4.2.2 Radio Telephony Phraseology

Whenever communicating with aircraft, standard ICAO phraseology shall be used. There is always a danger of misunderstanding/miscommunication when using local sayings and acronyms. Note that there can be many other communications in progress at the time of your particular need to communicate. There may be one or several frequencies available on the apron and the remote area for de-icing operations. Any other ongoing communication shall not be interrupted so that the particular communication would not be compromised. When starting and ending a VHF-communication, remember that there is a delay for the transmission to "open". First press the tangent and then talk. When ending, finish your communication and then release the tangent.

There are some basic rules of communication: first think what you are going to say, hold the microphone close to your mouth, speak clearly and with a normal speed, avoid disturbing sounding (aaaa…. hmmmm), always read back what you have been told, identify yourself (e.g. de-icing vehicle # or coordinator) and always address the other party with the same call-sign that has been identified. Aircraft are identified in many cases by register when performing de-icing. If the procedure is to communicate with flight numbers then use this process. Registration numbers are always easier to identify when de-icing vehicles are moving around aircraft and on the apron. Flight numbers do not clearly separate one aircraft from the other (to the de-icing crew) but this procedure may be used on e.g. a remote de-icing pad where there are no other aircraft at one particular place. Verify whenever in doubt. A correct ethical communication procedure shall be used at all times.

An example of a de-icing communication between a vehicle (truck #2) and an aircraft (OH-LVA) at a gate stand:

DE-ICE:	"Oscar-Hotel-Lima-Victor-Alfa, De-icing truck number two" (the first two letters, OH, can be left out if there is no compromising safety of mixing transmissions)
A/C:	"De-ice number two, Lima-Victor-Alfa, go ahead"
DE-ICE:	"Lima-Victor-Alfa, De-ice number two, we are ready to start de-icing, any requests for treatment" (asked only if no procedure decided beforehand)
A/C:	"De-ice number two, Lima-Victor-Alfa, we would like a two step de-icing/anti-icing with Type-IV 100% for anti-icing, check the under wings for any ice"
DE-ICE:	"Lima-Victor-Alfa, De-ice number two, we will use a two step procedure with Type-I (30/70 mix, optional) for de-icing and Type-IV 100% for anti-icing, we will check the under wings for any contamination"
A/C:	"De-ice number two, Lima-Victor-Alfa, the aircraft is configured for de-icing you can start treatment now"
DE-ICE:	"Lima-Victor-Alfa, De-ice number two, we will start now"
-	After the necessary de-icing/anti-icing
DE-ICE:	"Lima-Victor-Alfa, De-ice number two, de-icing/anti-icing completed, under wings checked and cleaned, (the anti-icing code……….)"
A/C:	"De-ice number two, Lima-Victor-Alfa, (copy the anti-icing code……….)"

All communication is based on the assumption that both parties understand the proceedings of a proper de-icing/anti-icing operation. Some aircraft may have other requests such as requiring the information when de-icing the tail area etc. All communication shall be read back clearly. Always ask again to verify transmission if uncertain of the procedure. Many times both the de-icing operator and the A/C crew have English as a foreign language. In these cases it is even more important to verify any procedure. Avoid sayings that can be misunderstood as any information for a final release (e.g. when two de-icing trucks are talking to each other over the frequency and verifying procedures), such as "de-ice #2 you're ready?" could be misunderstood to the A/C as "de-ice number two is ready". At this point the A/C may begin start procedures and or pushback while waiting for the holdover time information etc.

7.4.2.2.1 ICAO phraseology

Some of the basic ICAO phraseology and wordings. Note that numbers can be used in a different way when communicating about de-icing items, such as quantity of fluids used. Call signs shall always be used correctly but any special information can be adapted according to the situation. The main idea is that both parties understand each other clearly. Note that aircraft may communicate with UTC time indications. Even so, de-icing events are always communicated as a local time.

A	Alfa	(al-fah)
B	Bravo	(brah-voh)
C	Charlie	(char-lee) or (shar-lee)
D	Delta	(dell-ta)
E	Echo	(eck-oh)
F	Foxtrot	(foks-trot)
G	Golf	(golf)
H	Hotel	(hoh-tel)
I	India	(in-dee-ah)
J	Juliett	(jew-lee-ett)
K	Kilo	(key-loh)
L	Lima	(lee-mah)
M	Mike	(mike)
N	November	(no-vem-ber)
O	Oscar	(oss-cah)
P	Papa	(pah-pah)
Q	Quebec	(keh-beck)
R	Romeo	(row-me-oh)
S	Sierra	(see-air-rah)
T	Tango	(tang-go)
U	Uniform	(you-nee-form) or (oo-nee-form)
V	Victor	(vik-tah)
W	Whiskey	(wis-key)
X	X-ray	(ecks-ray)
Y	Yankee	(yang-key)
Z	Zulu	(zoo-loo)

1	One	(wun)
2	Two	(too)
3	Three	(tree)
4	Four	(fow-er)
5	Five	(fife)
6	Six	(six)
7	Seven	(sev-en)
8	Eight	(ait)
9	Nine(r)	(nin-er)
0	Zero	(zee-ro)

10	One zero	(wun, zee-ro)
75	Seven Five	(sev-en, fife)
100	Hundred	(hand-red)
1000	Thousand	(tau-send)

Frequency:	131,900	One Three One Decimal Niner Zero Zero
Time:	09:20	Zero Niner Two zero

Some common phrases and their meaning. Note that common wordings shall not be used without confirming the sender and recipient.

Acknowledge	Say that you have received and understood the transmission
Affirm	A positive reply
Approved	Permission granted
Check	Inspect/verify something
Confirm	Make sure that something is done
Contact	Take radio contact with someone

Correct	The right way to proceed
Correction	Something said/informed wrongly and continued with the right message
Disregard	Do not note the previous message
Go ahead	Continue with transmission/procedure
How do you read	Verifying the transmission and readability
Monitor	Listen to the frequency
Report	Inform of the procedure
Request	Ask for something
Roger	Have received and understood the message (not recommended when multiple communication is ongoing, needs a call sign verification)
Say again	Repeat the message
Stand by	Wait for the transmission to continue after a moment
Verify	Confirm/check/inspect something

7.5 Interpreting de-icing/anti-icing fluid and hold-over-time tables

There are basically two different tables in use, generic and brandname. The generic table is developed using the lowest holdover times, attained from the certified fluids, for each cell. This table may show lower holdover times than the particular fluid actually provides but the idea is that the table can be used wherever these certified fluids are in use, regardless of brand. The brandname holdover timetable is attained for one particular fluid and cannot be used for any other fluids. If the fluid provided at some station is not the one for the table in use, then the generic table shall be used. The table may also vary in content, regarding columns used (e.g. snow, light snow, very-light snow), between organisations/countries (AEA-FAA/TC). The airline decides in its own procedures, which table to use regardless of what procedure is in use in any particular region.

Holdover time is obtained by anti-icing fluids remaining on the aircraft surfaces. With a one-step de-icing/anti-icing operation the holdover time begins at the start of the operation and with a two-step operation at the start of the final (anti-icing) step. Holdover time will have effectively run out when frozen deposits start to form/accumulate on treated aircraft surfaces. Due to their properties, Type I fluids form a thin liquid wetting film, which provides limited holdover time, especially in conditions of freezing precipitation. With this type of fluid no additional holdover time would be provided by increasing the concentration of the fluid in the fluid/water mix. Type II, III and type IV fluids contain a pseudoplastic thickening agent, which enables the fluid to form a thicker liquid wetting film on external aircraft surfaces. This film provides a longer holdover time especially in conditions of freezing precipitation. With this type of fluid additional holdover time will be provided by increasing the concentration of the fluid in the fluid/water mix, with maximum holdover time available from undiluted fluid. However, due to the many variables that can influence holdover time, these times should not be considered as minimum or maximum as the actual time of protection may be extended or reduced, depending upon the particular conditions existing at the time.

Note that heavy precipitation rates or high moisture content, high wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may also be reduced when aircraft skin temperature is lower than OAT. Therefore, the indicated times should be used only in conjunction with a pre-takeoff check. Certain fluids may be qualified according to fluid specifications but may not have been tested during winter to develop the holdover time guidelines. For use of holdover time guidelines consult Fluid Manufacturer Technical Literature for minimum viscosity limits of fluids as applied to aircraft surfaces. A degraded type II, III or type IV fluid may be used with the holdover time guideline for type I fluids. A type II, III or type IV fluid is considered degraded if the viscosity is below the minimum limit as provided by the fluid manufacturer. The type II fluid holdover time guideline may be used with degraded type IV fluids only after substantiation by holdover time testing. Holdover time guidelines can also be obtained for individual fluid products and these ”brand name” holdover times will be found to differ from the tables published in a generic holdover timetable. De-icing/anti-icing fluid used during ground de-icing/anti-icing is not intended for and does not provide protection during flight.

7.5.1 Type-I

This particular example shows a so-called generic holdover timetable. The table indicates times that can be used for all certified fluids. The lower limit of the published time span is used to indicate the estimated time of protection during moderate precipitation and the upper limit indicates the estimated time of protection during light precipitation. The responsibility for the application of these data remains with the user. Type I Fluid / Water Mixture is selected so that the Freezing Point of the mixture is at least 10 °C (18 °F) below actual OAT. De-icing/anti-icing fluid used during ground de-icing/anti-icing is not intended for and does not provide protection during flight.

The table is read by first verifying the outside air temperature, then the form of precipitation, the time cell to use is where these two parameters cross. The example shows a temperature between –3 °C and –6 °C, a snowfall precipitation is chosen and the times to use are between 0:05 minutes and 0:08 minutes. It is up to the captain to decide on which time is usable. If the de-icing crew is asked to give this information to the flight crew, it is essential to give the time span (e.g. 5-8 min.).All notes added to the table shall be read and used accordingly. Notes below this table are only examples.

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

OAT		Approximate Holdover Times Under Various Weather Conditions (hours : minutes)						
°C	°F	Active Frost	Freezing Fog	*Snow/ Snow Grains	**Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other***
-3 and above	27 and above	0:45	0:11 - 0:17	0:06 - 0:11	0:09 - 0:13	[illegible]	0:02 - 0:05	CAUTION: No Holdover time Guidelines exist
below -3 to -6	below 27 to 21	0:45	0:08 - 0:13	0:05 - 0:08	[illegible]	0:02 - 0:05		
below -6 to -10	below 21 to 14	0:45	0:06 - 0:10	0:04 - 0:06	0:04 - 0:07	0:02 - 0:05		
below -10	below 14	0:45	0:05 - 0:09	0:02 - 0:04				

7.5.2 Type-II/III/IV

This particular example shows a so-called generic holdover timetable. The table indicates times that can be used for all certified fluids. Type-II and –IV tables have a similar layout, except for the times indicated. Type-III holdover timetable is not included here as an example but the logic of interpreting the table and the layout is much the same. The lower limit of the published time span is used to indicate the estimated time of protection during moderate precipitation and the upper limit indicates the estimated time of protection during light precipitation. The responsibility for the application of these data remains with the user. Anti-icing fluid used during ground de-icing/anti-icing are not intended for and do not provide protection during flight. Thickened fluid can be used as a de-icing fluid when sufficiently diluted but a 100% mixture is usually not used for de-icing purposes.

The table is read by first verifying the outside air temperature, then the form of precipitation and then the concentration (%) of fluid used. The time cell to use is where these parameters cross. It is important not to confuse the concentration of fluid used because a false reading can lead to a dramatic error in holdover times. The example shows a temperature between –0 °C and –3 °C, a concentration of 75/25 fluid mixture and a snowfall precipitation is chosen. The times to use are between 0:25 minutes and 0:50 minutes. It is up to the captain to decide on which time is usable. If the de-icing crew is asked to give this information to the flight crew, it is essential to give the time span (e.g. 25-50 min.).The difference in fluid mixture depends on the procedures used by each de-icing provider. Some providers only offer one concentration (e.g. 100%) when others mix the glycol with water (e.g. 75% glycol and 25% water). All notices added to the table shall be read and used accordingly. Notes below this table are as an example only.

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

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

7.6 Local frost prevention

Local frost prevention in cold soaked wing areas is a procedure to try to prevent the need for an actual de-icing/anti-icing event at the departure time. 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 being de-iced/anti-iced prior to the subsequent departure. This procedure is mainly aimed for the prevention of local frost formation in cold soaked wing tank areas during transit stops. This procedure does, however, not supersede standard de-icing/anti-icing procedures. This procedure also does not relieve from any requirements for treatment and inspections in accordance with aircraft manufacturer manuals. The definition of local frost build-up is a limited formation of frost in local wing areas sub-cooled by cold fuel or large masses of cold metal; this type of frost does not cover the entire wing!

For the procedure a suitable spray equipment should be used to apply a proper coating of undiluted type II, III or IV anti-icing fluid on the wings in the limited cold soaked areas where formation of frost may be expected due to contact of the wing skin with sub cooled fuel or masses of cold metal. A proper coating completely covers the treated area with visible fluid. This preventive procedure is merely a precaution and it does not rule out clear ice checks or any other aircraft manufacturer requirements, nor the requirement that aircraft surfaces are clear of frost, slush/sleet, snow and ice accumulation. This local frost prevention procedure shall only be carried out if approved by the operator of the aircraft to be treated, and it shall only be carried out by properly qualified and trained personnel.

This local frost prevention procedure shall be applied on clean wings immediately following arrival of the aircraft. Application is acceptable at the latest when frost just starts to build up, but in this case the fluid shall be applied at a minimum temperature of +50 °C. If precipitation occurred between application of the fluid and dispatch of the aircraft and/or if precipitation is expected before takeoff, a standard two-step de-icing/anti-icing treatment shall be performed. Both wings shall receive the same and symmetrical treatment (e.g. the same area in the same location shall be sprayed), also when conditions would not require the treatment of both wings. Note that aerodynamic problems could result if this requirement is not met. A holdover time shall not be assigned to a local frost prevention treatment since the treatment does not cover the entire aircraft or wing surface respectively.

Since the anti-icing fluid is heated to +50 °C (when using the fluid for frost that just starts to build up) no minimum viscosity limits are relevant. Using this “flowing” fluid can cause it to drain off more quickly than normal thickened fluid. This can cause the wing to ice up at certain areas and it must be noted when inspecting the aircraft.

7.6.1 Manual de-icing

Manual de-icing is perhaps the only thing that has remained as a considerable option after all the different de-icing procedures were developed. Manually cleaning an aircraft may seem very hard. Manual de-icing can be either using brooms/brushes, using wing/propeller covers or using air blowers. All of these options will reduce the amount of contamination on the surfaces even if the surface is not fully clean. De-icing at the time of departure will be considerably faster and saves fluid if preliminary measures have been taken. Removing covers or using forced air is perhaps self-explanatory but the procedure of using brushes/brooms for de-icing must be thought out before starting. Caution shall be taken when cleaning upper surfaces and safety harnesses shall be used.

Consider the direction of sweeping so as not to direct snow or other contamination into gaps and cavities. A general direction from the front backwards is recommendable (note the differences of the external controls of the wings, e.g. spoilers, flaps and slats). The surfaces should be checked before starting, to note any possible ice underneath the snow. Light powdery snow is preferred to be removed manually. Normal de-icing/anti-icing could lead to a de-icing/anti-icing “cycle” (because of wet surfaces where similar light snow adheres) when flying to different stations (mainly short flights) simply because the process was started at the first departure point. Information of the procedure and any findings shall be given to the flight crew. The flight crew will decide on further process for de-icing and anti-icing. The need for inspecting the surfaces before departure is still required in spite of the manual de-icing. Note that the clean surfaces after a manual de-icing procedure shall not be considered as an anti-icing procedure.

7.6.2 Precautionary measures

Many aircraft and airport operations may have their own precautions to be noted in de-icing operations. These requirements shall be noted and procedures followed accordingly. The training and operations program should include these elements. Such procedures can be e.g. preliminary de-icing/anti-icing before departure, limitations on de-icing/anti-icing for smaller aircraft such as turboprop A/C, fluid and gel residue problems and the limitations on operation. The basic concept is still a clean aircraft whether it is performed beforehand or performed for special aircraft. Each operator will indicate their particular operational limitations and all information about such procedures should be available for the de-icing provider.

Gel residue is a problem for non hydraulic power controlled aircraft. The thickened anti-icing fluid has a tendency to dry out on the surface/cavities and swell when in contact with water/fluid. This can be found when repeated treatments of anti-icing fluid is sprayed on the aircraft. The fluid dries and becomes almost invisible to see but when a mist of water is sprayed it can swell ten-fold. This swelled fluid, or gel, may cause a weight increase, instability and/or vibration in-between controls and when the aircraft reaches a higher altitude it can freeze. Furthermore it may block the movement of flight control surfaces. It is important to consider this phenomenon when performing anti-icing and precautions should be taken when necessary. Fluid residue can be found quite often on the trailing edges of the wing after a flight. If the temperature is low, this fluid may freeze or collect contamination when precipitation exists (e.g. dry powdery snow). Any contamination has to be removed prior to departure.

7.7 Alternative de-icing/anti-icing methods

There are options available for conventional de-icing/anti-icing. These procedures may not be available at every airport and for every provider. Such alternatives may be forced air, forced air/fluid-mix, infrared de-icing, infrared ice detection systems, non-glycol de-icing fluids etc. Not all operators approve these procedures so the operation is limited and depends on the user. The de-icing operations are under constant development and new innovations are presented to the operators and providers as they are available. Vehicles and de-icing tools are also developed as the airline industry demands. New aircraft present new challenges for the de-icing business and new quality requirements set limitations and standards on equipment and fluid, and their use. Regional differences may present the need for optional procedures and such procedures should be informed to the user before offering the service. It must be understood that some aircraft manufacturers may also have limitations on some operational alternatives and every aspect should be taken into account before the use.

8 OFF GATE DE-ICING/ANTI-ICING OPERATION

8.1 Airport operations

The operation of any de-icing facility should serve the airlines efficiently. There are a number of ways to manage this. Local settings may demand one sort of operation for one airport that could be unusable for another location. There are gate de-icing operations, centralised and remote de-icing operations. A centralised de-icing is merely a designated area for de-icing (which could be a place on the apron or close to the runway) and a remote area is usually sited close to the departure runway. There should be flexibility in de-icing, a mix operation is one solution for areas where there are no other restrictions for gate and remote de-icing procedures. Aircraft types set their own requirements and limitations on how they are able to receive the de-icing/anti-icing (e.g. propeller aircraft). The procedures used at one particular airport should be clearly defined in a winter operation program.

8.1.1 Precautionary measures

There are some elements that should be covered in the de-icing procedures, such as: the manoeuvring of ground vehicles at the pad, the movement of aircraft at the pad, environmental limitations restricting operations, lighting system, the infrastructure itself (fluid filling, storage, shelters, coordination etc). The airport settings and requirements regarding de-icing operations should be consulted. All the de-icing/anti-icing procedures remain the same (e.g. pre- and post-checks, release, quality checks etc.) regardless of the place of operation. However, each new element (remote) adds procedures to the basic requirements of operation. These procedures should be carefully checked before the start of the operation, especially if the same de-icing crew performs both gate de-icing and at times remote de-icing. All the variables should be covered in training.

8.1.1.1 Centralised/remote de-icing/anti-icing

During off-gate de-icing/anti-icing a two-way communication between pilot and de-icing/anti-icing operator/supervisor shall be established prior to the de-icing/anti-icing treatment. This shall be done by VHF radio or alternatively message boards. In case VHF is used, the register or “tail number” of the aircraft instead of flight number should be used during all communications. This procedure may vary for some locations and local operational procedures shall be adopted. During treatment all necessary information to cockpit shall be given by this means (beginning of treatment, treatment of sections requiring de-activation of aircraft systems, anti-icing code, etc.). Contact with pilot may be closed after anti-icing code and readiness for taxi-out has been announced.

When off-gate de-icing/anti-icing area is entered by taxiing, a sufficient taxi and stopping guidance shall be arranged, or marshaller assistance shall be given. In case radio contact must be established before entering the de-icing/anti-icing area, the signs with clearly marked operation frequency must be visible from the cockpit before entering this area. The de-icing/anti-icing operator together with the airport authorities must publish all necessary information about how to operate on the off-gate site by NOTAM or in local AIP. This information has to include at least the location of, and standard taxi routing to the de-icing/anti-icing area, means to coordinate the de-icing/anti-icing operation, means to communicate before and during the de-icing/anti-icing operation and information about taxi and stopping guidance.

The responsibility to determine the need for de-icing/anti-icing before dispatch lies with the qualified person who performs the departure check at the gate. This information shall be given written or aurally to the Commander of the aircraft, who is after that responsible to proceed in order to get proper treatment. After treatment, the result shall be checked by a trained and qualified person and the anti-icing code shall be given to the Commander, after which the Commander is responsible for the airworthiness of the aircraft.

The location of the remote area at the airport depends on the sort of traffic flow each airport has. Some airports may have a centrally located area through which all aircraft pass when again at some airports there is an area before each runway. The operation must have predetermined procedures established on how to move from one location to another, how to coordinate the operation and how to communicate etc. The traffic management is an essential part of the de-icing coordination. Note that whenever de-icing at a remote area there are aircraft moving to and from the pad. Ramp areas usually have clearly defined paths along which to drive but a remote area is different because variable sized aircraft may move to and from the same positions and wingspans have to be noted.

The procedure on where to park ground vehicles and when to move around the aircraft are issues that need to be clearly defined and made aware to all users/operators. In general, no movement on the pad without a clear signal from a coordinator or team-leader, is allowed and no de-icing/anti-icing operation can be performed before the A/C is ready and has given a go ahead. The logistics must be easily handled on a remote area unless the access to the ramp area is specifically routed. Filling de-icing/anti-icing fluids and fuel for the vehicles must be well planned and a filling station should be positioned so that the additional operations do not effect the de-icing efficiency and throughput. Using a remote area where there are several de-icing providers can be complicated unless a clear procedure has been planned. All providers should communicate to one coordinator and perform the de-icing to their customers accordingly. Moving around the remote pad without notification and communication can cause hazardous situations. The logistics should also be settled between all providers in case they are using different fluids.

8.2 Aircraft throughput

The aircraft throughput is an element that all airlines wish to be solved. The departure of any flight should not be compromised because of a remote operation. The CTOT-times can be affected and additional delays experienced if a sufficient throughput is not assured. The arrival time is also an important aspect when considering the late departure of a flight. Late departures will affect the whole cycle of flights due to being late at every stop. The remote area should be optimised to handle certain peak hours and the procedures should be clearly defined for all parties (ATC, airport, airlines and ground service providers). The area may not be suited to handle all departures so a mix operation should be considered. Some aircraft will perhaps not be able to shut down engines/propeller (if so needed by the de-icing operation) or make other preparations for de-icing at a remote stand and therefore need a de-icing procedure at the stand. These limitations should be noted when estimating the throughput.

An estimated throughput time list of different sized aircraft de-iced and anti-iced at the remote area should be introduced. Even if the list only gives estimates, the process is still easier to predict. The size, position and routing of aircraft on/to the remote area will affect the times. Weather situations will also have an impact on how long the de-icing process will take. Not all scenarios of weather should be calculated since there are too many variables to consider. An average time for three or four different weather situations (e.g. frost, snow, heavy snow and ice) should be taken into account and noted according to aircraft size (small, medium and large according to wingspan) and whether the de-icing/anti-icing is performed with two or more vehicles. The predetermined procedures will help the coordinator to plan the operation. Airlines and ATC will also benefit from such a list when calculating departures.

8.2.1 Air Traffic Control

The remote area is only intended for de-icing operations and the control of the area shall be clearly determined. The area needs a de-icing coordinator (or equivalent) to run the operation. It must be noted if a gate de-icing is also in operation at the same time that this may need additional coordination from another person. The procedures, of where and when to perform the de-icing, should be determined by the coordinator, with co-operation with ATC, the A/C and ground operators/representatives. Air traffic control should be involved/informed of the procedures. The de-icing coordinator shall have radiotelephone communication training and aircraft ground movement and clearance training (limited ATC ground control equivalent) whenever directing aircraft for the de-icing operation. ATC should not be involved in directing aircraft on the remote pad since the coordinator must know where and when aircraft are moving in order to direct the ground vehicles.

ATC will direct the aircraft to a predetermined position close to the remote area from where the coordinator will take control. The coordinator will direct the aircraft to a certain stand where de-icing/anti-icing can be performed. the coordinator will then direct the vehicles, after the A/C preparations have been verified, for the de-icing procedures. After the de-icing/anti-icing procedure is performed and the vehicles are in a safety area, the coordinator will direct the A/C to a position from where the A/C can contact ATC for further instructions. The coordinator is responsible for the movement of aircraft and ground vehicles on the remote pad and no movement shall be made without clearance. This is critical when there are several de-icing providers at the pad and different customers to service. The operational procedures shall be established beforehand and proper safety precautions shall be noted. A good communication procedure between all stakeholders must be introduced and the procedure must be noted by all airlines using the area.

8.2.2 Safety areas

The remote area may be able to handle different size aircraft at different positions or the area is set with a predetermined A/C stand procedure. As earlier mentioned, no movement shall be made on the pad without clearance from the coordinator or team leader. The vehicles shall stand in a safety area before and after the de-icing/anti-icing is performed. This area shall be of sufficient size and placed where there is no risk of interfering with nearby aircraft moving to and from the pad. When de-icing operations are performed simultaneously on nearby positions caution must be taken and the safety area should be of sufficient size to hinder the vehicles from colliding when positioning themselves inside the safety area. The safety area can be positioned either on both sides of the aircraft or on the end of the pad from where the ground vehicles move in each case. It is highly important to note that whenever giving the final release, the vehicle must be inside the safety area. There may also be different vehicles performing different tasks for a particular aircraft (e.g. underwing de-icer, check equipment etc.) and all movement around the aircraft must be coordinated. There may also be fluid suction trucks and apron cleaning/maintenance vehicles on the remote pad during de-icing operations and these vehicles should also be in contact with the coordinator.

8.3 De-icing/anti-icing procedures

The procedure used for de-icing and anti-icing at the remote area differs somewhat from a general gate de-icing. The main difference is perhaps that the engines are running and additional procedures are required for the operation, such as added communication, safety area and positioning, coordination control, multiple vehicle de-icing etc. All variations and differences from gate de-icing must be included in both theoretical and practical training. A remote area does not exclude the need for anti-icing even if the area is close to the runway. Whenever there is precipitation, some form of anti-icing shall be performed and as earlier noted type-I fluids have limited holdover times that may not be sufficient if the A/C needs to stand in line or hold before departure. If a mix operation is common procedure then it must be clear that the de-icing crew is able to perform both duties and operate all equipment (if there are variations). Precautions must be noted, such as jetblast, engine inlet suction, APU running, moving aircraft etc.

A preliminary selection of aircraft, that can be de-iced at the remote and aircraft that need to be de-iced at stand, must be decided. Certain limitations may also apply, such as snow or ice in areas on the A/C that is difficult (or comprises some hazard) to de-ice at the remote and needs to be pre cleaned before taxi. As a rule, A/C with turning propellers can not be de-iced, they need to be cleaned at stand (or otherwise propeller rotation halted). The remote area may have the possibility to provide electricity for start up and the procedures may differ in that case. It must be noted that the shutdown and start up of engines just before departure will add some time on the throughput for these particular aircraft and it may in some cases not be possible for the A/C to do so. Some aircraft have mandatory hands-on checks (e.g. wings and leading edges) and the de-icing operation must be considered accordingly.

The positioning of vehicles around the aircraft depends on the aircraft being de-iced/anti-iced and equipment in use. In general, only closed cabin versions of de-icing vehicles should be used for a remote operation. This is a safety recommendation and it should be noted that jetblast, heat of the jetblast, engine inlet suction and noise are elements which hazard can be reduced by using closed cabin equipment. The amount of vehicles to use for a particular aircraft depends on the A/C size and availability of equipment. In general, two vehicles should be used as a minimum for each aircraft. Four vehicles will increase the efficiency of the de-icing operation but it is not always possible to provide such an amount. It must be clear that there should be no driving behind the jetblast of a running engine and safety zones must be clearly defined. Note that the area is different for different aircraft but in general a sufficient distance from the jetblast shall be used (note idle and brake-off thrust).

8.3.1 De-icing/anti-icing spray- and operational procedures

The de-icing/anti-icing spray operation on the remote area must be defined according to how many vehicles there are in use for each particular case. Generally two to four de-icing vehicles can be used for de-icing/anti-icing one aircraft and additional equipment for underwing and checks, if applicable. Two de-icing vehicles are recommended as a minimum amount so as there would not be a need to drive behind the jetblast of the aircraft. Large aircraft are recommended to be treated with four vehicles whenever possible. If smaller propeller aircraft (assuming the propellers or engine can be stopped) are de-iced at the remote area, then one de-icing vehicle can be sufficient. The size of the remote area and the operation at the area varies from one airport to another but the basic concept remains the same.

The A/C surface areas to be de-iced and anti-iced must also be decided in order to start with the correct procedures. The procedure to use also depends on what kind of de-icing vehicle is in use (with boom extension or a boomless spray). Assuming a vehicle with a boom is used and if the fuselage needs de-icing, then the start would be at the front of the aircraft moving backwards, so the treated area of the fuselage would extend over the wing area at first. When approaching the wing, with the fuselage treated from the front over the wings, a normal de-icing/anti-icing of the wing would be performed. The wings of conventional design usually are higher at the tip and lower at the root. This indicates that the procedure should be started from the wingtip and moved inwards. Some aircraft have a higher wing root and thus the procedure should be continued from the root outwards. The procedure used for a high wingtip designed wing can be performed placing the vehicle halfway along the wing and thus with a boom extension all necessary areas can be reached in proper sequence. After the wings have been treated the aft-fuselage should be continued behind the wing but when reaching the tail section the spray procedure should be moved to cover the higher vertical stabilizer and treated downwards. After the vertical stabilizer has been treated, the aft-fuselage section at the tail root should be finished and the horizontal stabilizer should be treated. The vehicles should then move to the safety area from where the leading de-icing vehicle (team-leader) should make the final release (anti-icing code).

The previous example assumed two vehicles where in use. If four vehicles are used, the aft-section should be treated by the other two vehicles in the same manner. Some aircraft manufacturer and/or operator may require thickened fluid for the fuselage, then such an anti-icing treatment should be added to the procedure while moving around the aircraft. It is important that both sides are treated symmetrically and it is up to the teamleader to verify that the proper procedure is used. Symmetrical treatment can mean that both wings are treated the same way or both wings and both sides of the tail or both wings, both sides of the tail and also the fuselage is treated in the same way. The positioning of the remote area regarding the wind should also be noted. If the area is sideways to the wind (runway direction) it can make the other side of the aircraft surfaces more difficult to spray (headwind). It is essential that the spray procedure is as close to the surface as possible so the proper amount of fluid, heat and pressure is concentrated on the surface. Each case is different depending on the airline procedures (if differing from standard procedures), aircraft type, remote area and weather. Such differences should be noted before the start of the operation. Some aircraft may have weight instability, tail heavy, if the amount of snow/ice is very notable on the surfaces. In that case the tail may need a treatment before the start of the other sections in order to minimise any weight instability. The aircraft may also need to be pre-treated at stand before taxi, if the amount of contamination is notable, so as not to lead to an overweight situation.

The general safety concept while de-icing/anti-icing aircraft with engines running is to avoid the engine inlet and exhaust (jetblast). The equipment should be positioned in such a way that there is no danger of suction of foreign objects in the engines or that the jetblast could tilt the de-icing vehicle or cause dangerous situations. With proper movement and positioning of the vehicle and boom extension, the procedure can be safely performed with regards to the A/C engine safety areas. When de-icing/anti-icing large four engine aircraft, it would be recommended to shut down the outer engines. This procedure shall be verified with the flight crew (as any engine shut down/start up situation). If the outer engines cannot be shut down, then the procedure shall be adapted so that the vehicles move far enough behind the aircraft and in-between the exhaust (jetblast) "lines", as close to the fuselage as possible, in order to be able to de-ice/anti-ice the aft-section and the tail. The front section and the wings can be treated as the vehicles drive between the engines (in-between safety areas). This procedure may be more time consuming but the safety of the operation must be at firsthand in mind.

Note that the de-icing coordinator will communicate with the flight crew of the aircraft, including any special situations, and will inform the de-icing crew of the procedure. The teamleader will then organise the vehicles and the procedures around that particular aircraft. Note that a visual check is always mandatory whenever performing de-icing/anti-icing. Some aircraft may also need a tactile check. Underwing de-icing should be performed before the wing upper surfaces are treated. This is a safety issue, so as little as possible of the glycol runs on the vehicle windows (if upper surfaces would be treated first), that can impede visibility, while performing the underwing de-icing.

8.3.2 Pre- and post- de-icing/anti-icing checks

De-icing and anti-icing checks can be performed at the remote area but this is very limited. Required pre- and post-checks do not vary according to where the de-icing/anti-icing is performed. Proper checks and the determination of the need for de-icing should be performed at the stand/gate where there is more time, proper equipment and no hazard of running engines. The differences of required checks to be performed may vary between companies, and the procedure must be clear to all involved. A visual check is always performed but tactile checks need special equipment at the remote area. Some aircraft may be limited by aircraft directives and thus mandatory checks have to be performed accordingly. All required procedures must be clear before the aircraft taxis to the remote area. The coordinator will inform the de-icing crew of all requests and optimises the operation. The decision to pre-treat the aircraft at stand should also be made in good time in order to coordinate the operation. Note that the anti-icing code, in itself, always contain a verification that the areas are clean (and protected) and checked. Each particular de-icing company have their own equipment to perform these checks and the procedure must be adopted accordingly.

8.4 Management of the centralised de-icing/anti-icing operation

A management and procedure plan should be available at the airport in relevant publications. This program shall explain the necessary procedures of the de-icing operation that is needed for airline operation. The remote de-icing operation must be clearly determined and informed to all stakeholders. A de-icing program must be established irrespective of if it is a remote only or a mix operation. The procedures, the throughput, the options, the checks, the communication etc. must be clearly defined and responsible persons must be introduced. A remote de-icing operation (including a mix) must have a coordination operation. The operation should be established accordingly even if there are several de-icing providers using the same area. Logistics of the de-icing operation must be clear and not hinder the operation. The area of responsibility, the decision of where to de-ice must be clear and such procedures must be communicated with the ATC. The operation may vary according to what each airport can provide, how long the season is and how the peak hours are divided. The de-icing equipment may also limit the possibilities. A dialog should be established periodically with the stakeholders to discuss and agree on procedures. The on-time departure benefits all and the "provider-customer" scenario must be planned accordingly to be as effective and efficient as possible.

9 AIRCRAFT TYPES

9.1 Consideration of aircraft variations

The de-icing/anti-icing procedures can in general be performed according to standard recommendations. However, there are some variations between aircraft, companies, airports and regulations related to a typical A/C scenario. All aircraft related limits shall be taken into account and the differences informed to the de-icing crew. The application of de-icing/anti-icing fluid shall be in accordance with the requirements of the airframe/engine manufacturers. The winter operation plan should reflect the particular airport and the aircraft it serves (e.g. passenger traffic, cargo, and business). There are also a wide variety of aircraft to consider (e.g. small transport, medium-large transport, business jets, propeller aircraft etc.) when providing guidelines for the operation. It is impossible to introduce (and remember) each aircraft type and its particular limitations so a more general approach is in place. It is up to the airline to provide special instructions of procedures if they deviate from normal.

9.1.1 Aircraft no-spray areas in general

Basic areas of caution when de-icing/anti-icing are engine-inlets, APU inlet/exhaust, windows, doors/seals, brakes/landing gear, vents, probes, sensors, cavities and any opening where sprayed fluid is not allowed. Additionally composite parts may have their own limitations regarding de-icing fluids and temperatures, such as composite propellers. There are many variations but these general areas shall be avoided whenever possible. Some splashes of fluid and fluid drained cannot be avoided but direct spray on these parts is not allowed. Areas where fluid is allowed to be sprayed (e.g. the radome), but from where fluid flow-off can cause some problems (e.g. fluid flowing from the nose section on the windows during takeoff), should be noted and the procedure should be discussed together with the flight crew. The reasons why these areas are restricted and the consequences of what might happen if glycol/fluid is sprayed should be understood. Such incidents may be that sensors give false readings, engine and APU produce smoke inside the aircraft via the air intake (or break), glycol may stick on heated cockpit windows causing restricted view for the flight crew etc.

9.1.1.1 APU

The APU is critical for de-icing fluid and no spraying shall be directed towards the inlet or exhaust. There have been a number of cases where the APU has been destroyed due to de-icing fluids and some aircraft have restrictions of use during de-icing. The procedure for each case must be clear and general avoidance shall be noted. Engines are normally shut down but may remain running at idle during de-icing/anti-icing operations. Air conditioning and/or APU air shall be selected OFF, or as recommended by the airframe and engine manufacturer. All the preparations should be performed beforehand so the de-icing/anti-icing operation is not interrupted. Proper communication shall be established so the procedure can be performed accordingly. Aircraft in general have their APU situated in the aft tail section. The APU intake can be on either side of the tail as well as the exhaust. Older design (and some eastern production) can have the APU located in the landing gear section under the wing/fuselage and the exhaust directed through the wing or the wing root. The air-conditioning is usually in operation whenever the APU is. This can cause glycol to be sucked in the air system and thus produce smoke inside the cabin. The flight crew shall be informed before the start of the de-icing so they can make the appropriate adjustments.

9.1.2 Jet-aircraft vs. propellers

Normal jet-engine aircraft are perhaps the conventional aircraft to de-ice/anti-ice. Even so, many propeller aircraft perform a variety of flights and need de-icing/anti-icing just as any other aircraft. The procedure in itself does not vary because of engine differences. The wings, tail and fuselage are treated the same way. There may be differences on what sort of anti-icing is allowed (thickened fluid) or how the anti-icing fluid affects performance. The propellers may have some requirements on how to de-ice or simply to avoid de-icing. Note that the de-icing check also includes the propellers. Propeller aircraft are generally treated at the stand because rotating propellers cause a hazard. If the procedure is performed at a remote area, appropriate procedures shall be established and engine shutdown/start-up procedures (if performed) shall be well known. Some propeller aircraft have the possibility to stop the rotation of the propeller for a limited time (prop-brake). If the de-icing/anti-icing is performed and engines are started, whether it is on a remote or at stand, the correct sequence shall be known and communicated. The aircraft is said to have a left-hand and a right-hand side according to the captain's view forward. The engines are also numbered according to the captain's view starting from left to right (number one on the left-hand side and number two on the right-hand side for a twin-engine A/C). The correct communication shall be used when performing this kind of de-icing/anti-icing operation.

9.1.2.1 Aircraft ice detection and prevention systems

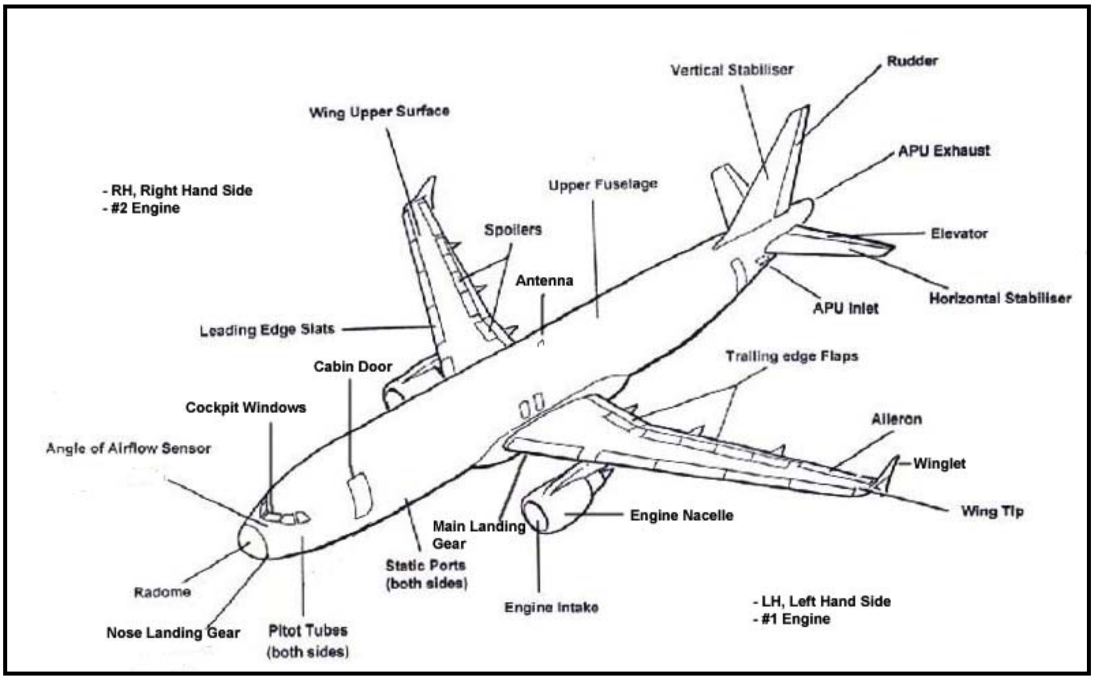
Aircraft have a wide variety of anti-icing or de-icing systems while in-flight. The protective systems are, however, not in use during the ground stop. Areas and systems protected by the aircraft can be the wing leading edges, the tail (vertical and horizontal) leading edges, engine inlet leading edges, probes, ports, tubes, antennas, propellers, cockpit windows even upper surfaces of the wing (tank area mainly). The main anti-icing system used is electricity and heated air taken from engines. Propeller aircraft and some equally sized jets use so-called de-icing boots. These boots do not prevent the ice from forming but they remove it after it has formed. The systems must be generally understood and the limitations noted.

As an example, the wing leading edge can be heated during flight from the engine outwards but the leading edge between the wing root and the engine may in some cases not be heated. This difference shall be noted when checking the aircraft for ice. The same issue is relevant for the tail section where there may in some case not be any heating at all on the leading edges. The propellers are also not protected for the whole length and it shall be checked accordingly. The engine inlet leading edges are heated during flight but not on ground. This shall be noted when cleaning and checking the aircraft. All static ports and pitot tubes including other probes and sensors shall be free from ice before takeoff. Note that the engine inlet also contains some probes that should be checked. These systems give relevant information for the flight and are in some cases electrically heated (depending on aircraft type and options used), but they do not perform correctly unless clean. Some wings are protected from freezing with a heated cover (usually tank area). This area can, however, be iced up if the melted precipitation has frozen overnight when the system has not been in use. Note that if the wing heating is used during the ground stop/taxi (e.g. some business jets), the viscosity of the thickened fluid used can be degraded due to the excess heating of the fluid.

9.1.3 Common aircraft types and design

Aircraft can be designed in different ways and in different sizes to serve certain needs for some particular operation. As an example: commuter aircraft have some limitations and requirements on short-haul routes with short runways and turn-arounds, cargo aircraft have requirements on weight carried and thus size of aircraft, airliners have variable requirements and limitations extending from fuel burn, range, noise limitations to passengers carried. Business aircraft have in general speed, cost efficiency and easy access of operation as a requirement. All elements are considered for each customer and the result is a variety of aircraft in operation. Notable variables, other than size, can be low-wing vs. high-wing design, wing mounted engines vs. fuselage mounted engines, propeller A/C vs. jet A/C etc. Major aircraft manufacturers are currently Airbus and Boeing, dominating the market. Eastern production, containing a variety of Antonov, Tupolev, Ilyuishin and other designs. Smaller sized/mid sized aircraft vary from e.g. BAe, Embraer, EADS ATR, Fokker, Bombardier, Saab etc. and business jets have a large variety of aircraft available.

The aircraft even named differently and of different shape and size, have a general concept of design and function. These parts on the aircraft are named alike and refer to the same controls etc. Here is an example of an imaginary aircraft, for an airline, of conventional design and medium size. The parts listed here are for reference only and do not mean that each aircraft should have the same systems and controls.



Picture 9-1 Aircraft Controls and Description

9.1.4 Precautions with aircraft turn-around

It must be noted that many airlines and companies have their special requirements on de-icing procedures and checks. Many of these requirements are based on mandatory manufacturer or regulator requirements but there are also company-based limitations. The limitations and requirements can be such as a mandatory hands-on check for contamination on wings and leading edges or positioning of elevator before the start of anti-icing. Some companies may have adapted these procedures even if there is no mandatory requirement. Performing preventive de-icing/anti-icing on aircraft for a turn-around must be based on mutual understanding and communication. No de-icing operation can be performed without permission from the airline and flight crew (commander).

10 ENVIRONMENT

10.1 Airport layout and environmental considerations

De-icing/anti-icing fluid is a chemical product with environmental impact. De-icing fluids are not the only chemical used at airports and by far not the most hazardous. Even so, care should be taken whenever using de-icing fluids. Some airports have restricted the use of de-icing fluids at some areas whereas at some airports drainage covers the majority of the airport area. Glycol is a biodegradable fluid but when in contact with ground water it uses a lot of oxygen, which has an environmental impact. Additives in the glycol is another issue. Fluids are also, at times, used in large quantities and this can have a “peak” impact on the environment. Airports can be located near lakes, rivers or over ground water and this in turn sets strict requirements on how wastewater/stormwater is collected, contained and treated. The size of the airport and the airlines using the airport will have an effect on the quantities of de-icing fluids used (assumed that the airport is in general a winter operation airport). Airports usually provide the fluid collection equipment but some de-icing operators may also be responsible for this element. Sprayed fluid (becoming waste water) is not the only issue, also contaminated snow must be taken into account and collected in a place where the snow can melt and be taken care off.

Aircraft de-icing fluids are not the only de-icing fluids that are sprayed, also apron de-icing fluids (e.g. acetates) are used extensively and this has similar environmental impact as aircraft de-icing fluids. The airport infrastructure and how it is operated, has a major role in environmental issues. Aircraft may be de-iced at gate or at a remote area but the waste glycol needs to be collected according to a predetermined plan. Aircraft de-icing fluids will run off the wing all the way from the gate and taxiway to the runway and takeoff (where the majority of fluid left on the surfaces is drained off). The whole chain must be considered and not only the time of de-icing. The de-icing crew has no control on other issues than what is relevant for the actual de-icing/anti-icing work. Issues like: taking samples, testing the spray nozzle or other tests, place on apron where the aircraft are sprayed etc. can be controlled by the de-icing crew and should be performed according to known and accepted procedures.

10.1.1 Glycol identification and environmental impact

During fluid handling, avoid any unnecessary spillage and comply with local environmental and health laws and refer to the manufacturer's safety data sheet. Even if the de-icing operations are performed in a defined area, collected snow and fluid drained from aircraft while taxing or during takeoff may find their way into the ground water. Approximately 1 g of glycol consumes 0,8-1,3 g of oxygen in waters. The degradation of glycol in the water can take from one day to a week depending on the amount of glycol and the time period when de-icing fluids are used extensively. The biodegradation of ethylene and propylene glycols in soil also depends on the temperature. For instance, in a temperature of –2 °C ethylene/propylene biodegradation is 3,0/2,3 mg glycol/(kg soil*day) when in a temperature of +20 °C the same glycols rates are 66,3/83,5 mg glycol/(kg soil*day) respectively. The airport needs a wastewater treatment plan to consider this issue.

The de-icing operation can not be limited on how much fluid is consumed, as this is dependent on weather and aircraft contamination. There is a specific margin on minimum fluid used (e.g. 1 litre/m^2 surface area) that is recommended and this shall not be compromised. However, the technique of spraying and removing contamination should be well trained and adapted which will minimise any excess consumption. A remote de-icing area does not remove the need for use of thickened fluids, as this is also dependent on weather and precipitation. The drainage should be organised by the airport with winter operations in mind and the de-icing operator should limit spillage by proper training and with defined procedures.

As mentioned, any extra spraying (other than aircraft) shall be contained to a specific area according to a defined procedure. Sample testing and other relevant use of glycol can for example be sprayed into a container and thus collected. This collected fluid is not necessarily reusable but it is contained from draining into the ground/surface water. There are other issues that can limit the use of glycol, such as the use of forced air, using propeller/wing covers, infrared technology, brushes and brooms, storing aircraft in hangars etc. Some airlines also approve of using water for de-icing; temperature and regions where it is possible without freezing though limit this. Even if the glycol (ethylene and propylene) is considered fairly non-toxic to the aquatic environment, the use should be limited and well estimated whenever possible. The use of glycol in large quantities can have a serious impact on fish and wildlife if drained into the water. There should be a good dialogue between the de-icing operator and the airport and environmental authorities in order to improve related issues.

10.1.2 Collection and disposal of fluids

Airports use a variety of collection methods, including gate and ramp area drainage collection systems, storm sewer plugs, designated aircraft de-icing pads, temporary de-icing pads, storm drain valves and specially designed glycol-vacuum vehicles (that can also be used by de-icing operators). There are also constructed wetlands near or at the airport through where the waste fluid is drained and cleaned biologically. The system at each airport is different but the same elements are there to suit each local region best. Collected wastewater is then processed to recycle/recover glycol, treated on site, discharged to a publicly owned treatment plant or a combination of these. The more contained the de-icing operation is the better the glycol is recovered but this has again an effect on the aircraft throughput and departure reliability (depending on the operation and size of the area). A good drainage system and collection plan is as good to collect the fluid as is a restricted remote area. There are many variations and local settings must be adapted. The airport usually performs the disposal of the (de-icing) wastewater but some airports have a recycling plant where the issue is partially handled.

10.1.3 Recycling of glycol

The use of de-icing and anti-icing fluids is based on the fact that they are tested and certified. However, many airports collect and recycle their fluids but the re-use of this glycol is dependent on approval and certification. The recycled glycol is so far only used as a de-icing fluid and not converted further into anti-icing fluids. There are many benefits for recycling glycol such as the containment of wastewater and financial benefits of reusing the fluid. The process in itself can benefit the airport (e.g. less waste water due to the recycling process) and the airlines (cheaper fluids) as well as the recycling company and the fluid manufacturers (when involved in the process). The recycling can never be independent from manufacturer produced glycol as the wastewater is not collected 100 % and the process eliminates a certain amount of the fluids. The processed fluid must also be approved for reuse, not only from a manufacturer and standardisation point of view, also by the airlines using this recycled fluid as a normal procedure. With approved procedures and defined and controlled operation, the fluid is as good as any newly manufactured equivalent.

Recycling systems rely on a series of standard separation techniques to remove water and suspended solids and in some cases surfactants, corrosion inhibitors, and other additives from contaminated wastewater. The glycol recycling process generally consists of several steps, which may include filtration, ion exchange, nanofiltration, flocculation, reverse osmosis, evaporation and distillation. The process depends on the system used and what outcome is desired (e.g. is going to be used for aircraft de-icing or is going to be used for the automotive industry). The fluid is first filtrated to remove larger contaminants, then it is processed through a series of ion-exchange columns after which nanofiltration can remove further thickening agents and surfactants. Water may be removed by distillation (since glycol has a higher boiling point). Some techniques use a large amount of energy whereas some companies use less energy-intensive solutions. Biological recycling is also an option but it needs another sort of operation and more time. Although recycling systems can successfully recover glycol from storm water with concentrations as low as 2,5 %, involved stakeholders strive to make the process economically sound in order to benefit all.

11 DE-ICING/ANTI-ICING EQUIPMENT

11.1 Variations of de-icing/anti-icing equipment

There are many different vehicles on the market that are able to perform the de-icing operation. These vehicles range from small to large, from open basket to closed cabin, from a one-man operated to a two-man operated, from fixed spray nozzles to extended boom nozzles, from movable units to fixed units etc. The vehicles have been developed for specific tasks at 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 burners that heat up the fluid before spraying. Some vehicles have a three tank (de-icing/anti-icing fluid) version with Type-I, Type-II/III/IV and water separately when some have only one or two tanks with pre-mixed fluid. The concept has been designed to fulfil the requirements of one particular operator and operation. One concept is the same for all that is that they are all lifting devices that require a 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.

11.1.1 Equipment safety precautions

The de-icing vehicle contains many areas where safety precautions must be noted. Some of these areas to be noted are the use of hot fluids, the high pressure of the spray, large and heavy vehicles moving around aircraft, precautions when filling the vehicle, precautions when using the boom and manoeuvring, communication between the sprayer and the driver (where applicable), the at times poor visibility while spraying, the use of safety harnesses among other things. The use of the vehicle should be performed in a manner that the following user can continue without any doubts of the safe performance of the vehicle. Any discrepancies shall be informed and noted, and measures shall be taken to indicate to other users that the vehicle may not be usable or that the 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 in the vehicle should be checked for proper performance, e.g. fluid quantity indication, burner 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 glycol on the ground. It is recommended to test the brakes before approaching the aircraft to verify how slippery the surface is and in general test the performance of the brakes.

11.1.1.1 Emergency requirements

A certain amount of emergency solutions are mandatory for a de-icing 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/in the vehicle, an emergency lowering system of the boom, a fire extinguisher and a system to prevent any overheating, overfilling and overpressure in the de-icing fluid system. A way of communicating must be in place in order to be able to solve situations with the person in the basket/cabin. The operation and monitoring of these systems shall be included in the training and each different vehicle requires similar type training.

11.1.2 Operational use of equipment and quality control

There are some limitations on the use of de-icing vehicles. These limitations refer, among others, to the maximum wind velocity with the boom elevated, operational speed in de-icing/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 13-15 m for large transports and under 10 m for small transports. The boom (basket) in itself may not in some case 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 further 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 and/or requirements shall be referred to in the current de-icing 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 vehicle also need labelling at all appropriate areas, such as hoses, fluids, filling ports, instructional plates etc. Labelling of different hoses and filling ports is important so no confusion would exist when performing de-icing and anti-icing respectively. Since some operators use uncoloured de-icing and anti-icing fluids, this aspect is even more important. Spray tests must be performed periodically for thickened fluid in order 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 these functions are working and that they have been appropriately maintained. A maintenance schedule shall be introduced and 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 (+60 °C for Type-I/water mix when used as anti-icing and +50 °C for thickened fluid when used for preventive de-icing for frost building up). The vehicle may also be able to provide data for the customer after each de-icing event (if requested). Minimum parameters shall be recorded, such as the date, aircraft de-iced/anti-iced, fluid used/mixtures and holdover time started. Additional data is usually collected and thus also provided.

11.1.2.1 Filling station

Each filling station is designed to serve the particular vehicles in use. The filling of fluid can be performed by an automated system controlling 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 so as not to mix fluids. Application equipment shall be cleaned thoroughly before being initially filled with de-icing/anti-icing fluid in order to prevent fluid contamination. De-icing/anti-icing fluid in trucks shall not be heated in confined or poorly ventilated areas. The heating of fluids in containers/tanks may be performed electrically or not heated at all (anti-icing fluid is generally not heated). Cold fluid can be filled in the tanks if the vehicle is equipped with a burner that heats up the fluid before spraying. Thickened fluid is not heated in either the vehicle or at the filling station (unless used diluted as a de-icing fluid). The level/amount of fluid and fluid temperatures both for the filling station and vehicles parked should be monitored in order to secure a sufficient amount and sufficiently heated fluid when needed. The operation of the filling station shall be included in the training and all necessary precautions noted.

11.1.3 Equipment communication requirements

The de-icing 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 so as not to continue the de-icing operation with misleading or no communication at all. When two or more vehicles are de-icing 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. Certain airports have separate frequencies for different areas of de-icing operation. The communication equipment must be suited for the local setting and the personnel trained accordingly.

11.1.4 Equipment fluid use and spray alternatives

As earlier mentioned, there are variations between equipment. The variations also reflect on how the de-icing/anti-icing fluids are stored in the vehicle and how it is sprayed. Basically the fluids can be either premixed before use or a proportional mixing system according to selection will mix the appropriate solution of glycol and water. Thickened fluid is not generally mixed with water but some operators do use this fluid diluted as a de-icing fluid. The differences are mainly dependent on what particular need each operator has and how local settings are set up. Vehicles using pre-heated fluid should monitor the temperature. Vehicles using so-called burners should verify the correct temperature while spraying. Note that when the vehicle has not been in use for some time, it may take time to reach 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/hour. The heating of water/Type-I can also generate heat for the thickened fluid. This should be monitored so the temperature would not rise too high. The fluid flow depends on the particular fluid used and the equipment in use. Generally a flow rate of 20 – 100 l/min may be used for non-Newtonian fluids (thickened). The demand is that the viscosity loss is minimal after pumping and spraying so as not to degrade the fluid below the minimum viscosity. The pumps, lines and nozzles should be such that minimum viscosity loss is achieved after spraying. The demand of spray pressure and flow rate depends largely on elements such as the contamination on aircraft surfaces, wind conditions, temperature of fluid, spraying distance etc. Generally a 50 – 275 l/min flow rate at a pre-nozzle discharge pressure of 650 kPa with the boom fully elevated will be suitable for any de-icing task.

To perform an effective de-icing operation, the de-icer 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 shaped and 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 would become stronger instead of leaner if something fails. It is up to the operator to make periodical and daily checks for the fluids as well as visual checks according to current standards and recommendations to make sure that correct mixtures are used. The de-icing fluid (lean mixture) and water in the lines may freeze if cold temperatures exist. Purging the lines, filling them with a high concentration of glycol should eliminate this. In turn when de-icing 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.

11.1.5 Data collection

To enable useful evaluation and follow-up of operator performance, a system for recording and controlling operations should be established. The particular data relates to the general customer needs but regulations also require a record keeping of this data. The data is usually computerised and the system records automatically some parameters (e.g. mixtures, time of de-icing and time of anti-icing etc.) but this can also be recorded manually. The details fed into 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 for the customer when requested. The data is also an invoicing requirement unless otherwise settled between operators/airlines. There are different ways of providing and recording this data, such as instant invoice capability or remotely via the coordinator or as a hand made receipt. Some airports also need verification of where and how much de-icing fluid has been used. This data should be recorded as seasonal information and not needed on a daily basis. Some companies also require Internet based record keeping for all de-icing events in order to fulfil certain aircraft specific data analysis and reporting as well as the generally required event information.

12 DE-ICING/ANTI-ICING COORDINATION

12.1 General

Any winter operation needs a coordinated effort to produce an effective and efficient de-icing procedure. Many airlines and de-icing providers use this coordination procedure to improve safety and departure reliability. Airports are differently planned and serve different aircraft and traffic flow but whenever there is a winter operation some coordination is needed. The coordination can be established according to the local needs and settings. If the de-icing volume is reasonably large then a coordination system is a must. Coordination can be established for both gate and remote de-icing operations, they can even serve both procedures simultaneously. The area of responsibility lies with the allocation of de-icing work, the control of de-icing vehicle resources for aircraft, management of de-icing events, communication control, safety considerations and special occurrences (problem solving) or ad-hoc situations. Local requirements must be followed and the procedures adapted accordingly. A management plan should be introduced to clarify de-icing procedures and different situations related to the operation and responsibilities.

12.2 Management of de-icing/anti-icing procedures

When establishing a (winter operation) coordination management plan, such things should be considered as: what is the volume of de-icing events, where should the emphasis be made for an effective coordination, what is the expected outcome of the coordination, can the coordination serve other customers, are all stakeholders involved, what sort of infrastructure is needed, does the season and climate set any requirements for the coordination, what are the local limitations. The list can be continued but the main idea is to make the coordination as easily managed as possible without compromising safety, efficiency and effectiveness of de-icing operations but at the same time involving all stakeholders.

The airport or local settings can offer possibilities and/or limitations to build a coordination system. An ideal place to coordinate is somewhere with good visibility, good communication possibilities (ATC, ground support divisions, aircraft and all de-icing vehicles), possibility for problem solving with relevant stakeholders and easy access for personnel. The volume of de-icing events is relevant when building up a system. The benefits of a good coordination system is that all operators have one place to make their requests, there is always someone standing by and situations can be solved without complex procedures. The season of de-icing should be clear when there is a need to establish a "stand by crew". Note that even summer operations may have the need for a de-icing (ref. clear ice) and a back-up plan for such events should be clear. It is recommended to have an agreement with a ground service provider (or similar) who is always present and can offer back-up service when the main de-icing staff is unavailable. Note that anyone performing de-icing/anti-icing must be trained and qualified.

12.2.1 Coordination recommendations

The coordinator must have good experience of winter operations and be able to solve situations as they appear. Relating requirements are explained in chapter 2.1.3.5. The coordinator must be able to handle several de-icing situations at different times of operation. Some items included in the procedures may be to organise resources, control vehicle fluid consumption and filling according to the flow of aircraft, verify quality of fluids, give taxi instructions at the centralised de-icing area (or provide contact information), involve stakeholders (e.g. apron suction trucks, other operators), record keeping and to be a source of information (troubleshooting) when needed. The coordinator is constantly monitoring all communications and operations and can therefore supervise the safety of de-icing operations. The coordinator may need to be aware of environmental aspects and monitor the operations accordingly. Fluid availability and logistics is one important part of coordinating a de-icing operation. The coordinator should be able to provide the A/C with pertinent information of the de-icing procedure if the de-icing crew is unable to provide such information. Note that at remote areas other de-icing providers may share the same de-icing pad but not the same coordination. This situation should be clarified beforehand and procedures should be set up for mutual understanding and foremost because of safety.

12.2.2 Communication procedures

The coordinator has a role of supervising correct communication between the de-icing operator to the aircraft and correcting possible misunderstandings. Refer to chapter 6.5.2.1 for off gate de-icing/anti-icing communications. The basic communication does not change with or without a coordinator. Communication can be performed via VHF (normally) or by any other means (e.g. message boards, UHF, phone etc.). If the coordinator acts as a team leader among the de-icing group, communication can be provided by intercom (headsets) to the aircraft. Note that if the coordinator gives a final release code, it must be made sure that all vehicles are clear from the aircraft and in a safety area before communicating. Visual indication of the procedures shall be made possible for the coordinator in order to provide correct and exact information of the situation. Aircraft may ask questions regarding the fluid, holdover time and/or the procedure itself and necessary information must be readily available by the coordinator.

12.2.3 Safety considerations

It is up to the de-icing coordinator to verify de-icing/anti-icing procedures and take into account variations between company procedures. This information must be informed to the de-icing crew whenever relevant. The de-icing coordinator is responsible to control the movement of de-icing vehicles on the ramp and the remote area. Safety issues shall be noted and informed/reminded to the de-icing crew. Emergency situations shall be considered beforehand and a plan of such events shall be available. Issues like personnel accidents, collision with aircraft, accidents with fluid handling etc. must be considered and a procedure must be followed accordingly. The coordinator shall have contact with relevant parties to solve the situation and act according to the situation. Procedures shall be practised and communication channels must be organised. Relevant safety aspects must be considered in the winter operation program and such procedures must be emphasised by the coordinator.

12.2.4 Airport layout and local compliance

The airport infrastructure should support the winter operations and the need for a de-icing/anti-icing program. Such predetermined issues must be well defined and approved by all local stakeholders. The de-icing coordination is one key point in operating an effective winter operation. This part of the process should support other elements that are relevant for a safe and on-time departure. The location of the de-icing coordinator is important in order to control the operation. Visibility to the ramp (and remote) should be made available on site or by cameras. The location, visibility and communication elements are even more important when the operation is spread out. Each organisation should estimate the need for several coordinators according to the peak hours and operation as a whole. The coordinator may be in contact with airlines, airport departments (such as ramp cleaning, A/C positioning), ATC etc. and it is therefore important to have a good dialogue with these relevant stakeholders in order to make the process as effective and safe as possible. Local regulations and restrictions must be noted and the operation must be adapted accordingly.

13 QUALITY CONTROL

13.1 De-icing quality programme

As quality of procedures and operation is a very important aspect of the de-icing sector, it is vital that each operator establishes a quality assurance programme. The program shall include each station where de-icing operations are performed to ensure correct procedures. The quality control shall include at least the following subjects:

a) Periodical auditing (internal and external, e.g. IATA-DAQCP where relevant)
b) Training, qualification and records
c) Methods and procedures
d) Publications
e) Equipment
f) Fluids

The operator shall document, implement and maintain a quality assurance system and continually improve its effectiveness. The operator shall also note local limitations and requirements and include these areas in the program. The programme must ensure compliance with the relevant sections of aviation regulations at all on-line stations where aircraft de-icing/anti-icing is either normally carried out, or where local conditions may periodically lead to a requirement for aircraft to be de-iced/anti-iced. Deficiencies, in regard to a station's local de-/anti-icing procedures, will be identified and subsequently actioned through this programme, thereby ensuring that the required safety standards are maintained. The programme shall include the responsible person/persons that will ensure:

a) Compliance with this programme
b) That any outstanding deficiencies (negative responses) identified, are resolved as a matter of urgency
c) That an effective audit programme is maintained

When providing de-icing/anti-icing services, a standard ground handling agreement with a de-icing/anti-icing attachment should be made. This agreement defines the requirements for the de-icing/anti-icing services that have to be fulfilled. The agreement should include procedures, responsibilities and liabilities, documentation and quality control. As an option, used materials, e.g. fluid type, vehicle type or other means of de-icing/anti-icing equipment, could be mentioned in the agreement in order to clarify the procedure.

13.2 Quality control

Prior to the start of each winter period a complete “De-icing/Anti-icing - Quality Assurance Check" shall be performed. This programme shall be made periodically during the season (e.g. in the beginning and middle of the season). A report shall be made of each audit and copies of this report should be distributed to the responsible person at each station. Ensure that all negative responses are actioned within the time scale annotated in the report. Then complete and distribute updated copies of the report. Local settings must be noted and the length of the season recognised. Any audit programme will not remove the need for other airlines/operators using the service, to make their own audits or as a pool audit by the DAQCP.

The Company responsible for the de-icing/anti-icing operation shall maintain vehicles/equipment, fluids, training, qualifications and procedures, in accordance with the latest edition of the relevant specifications or the recommendations on de-icing/anti-icing. Personnel carrying out the de-icing/anti-icing operation, and the person responsible for final release/dispatch of the aircraft are responsible for ensuring that the task is performed in accordance with the requirements detailed in the latest edition of the relevant specifications or the recommendations on de-icing/anti-icing. When a new station is to be opened up, an initial inspection must be carried out, before the start of operations. Responsibility for the delegation, regulation and control of aircraft ground de-icing/anti-icing operations are defined in each company procedure.

13.2.1 Quality procedures

The laboratory checks shall be performed for the fluids at the start and in the middle of the de-icing season and upon request by the airline. The fluid samples shall be taken from all storage tanks and from all de-icing/anti-icing vehicle nozzles. Samples shall be taken in all concentrations used for anti-icing (T-II/III/IV). Perform the laboratory check for fluids as follows:

Type I fluid:

a) Perform a visual contamination check
b) Perform a refractive index check
c) Perform a pH-value check

Type II, III and type IV fluids:

a) Perform a visual contamination check
b) Perform a refractive index check
c) Perform a pH-value check
d) Perform a laboratory viscosity check (for samples from anti-icing spray nozzle(s) and storage tank(s))

To ensure that the necessary safety margins are maintained between the start of the de-icing/anti-icing operation and takeoff, the fluid used to both de-ice and anti-ice aircraft surfaces, must be in an ”ex-fluid manufacturers” condition and at the correct concentration. Due to the possible effect of vehicle/equipment heating and/or delivery system components on fluid condition, it is necessary for the sampling method to simulate typical aircraft application.

The application can be made onto a clean polythene sheet (approx. 2m x 2m) laid directly on the ground, or onto an aluminium plate with associated recovery system. Depending on wind speed/direction at the time of sampling the polythene sheet may require to be weighted down at the edges, to prevent movement. The distance between the spray nozzle and the surface shall be approximately 3m and the fluid shall be sprayed perpendicular to the surface. Where different spray patterns and flow rates are used during routine de-icing/anti-icing operations, samples shall be taken at typical nozzle settings (e.g. fine, medium or coarse) and flow rates for anti-icing. Other similar sampling procedures may be used as long as the procedure simulates a real spraying situation and that the procedure itself is not the reason for the degradation of the fluid.

Select the required flow rate/spray pattern for the fluid to be sampled. Spray the fluid to purge the lines and check the concentration of a sample, taken from the gun/nozzle after purging. Should the refractive index indicate that the lines have not been adequately purged, repeat previous item until the concentration is correct for the fluid to be sampled (on certain vehicles it may be necessary to spray more than 50 litres. of fluid, before the lines are completely purged). Direct the fluid onto the sampling surface and spray an adequate amount of fluid to allow for a 1-litre sample to be taken. Where a polythene sheet is used for sampling purposes, carefully lift the corners of the sheet and collect 1 litre of the fluid in a clean and dry bottle. For reference purposes, take a 1 litre sample of the base fluid from the storage facility and a 1 litre sample from the fluid tank of the de-icing/anti-icing equipment/vehicle being sampled. Attach a label to each sample, providing the following data:

a) Station name (and/or IATA code)
b) Date sample was taken

c) Handling company (and/or IATA code)
d) Identification of de-icing/anti-icing equipment/vehicle (e.g. Elephant Beta, Fixed Rig, etc.)
e) Vehicle/Rig number (or tank/batch number if taken from station)
f) Brand name and Type of the fluid (e.g. Kilfrost ABC-3/Type II, Clariant MPII 1951/Type II, etc.)
g) Indicate flow rate and spray pattern
h) Detail where the sample was taken from (e.g. nozzle, storage tank or equipment/vehicle tank)
i) Mixture strength (e.g. 100/0, 75/25, etc.)
j) Other information
k) Sample taken by

The sampling procedure ensures that the required safety standards concerning the de-icing/anti-icing fluid quality are maintained. When discrepancies are found, further investigation has to be conducted prior to use of the fluid. Before filling the tank with the de-icing/anti-icing fluid it shall be established that the brand name and the concentration of the product mentioned in the packing list corresponds to the brand name and the concentration mentioned in the storage tank. A sample of the delivered product shall be taken and checked from each batch before the storage tank/vehicle is filled. Field check for fluids shall be made always when station inspection is made. The samples shall be taken from the storage tank and from the de-icing/anti-icing equipment nozzle.

13.2.1.1 Fluid Check Methods

Check of documentation
Check that the fluid delivered corresponds to the fluid ordered. Make sure the brand name and concentration of the product specified in the delivery documents corresponds to the delivered fluid. Each container/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.

Visual Contamination Check
a) Put fluid from the sample into a clean glass bottle or equivalent
b) Check for any kind of contamination (e.g. rust particles, metallic debris, rubber parts, etc.)
c) The check can be made by any equivalent method

Refractive Index Check
a) Make sure the refractometer is calibrated and clean
b) Put a fluid drop taken from the sample or from the nozzle onto the test screen of the refractometer and close the prism. Note that you should purge the line well before taking a sample for the refractive index check.
c) Read the value on internal scale and use the correction factor given by the manufacturer of the fluid in case the temperature of the refractometer is not 20ºC
d) Compare the value with the figures from the fluid manufacturer*
e) Clean the refractometer and return it into the protective cover
f) The check can be made by any equivalent method

*) If a fluid manufacturer has not published any tolerances for the refractive index of diluted fluids, the measured refractive index shall be within limits corresponding to a concentration not lower than the nominal concentration and not higher than 7% above the nominal concentration. For type I fluids, the highest concentration at which a product may be used must also be observed.
Example: For a sample with 50% nominal concentration, the measured refractive index must correspond to minimum 50% and maximum 57% concentration

PH-value Check**

a) Take a piece of pH paper and put it in the fluid so that the pH paper becomes wetted with the fluid
b) Remove the pH paper from the fluid and compare its colour with the colour of the table provided with the pH paper and read the corresponding pH value
c) Compare the pH-value with the figures from the fluid manufacturer
d) The check can be made by any equivalent method
e) pH check in the laboratory should be performed with a pH-measurement instrument

Field Viscosity Check

a) This check shall be made with a falling ball method, where the reference liquids represent the minimum and maximum allowed viscosity of the tested product
b) Put the sample into a clean sample tube
c) Fill the glass tube completely, insert the steel ball into the glass and close it
d) Return the glass into the test tool and turn it vertically and let all steel balls reach the lower end of the test tubes
e) After all 3 balls have reached the bottom of the tubes, turn the tool ±180 degrees to a full vertical position
f) The balls will move downwards with a different speed
g) The speed of the middle steel ball shall be between the speed of the two other balls or be equal to the speed of one of them
h) The check can be made by any equivalent method

Laboratory Viscosity Check

a) Perform the viscosity check in accordance with AIR 9968
b) The measurements shall be carried out at rotation speeds of 0.3 rpm
c) The temperatures at which the measurements are made and the spindle number shall be reported
d) Compare the viscosity values with figures from fluid manufacturer
e) The check can be made by any equivalent method
f) Relevant test procedure documents shall be used, e.g. SAE AIR 9968

De-icing/Anti-icing Vehicle Fluid Checks (Concentration Check).

a) Fluids or fluid/water mixture samples shall be taken from the de-icing/anti-icing vehicle nozzles on a daily basis when vehicles are in use. Perform a refractive index check according to given procedures. The sample shall also be protected against precipitation.
b) Samples may be taken from the truck tank instead of at the nozzle from trucks filled with "premixed" or undiluted fluids.
c) Operational setting for flow and pressure shall be used for trucks with proportional mixing systems. Allow the selected fluid concentration to stabilise before taking sample.
d) The interval for refractive index checks has to be determined by the handling company in accordance with the system design for trucks with automated fluid mixture monitoring system.

Checks on (directly or indirectly) heated Fluids

a) Fluid or fluid/water mixture samples shall be taken from the de-icing/anti-icing vehicle tanks. As a guideline, the interval should not exceed two weeks, but it may be adjusted in accordance with local experience.
b) Perform a Refractive Index Check

**) Perform this check if it is suitable to identify contaminants in the fluid and/or detect degradation of the fluid used.

The idea of the visual check is to identify the correct colouring and look for any particles of dirt, rust or other substances that should not be in the fluid. It is also a good indication to note the colour of the mixture if it looks as lean or strong as the selected mixture rate should approximately be.

The refractive index check is a check to identify the correct mixture rate as to have a correct freezing point for the fluid. This can also be directly identified with a freezing point check of the fluid. The other point is to have the correct fluid mix as freezing point and aerodynamic problems may appear if the fluid is too lean or strong respectively.

The pH-check only identifies if the fluid is a neutral fluid as glycol should be. As this is very difficult to identify precisely with pH-paper a laboratory test sample may be more representative. This is not always possible to do in a laboratory and the main point is to identify that the fluid is not contaminated with e.g. an acid substance that may change the correct performance of the fluid when mixed with the glycol in great amounts. Another possibility is to identify aircraft glycol from runway glycol when they are not coloured. This can be noted with visibly different pH-values, even with a paper test.

The field viscosity test is a test to identify if the viscosity of the delivered fluid is within tolerances. This may be performed with e.g. a “falling ball” test that may have minimum and maximum sample fluids as reference or by timing the falling ball. The fluid temperature of the sample taken should be as close as possible to the reference fluid and air bubbles should not be present as these elements change the result of the test. Always conduct a laboratory test if the field test is not reliable.

Concentration checks identify that the vehicle mixing system is functioning properly and that the fluid at nozzle is what has been selected. Note that the lines may have different mixtures of fluid or even water so the fluid at the nozzle can be something else than selected if not purging the lines properly. It issi sufficient to take a vehicle tank sample for pre-mix fluids.

Checking heated fluids in the storage tanks and vehicle tanks when they have been unused and heated for a long time identifies that the water content is correct in the water/glycol mixture (no evaporation).

13.2.2 Quality of training

De-icing/anti-icing procedures shall only be performed by trained and qualified persons. This relates to both ground- and flight crew. The operator is responsible to perform, evaluate and record any and all training performed for the personnel and subcontractors. The training shall cover all relevant areas and qualifications shall be issued accordingly. Material used shall be of the latest edition of any relevant subject. Material used for reference or training only shall be marked accordingly. Customer manuals used shall be of the latest edition and a system of revision shall be established with the company concerned. Training subjects shall include those mentioned in section 2 of this manual. Both initial and annual training is required, including practical training where applicable.

The quality programme should include an area of monitoring training success and the effectiveness of de-icing/anti-icing training received. A periodical review of the training should be established. The training should be recorded and tracked in a manner that is easily retrievable by responsible persons involved. Records shall be available at all stations (or retrievable) for proof of qualification.

13.2.3 Quality of operation

The quality control of daily operations shall be performed on regular intervals. This inspection is an internal quality assurance to assure the safety and effectiveness of operation for both the staff and the customer. The inspection shall include at least the following areas:

a) Inspection of the vehicle and relating equipment
b) Inspection of filling station and relevant systems
c) Daily checks and records
d) Performance of all de-icing/anti-icing related areas

e) Safety issues and special situations
f) Personnel and clothing/safety gear
f) Communication procedures
g) Delivery of fluids and quality checks/procedures
h) Records of de-icing/anti-icing events
i) Inspection of the management plan

The inspection (or auditing) of the operation is only one indication at a particular time on how procedures are established and followed. The quality control should check on how standardised the procedures are and how they are understood. The idea is to observe how the published requirements and procedures are conducted and how the required standard is achieved. The inspection (or audit) needs to be observed as an impartial reflection on the organisational procedures. The quality control should give indications on how the operation could be further developed. Meetings should be held with customers and representatives in order to improve or correct the de-icing/anti-icing operation.

13.2.3.1 Contract de-icing

Prior to using subcontractor work, a quality audit should be performed. The idea is to establish an idea of the contractor and how the subcontractor is able to give continuous service. After selection and training processes have been performed and the operation has started, a new audit should be performed to verify the correct procedures. Any operation that is contracted outside the company shall follow the same requirements and procedures as the company providing the service. The use of contracted de-icing/anti-icing personnel shall be noted when making arrangements with the customer. The responsibilities included in the de-icing/anti-icing operation remain the same whether the service is provided by a parent company or by a subcontracted company. Any training or qualification issue shall follow the same guidelines as for other de-icing staff. Training records shall be maintained by the contractor or it shall be verified by other means that the subcontractor has complied with all requirements.

The subcontracted company is responsible to provide only trained and qualified personnel for de-icing operations. Training instructors within the subcontracted company shall follow the same requirements as the contractor company. The subcontractor is responsible for the training (both theoretical and practical) and material used if performed internally. The flow of information, when issuing new/changed procedures after training must be verified so that it reaches all persons involved. A verification system, that the "de-icing procedure / bulletin" has been read and understood, shall be established by the subcontractor as proof that all personnel has received the information. The company contracting out de-icing work shall audit the subcontractor on a regular basis. Liability of operation shall be clear so there is no distracting elements that could affect responsibility issues. The management plan should include the subcontractor evaluation and continuance.

13.3 Standards and recommendations

Some Civil Aviation Authorities (CAA) have not yet defined the requirements for the de-icing process. However, standards and recommendations are published, which are accepted by airlines and operators as the guideline to follow (e.g. AEA recommendations). Many standards and recommendations are available for de-icing/anti-icing. These standards and recommendations shall be followed when procedures have been established. Different regions refer to some documentation when others refer to other documentation. The procedures do not differ dramatically between these documents but there are slight changes. Since many airlines have flights all around the world and originate from different parts of the world, different documentation, than locally referred to, may be adapted. Approval of procedures between ground service providers and airlines must be established. Different standards, norms and recommendations that may be in use are; ICAO, AEA, SAE (different publication according to operational area), ISO (different publication according to operational area), EN (European Standard). DAQCP may be accepted by many companies as an auditing organisation for inspection of de-icing/anti-icing procedures. Local requirements shall be noted where ever applicable.

14 TRAINING FUNDAMENTALS

14.1 General

This section is intended as a guide for instructors who are responsible for de-icing training (either theoretical or practical), producing material and evaluating training processes. It is important that there is a training program established that all instructors follow. De-icing operations as a ground service may seem less important to emphasise but this attitude should not be taken. De-icing 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. The new de-icing operators are all adults and the teaching process should be directed to such an audience with variable backgrounds in life. The instructor should show consistency in teaching, instil high standards for the process, detect unsafe habits and correct them, show professionalism and knowledge of the subject. If the trainer is not interested in the subject then the student will not take the process seriously. Even if the operational side may seem easy and manageable at first hand a knowledge of relevant items is needed to clarify the "what, why and how" of the whole process. The main purpose in education is to help the de-icing operator translate facts and knowledge into action.

14.1.1 The learning process

Each student sees a learning situation from a different perspective. Learning is an individual process. Knowledge cannot be poured into the student's head, the student can learn from individual experiences. It is clear enough that 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 subjects must be taught right at the first instance because it is much harder to "unteach" (wrong habits) than to teach new. Normal individuals acquire about 75% of their knowledge through the sense of sight, 13% through hearing and 6% through touch (additionally smell and taste). It can be seen that when teaching something that the student can see, hear and touch (theoretical + practical training) most of the learning process is covered.

There is no room for trial and error in de-icing operations. It is therefore a major responsibility for the instructor to organise demonstrations and explanations, and to direct student practice, so that the learner has better opportunities to understand the interrelationship of the many kinds of experiences that have been perceived. Adults tend to have their own idea of many processes since they may have previous experiences in many related work areas. It must be clear from the beginning that there can not be any improvising when it comes to safety of de-icing operations. When the student 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 is linked together.

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

14.2 The teaching process

The instructor should prepare each instructional session according to the level of the de-icing qualifications. All aspects may be relevant to cover but few issues can be more important for one group when some other issues can be important for another group. The training should be specific and not taught as a general subject. After the preparation a presentation of the de-icing procedure should be performed in a manner that the students can remember the procedures in practical application. The review and evaluation of procedures are performed with theoretical tests and practical assessments where applicable. A review and evaluation in any case is recommended because it is the only way to make sure that no misconceptions of the de-icing operations are remembered.

There are some elements that need to be noted when teaching de-icing operations for a group with different background knowledge of aviation procedures (if any experience at all). The main thing is to have a good arrangement of material and procedures to be taught. The student should not have to find out procedures for themselves in basic training. Some issues to remember is to keep the students motivated, informed and present all information consistently. It is important to identify mistakes and review the related issue to correct any misconceptions. The instructor should remember to admit errors in teaching instead of trying to improvise if he/she does not remember. Related elements that are doubtful 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 in English. It is the responsibility of the head of de-icing instructing to make available any relevant material. This material can be in any native language but the reference must be explained and covered in training. Not only de-icing procedure material should be delivered but all pertinent information that have something to do with the whole de-icing operation (e.g. airport regulations, winter programs, customer requirements etc.). All material should be distributed in basic training. Students in refresher training should receive all new information but basic material should be available concentrated for easy access. There is often more than one instructor teaching the procedures and an instructor briefing is recommended to be kept in order to clarify who and what is to be taught by whom (and related material).

14.2.1 Teaching methods

There are several ways to conduct de-icing training. The instructional session depends on the group at hand. De-icing procedures are usually presented in a "lecture method", which is not always the most productive 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 organised in an introduction, development and conclusion. The students must be made aware of their responsibility and develop a receptive attitude towards the subject. The appearance and attitude of the instructor towards the subject is important when giving students the first indication of the importance of de-icing. The introduction should get the students 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 organise the material to show the relationships between the main points. There are many subjects that need to be explained, that may not seem relevant at first, for an understanding of how de-icing operations reflect these elements. Meaningful transitions from one point to another keep the students oriented and helps them understand how each issue relates to the de-icing procedures. Examples of real cases are often used and it has a good effect for showing "what if" scenarios. It is important to focus on the main de-icing procedures when concluding the training to give a brief overview of the operation. An effective conclusion retraces the important elements of the lesson and relates them to the objective.

Alternative methods to "lectures" can be an illustrated talk where the instructor, with the help of visual aids, reflect the idea to the listeners. Depending on the size of the group a guided discussion method may be used. This method of instructing involves the students more but the student 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 give a healthy change for the theoretical part. Case studies can also be used for some subjects (such as vehicle incidents, A/C icing etc.) to cover lessons learned and get a brief discussion of the importance of de-icing. Human Factors are an important element of the training since case studies may give an valuable insight into the real operation that may perhaps otherwise be overlooked. However, most of the subjects are necessary to be explained in a lecture method but the lecture can be more effective with visual aids (pictures, films etc.).

Teaching 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 de-icing operation and set standards according to which all procedures are to be followed. After reviewing new and changed issues a discussion of de-icing 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 de-icing procedures has changed down the line 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 there is not as good a control of proceedings within a subcontracted company as in the main company. It is important that the correct procedures are understood and the training elements are covered, for subcontractor trainers, since there may not be any further control of instruction.

14.2.2 Instructional aids

Instructional aids should be used when teaching de-icing subjects because the material is in large provided as a lecture. Getting and holding students attention is essential to learning. The use of any instructional aids should be planned and fit in for a specific subject. Pictures, films, examples and relating tools can be used. Note that there are many old films and pictures for de-icing operations and their use is not recommended unless they still cover the subject correctly. Computer based training and presentation is a modern way of teaching any subject and it also gets the students attention. Computers are not available everywhere and de-icing programs are not either but traditional teaching aids can be as successful when used correctly. The instructor should perform an overview of the material before distributing or showing the relating subject material. It must be clear what the film or printed material contains in order to explain it correctly. This is especially so when using material that is not originating from within the company.

There is a large amount of relating material available for de-icing, standards and recommendations, vehicle and A/C documentation, videos etc., and the material should not be unfamiliar to the presenter as it may be to the student. Instead of simply distributing the material an explanation of the content should be made. Computer based instruction must be presented in a manner that is understandable for the student. If ”self-study” programs are available for de-icing then a briefing should be held over the subjects so the content is correctly read and understood. CBT-programs can be a helpful aid to reinforce something already presented. Any additional study program can also be harmful if English is the instructional language but the student lacks sufficient understanding of all terms and directions. Whenever using copied material, videos, CBT-programs etc., it must be made clear what are current procedures and what is for reference only.

14.3 Evaluation

Evaluating the de-icing training is one last process where misconceptions can still be corrected. It is very important that the evaluation benefits the student as well as the de-icing operation. Theoretical evaluation is performed with exams and practical evaluation can be performed by an assessment of operation. It must be clear in the beginning that the whole de-icing process contains an evaluation process. This may motivate the students to be more active towards the subjects. The evaluation does not benefit safety when it is introduced by surprise. The training program must contain procedures of training and evaluation. The evaluation process must be taken into account when building up the time schedule for training. Note that a good debriefing can clear up misconceptions better than simply failing or approving students. The ultimate goal of the whole training is to produce a safe de-icing operation.

15 POST SCRIPT

This manual covers most of the relevant areas of operation within the de-icing sector. The manual should be used as a guideline and latest revisions of standards and recommendations shall be used. Stakeholders involved in de-icing/anti-icing matters concerning ground operations are AEA, SAE, ISO and ICAO and added to these are relevant aviation organisations and regulating agencies. DAQCP is involved in quality matters relating to the training, equipment, fluids and operation of de-icing/anti-icing. Local regulations and airport limitations have not been included in this manual and they should be noted where applicable. This manual can be used as a guideline when composing an own company manual into any local language. The content and the message should not be altered but phrasing and wording of sentences may be needed in some case to make it more readable in other languages. Any revision of the original must be noted in the relevant manual in order to indicate possible changes. Any links to web-sites are meant to be impartial and only guide the reader to seek further information. No stand is taken on behalf of any company or organisation. References mentioned in this manual (bibliography) are intended as a guide for further study. AEA de-icing/anti-icing documentation is directly referenced in relevant sections and the latest revision shall be used as the main de-icing/anti-icing reference in operations. Other available standards are also noted.

ANNEX A

Aircraft Types

5th Edition
September 2008

Association of European Airlines

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1 ANNEX A

1.1 Aircraft Types

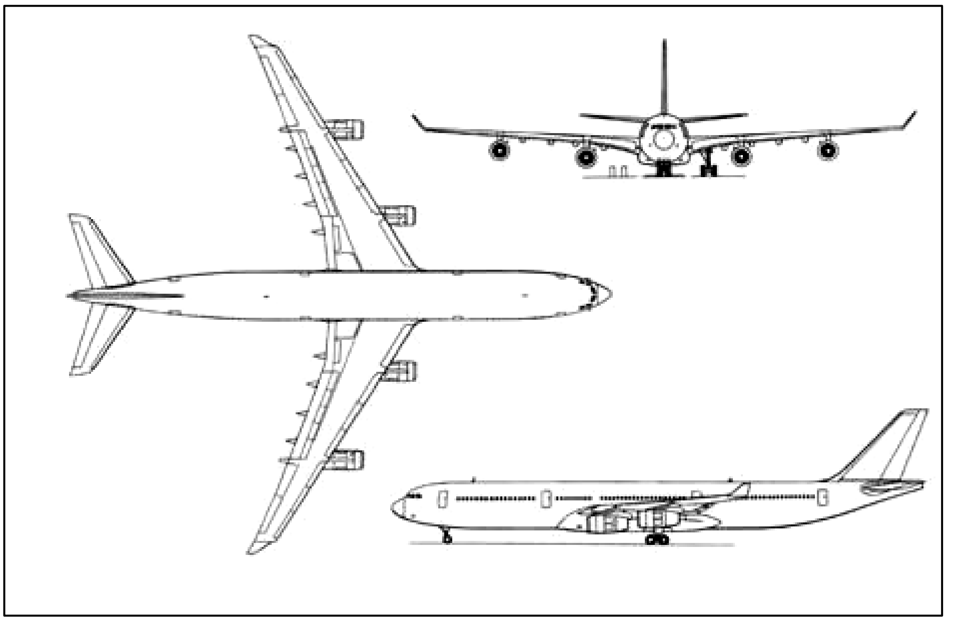
1.1.1 Airbus

All dimensions are for reference only. Latest revision of aircraft data shall be used in operation. The figures given may differ when compared with other manuals and therefore verification must be made if using these figures directly in operation. These numbers are rounded up for easier use in operation. The dimensions for the upper fuselage area and the vertical stabilizer surface area are not mentioned here. Relevant aircraft manufacturer and airline operator manuals should be referenced when treating these areas.

1.1.1.1 Airbus A340

Manufacturer	Airbus
Type	A340 (-200/-300)
Wing area	362 m^2
Horizontal stabilizer area	70 m^2
Total surface area	432 m^2
Height overall	17 m
Wingspan	61m
Fuselage, 1/3 surface area	351 m^2 (340-200), 376 m^2 (340-300)

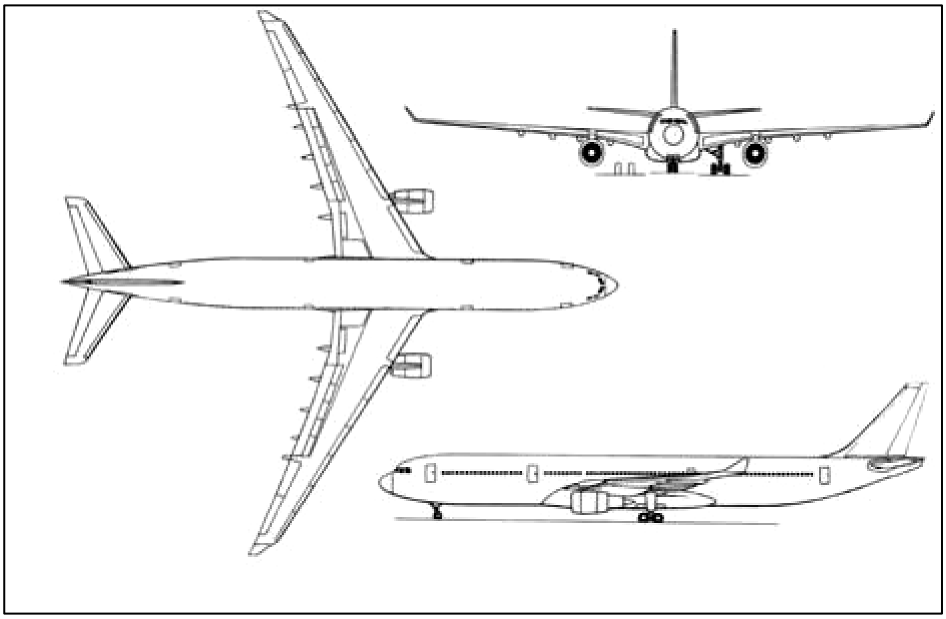
Manufacturer	Airbus
Type	A340 (-500/-600)
Wing area	437 m^2
Horizontal stabilizer area	70 m^2
Total surface area	507 m^2
Height overall	18 m
Wingspan	64 m
Fuselage, 1/3 surface area	401 m^2 (A340-500), 445 m^2 (A340-600)



1.1.1.2 Airbus A330

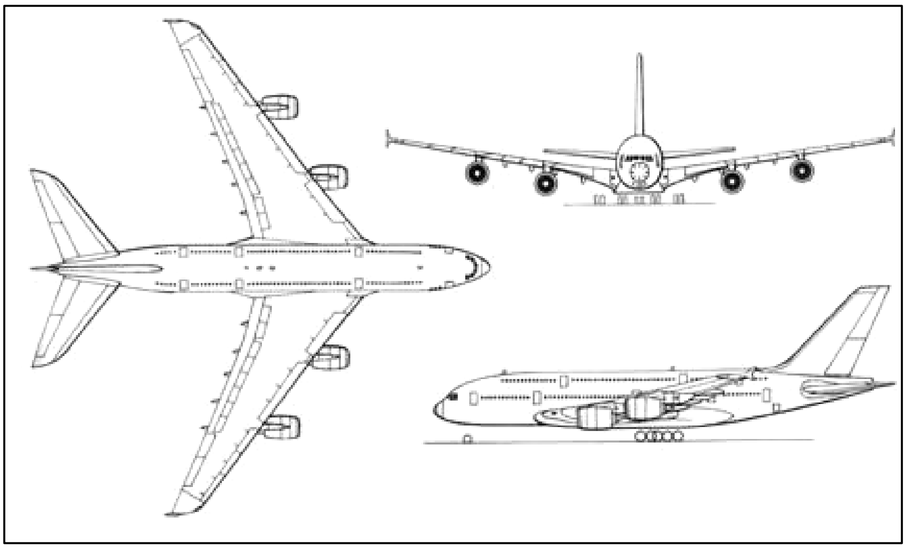
Manufacturer	Airbus
Type	A330 (-200)
Wing area	362 m^2
Horizontal stabilizer area	70 m^2
Total surface area	432 m^2
Height overall	18 m
Wingspan	61 m
Fuselage, 1/3 surface area	348 m^2

Manufacturer	Airbus
Type	A330 (-300)
Wing area	362 m^2
Horizontal stabilizer area	70 m^2
Total surface area	432 m^2
Height overall	17 m
Wingspan	61 m
Fuselage, 1/3 surface area	380 m^2



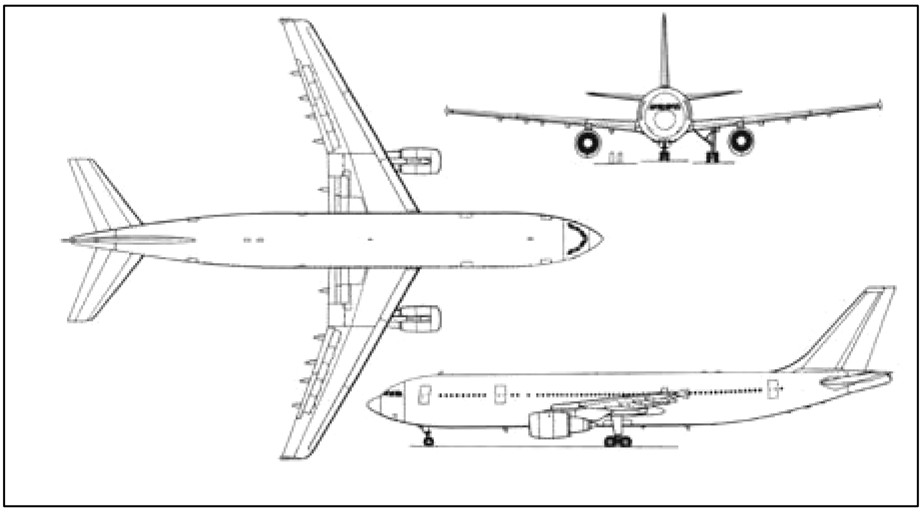
1.1.1.3 Airbus A380

Manufacturer	Airbus
Type	A380
Wing area	727 m^2
Horizontal stabilizer area	173 m^2
Total surface area	900 m^2
Height overall	24 m
Wingspan	80 m
Fuselage, 1/3 surface area	546 m^2



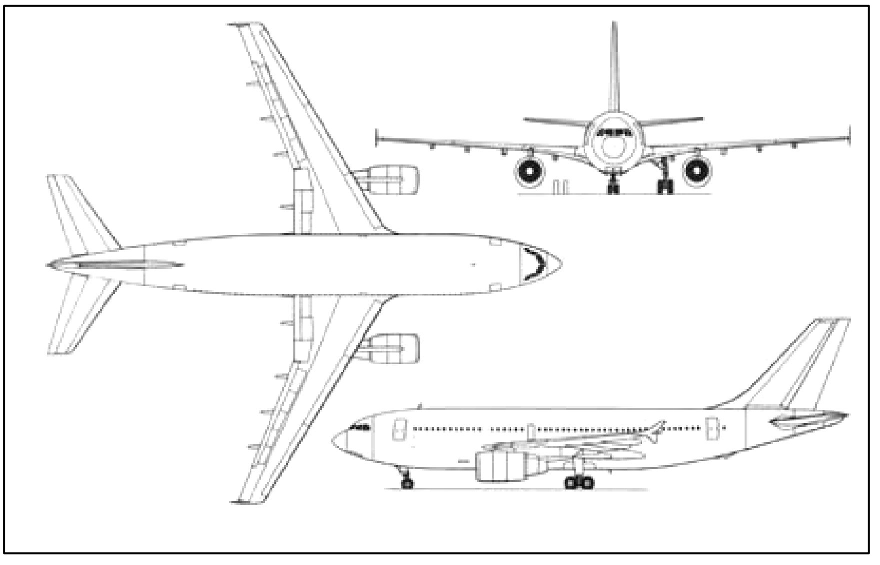
1.1.1.4 Airbus A300

Manufacturer	Airbus
Type	A300 (-600R)
Wing area	260 m^2
Horizontal stabilizer area	45 m^2
Total surface area	305 m^2
Height overall	17 m
Wingspan	45 m
Fuselage, 1/3 surface area	320 m^2



1.1.1.5 Airbus A310

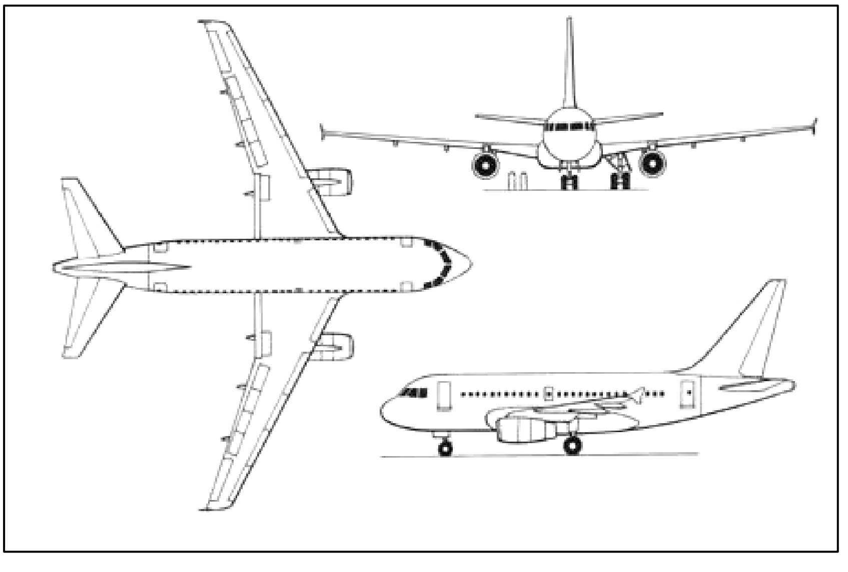
Manufacturer	Airbus
Type	A310
Wing area	219 m^2
Horizontal stabilizer area	45 m^2
Total surface area	264 m^2
Height overall	16 m
Wingspan	44 m
Fuselage, 1/3 surface area	276 m^2



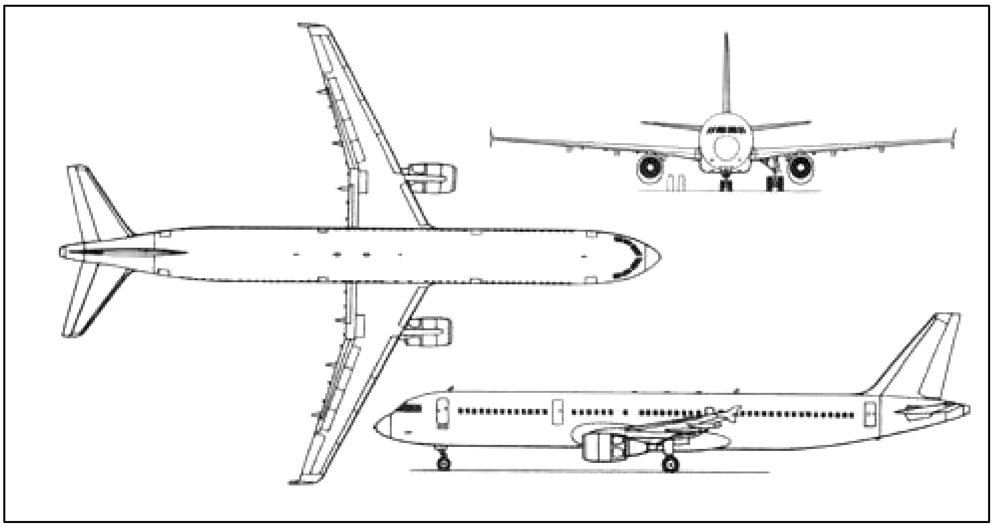
1.1.1.6 Airbus A318/319/320/321

Manufacturer	Airbus
Type	A321 / A320 / A319 / A318
Wing area	123 m^2
Horizontal stabilizer area	31 m^2
Total surface area	154 m^2
Height overall	13 m / 12 m / 12 m / 12 m
Wingspan	35 m / 35 m / 34 m / 35 m
Fuselage, 1/3 surface area	130 m^2 (A318), 140 m^2 (A319), 156 m^2 (A320), 185 m^2 (A321)

Airbus A318



Airbus A321



1.1.2 Boeing

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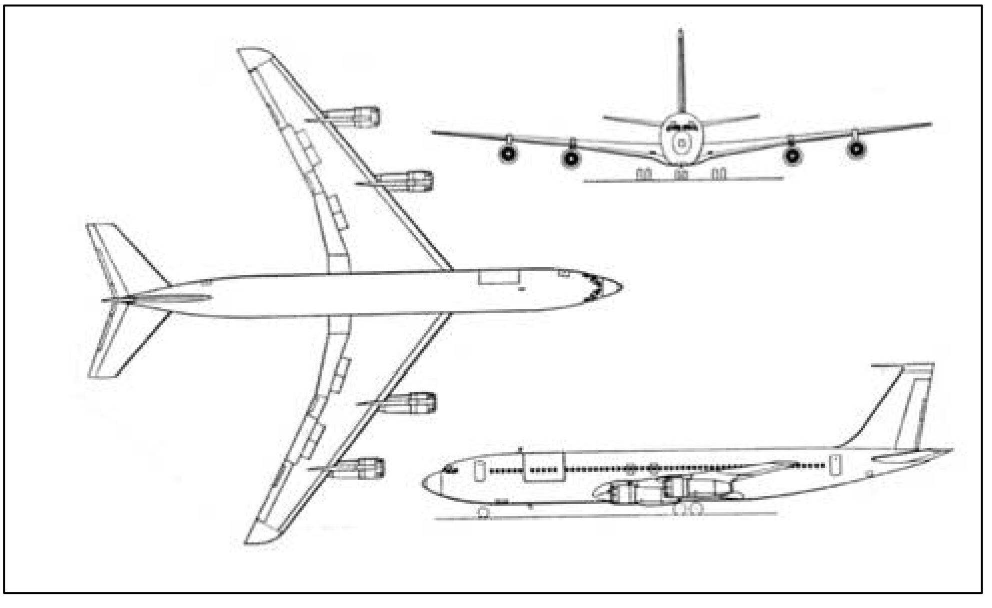
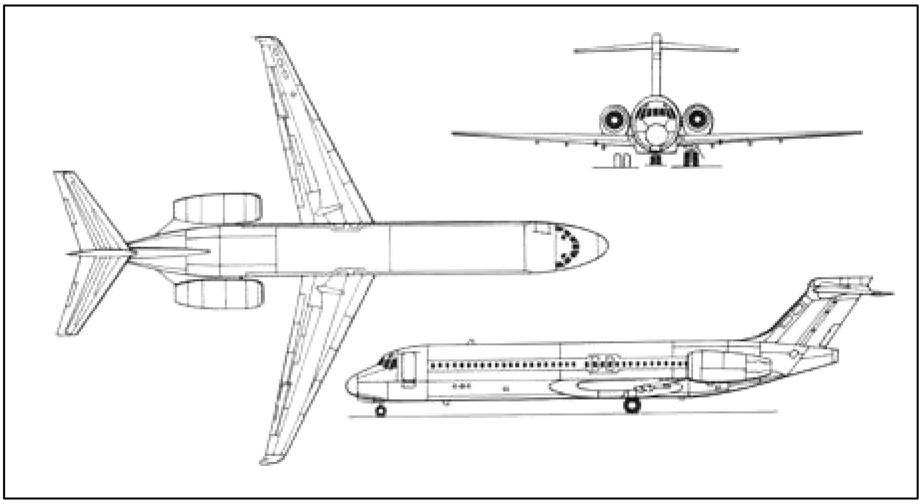
1.1.2.1 Boeing 707

Manufacturer	Boeing
Type	B-707
Wing area	184 m^2
Horizontal stabilizer area	59 m^2
Total surface area	243 m^2
Height overall	13 m
Wingspan	40 m
Fuselage, 1/3 surface area	174 m^2



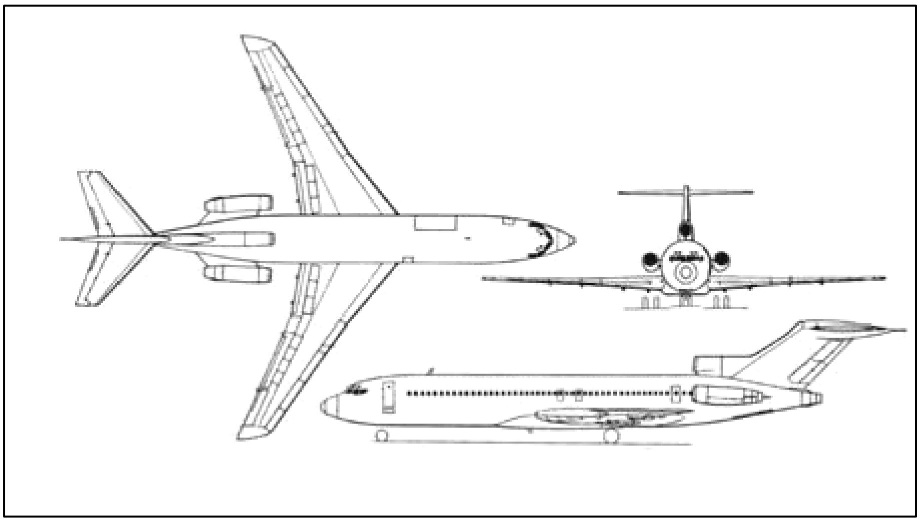
1.1.2.2 Boeing 717

Manufacturer	Boeing
Type	B-717-200
Wing area	93 m^2
Horizontal stabilizer area	26 m^2
Total surface area	119 m^2
Height overall	9 m
Wingspan	29 m
Fuselage, 1/3 surface area	193 m^2



1.1.2.3 Boeing 727

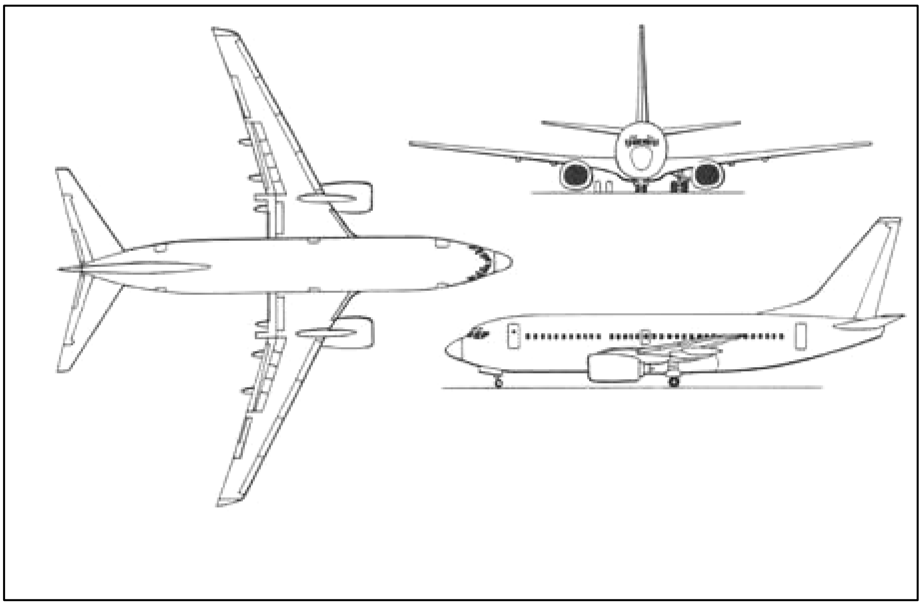
Manufacturer	Boeing
Type	B-727
Wing area	158 m^2
Horizontal stabilizer area	35 m^2
Total surface area	193 m^2
Height overall	11 m
Wingspan	33 m
Fuselage, 1/3 surface area	122 m^2



1.1.2.4 Boeing 737

Manufacturer	Boeing
Type	737 (-600/-700/-800/-900)
Wing area	125 m^2
Horizontal stabilizer area	33 m^2
Total surface area	158 m^2
Height overall	13 m
Wingspan	35 m
Fuselage, 1/3 surface area	123 m^2 ((B737-600), 132 m^2 (-700), 156 m^2 (-800), 166 m^2 (-900)

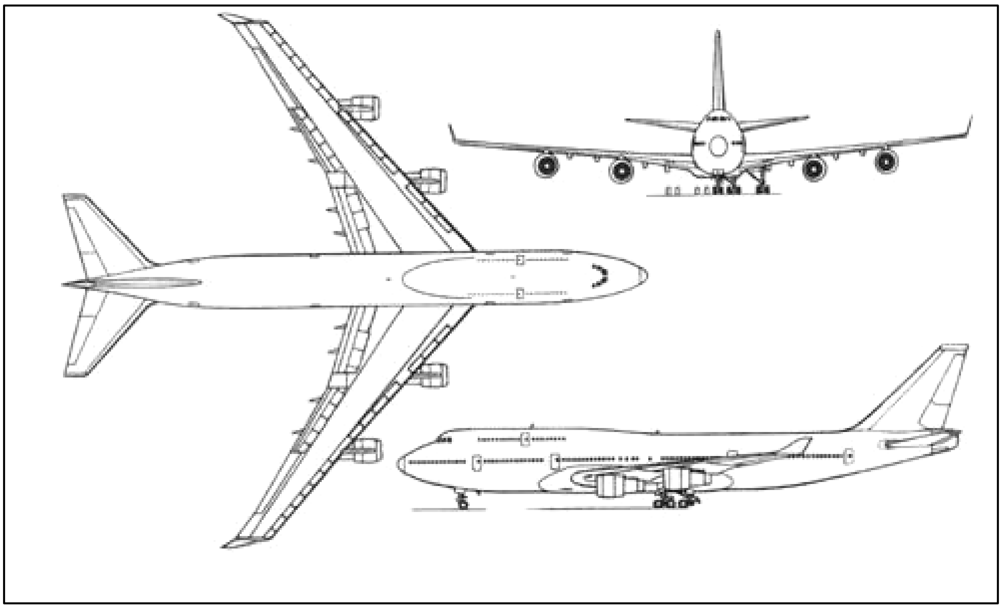
Manufacturer	Boeing
Type	737 (-200/-300/-400/-500)
Wing area	92 m^2 (-200) / 106 m^2
Horizontal stabilizer area	32 m^2
Total surface area	124 m^2 / 138 m^2
Height overall	12 m (-200) / 12 m
Wingspan	29 m (-200) / 29 m
Fuselage, 1/3 surface area	143 m^2



1.1.2.5 Boeing 747

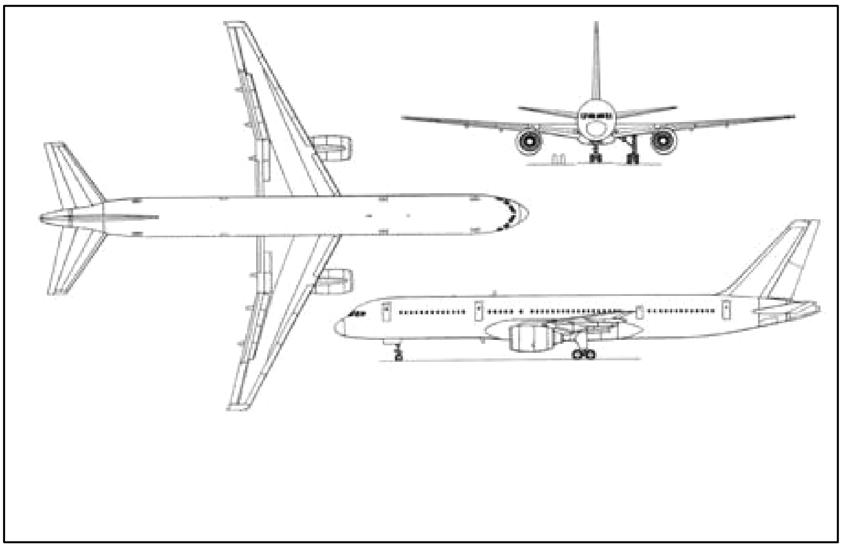
Manufacturer	Boeing
Type	747-100/-200/-300
Wing area	527 m^2
Horizontal stabilizer area	137 m^2
Total surface area	664 m^2
Height overall	20 m
Wingspan	60 m
Fuselage, 1/3 surface area	481 m^2

Manufacturer	Boeing
Type	747-400
Wing area	542 m^2
Horizontal stabilizer area	137 m^2
Total surface area	679 m^2
Height overall	20 m
Wingspan	65 m
Fuselage, 1/3 surface area	481 m^2



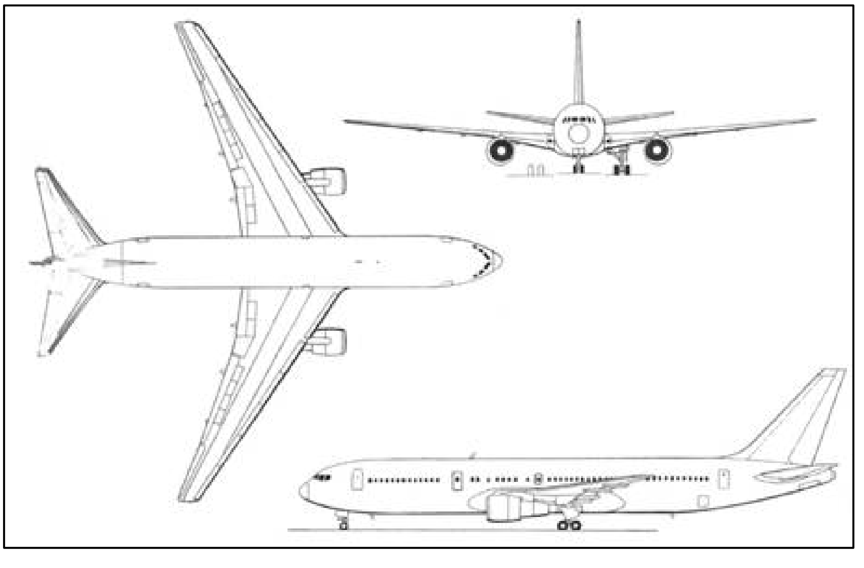
1.1.2.6 Boeing 757

Manufacturer	Boeing
Type	757-200
Wing area	186 m^2
Horizontal stabilizer area	51 m^2
Total surface area	237 m^2
Height overall	14 m
Wingspan	39 m
Fuselage, 1/3 surface area	186 m^2, 215 m^2 (B757-300)



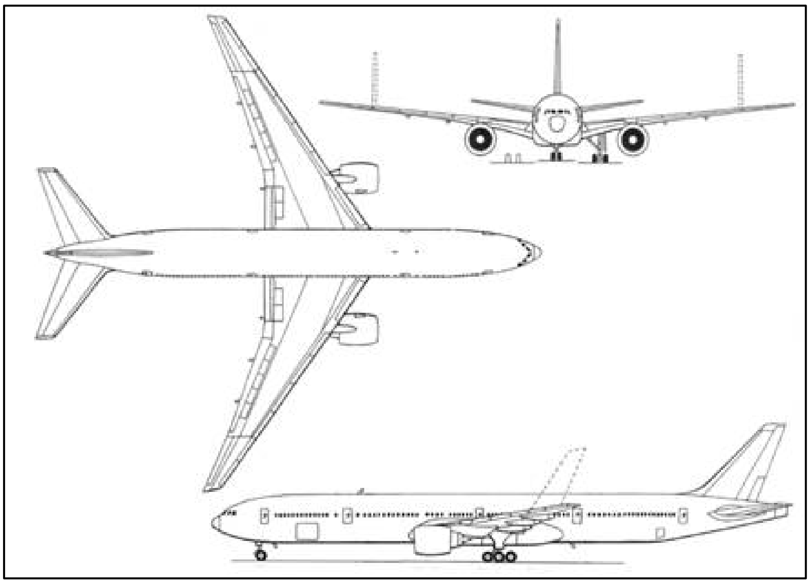
1.1.2.7 Boeing 767

Manufacturer	Boeing
Type	767 (-200/-300/-400)
Wing area	284 m^2
Horizontal stabilizer area	60 m^2
Total surface area	344 m^2
Height overall	16 m
Wingspan	48 m
Fuselage, 1/3 surface area	255 m^2 (B767-200), 289 m^2 (B767-300), 323 m^2 (B767-400)



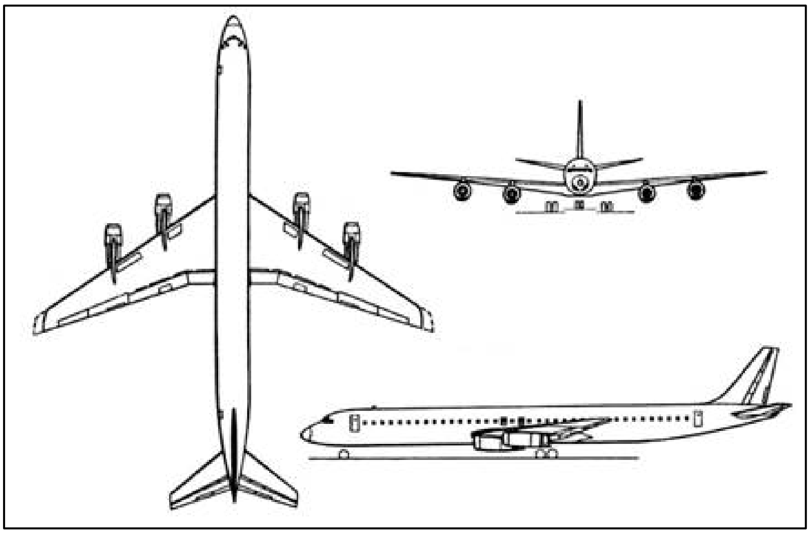
1.1.2.8 Boeing 777

Manufacturer	Boeing
Type	777 (-200 and -300 / 200LR and 300ER)
Wing area	428 m^2 (-200 and -300) / 431 m^2 /200LR and 300ER)
Horizontal stabilizer area	102 m^2
Total surface area	530 m^2
Height overall	19 m
Wingspan	61 m
Fuselage, 1/3 surface area	414 m^2 (-200/200LR), 480 m^2 (-300/300ER)



1.1.2.9 Boeing/MD DC-8

Manufacturer	Boeing/MD
Type	DC-8 Super 62/63
Wing area	272 m^2
Horizontal stabilizer area	51 m^2
Total surface area	323 m^2
Height overall	13 m
Wingspan	44 m
Fuselage, 1/3 surface area	199 m^2

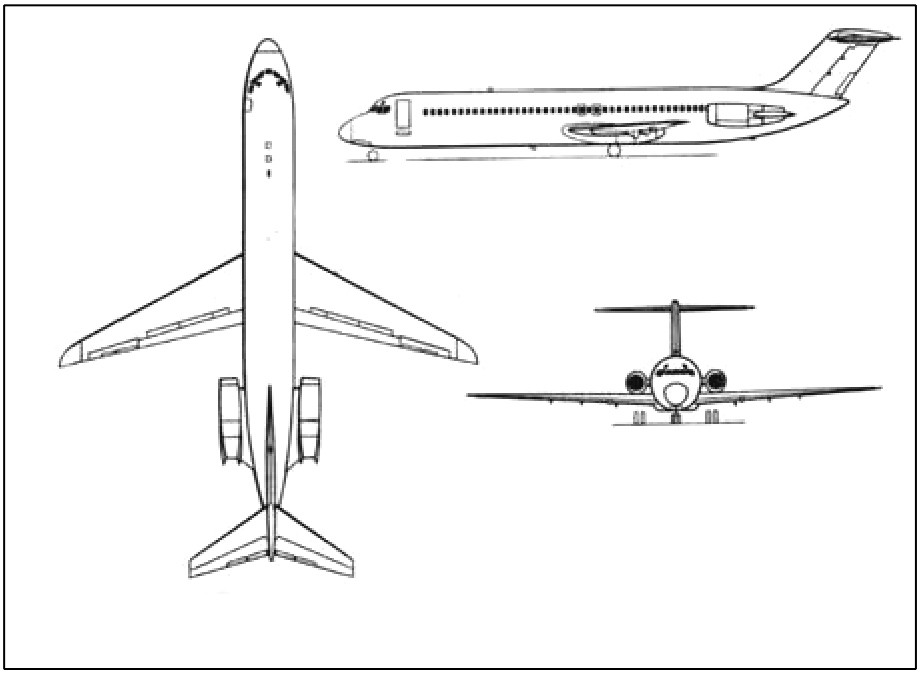


1.1.2.10 Boeing/MD, DC-9, MD-80, MD-90

Manufacturer	Boeing/MD
Type	DC-9-50
Wing area	93 m^2
Horizontal stabilizer area	26 m^2
Total surface area	119 m^2
Height overall	9 m
Wingspan	29 m
Fuselage, 1/3 surface area	158 m^2

Manufacturer	Boeing/MD
Type	MD80/82/83
Wing area	118 m^2
Horizontal stabilizer area	30 m^2
Total surface area	148 m^2
Height overall	10 m
Wingspan	33 m
Fuselage, 1/3 surface area	158 m^2

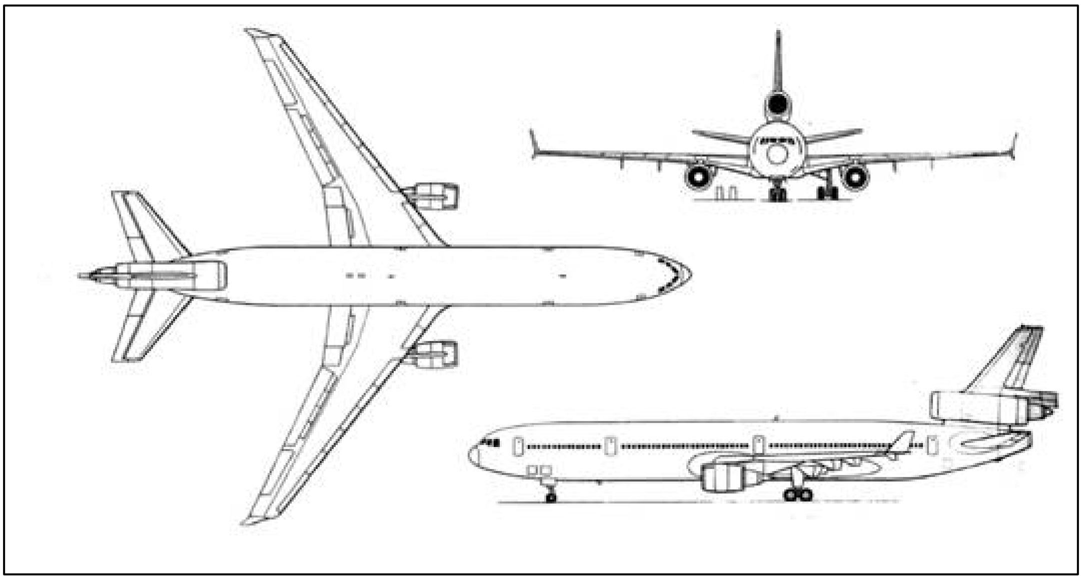
Manufacturer	Boeing/MD
Type	MD90-30
Wing area	113 m^2
Horizontal stabilizer area	30 m^2
Total surface area	143 m^2
Height overall	10 m
Wingspan	33 m
Fuselage, 1/3 surface area	163 m^2



1.1.2.11 Boeing/MD, DC-10, MD-11

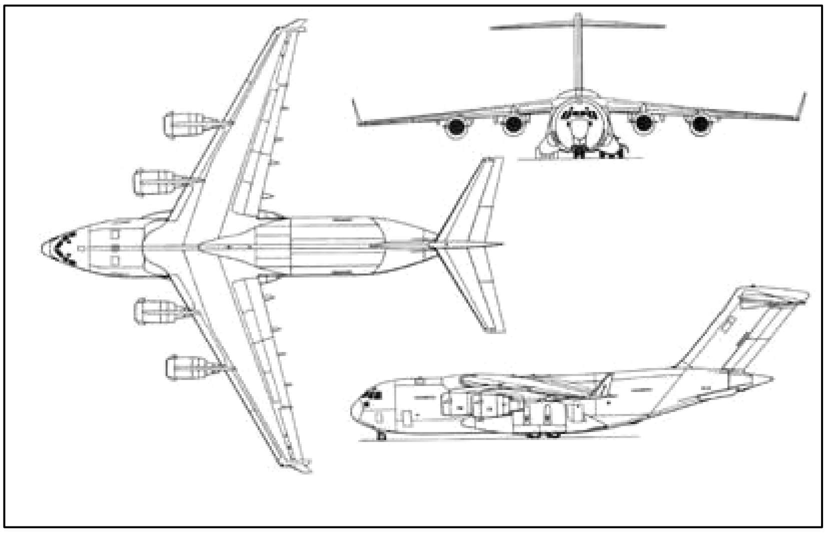
Manufacturer	Boeing/MD
Type	MD-11
Wing area	339 m^2
Horizontal stabilizer area	86 m^2
Total surface area	426 m^2
Height overall	18 m
Wingspan	52 m
Fuselage, 1/3 surface area	386 m^2

Manufacturer	Boeing/MD
Type	DC-10
Wing area	368 m^2
Horizontal stabilizer area	97 m^2
Total surface area	465 m^2
Height overall	18 m
Wingspan	51 m
Fuselage, 1/3 surface area	348 m^2



1.1.2.12 Boeing C17

Manufacturer	Boeing
Type	C17A Globemaster III
Wing area	354 m^2
Horizontal stabilizer area	79 m^2
Total surface area	433 m^2
Height overall	17 m
Wingspan	52 m
Fuselage, 1/3 surface area	384 m^2



1.1.3 Other Aircraft

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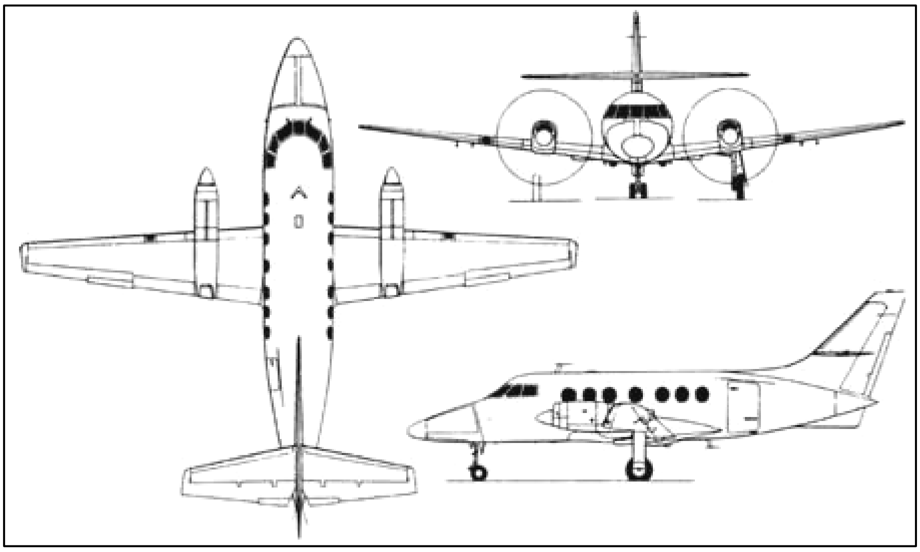
1.1.3.1 Bae, ATP

Manufacturer	Bae
Type	ATP
Wing area	79 m^2
Horizontal stabilizer area	16 m^2
Total surface area	95 m^2
Height overall	8 m
Wingspan	31 m
Fuselage, 1/3 surface area	69 m^2

1.1.3.2 Bae, Jetstream

Manufacturer	Bae
Type	Jetstream 31
Wing area	26 m^2
Horizontal stabilizer area	8 m^2
Total surface area	34 m^2
Height overall	6 m
Wingspan	16 m
Fuselage, 1/3 surface area	30 m^2

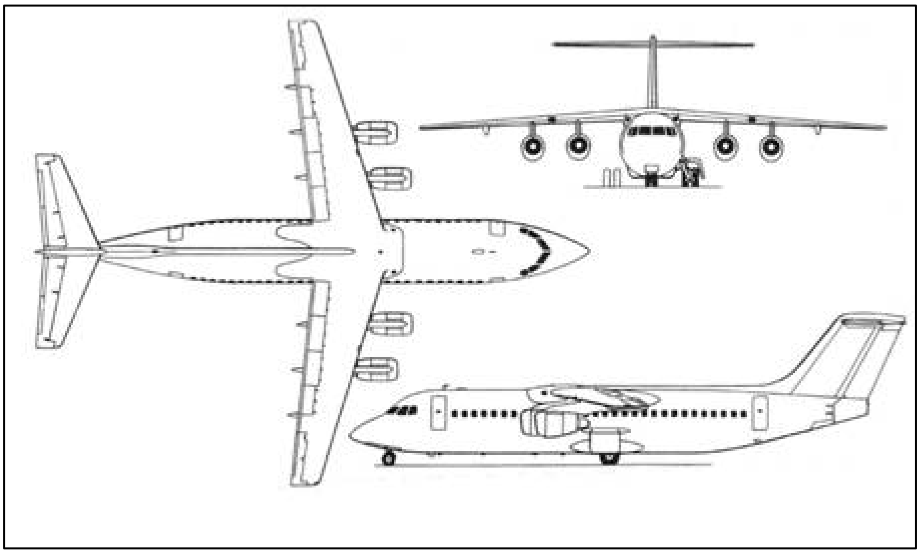
Manufacturer	Bae
Type	Jetstream 41
Wing area	33 m^2
Horizontal stabilizer area	9 m^2
Total surface area	42 m^2
Height overall	6 m
Wingspan	19 m
Fuselage, 1/3 surface area	40 m^2



1.1.3.3 Bae, Avro RJ, 146

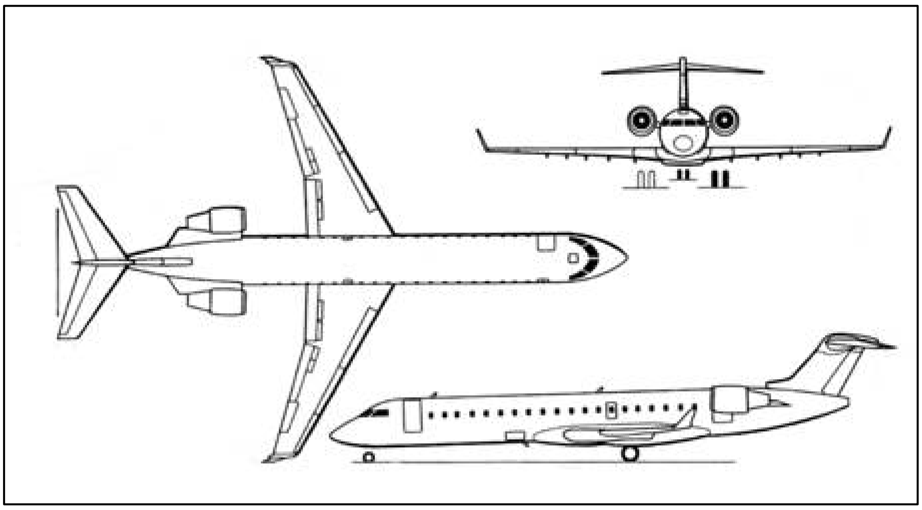
Manufacturer	Bae Systems
Type	AVRO RJ 70/85/100
Wing area	78 m^2
Horizontal stabilizer area	16 m^2
Total surface area	94 m^2
Height overall	9 m
Wingspan	27 m
Fuselage, 1/3 surface area	107 m^2

Manufacturer	Bae Systems
Type	146-300
Wing area	78 m^2
Horizontal stabilizer area	16 m^2
Total surface area	94 m^2
Height overall	9 m
Wingspan	27 m
Fuselage, 1/3 surface area	112 m^2



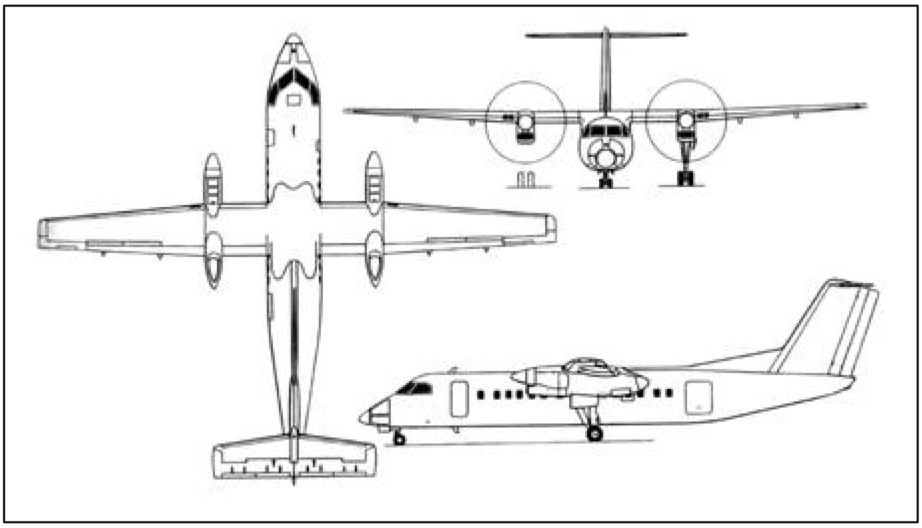
1.1.3.4 Bombardier, CRJ

Manufacturer	Bombardier
Type	CRJ-700
Wing area	69 m^2
Horizontal stabilizer area	21 m^2
Total surface area	90 m^2
Height overall	8 m
Wingspan	23 m
Fuselage, 1/3 surface area	91 m^2



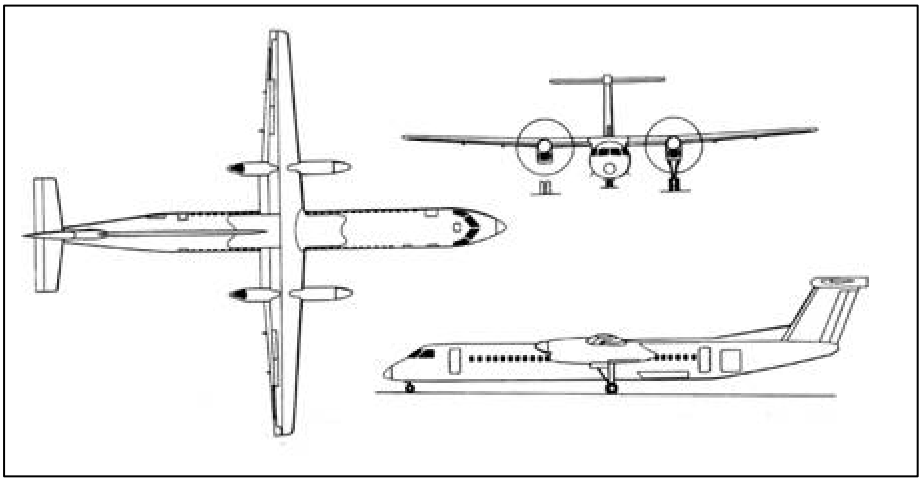
1.1.3.5 Bombardier, DHC-8, 100

Manufacturer	Bombardier
Type	DHC-8 DASH 8 Q100/200
Wing area	55 m^2
Horizontal stabilizer area	9 m^2
Total surface area	64 m^2
Height overall	8 m
Wingspan	26 m
Fuselage, 1/3 surface area	63 m^2



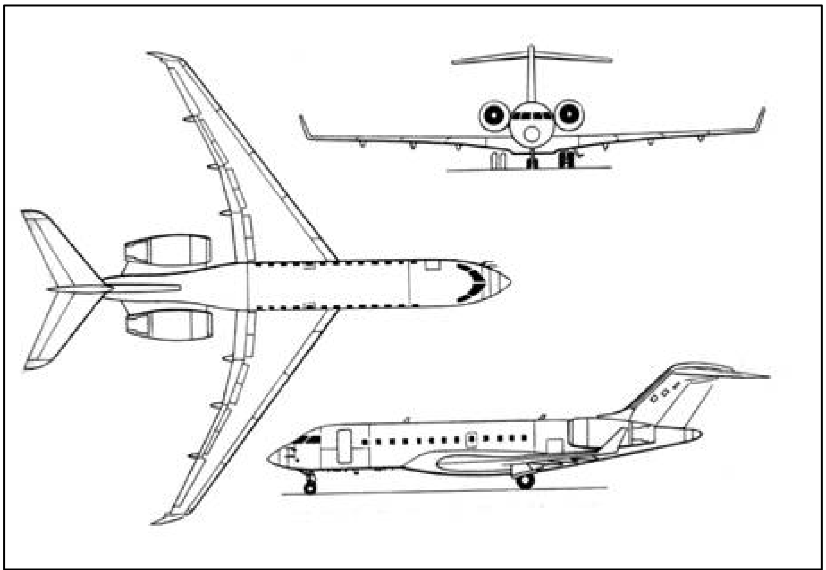
1.1.3.6 Bombardier, DHC-8

Manufacturer	Bombardier
Type	DHC-8 DASH 8 Q400
Wing area	64 m^2
Horizontal stabilizer area	17 m^2
Total surface area	81 m^2
Height overall	9 m
Wingspan	29 m
Fuselage, 1/3 surface area	63 m^2



1.1.3.7 Bombardier, GE

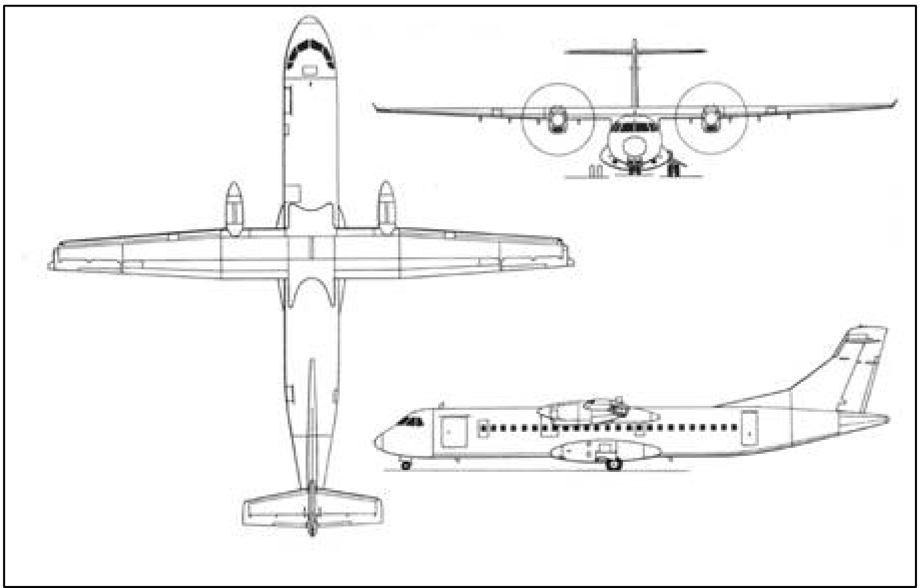
Manufacturer	Bombardier
Type	130-700 Global Express
Wing area	95 m^2
Horizontal stabilizer area	23 m^2
Total surface area	118 m^2
Height overall	8 m
Wingspan	29 m
Fuselage, 1/3 surface area	85 m^2



1.1.3.8 EADS, ATR-42/72

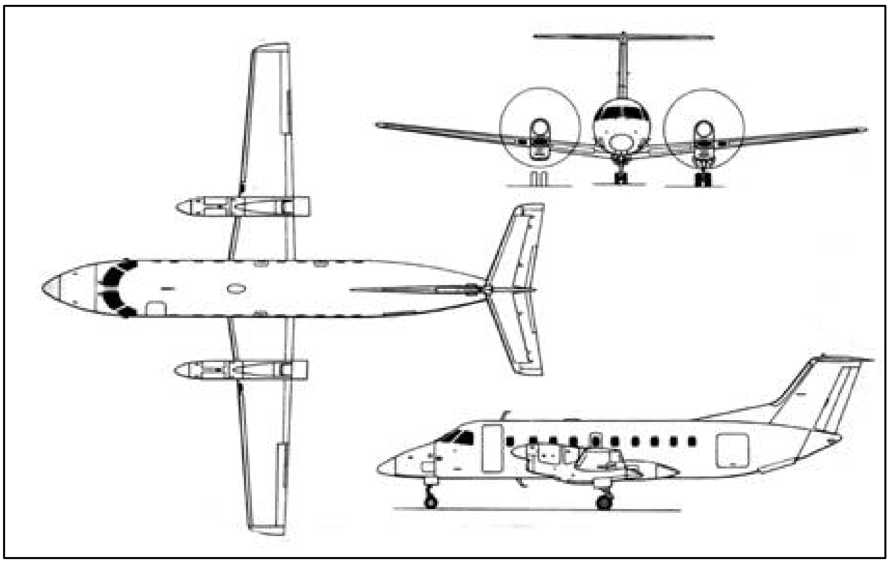
Manufacturer	EADS
Type	ATR-42
Wing area	55 m^2
Horizontal stabilizer area	12 m^2
Total surface area	67 m^2
Height overall	8 m
Wingspan	25 m
Fuselage, 1/3 surface area	55 m^2

Manufacturer	EADS
Type	ATR-72
Wing area	61 m^2
Horizontal stabilizer area	12 m^2
Total surface area	73 m^2
Height overall	8 m
Wingspan	28 m
Fuselage, 1/3 surface area	66 m^2



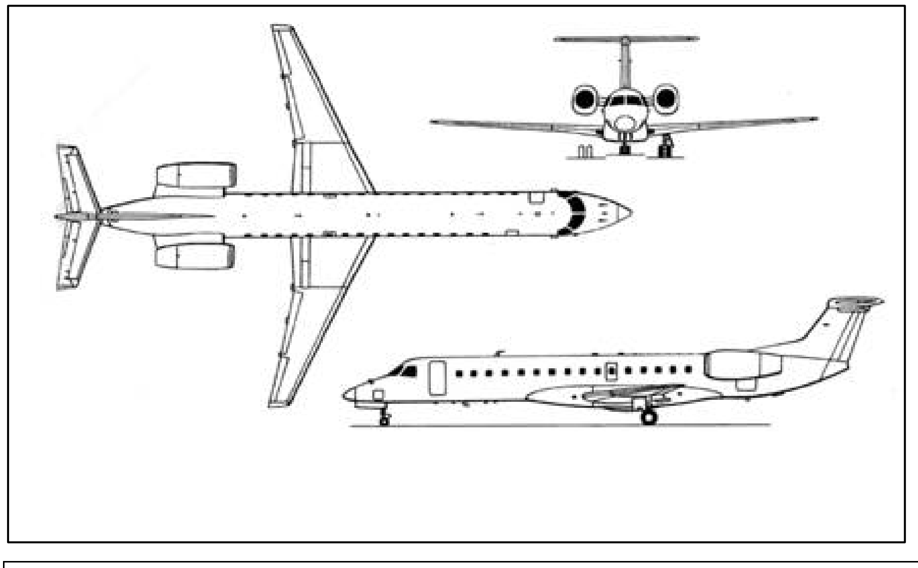
1.1.3.9 Embraer, 120

Manufacturer	Embraer
Type	120 Brasilia
Wing area	40 m^2
Horizontal stabilizer area	7 m^2
Total surface area	47 m^2
Height overall	7 m
Wingspan	20 m
Fuselage, 1/3 surface area	48 m^2



1.1.3.10 Embraer, 145

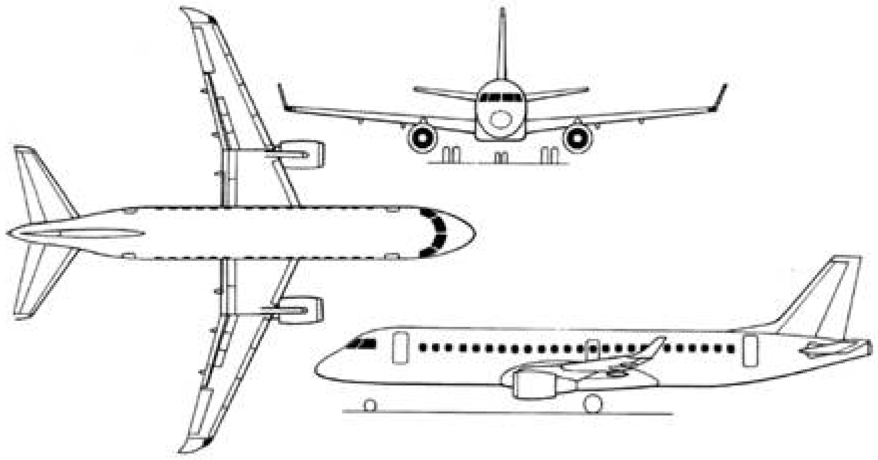
Manufacturer	Embraer
Type	ERJ-145
Wing area	52 m^2
Horizontal stabilizer area	12 m^2
Total surface area	64 m^2
Height overall	7 m
Wingspan	21 m
Fuselage, 1/3 surface area	71 m^2



1.1.3.11 Embraer, 170/175, 190/195

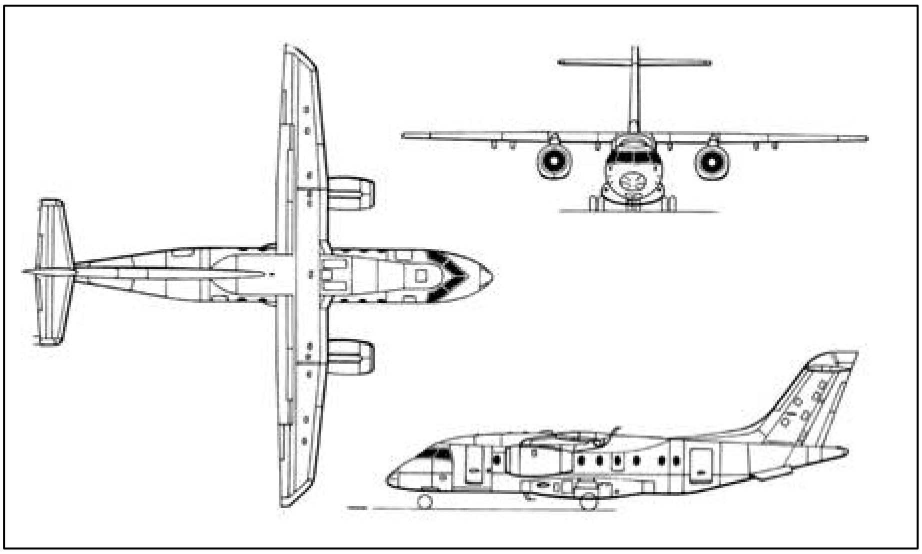
Manufacturer	Embraer
Type	ERJ-170/175
Wing area	73 m^2
Horizontal stabilizer area	24 m^2
Total surface area	97 m^2
Height overall	10 m
Wingspan	26 m
Fuselage, 1/3 surface area	94 m^2

Manufacturer	Embraer
Type	ERJ 190/195
Wing area	93 m^2
Horizontal stabilizer area	26 m^2
Total surface area	119 m^2
Height overall	11 m
Wingspan	29 m
Fuselage, 1/3 surface area	114 m^2



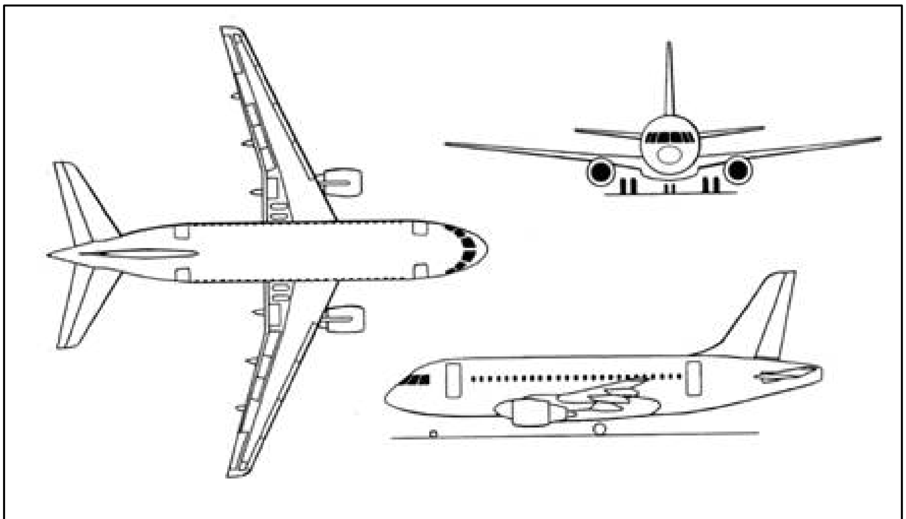
1.1.3.12 Fairchild, Dornier 328

Manufacturer	Fairchild
Type	Dornier 328 JET
Wing area	40 m^2
Horizontal stabilizer area	10 m^2
Total surface area	50 m^2
Height overall	8 m
Wingspan	21 m
Fuselage, 1/3 surface area	72 m^2



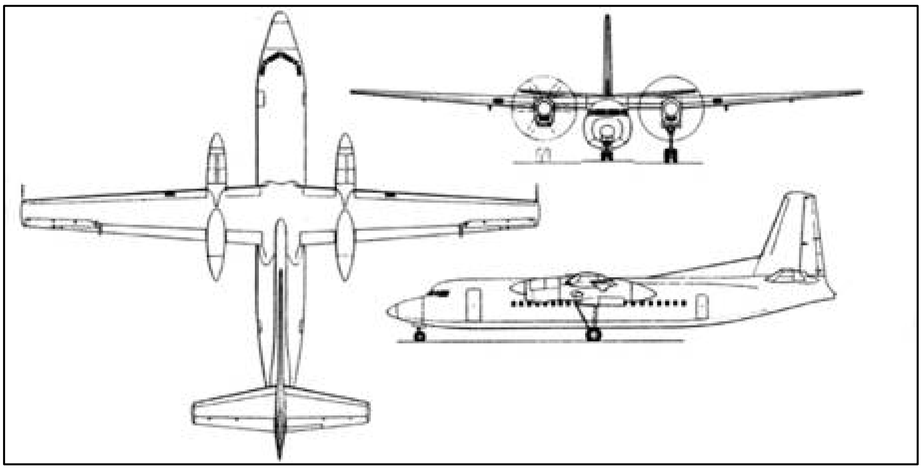
1.1.3.13 Fairchild, Dornier 728

Manufacturer	Fairchild
Type	Dornier 728 JET
Wing area	75 m^2
Horizontal stabilizer area	19 m^2
Total surface area	94 m^2
Height overall	4 m
Wingspan	28 m
Fuselage, 1/3 surface area	93 m^2



1.1.3.14 Fokker, 50

Manufacturer	Fokker
Type	50
Wing area	70 m^2
Horizontal stabilizer area	20 m^2
Total surface area	90 m^2
Height overall	9 m
Wingspan	29 m
Fuselage, 1/3 surface area	87 m^2



1.1.3.15 Fokker, 70

Manufacturer	Fokker
Type	70
Wing area	94 m^2
Horizontal stabilizer area	24 m^2
Total surface area	117 m^2
Height overall	9 m
Wingspan	29 m
Fuselage, 1/3 surface area	107 m^2

1.1.3.16 Fokker, 27

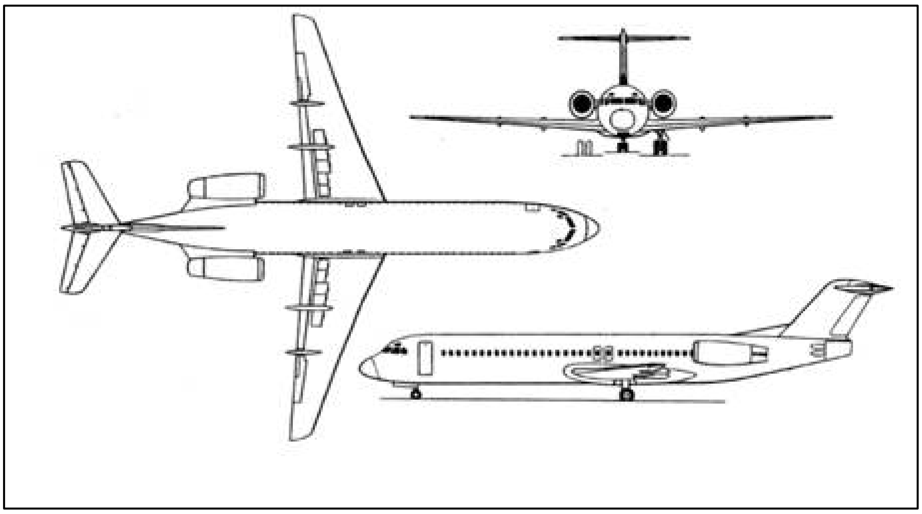
Manufacturer	Fokker
Type	27
Wing area	70 m^2
Horizontal stabilizer area	16 m^2
Total surface area	86 m^2
Height overall	9 m
Wingspan	29 m
Fuselage, 1/3 surface area	87 m^2

1.1.3.17 Fokker, 28

Manufacturer	Fokker
Type	F28 Fellowship
Wing area	79 m^2
Horizontal stabilizer area	20 m^2
Total surface area	99 m^2
Height overall	9 m
Wingspan	29 m
Fuselage, 1/3 surface area	95 m^2

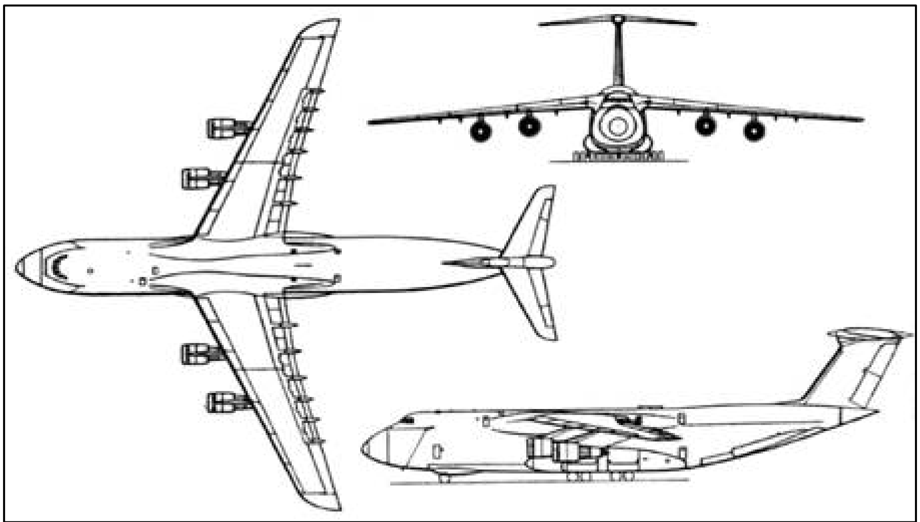
1.1.3.18 Fokker, 100

Manufacturer	Fokker
Type	100
Wing area	94 m^2
Horizontal stabilizer area	24 m^2
Total surface area	118 m^2
Height overall	9 m
Wingspan	29 m
Fuselage, 1/3 surface area	123 m^2



1.1.3.19 Lockheed, Galaxy

Manufacturer	Lockheed
Type	Galaxy C-5
Wing area	576 m^2
Horizontal stabilizer area	90 m^2
Total surface area	666 m^2
Height overall	20 m
Wingspan	68 m
Fuselage, 1/3 surface area	513 m^2



1.1.3.20 Lockheed, Hercules

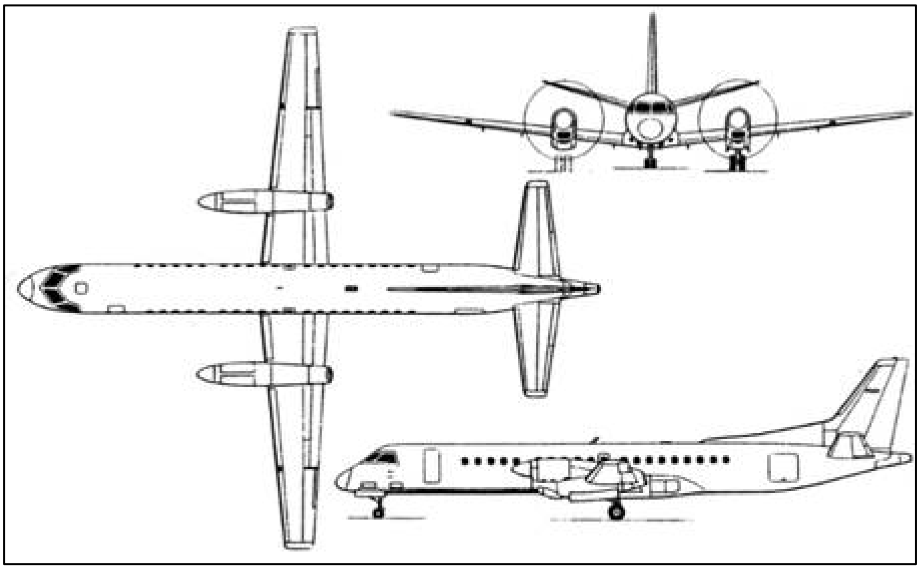
Manufacturer	Lockheed
Type	Hercules C-130J
Wing area	163 m^2
Horizontal stabilizer area	36 m^2
Total surface area	199 m^2
Height overall	12 m
Wingspan	41 m
Fuselage, 1/3 surface area	135 m^2

1.1.3.21 Saab, 340

Manufacturer	Saab
Type	340B
Wing area	42 m^2
Horizontal stabilizer area	12 m^2
Total surface area	54 m^2
Height overall	7 m
Wingspan	22 m
Fuselage, 1/3 surface area	48 m^2

1.1.3.22 Saab, 2000

Manufacturer	Saab
Type	2000
Wing area	56 m^2
Horizontal stabilizer area	19 m^2
Total surface area	75 m^2
Height overall	8 m
Wingspan	25 m
Fuselage, 1/3 surface area	66 m^2



1.1.4 General Russian and eastern production aircraft types

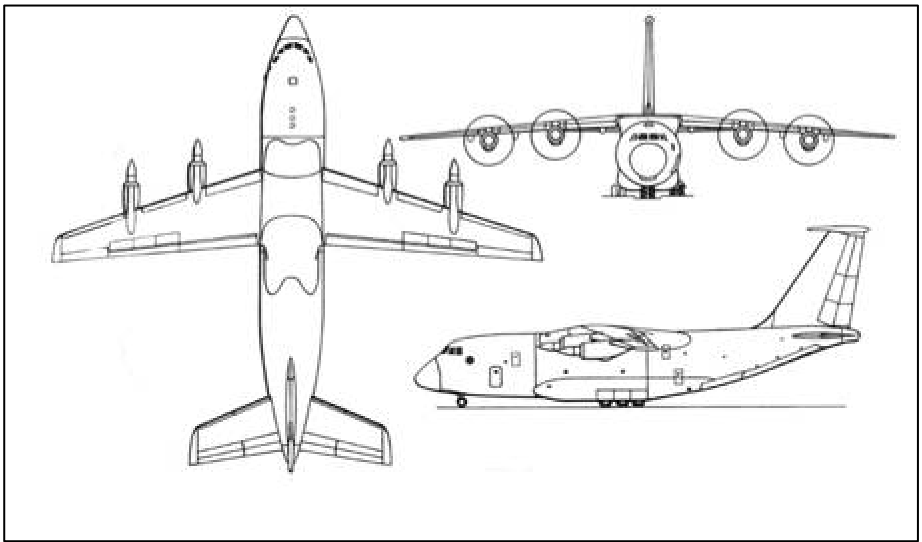
All dimensions are for reference only. Latest revision of aircraft data shall be used in operation. The figures given may differ when compared with other manuals and therefore verification must be made if using these figures directly in operation. These numbers are rounded up for easier use in operation. The dimensions for the upper fuselage area and the vertical stabilizer surface area are not mentioned here. Relevant aircraft manufacturer and airline operator manuals should be referenced when treating these areas.

1.1.4.1 Antonov, AN-12

Manufacturer	Antonov
Type	AN-12
Wing area	130 m^2 (estimate)
Horizontal stabilizer area	30 m^2 (estimate)
Total surface area	160 m^2 (estimate)
Height overall	11 m
Wingspan	38 m
Fuselage, 1/3 surface area	121 m^2 (estimate)

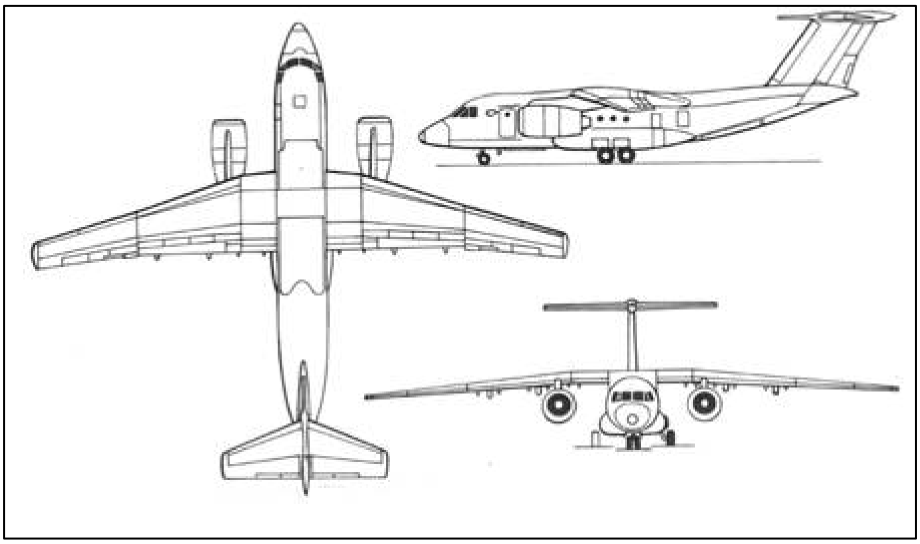
1.1.4.2 Antonov, AN-70

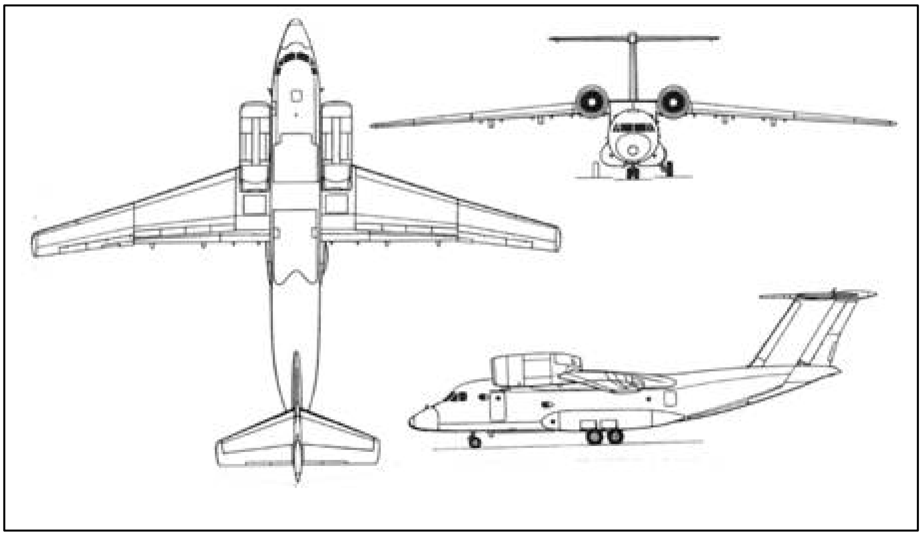
Manufacturer	Antonov
Type	AN-70
Wing area	250 m^2 (estimate)
Horizontal stabilizer area	40 m^2 (estimate)
Total surface area	290 m^2 (estimate)
Height overall	17 m
Wingspan	45 m
Fuselage, 1/3 surface area	158 m^2 (estimate)



1.1.4.3 Antonov, AN-74, AN-74T

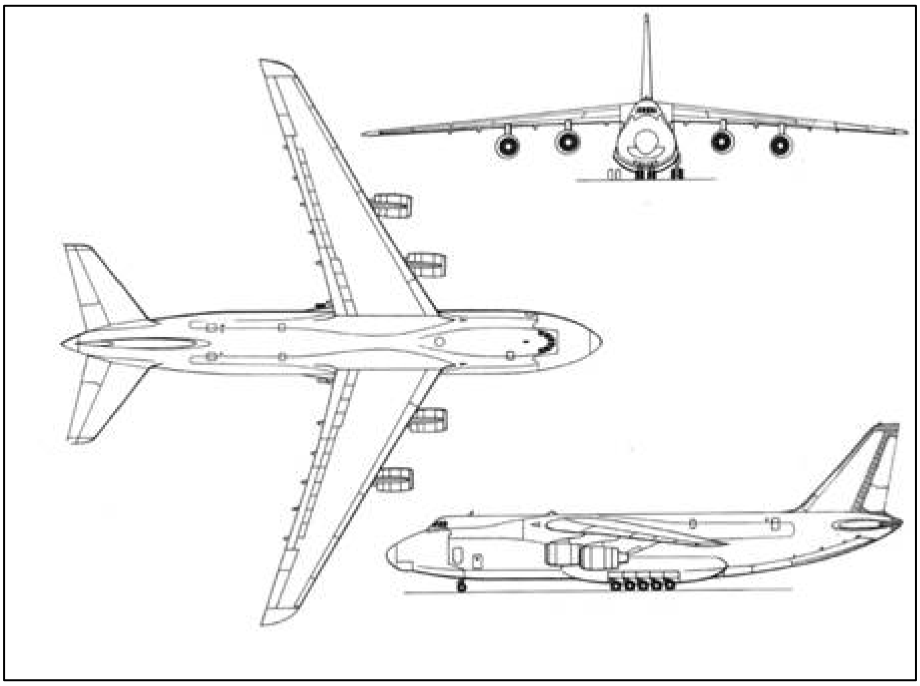
Manufacturer	Antonov
Type	AN-74
Wing area	99 m^2
Horizontal stabilizer area	24 m^2
Total surface area	123 m^2
Height overall	9 m
Wingspan	32 m
Fuselage, 1/3 surface area	91 m^2





1.1.4.4 Antonov, AN-124

Manufacturer	Antonov
Type	AN-124
Wing area	628 m^2
Horizontal stabilizer area	100 m^2 (estimate)
Total surface area	728 m^2
Height overall	22 m
Wingspan	74 m
Fuselage, 1/3 surface area	527 m^2



1.1.4.5 Ilyushin, Il-62

Manufacturer	Iljushin
Type	Il-62
Wing area	280 m^2
Horizontal stabilizer area	36 m^2
Total surface area	316 m^2
Height overall	13 m
Wingspan	44 m
Fuselage, 1/3 surface area	211 m^2

1.1.4.6 Ilyushin, Il-76

Manufacturer	Iljushin
Type	Il-76
Wing area	300 m^2
Horizontal stabilizer area	46 m^2
Total surface area	346 m^2
Height overall	15 m
Wingspan	51 m
Fuselage, 1/3 surface area	234 m^2

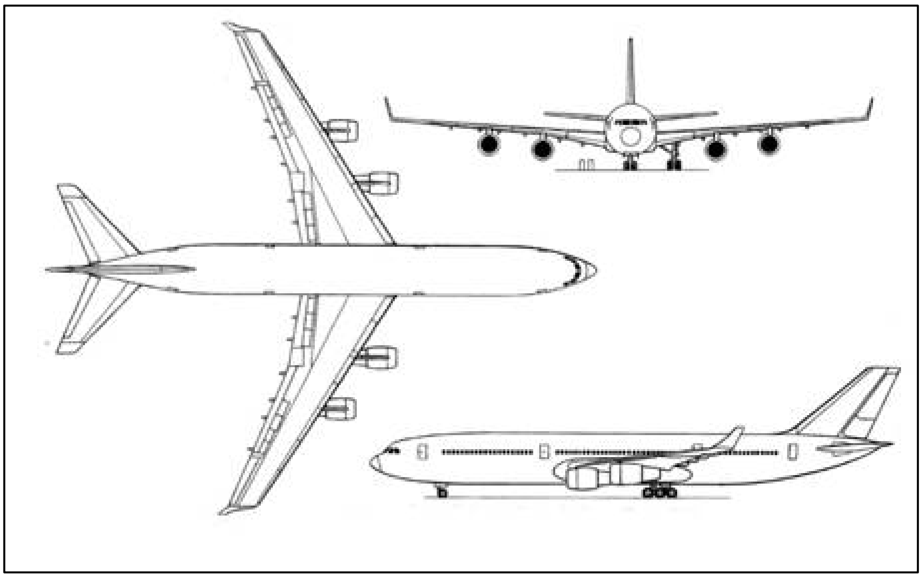
1.1.4.7 Ilyushin, Il-86

Manufacturer	Iljushin
Type	Il-86
Wing area	320 m^2
Horizontal stabilizer area	46 m^2
Total surface area	366 m^2
Height overall	16 m
Wingspan	49 m
Fuselage, 1/3 surface area	355 m^2

1.1.4.8 Ilyushin, Il-96

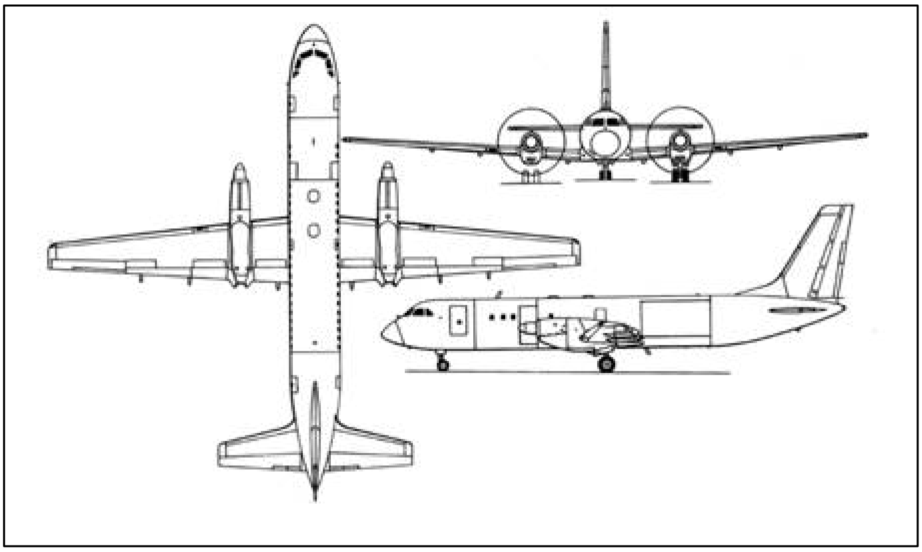
Manufacturer	Iljushin
Type	Il-96 (-300)
Wing area	392 m^2
Horizontal stabilizer area	97 m^2
Total surface area	489 m^2
Height overall	18 m
Wingspan	61 m
Fuselage, 1/3 surface area	353 m^2

Manufacturer	Iljushin
Type	Il-96M
Wing area	392 m^2
Horizontal stabilizer area	97 m^2
Total surface area	489 m^2
Height overall	16 m
Wingspan	61 m
Fuselage, 1/3 surface area	353 m^2



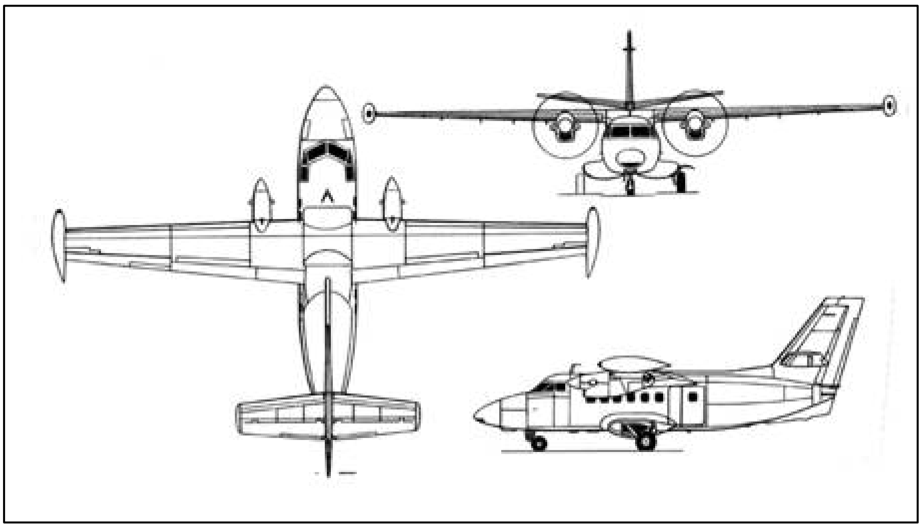
1.1.4.9 Ilyushin, Il-114

Manufacturer	Iljushin
Type	Il-114
Wing area	82 m^2
Horizontal stabilizer area	24 m^2
Total surface area	106 m^2
Height overall	10 m
Wingspan	30 m
Fuselage, 1/3 surface area	80 m^2



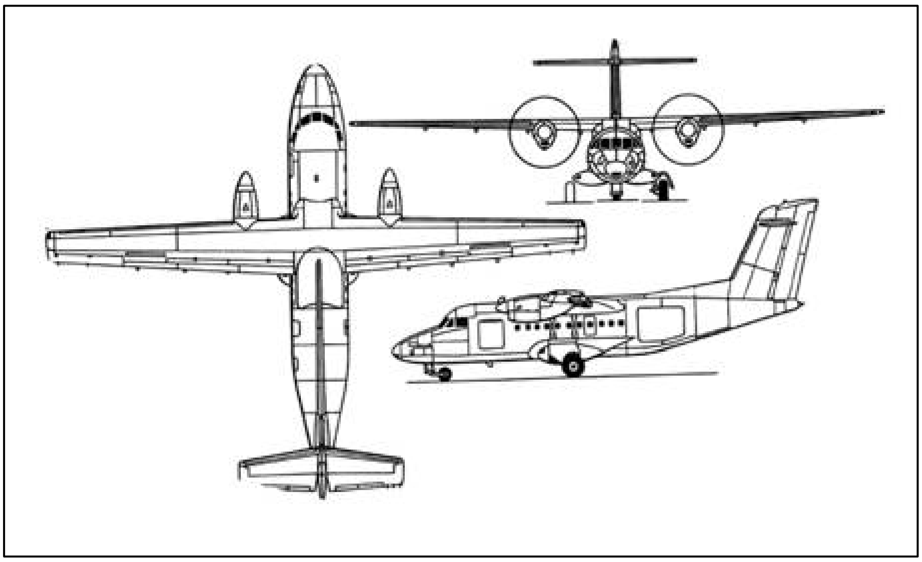
1.1.4.10 Let, L410

Manufacturer	Let
Type	L410
Wing area	35 m^2
Horizontal stabilizer area	7 m^2
Total surface area	42 m^2
Height overall	6 m
Wingspan	20 m
Fuselage, 1/3 surface area	30 m^2 (estimate)



1.1.4.11 Let, L610

Manufacturer	Let
Type	L610G
Wing area	56 m^2
Horizontal stabilizer area	9 m^2
Total surface area	65 m^2
Height overall	9 m
Wingspan	26 m
Fuselage, 1/3 surface area	61 m^2

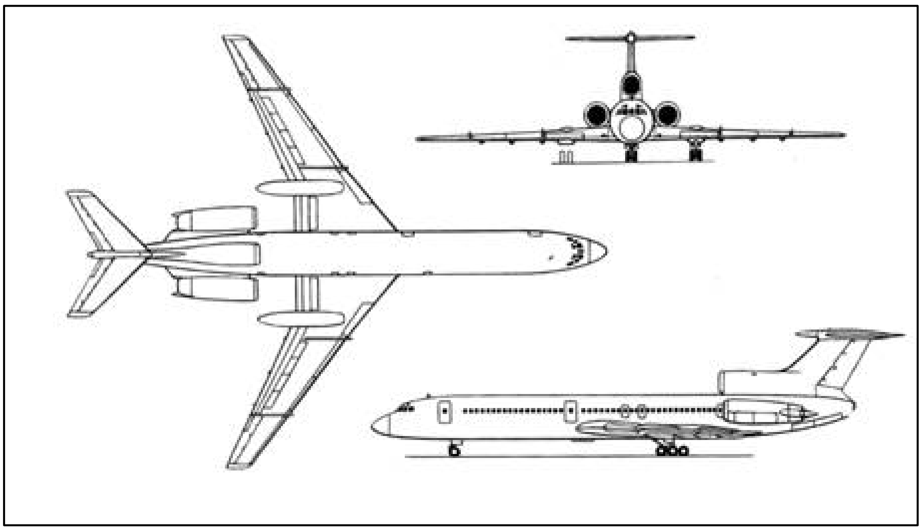


1.1.4.12 Tupolev, TU-134

Manufacturer	Tupolev
Type	TU-134
Wing area	128 m^2
Horizontal stabilizer area	31 m^2
Total surface area	159 m^2
Height overall	10 m
Wingspan	29 m
Fuselage, 1/3 surface area	113 m^2

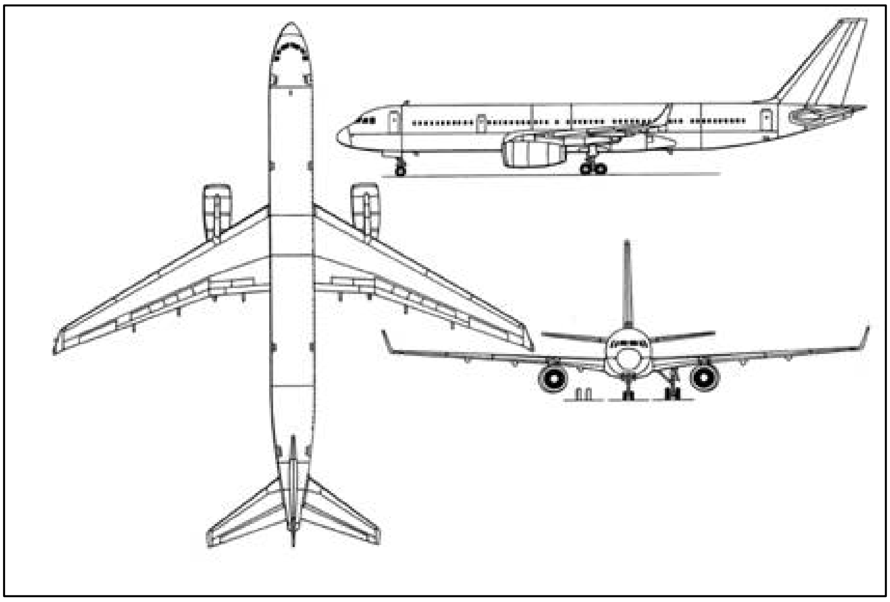
1.1.4.13 Tupolev, TU-154

Manufacturer	Tupolev
Type	TU-154M
Wing area	202 m^2
Horizontal stabilizer area	43 m^2
Total surface area	245 m^2
Height overall	12 m
Wingspan	38 m
Fuselage, 1/3 surface area	191 m^2



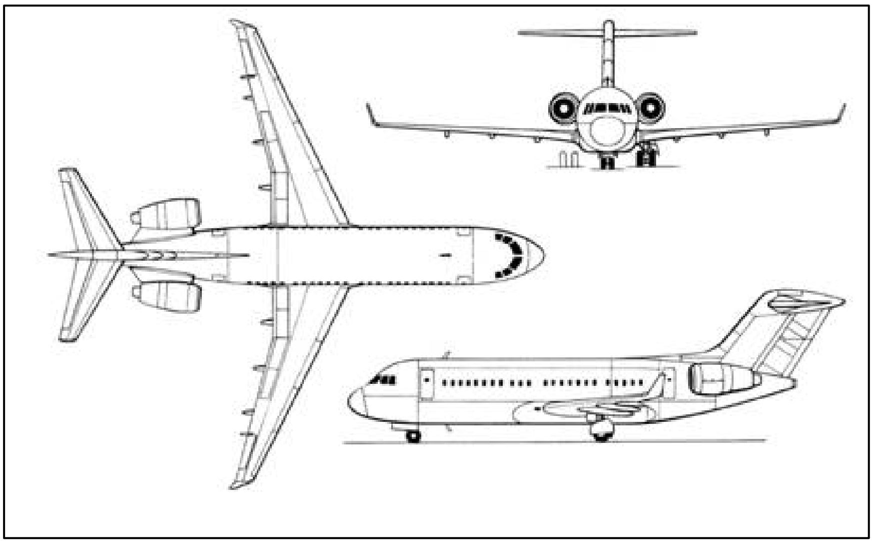
1.1.4.14 Tupolev, TU-204

Manufacturer	Tupolev
Type	TU-204
Wing area	183 m^2
Horizontal stabilizer area	43 m^2
Total surface area	226 m^2
Height overall	14 m
Wingspan	42 m
Fuselage, 1/3 surface area	255 m^2



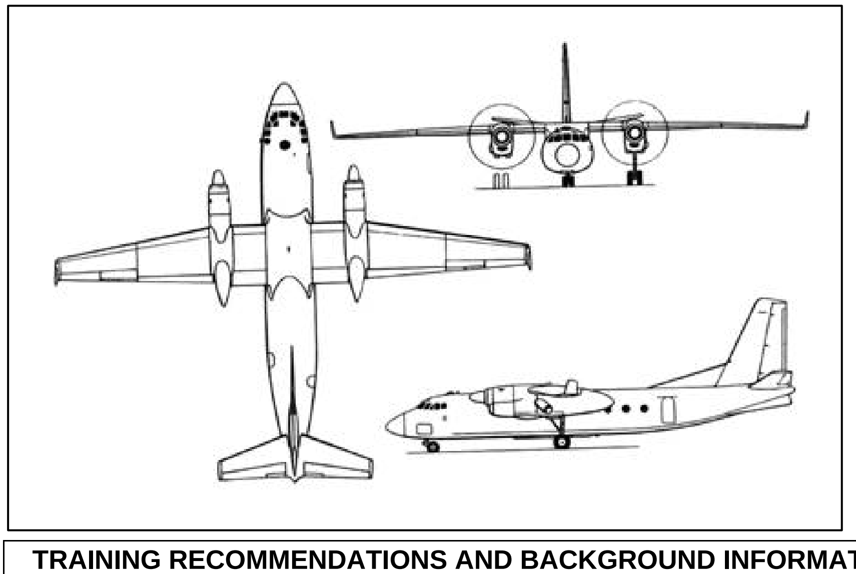
1.1.4.15 Tupolev, TU-334

Manufacturer	Tupolev
Type	TU- 334/336/354
Wing area	84 m^2
Horizontal stabilizer area	24 m^2
Total surface area	108 m^2
Height overall	10 m
Wingspan	30 m
Fuselage, 1/3 surface area	124 m^2



1.1.4.16 XAC

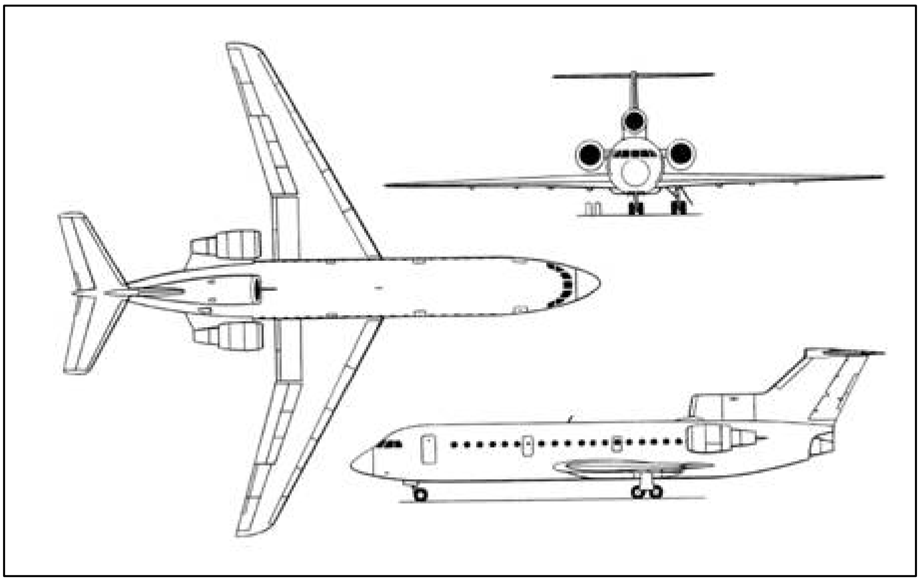
Manufacturer	XAC
Type	MA-60
Wing area	75 m^2
Horizontal stabilizer area	24 m^2 (estimate)
Total surface area	99 m^2
Height overall	9 m
Wingspan	25 m (estimate)
Fuselage, 1/3 surface area	69 m^2 (estimate)



1.1.4.17 Yakolev, YAK-40/42

Manufacturer	Yakolev
Type	YAK-40
Wing area	70 m^2
Horizontal stabilizer area	24 m^2 (estimate)
Total surface area	94 m^2
Height overall	7 m
Wingspan	25 m
Fuselage, 1/3 surface area	91 m^2

Manufacturer	Yakolev
Type	YAK-42D
Wing area	150 m^2
Horizontal stabilizer area	28 m^2
Total surface area	178 m^2
Height overall	10 m
Wingspan	35 m
Fuselage, 1/3 surface area	91 m^2

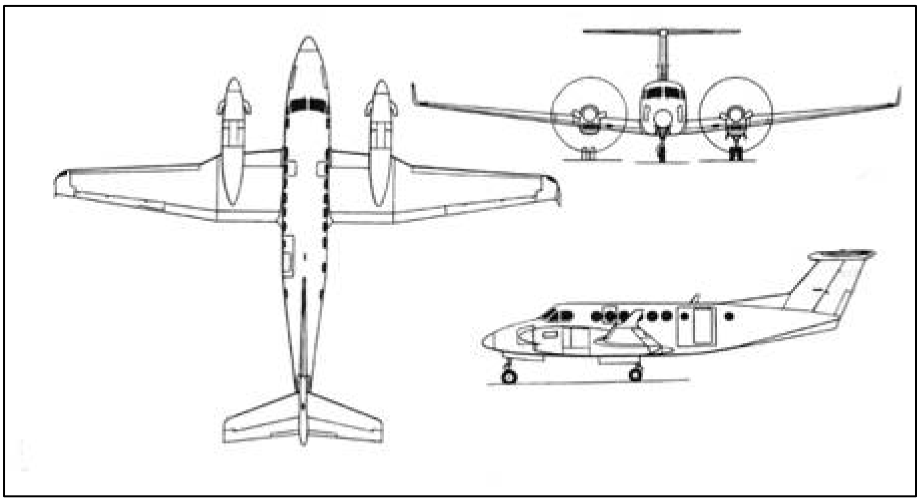


1.1.5 General Business Jets, small aircraft

All dimensions are for reference only. Latest revision of aircraft data shall be used in operation. The figures given may differ when compared with other manuals and therefore verification must be made if using these figures directly in operation. These numbers are rounded up for easier use in operation. The dimensions for the upper fuselage area and the vertical stabilizer surface area are not mentioned here. Relevant aircraft manufacturer and airline operator manuals should be referenced when treating these areas.

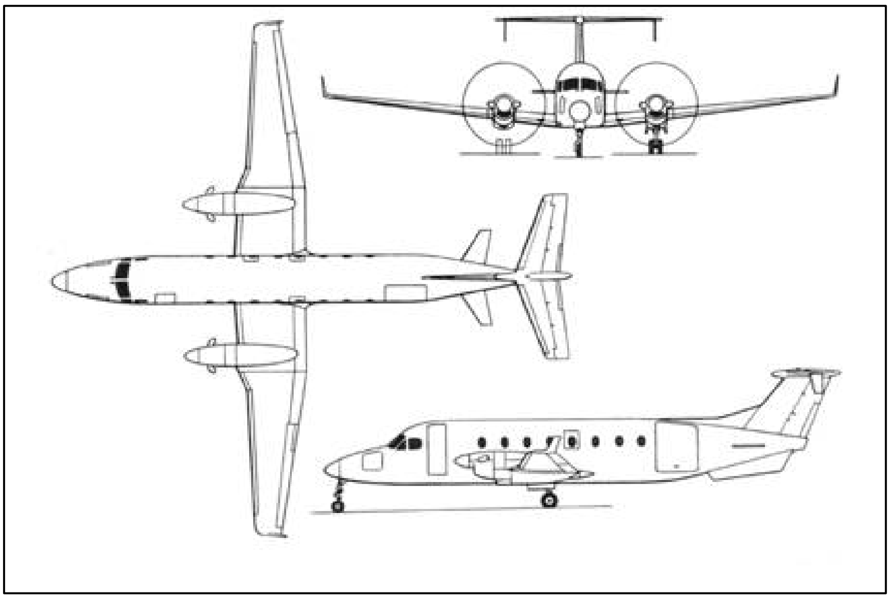
1.1.5.1 Beech, King Air 350

Manufacturer	Beech
Type	King Air 350
Wing area	29 m^2
Horizontal stabilizer area	7 m^2
Total surface area	36 m^2
Height overall	5 m
Wingspan	17 m
Fuselage, 1/3 surface area	20m^2 (estimate)



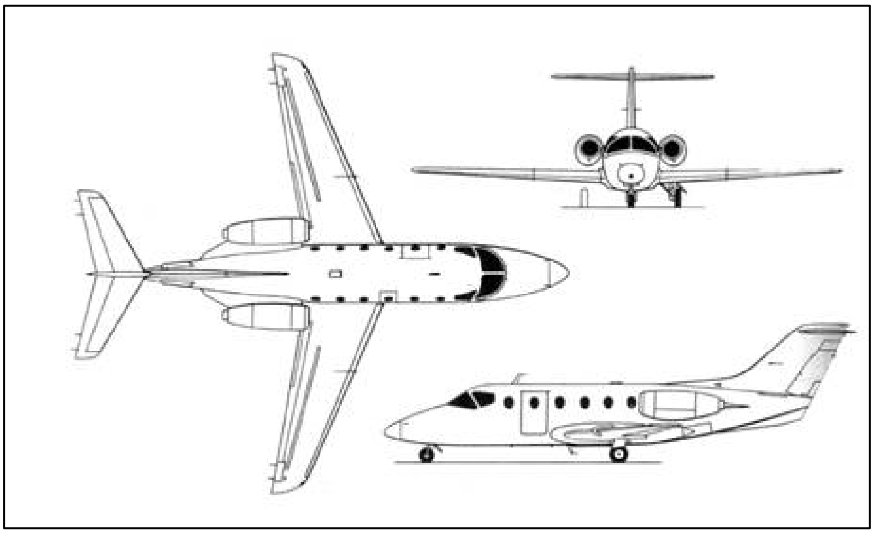
1.1.5.2 Beech, 1900

Manufacturer	Beech
Type	1900 D
Wing area	29 m^2
Horizontal stabilizer area	7 m^2
Total surface area	36 m^2
Height overall	5 m
Wingspan	17 m
Fuselage, 1/3 surface area	35 m^2



1.1.5.3 Beech, 400

Manufacturer	Beech
Type	Beechjet 400 A
Wing area	23 m^2
Horizontal stabilizer area	6 m^2
Total surface area	29 m^2
Height overall	5 m
Wingspan	14 m
Fuselage, 1/3 surface area	30 m^2

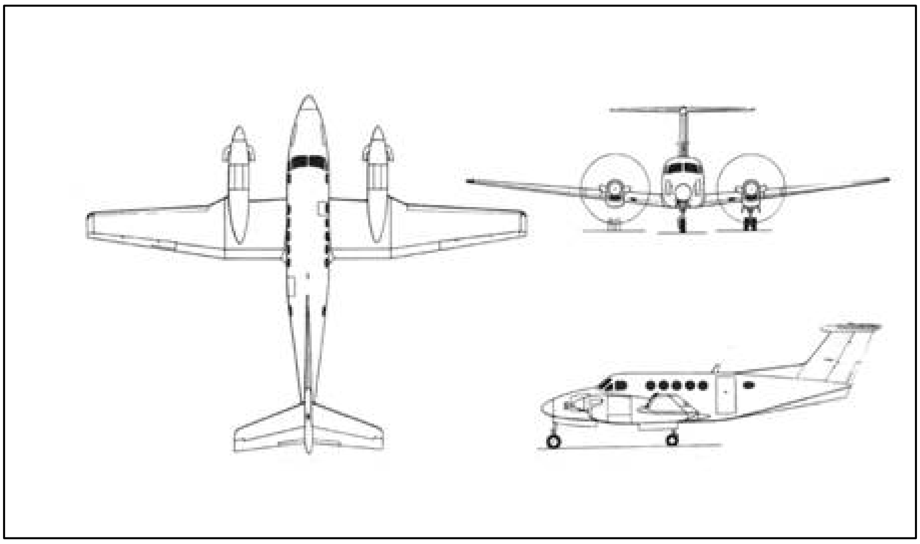


1.1.5.4 Beech, King Air 90

Manufacturer	Beech
Type	King Air C90B/C90SE
Wing area	28 m^2
Horizontal stabilizer area	5 m^2
Total surface area	33 m^2
Height overall	5 m
Wingspan	14 m
Fuselage, 1/3 surface area	15 m^2

1.1.5.5 Beech, King Air 200

Manufacturer	Beech
Type	King Air B200
Wing area	29 m^2
Horizontal stabilizer area	5 m^2
Total surface area	34 m^2
Height overall	5 m
Wingspan	17 m
Fuselage, 1/3 surface area	19 m^2

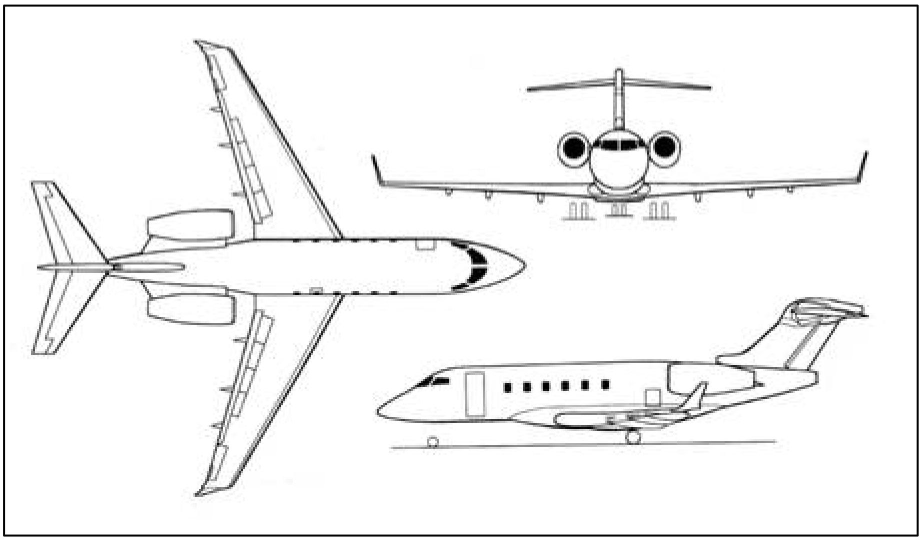


1.1.5.6 Bombardier, CL 100/200

Manufacturer	Bombardier
Type	CL 100/200
Wing area	55 m^2
Horizontal stabilizer area	10 m^2
Total surface area	65 m^2
Height overall	7 m
Wingspan	22 m
Fuselage, 1/3 surface area	75 m^2

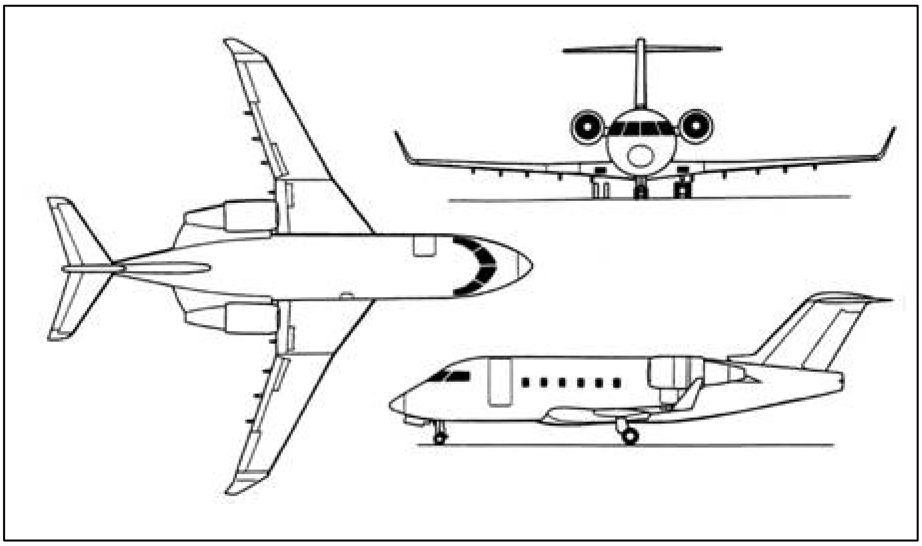
1.1.5.7 Bombardier, Continental

Manufacturer	Bombardier
Type	130-100 Continental
Wing area	49 m^2
Horizontal stabilizer area	4 m^2
Total surface area	53 m^2
Height overall	7 m
Wingspan	20 m
Fuselage, 1/3 surface area	51 m^2



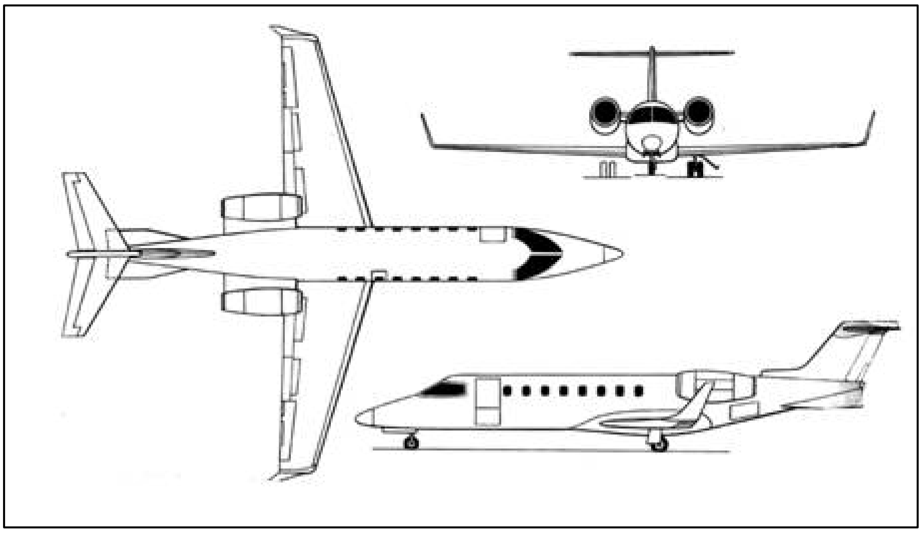
1.1.5.8 Bombardier, Challenger

Manufacturer	Bombardier
Type	Canadair CL600 Challenger
Wing area	49 m^2
Horizontal stabilizer area	7 m^2
Total surface area	56 m^2
Height overall	7 m
Wingspan	20 m
Fuselage, 1/3 surface area	59 m^2



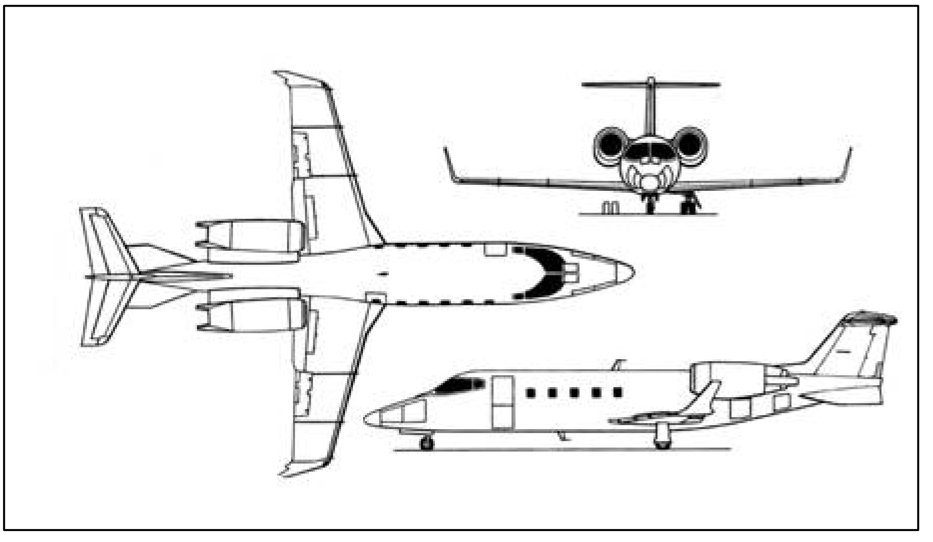
1.1.5.9 Bombardier, Learjet 45

Manufacturer	Bombardier
Type	LearJet 45
Wing area	29 m^2
Horizontal stabilizer area	5 m^2
Total surface area	34 m^2
Height overall	5 m
Wingspan	15 m
Fuselage, 1/3 surface area	33 m^2



1.1.5.10 Bombardier, Learjet 60

Manufacturer	Bombardier
Type	LearJet 60
Wing area	25 m^2
Horizontal stabilizer area	6 m^2
Total surface area	31 m^2
Height overall	5 m^2
Wingspan	14 m
Fuselage, 1/3 surface area	36 m²



1.1.5.11 Bombardier, Learjet 31A

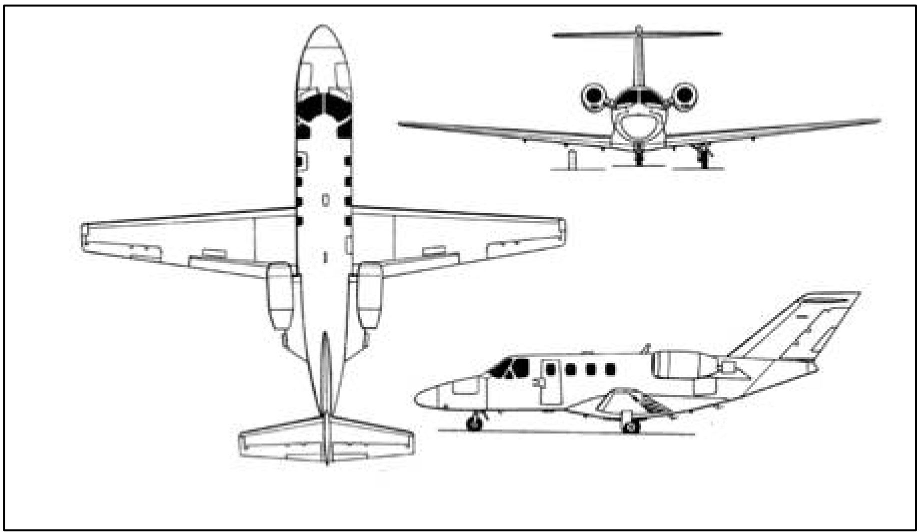
Manufacturer	Bombardier
Type	Learjet 31A
Wing area	25 m^2
Horizontal stabilizer area	6 m^2
Total surface area	31 m^2
Height overall	4 m
Wingspan	14 m
Fuselage, 1/3 surface area	25 m²

1.1.5.12 Cessna, Citation CJ1

Manufacturer	Cessna
Type	525 Citation CJ1
Wing area	23 m^2
Horizontal stabilizer area	6 m^2
Total surface area	29 m^2
Height overall	5 m
Wingspan	15 m
Fuselage, 1/3 surface area	20 m²

1.1.5.13 Cessna, Citation CJ2

Manufacturer	Cessna
Type	525 Citation CJ2
Wing area	25 m^2
Horizontal stabilizer area	7 m^2
Total surface area	32 m^2
Height overall	5 m
Wingspan	15 m
Fuselage, 1/3 surface area	24 m^2



1.1.5.14 Cessna, Citation Bravo

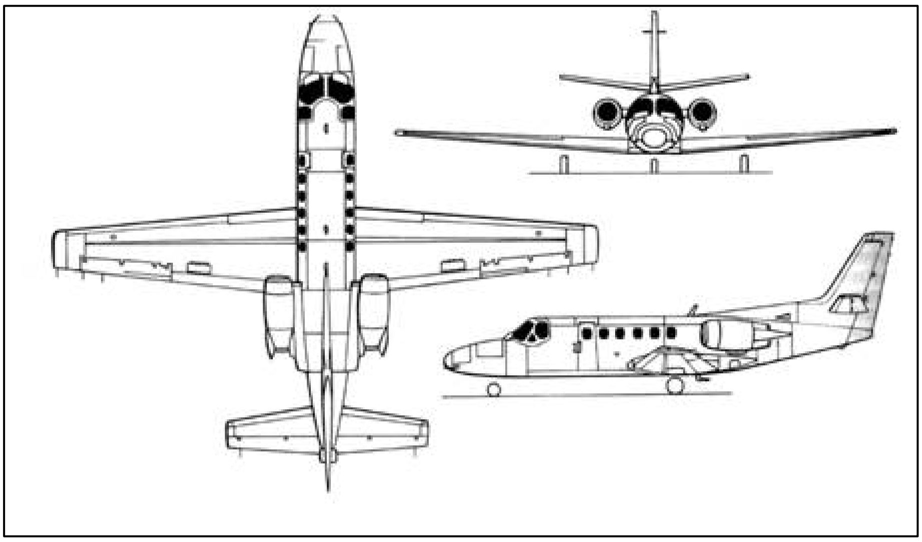
Manufacturer	Cessna
Type	550 Citation Bravo
Wing area	30 m^2
Horizontal stabilizer area	7 m^2
Total surface area	37 m^2
Height overall	5 m
Wingspan	16 m
Fuselage, 1/3 surface area	26 m^2 (estimate)

1.1.5.15 Cessna, Citation Encore

Manufacturer	Cessna
Type	560 Encore
Wing area	24 m^2
Horizontal stabilizer area	8 m^2
Total surface area	32 m^2
Height overall	5 m
Wingspan	16 m
Fuselage, 1/3 surface area	23 m^2

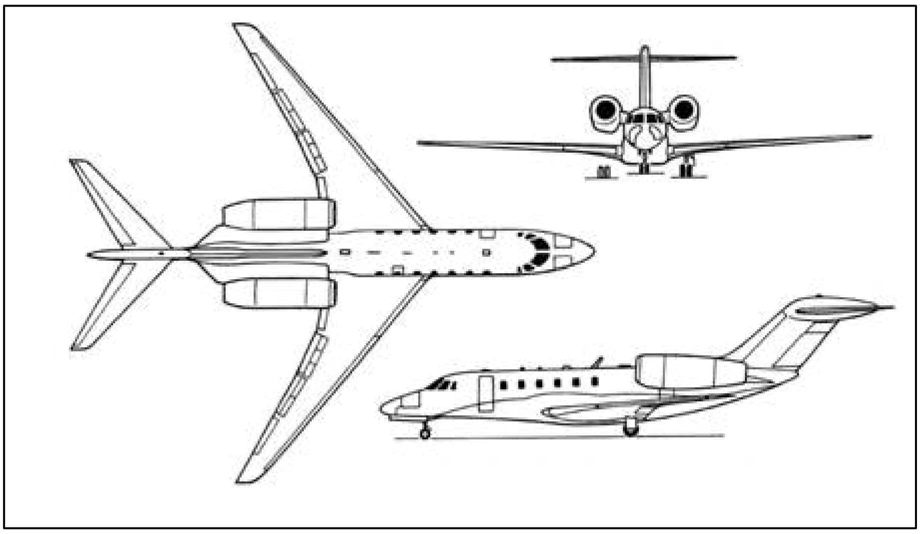
1.1.5.16 Cessna, Excel

Manufacturer	Cessna
Type	560 Excel
Wing area	35 m^2
Horizontal stabilizer area	8 m^2
Total surface area	43 m^2
Height overall	6 m
Wingspan	16 m
Fuselage, 1/3 surface area	34 m^2



1.1.5.17 Cessna, Citation X

Manufacturer	Cessna
Type	750 Citation X
Wing area	49 m^2
Horizontal stabilizer area	12 m^2
Total surface area	61 m^2
Height overall	6 m
Wingspan	20 m
Fuselage, 1/3 surface area	39 m^2

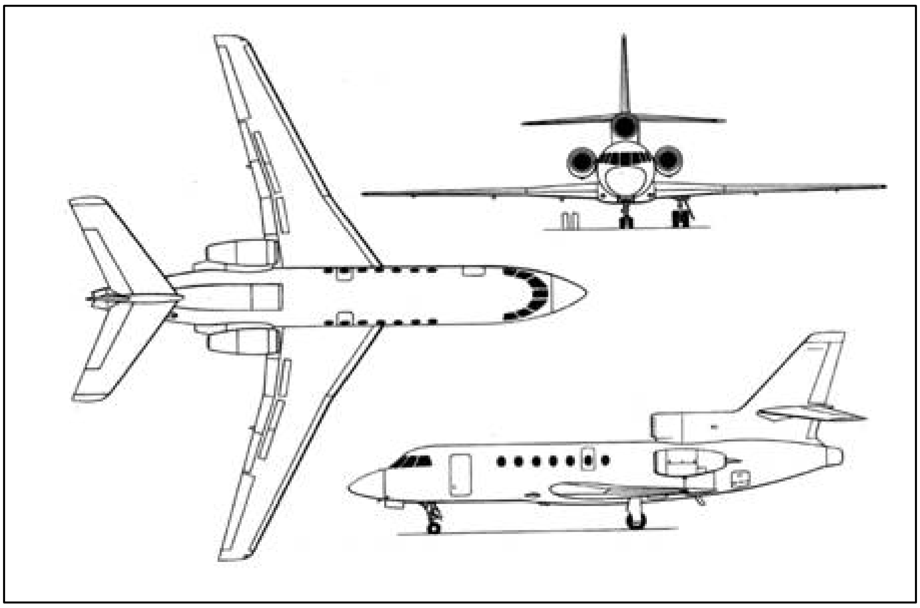


1.1.5.18 Cessna, Sovereign

Manufacturer	Cessna
Type	680 Citation Sovereign
Wing area	48 m^2
Horizontal stabilizer area	13 m^2
Total surface area	61 m^2
Height overall	7 m
Wingspan	20 m
Fuselage, 1/3 surface area	34 m^2

1.1.5.19 Dassault, Falcon 50

Manufacturer	Dassault
Type	Falcon 50 EX
Wing area	47 m^2
Horizontal stabilizer area	14 m^2
Total surface area	61 m^2
Height overall	7 m
Wingspan	19 m
Fuselage, 1/3 surface area	39 m^2

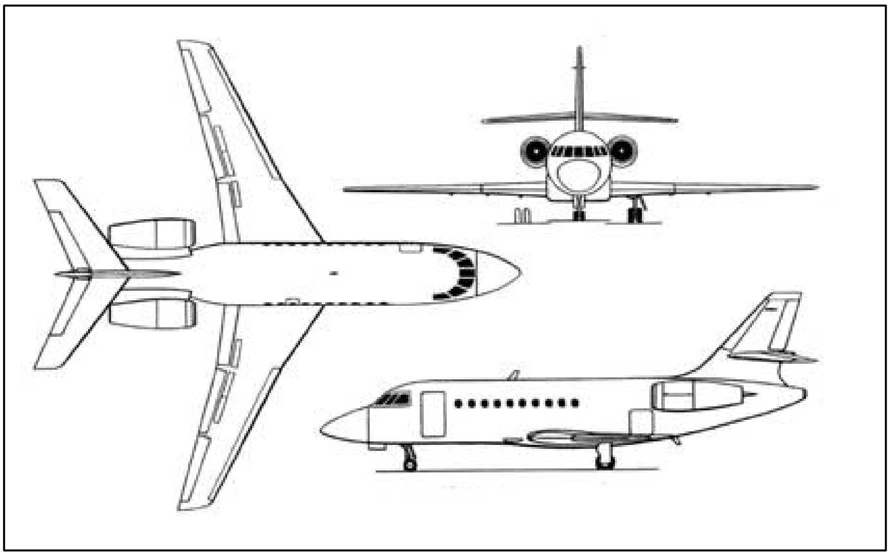


1.1.5.20 Dassault, Falcon 900

Manufacturer	Dassault
Type	Falcon 900B/C and 900EX
Wing area	49 m^2
Horizontal stabilizer area	14 m^2
Total surface area	63 m^2
Height overall	8 m
Wingspan	20 m
Fuselage, 1/3 surface area	53 m^2

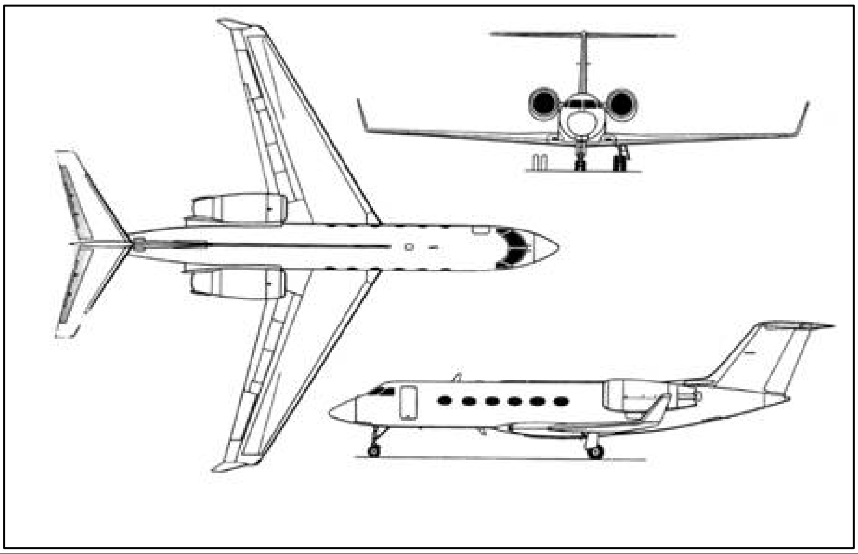
1.1.5.21 Dassault, Falcon 2000

Manufacturer	Dassault
Type	Falcon 2000
Wing area	50 m^2
Horizontal stabilizer area	14 m^2
Total surface area	64 m^2
Height overall	8 m
Wingspan	20 m
Fuselage, 1/3 surface area	53 m^2



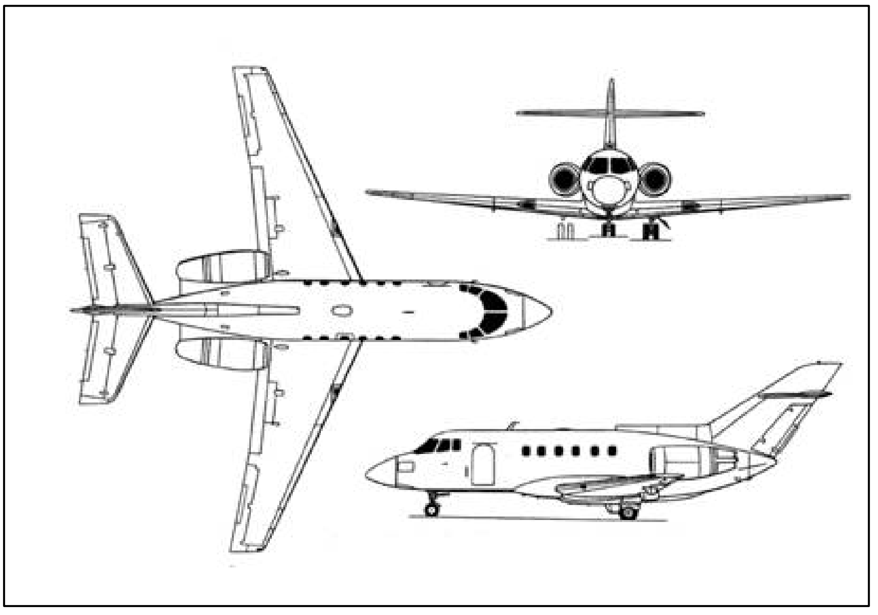
1.1.5.22 Gulfstream, IV

Manufacturer	Gulfstream Aerospace
Type	IV.SP, IV-MPA and IV-B
Wing area	89 m^2
Horizontal stabilizer area	19 m^2
Total surface area	108 m^2
Height overall	8 m
Wingspan	24 m
Fuselage, 1/3 surface area	74 m^2 (estimate)



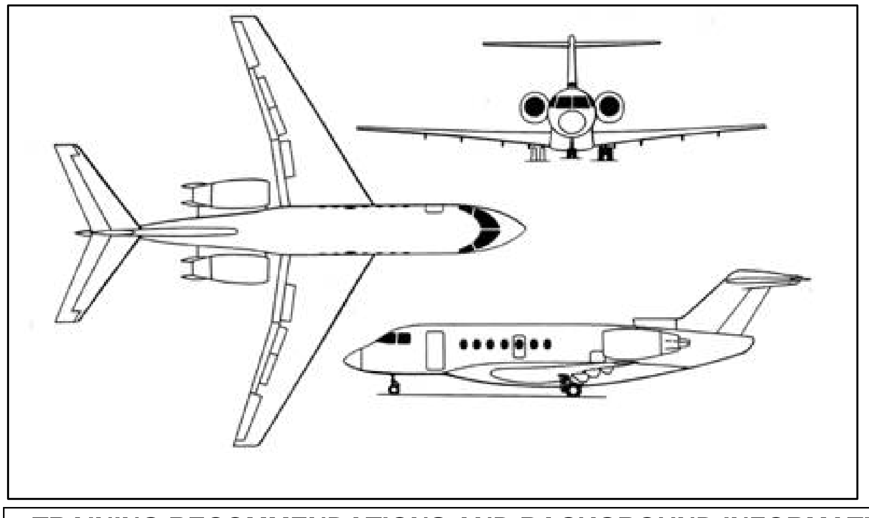
1.1.5.23 Hawker, 800

Manufacturer	Hawker
Type	800 XP
Wing area	35 m^2
Horizontal stabilizer area	10 m^2
Total surface area	45 m^2
Height overall	6 m
Wingspan	15 m
Fuselage, 1/3 surface area	30 m^2



1.1.5.24 Hawker, Horizon

Manufacturer	Hawker
Type	Horizon
Wing area	50 m^2
Horizontal stabilizer area	14 m^2
Total surface area	64 m^2
Height overall	6 m
Wingspan	19 m
Fuselage, 1/3 surface area	43 m^2

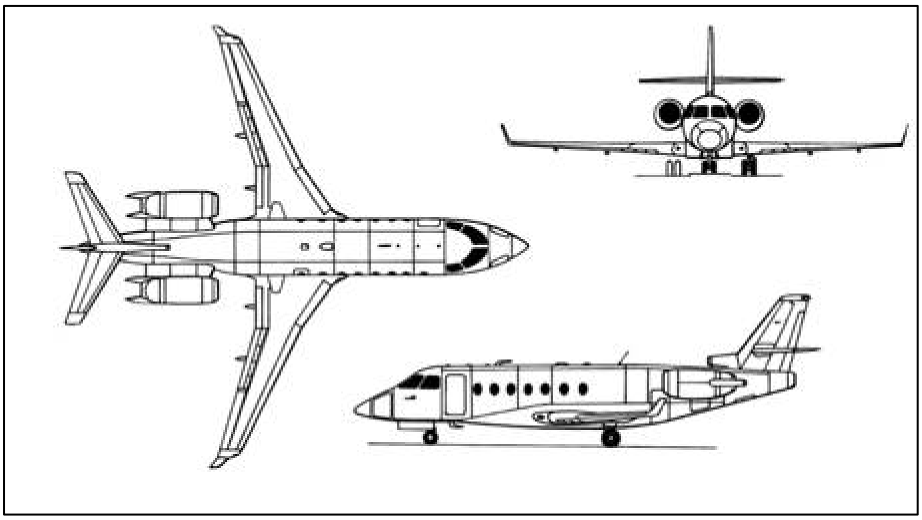


1.1.5.25 IAI, Astra

Manufacturer	IAI
Type	1125 Astra SPX
Wing area	30 m^2
Horizontal stabilizer area	10 m^2
Total surface area	40 m^2
Height overall	6 m
Wingspan	17 m
Fuselage, 1/3 surface area	34 m^2

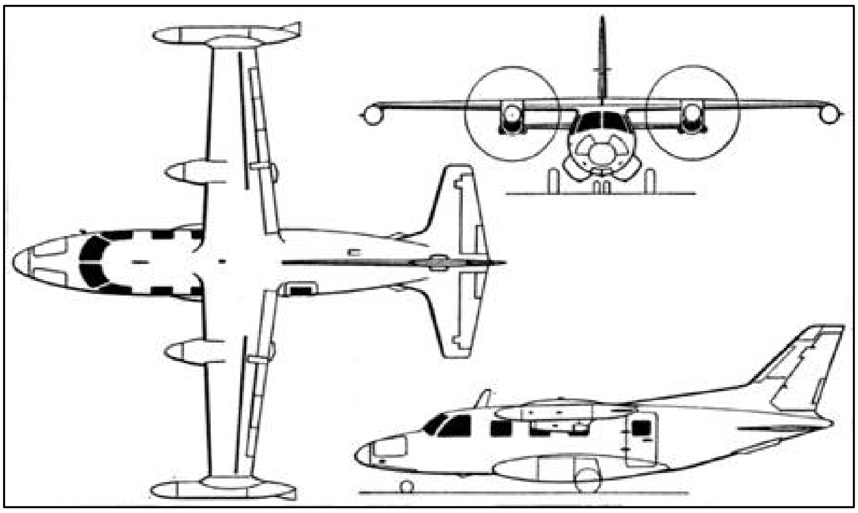
1.1.5.26 IAI, Astra

Manufacturer	IAI
Type	Galaxy
Wing area	30 m^2
Horizontal stabilizer area	10 m^2
Total surface area	40 m^2
Height overall	6 m
Wingspan	17 m
Fuselage, 1/3 surface area	34 m^2



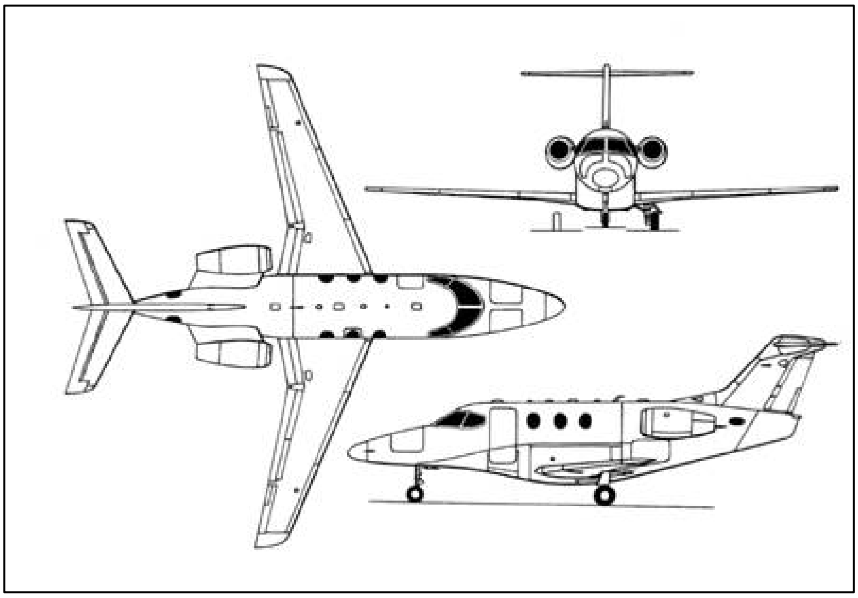
1.1.5.27 Mitsubishi, MU-2

Manufacturer	Mitsubishi
Type	MU-2J
Wing area	17 m^2
Horizontal stabilizer area	5 m^2
Total surface area	22 m^2
Height overall	5 m
Wingspan	12 m
Fuselage, 1/3 surface area	18 m^2 (estimate)



1.1.5.28 Raytheon, Premier

Manufacturer	Raytheon
Type	Premier 1
Wing area	23 m^2
Horizontal stabilizer area	5 m^2
Total surface area	28 m^2
Height overall	5 m
Wingspan	14 m
Fuselage, 1/3 surface area	26 m^2 (estimate)

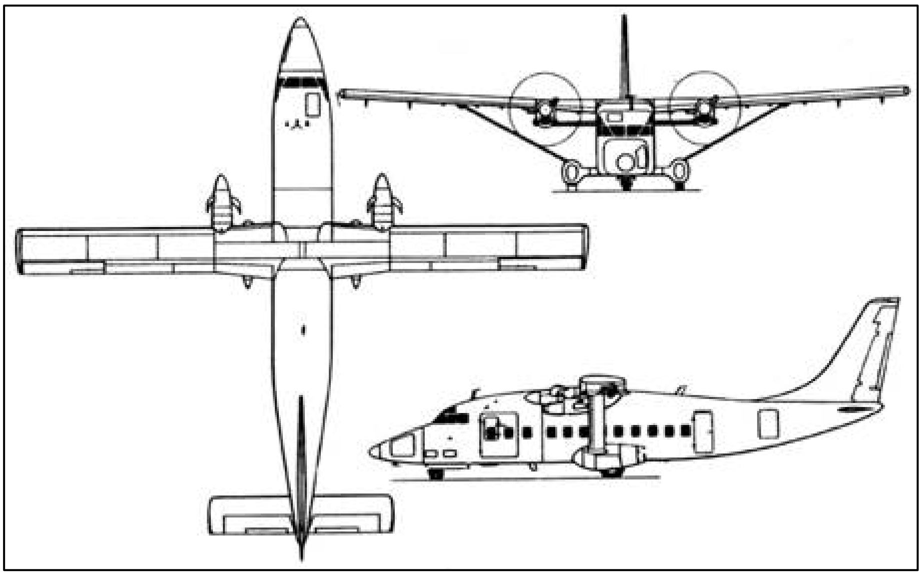


1.1.5.29 Shorts, 330

Manufacturer	Shorts
Type	330
Wing area	43 m^2
Horizontal stabilizer area	8 m^2
Total surface area	51 m^2
Height overall	5 m
Wingspan	23 m
Fuselage, 1/3 surface area	27 m^2

1.1.5.30 Shorts, 360

Manufacturer	Shorts
Type	360
Wing area	43 m^2
Horizontal stabilizer area	10 m^2
Total surface area	53 m^2
Height overall	8 m
Wingspan	23 m
Fuselage, 1/3 surface area	27 m^2



1.1.5.31 Sino, Swearinger

Manufacturer	Sino
Type	Swearinger SJ30-2
Wing area	18 m^2
Horizontal stabilizer area	4 m^2
Total surface area	22 m^2
Height overall	5 m
Wingspan	13 m
Fuselage, 1/3 surface area	9 m^2 (estimate)

1.1.6 Aircraft category

The aircraft wingspan and category is modified from the ICAO Aerodrome Design Manual. The dimensions are as a reference only and up to date tables shall be used in operation. The wingspan is a good indication on the distances needed for separation of aircraft. Remote de-icing/anti-icing should also consider the safety distance that is needed inbetween aircraft. These figures are rounded up for easier use in operation and therefore does not necessary reflect the exact category or wingspan.

This table is sorted by category.

MANUFACTURER	TYPE	CATEGORY	WINGSPAN
Airbus	A380 (in service 2005)	F	80
Antonov	AN-124	F	74
Lockheed	Galaxy C-5	F	68
Boeing	747-400	E	65
Airbus	A340 (-500/-600)	E	63
Boeing	777 (-2LR/-3ER)	E	63
Boeing	777 (-200/-300)	E	61
Airbus	A330 (-200)	E	61
Airbus	A330 (-300)	E	61
Airbus	A340 (-200/-300)	E	61
Ilyushin	Il-96 (-300)	E	61
Ilyushin	Il-96M	E	61
Boeing	747-100/-200/-300	E	60
Boeing/MD	MD-11	D	52
Boeing	C17A Globemaster III	D	52
Ilyushin	Il-76	D	51
Boeing/MD	DC-10	D	51
Ilyushin	Il-86	D	49
Boeing	767 (-200/-300/-400)	D	48
Airbus	A300 (-600R)	D	45
Antonov	AN-70	D	45
Airbus	A310	D	44
Boeing/MD	DC-8	D	44
Ilyushin	Il-62	D	44
Tupolev	TU-204	C	42
Lockheed	Hercules C-130J	D	41
Boeing	B-707	D	40
Boeing	757-200	D	39
Antonov	AN-12	D	38
Tupolev	TU-154M	D	38
Yakolev	YAK-42D	D	35
Boeing	737 (-600/-700/-800/-900)	C	35
Airbus	A318	C	35
Airbus	A320	C	35
Airbus	A321	C	35
Airbus	A319	C	34
Boeing	B-727	C	33
Boeing/MD	MD80	C	33
Boeing/MD	MD90	C	33

MANUFACTURER	TYPE	CATEGORY	WINGSPAN
Antonov	AN-74	C	32
Ilyushin	Il-114	C	30
Tupolev	TU- 334/336/354	C	30
Fokker	27	C	29
Fokker	50	C	29
Tupolev	TU-134	C	29
Boeing	737 (-300/-400/-500)	C	29
Embraer	ERJ 190/195	C	28
Bombardier	130-700 Global Express	C	29
Boeing/MD	DC-9-50	C	29
Boeing	B-717-200	C	29
Bombardier	DHC-8 DASH 8 Q400	C	29
Boeing	737 (-200)	C	29
Fokker	100	C	29
Fokker	70	C	29
Fokker	F28 Fellowship	C	29
Fairchild	Dornier 728 JET	C	28
EADS	ATR-72	C	28
Bae Systems	146	C	27
Bae Systems	AVRO RJ 70/85/100	C	27
Embraer	ERJ-170/175	C	26
Bombardier	DHC-8 DASH 8 Q100/200	C	26
Let	L610G	C	26
XAC	MA-60	C	25
Yakolev	YAK-40	C	25
Saab	2000	C	25
EADS	ATR-42	C	25
Gulfstream Aerospace	IV.SP, IV-MPA and IV-B	C	24
Bombardier	CRJ-700	C	24
Shorts	360	C	23
Shorts	330	C	23
Bombardier	CL 100/200	C	22
Saab	340B	B	21
Fairchild	Dornier 328 JET	B	21
Embraer	ERJ-145	B	21
Let	L410	B	20
Embraer	120 Brasilia	B	20
Cessna	750 Citation X	B	20
Bombardier	130-100 Continental	B	20
Bombardier	Canadair CL600 Challenger	B	20
Dassault	Falcon 2000	B	20
Dassault	Falcon 900B/C and 900EX	B	20
Cessna	680 Citation Sovereign	B	20
Bae	ATP	B	19
Dassault	Falcon 50 EX	B	19
Hawker	Horizon	B	19
IAI	1125 Astra SPX	B	17
Beech	King Air 350	B	17
Beech	King Air B200	B	17
Beech	1900 D	B	17

MANUFACTURER	TYPE	CATEGORY	WINGSPAN
IAI	Galaxy	B	17
Cessna	550 Citation Bravo	B	16
Cessna	560 Encore	B	16
Cessna	560 Excel	B	16
Bae	Jetstream 41	B	16
Bae	Jetstream 31	B	16
Bombardier	LearJet 45	B	15
Hawker	800 XP	B	15
Cessna	525 Citation CJ1	B	15
Cessna	525 Citation CJ2	B	15
Beech	King Air C90B/C90SE	B	14
Raytheon	Premier 1	B	14
Bombardier	Learjet 31A	B	14
Bombardier	LearJet 60	B	14
Beech	Beechjet 400 A	B	14
Sino	Swearinger SJ30-2	B	13
Mitsubishi	MU-2J	B	12

1.1.7 Recommended minimum amount of fluid for anti-icing

The amount of anti-icing fluid required is largely dependent on the prevailing conditions during the de-icing/anti-icing operation. Weather conditions, such as strong winds, will have an effect on how much of the anti-icing fluid will reach the aircraft surfaces. Other elements having an influence on the adequate amount of anti-icing fluid actually needed on the surface can be jet blast, spray distance, spray technique, visibility, colouring of fluids and the presence of first step fluid on the surfaces. Also, the specific properties of the used anti-icing fluid may have an influence on the amount to be sprayed.

The table below gives recommended minimums for the anti-icing step in favourable conditions. The amount of anti-icing fluid (second step) mentioned here is only as a guideline and current operational conditions must be taken into account. These figures include a buffer, depending on aircraft type, to account for the necessary degree of overspraying in order to achieve an even and sufficient fluid layer. The actual amount of fluid used will need to be increased in adverse conditions. Vertical stabilizer surface area and upper fuselage area are not mentioned here. Refer to the aircraft manufacturer and/or the airline operator for recommendations for these areas.

This table is sorted by manufacturer.

MANUFACTURER	TYPE	CATEGORY	RECOMMENDED MINIMUMS (litres)		
			WING	TAIL	WING+TAIL
Airbus	A300 (-600R)	D	360	70	430
Airbus	A310	D	300	70	370
Airbus	A318	C	180	50	230
Airbus	A319	C	180	50	230
Airbus	A320	C	180	50	230
Airbus	A321	C	180	50	230
Airbus	A330 (-200)	E	480	100	580
Airbus	A330 (-300)	E	480	100	580
Airbus	A340 (-200/-300)	E	480	100	580
Airbus	A340 (-500/-600)	E	570	100	670
Airbus	A380	F	910	220	1130
Antonov	AN-12	D	180	50	230
Antonov	AN-124	F	790	130	920
Antonov	AN-70	D	340	60	400
Antonov	AN-74	C	140	40	180
Bae	ATP	B	120	30	140
Bae	Jetstream 31	B	40	20	60
Bae	Jetstream 41	B	50	20	70
Bae Systems	146	C	110	30	140
Bae Systems	AVRO RJ 70/85/100	C	110	30	140
Beech	1900 D	B	50	20	70
Beech	Beechjet 400 A	B	40	10	50
Beech	King Air 350	B	50	20	70
Beech	King Air B200	B	50	10	60
Beech	King Air C90B/C90SE	B	50	10	60
Boeing	707	D	250	80	330
Boeing	717-200	C	140	40	180
Boeing	727	C	230	50	280

MANUFACTURER	TYPE	CATEGORY	RECOMMENDED MINIMUMS (litres)		
			WING	TAIL	WING+TAIL
Boeing	737 (-200)	C	130	50	180
Boeing	737 (-300/-400/-500)	C	150	50	200
Boeing	737 (-600/-700/-800/-900)	C	180	50	230
Boeing	747-100/-200/-300	E	690	180	870
Boeing	747-400	E	710	180	890
Boeing	757-200	D	260	70	330
Boeing	767 (-200/-300/-400)	D	390	90	480
Boeing	777 (-200/-300)	E	560	140	700
Boeing	777 (-2LR/-3ER)	E	565	140	705
Boeing	C17A Globemaster III	D	480	110	590
Boeing/MD	DC-10	D	500	140	640
Boeing/MD	DC-8	D	370	70	440
Boeing/MD	DC-9-50	C	140	40	180
Boeing/MD	MD-11	D	450	120	570
Boeing/MD	MD80	C	170	50	220
Boeing/MD	MD90	C	160	50	210
Bombardier	130-100 Continental	B	80	10	90
Bombardier	130-700 Global Express	C	140	40	180
Bombardier	Canadair CL600 Challenger	B	80	20	100
Bombardier	CL 100/200	C	80	20	100
Bombardier	CRJ-700	C	100	30	130
Bombardier	DHC-8 DASH 8 Q100/200	C	80	20	100
Bombardier	DHC-8 DASH 8 Q400	C	90	30	120
Bombardier	Learjet 31A	B	40	10	50
Bombardier	LearJet 45	B	50	10	60
Bombardier	LearJet 60	B	40	10	50
Cessna	525 Citation CJ1	B	40	10	50
Cessna	525 Citation CJ2	B	40	20	60
Cessna	550 Citation Bravo	B	50	20	70
Cessna	560 Encore	B	40	20	60
Cessna	560 Excel	B	60	20	80
Cessna	680 Citation Sovereign	B	70	20	90
Cessna	750 Citation X	B	80	20	100
Dassault	Falcon 2000	B	80	30	110
Dassault	Falcon 50 EX	B	70	30	100
Dassault	Falcon 900B/C and 900EX	B	80	30	100
EADS	ATR-42	C	80	20	100
EADS	ATR-72	C	90	20	110
Embraer	120 Brasilia	B	60	20	80

MANUFACTURER	TYPE	CATEGORY	RECOMMENDED MINIMUMS (litres)		
			WING	TAIL	WING+TAIL
Embraer	ERJ 190/195	C	140	40	180
Embraer	ERJ-145	B	80	20	100
Embraer	ERJ-170/175	C	110	40	150
Fairchild	Dornier 328 JET	B	60	20	80
Fairchild	Dornier 728 JET	C	110	30	140
Fokker	100	C	140	40	180
Fokker	27	C	100	30	130
Fokker	50	C	100	30	130
Fokker	70	C	140	40	180
Fokker	F28 Fellowship	C	120	30	150
Gulfstream Aerospace	IV.SP, IV-MPA and IV-B	C	130	30	160
Hawker	800 XP	B	60	20	80
Hawker	Horizon	B	80	30	110
IAI	1125 Astra SPX	B	50	20	70
IAI	Galaxy	B	50	20	70
Ilyushin	Il-62	D	380	50	430
Ilyushin	Il-76	D	410	70	480
Ilyushin	Il-86	D	440	70	510
Ilyushin	Il-96 (-300)	E	510	130	640
Ilyushin	Il-96M	E	510	130	640
Ilyushin	Il-114	C	115	34	149
Let	L410	B	60	20	70
Let	L610G	C	80	20	100
Lockheed	Galaxy C-5	F	720	120	840
Lockheed	Hercules C-130J	D	220	50	270
Mitsubishi	MU-2J	B	30	10	40
Raytheon	Premier 1	B	40	10	50
Saab	2000	C	80	30	110
Saab	340B	B	70	20	90
Shorts	330	C	70	20	90
Shorts	360	C	70	20	90
Sino	Swearinger SJ30-2	B	30	10	40
Tupolev	TU- 334/336/354	C	120	40	160
Tupolev	TU-134	C	180	50	230
Tupolev	TU-154M	D	280	60	340
Tupolev	TU-204	D	250	60	310
XAC	MA-60	C	110	40	140
Yakolev	YAK-40	C	100	40	140
Yakolev	YAK-42D	D	210	40	250

1.2 Aircraft Types – ’No Spray’ areas

The general restrictions below apply to all aircraft types. The list below states the requirements and the associated symbols, which are then used on the aircraft type diagrams on the following pages to indicate (where necessary) the locations of ‘no spray’ areas, for each of the aircraft types illustrated.
These illustrations are for general guidance only, and do not currently include every aircraft type and variant. Refer to the aircraft maintenance manual (AMM) or the Operator’s manual for further information. In case of conflict, the AMM, or the Operator’s manual, takes preference.

 Do not spray into engine openings.

 Do not spray flight deck windows or windscreens.

 Do not spray main cabin windows.

 Do not spray directly at or into pitot probes, TAT probes, or angle of attack sensors.

 Do not spray directly at static ports.

 Do not spray into APU inlet.

 Do not spray into APU exhaust.

 Do not apply fluid to aircraft brakes.

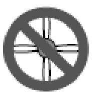
 Do not spray into engine exhaust.

 Do not spray into aircraft exhaust or intake vents.

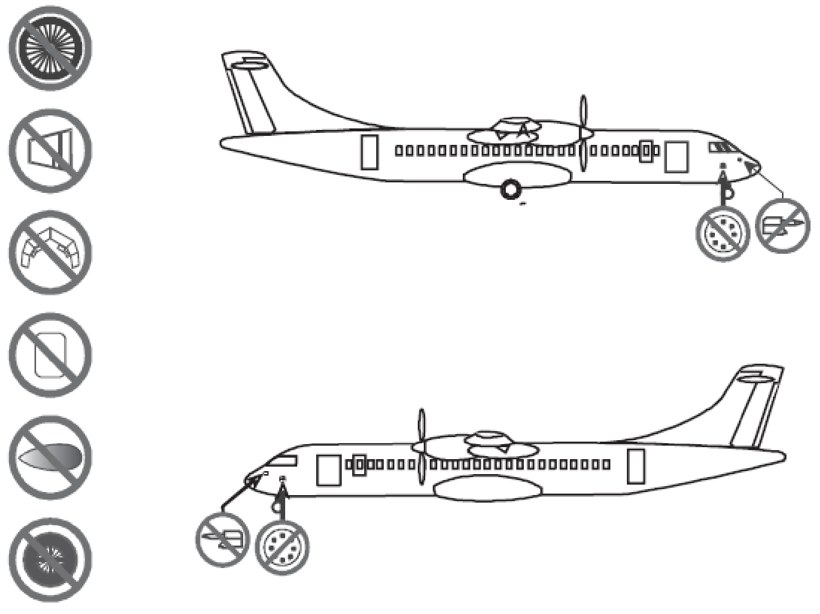
 Do not spray into avionic vents.

 Do not apply 100% Type II or IV to radome.

Apply deicing fluids at angles below 45 degrees.

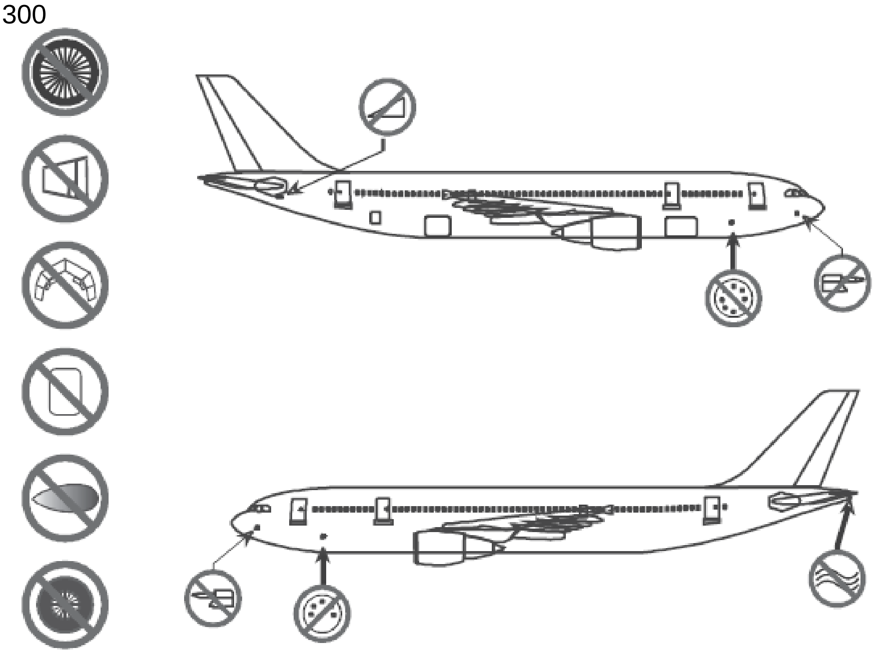
 Do not spray onto propellor blades and into engine openings.

1.2.1 ATR-72



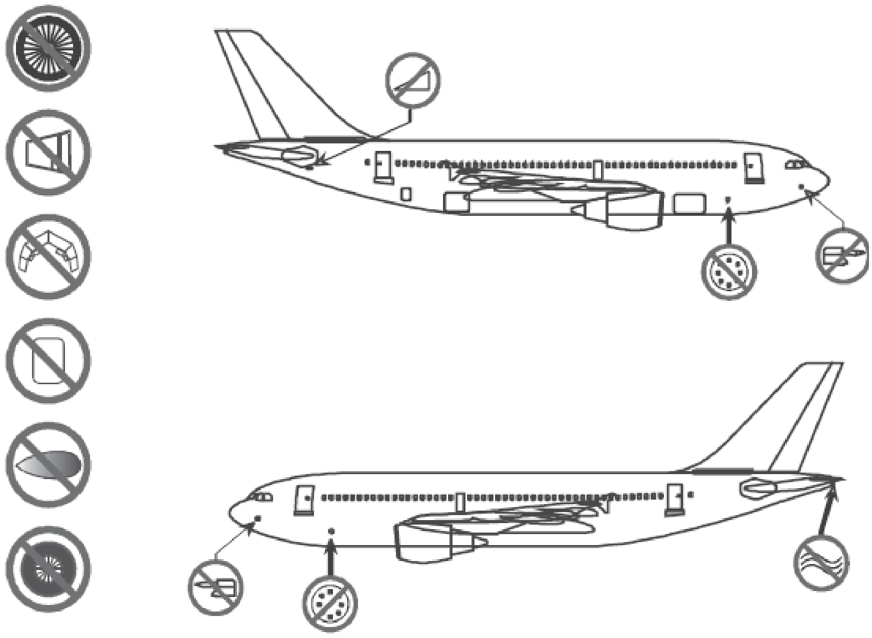
No Direct Application of De-icing/Anti-icing fluid allowed

1.2.2 Airbus A 300



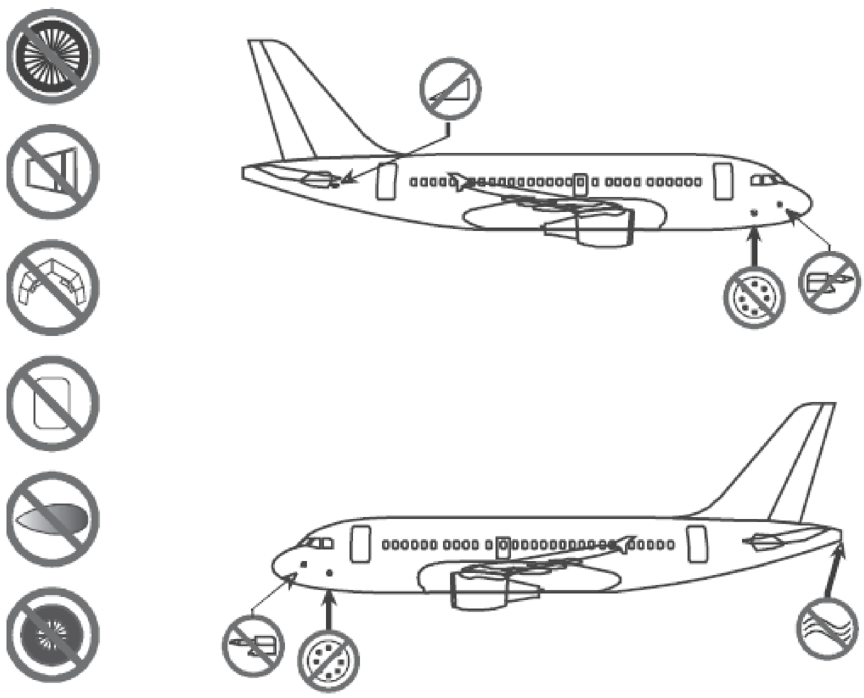
No Direct Application of De-icing/Anti-icing fluid allowed

1.2.3 Airbus A 310



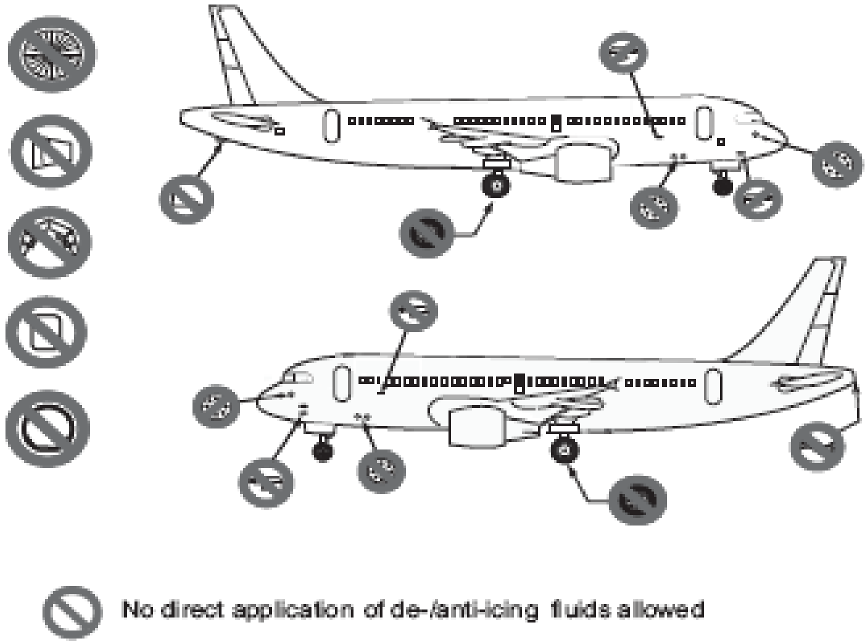
No Direct Application of Deicing/Anti-icing Fluid Allowed

1.2.4 Airbus A 318



No Direct Application of Deicing/Anti-icing Fluid Allowed

1.2.5 Airbus A 319



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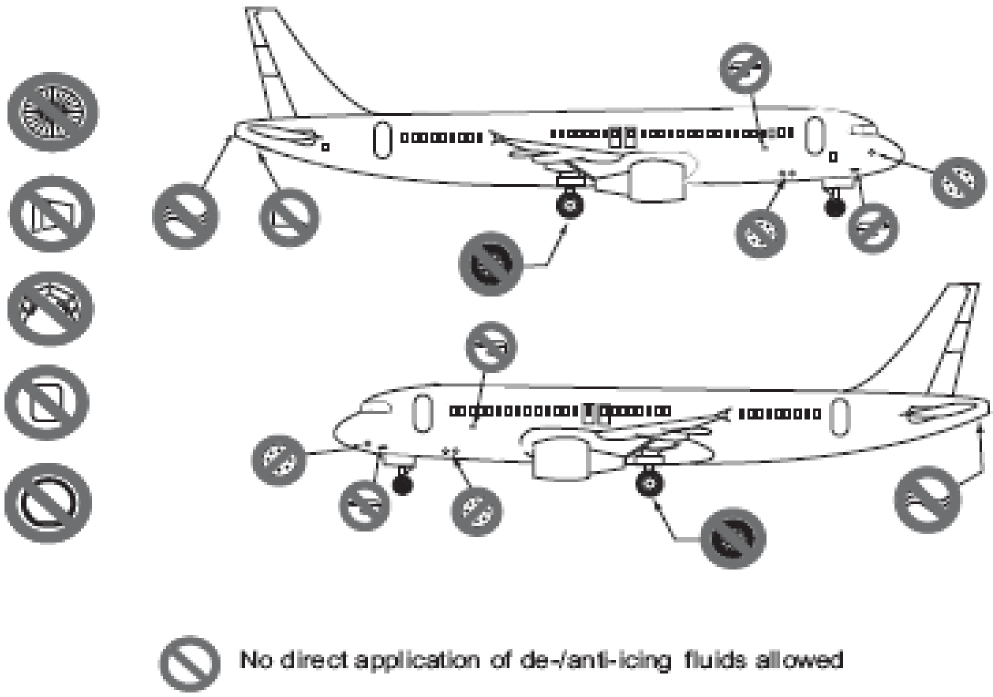

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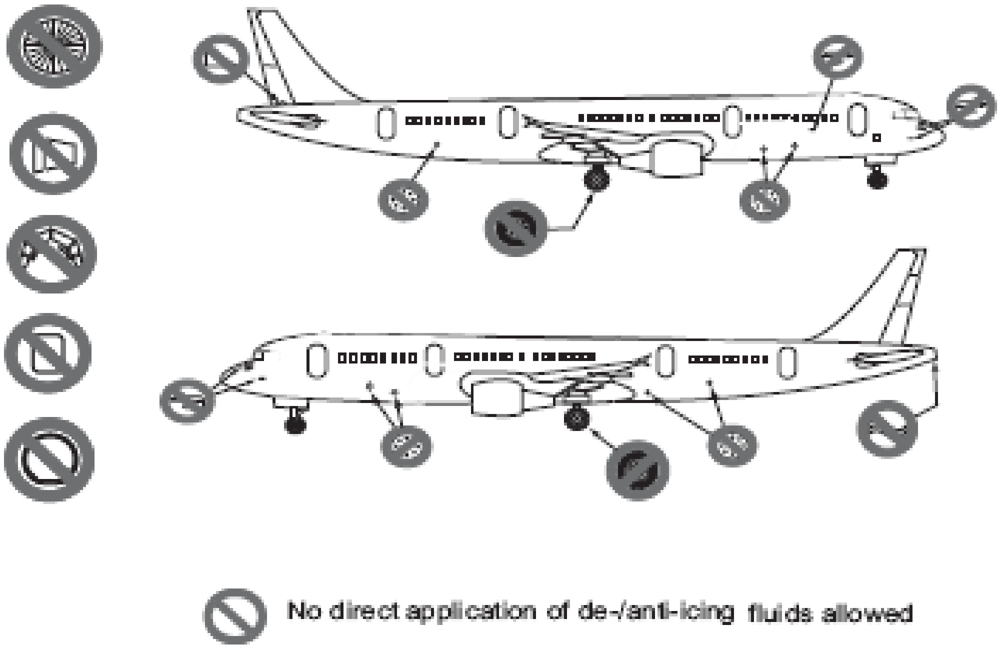

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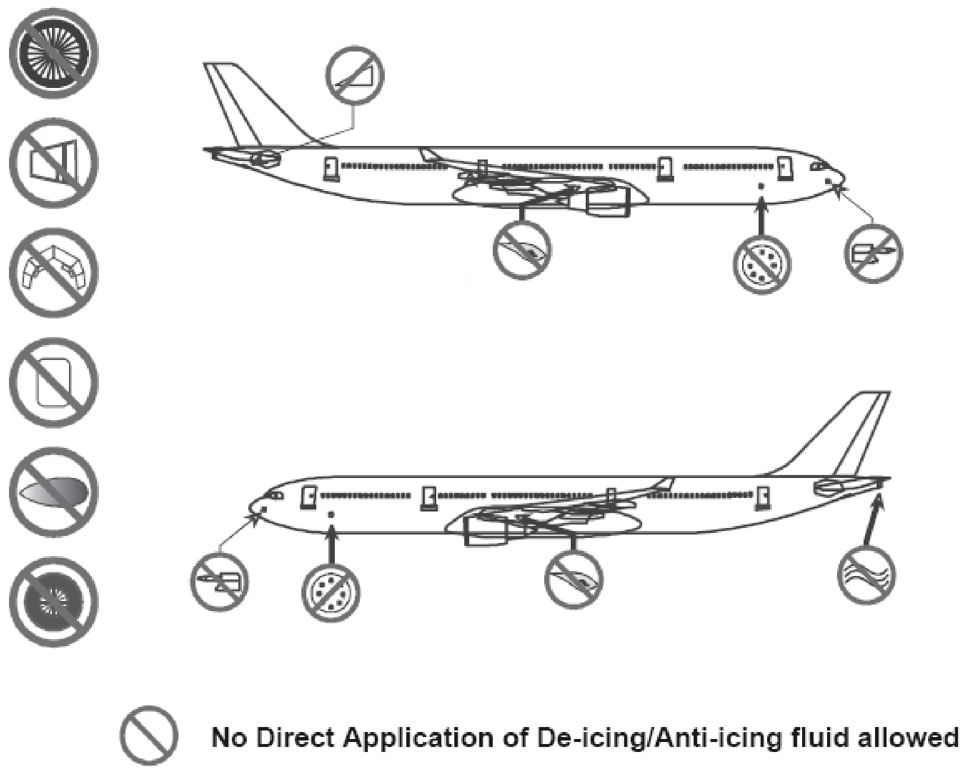

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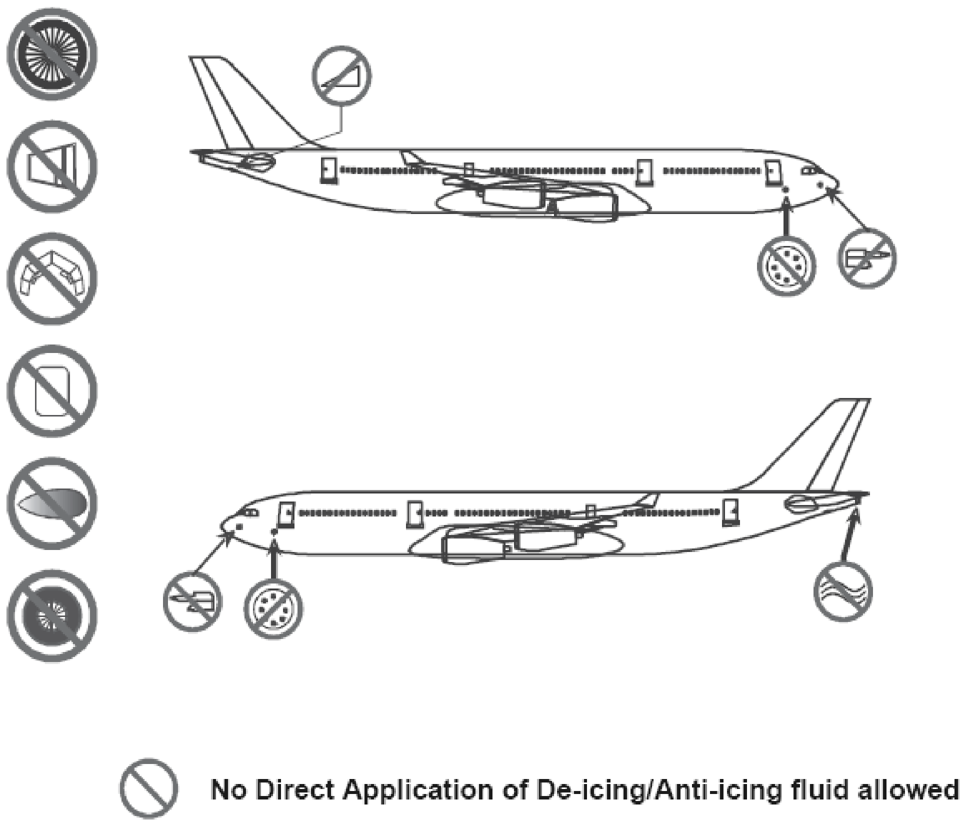

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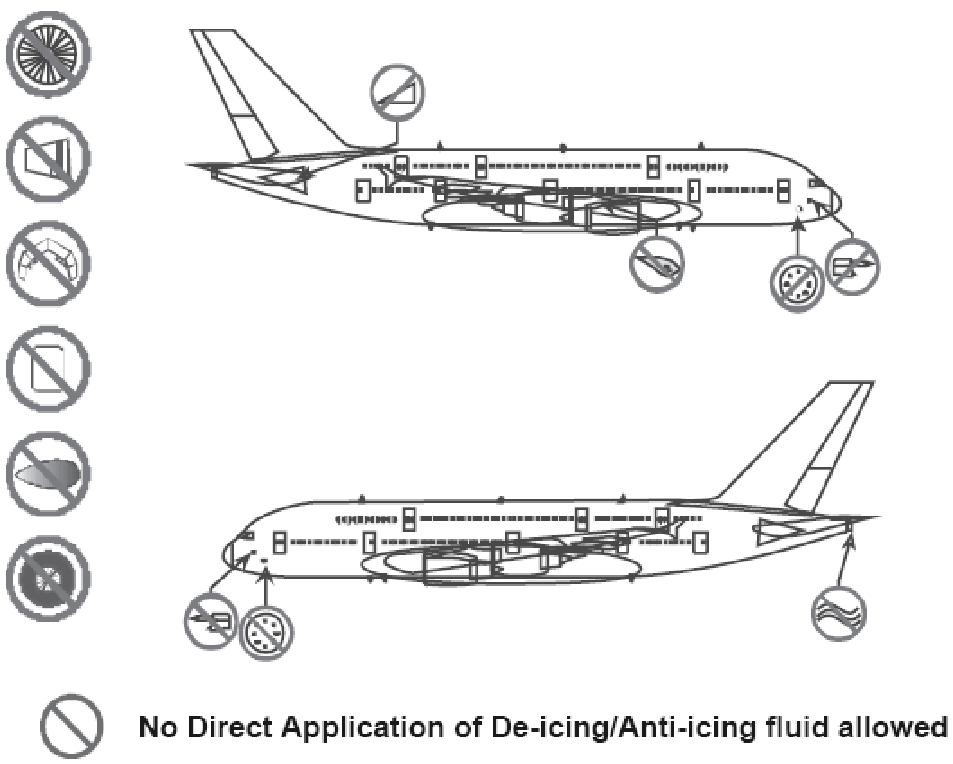
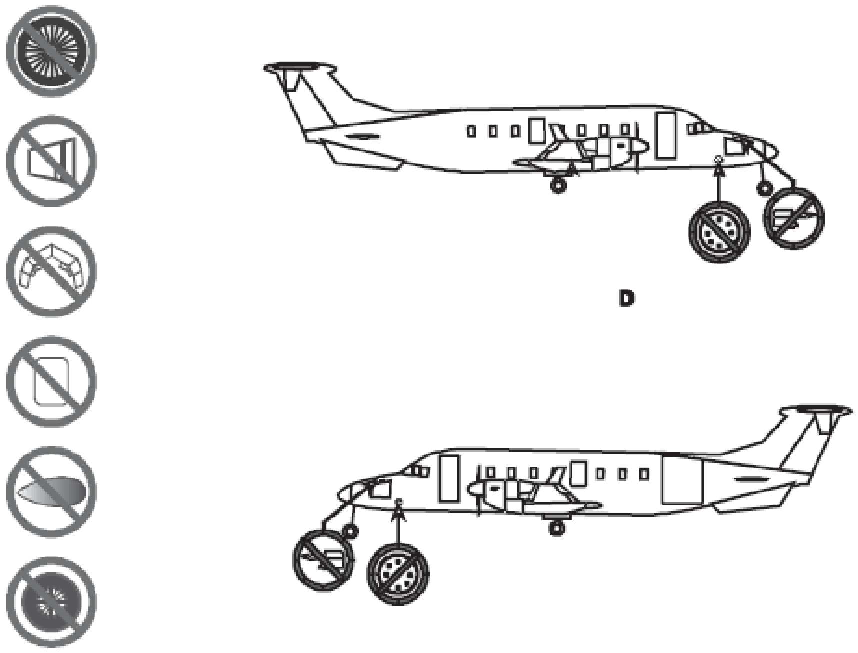
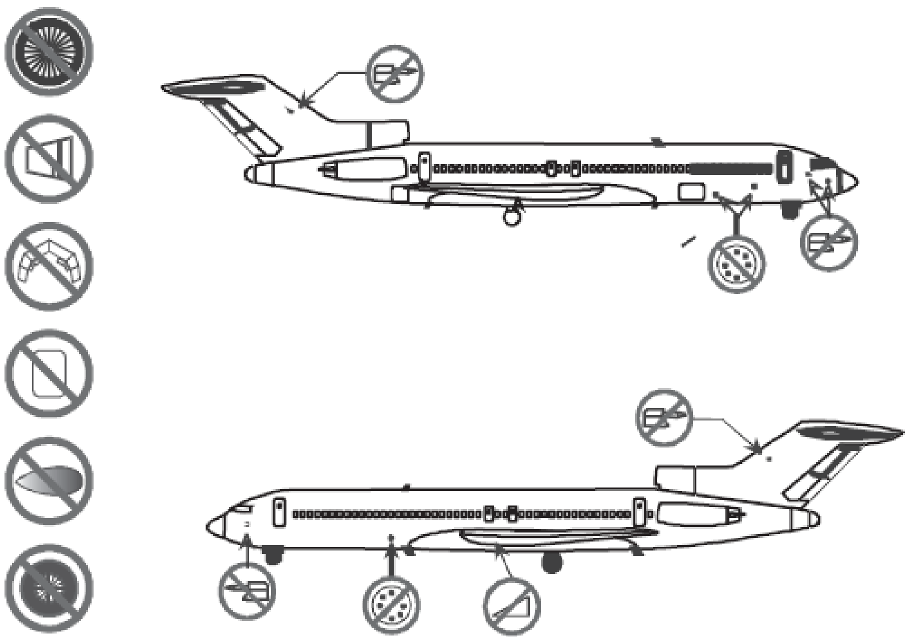


1.2.11 Beechcraft 1900



No Direct Application of De-icing/Anti-icing fluid allowed

1.2.12 Boeing 727



No Direct Application of De-icing/Anti-icing fluid allowed

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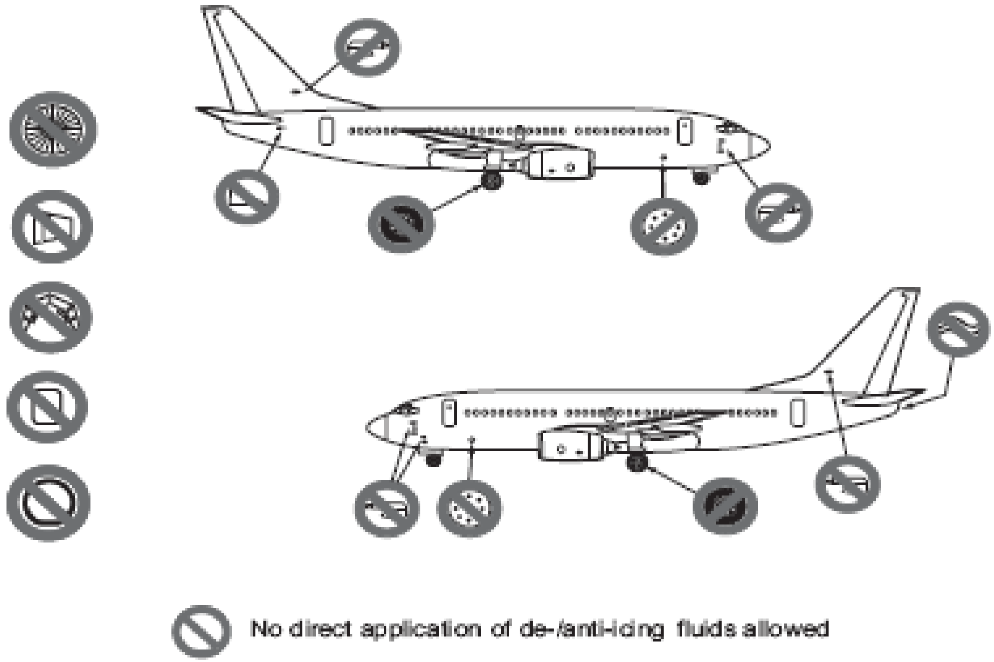
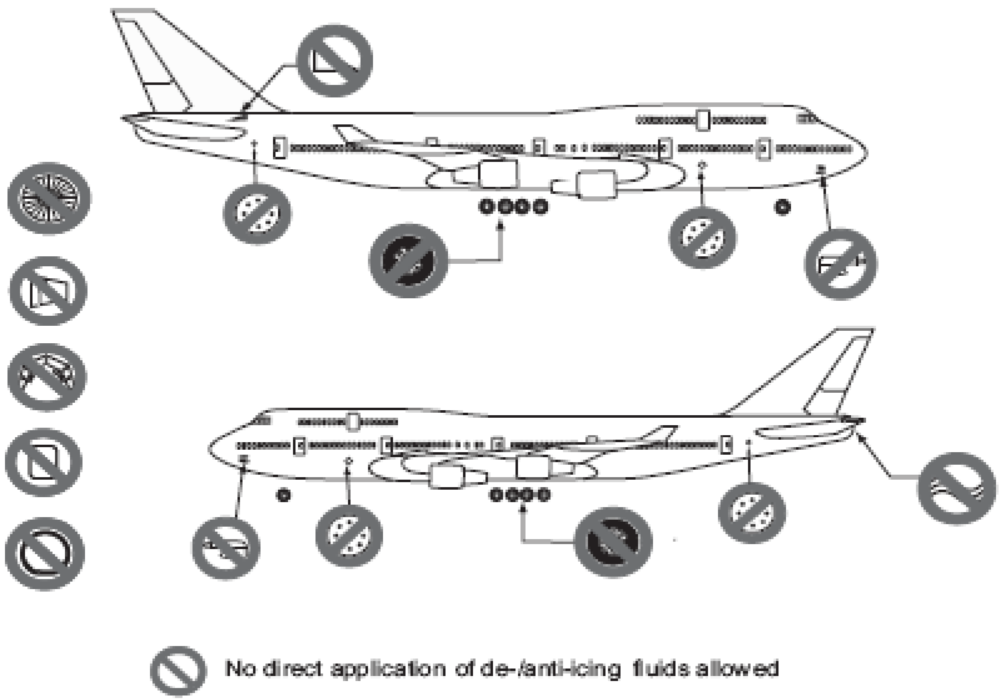


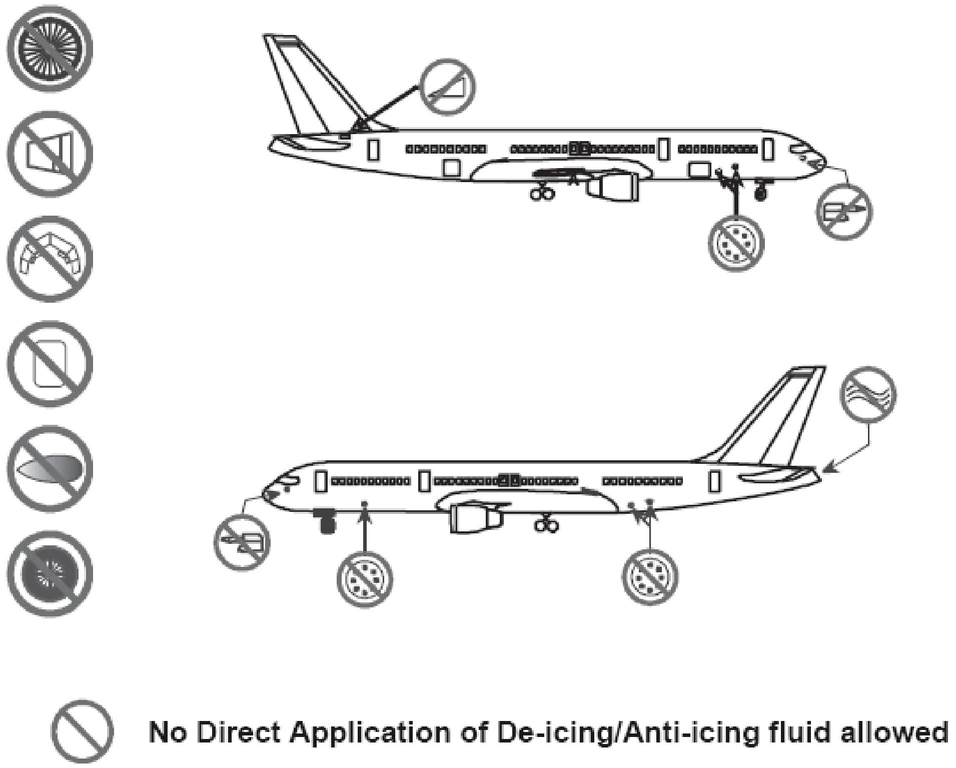
No direct application of de-/anti-icing fluids allowed

1.2.14 Boeing 747

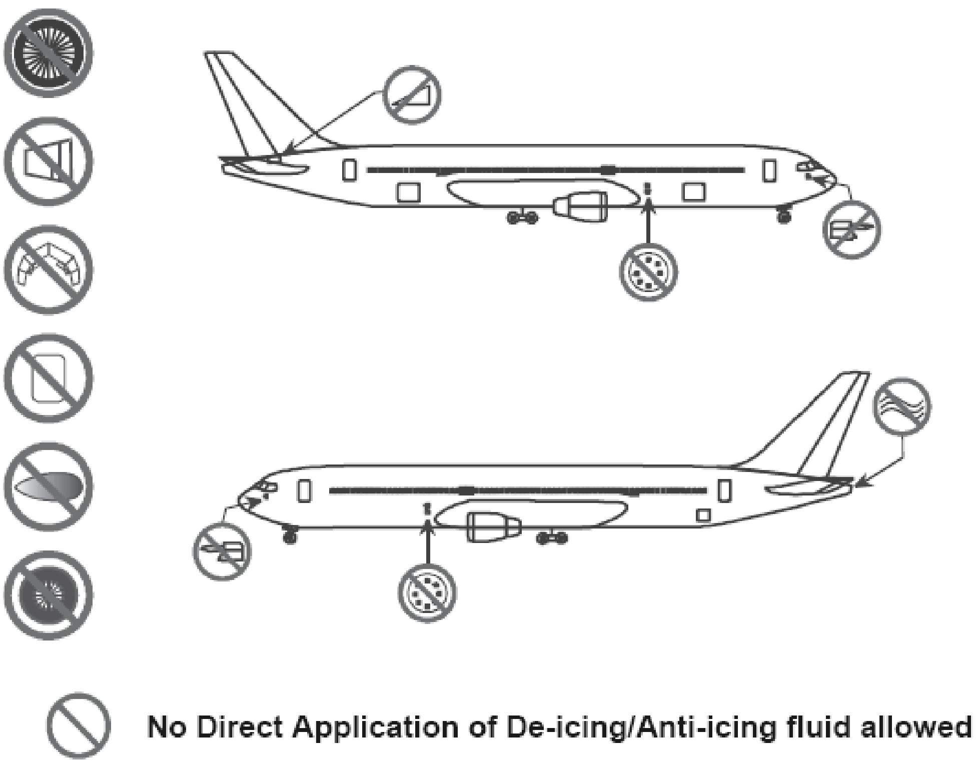


No direct application of de-/anti-icing fluids allowed

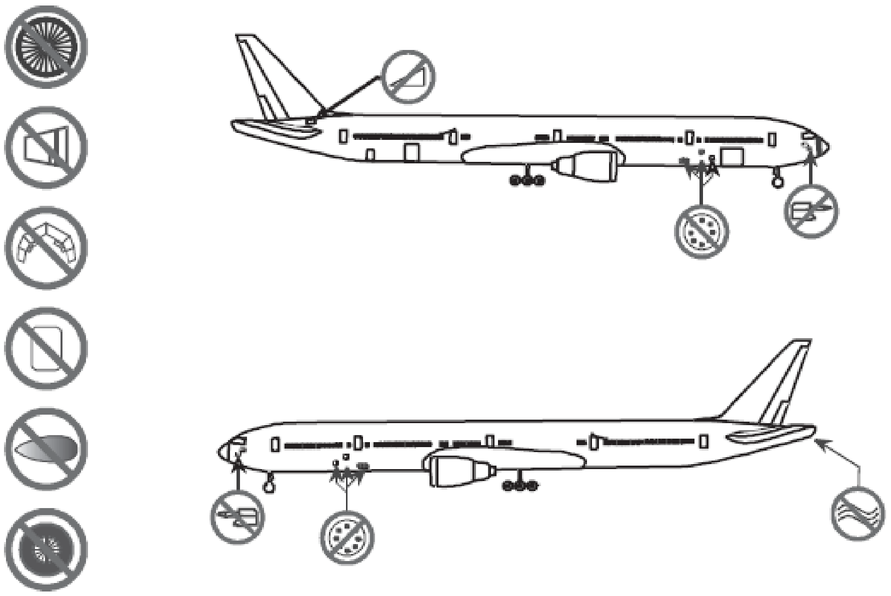
1.2.15 Boeing 757



1.2.16 Boeing 767

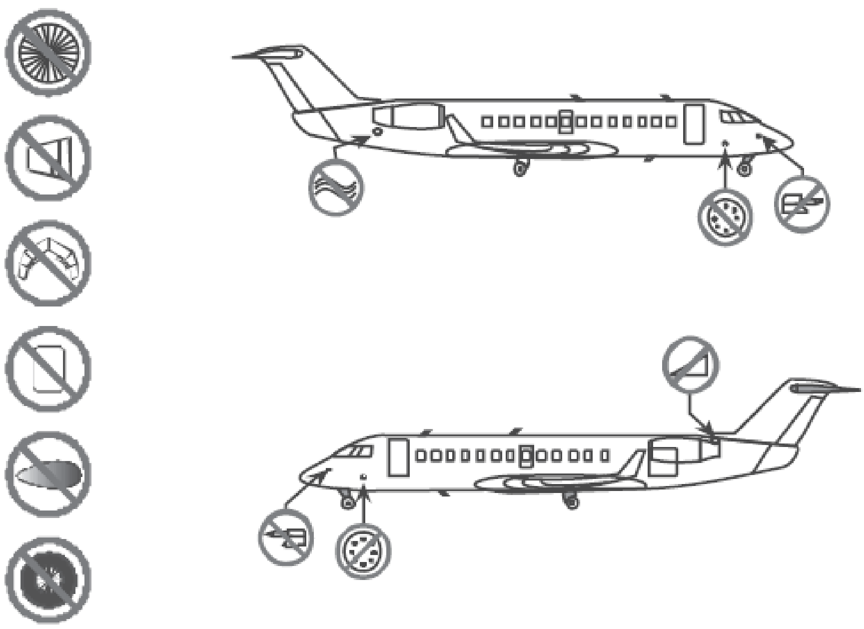


1.2.17 Boeing 777



No Direct Application of De-icing/Anti-icing fluid allowed

1.2.18 CRJ / CL 65



No Direct Application of De-icing/Anti-icing fluid allowed

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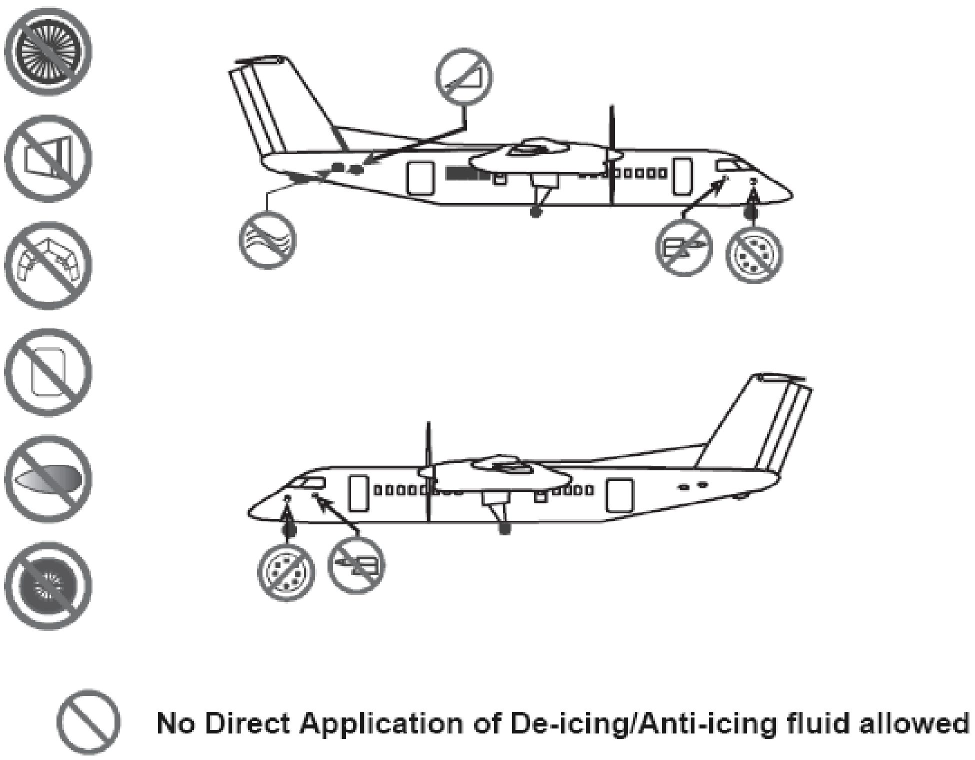
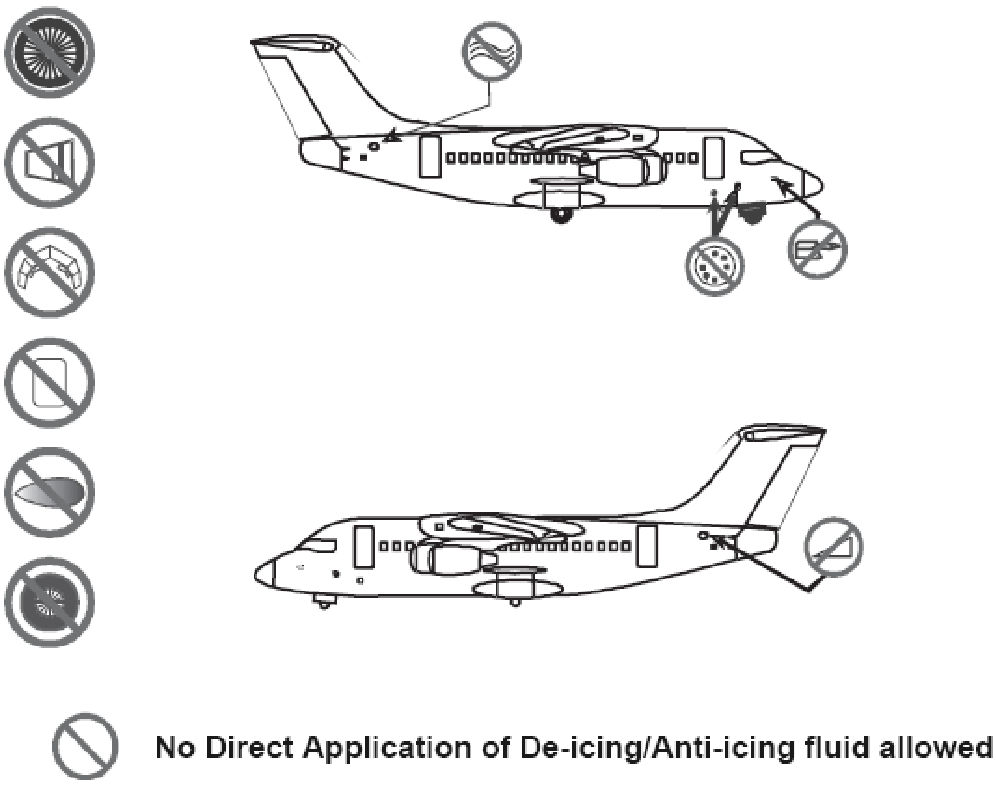
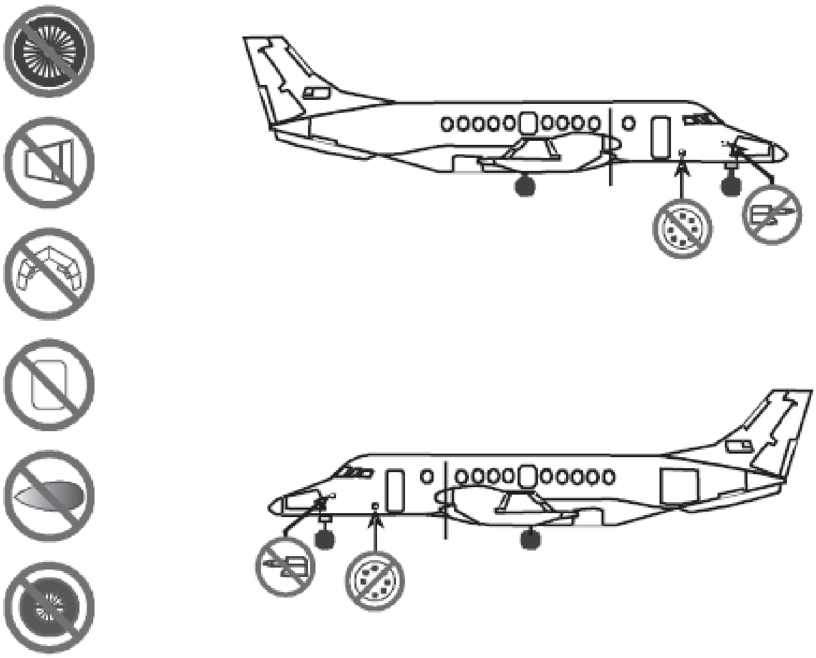


1.2.20 BAE 146

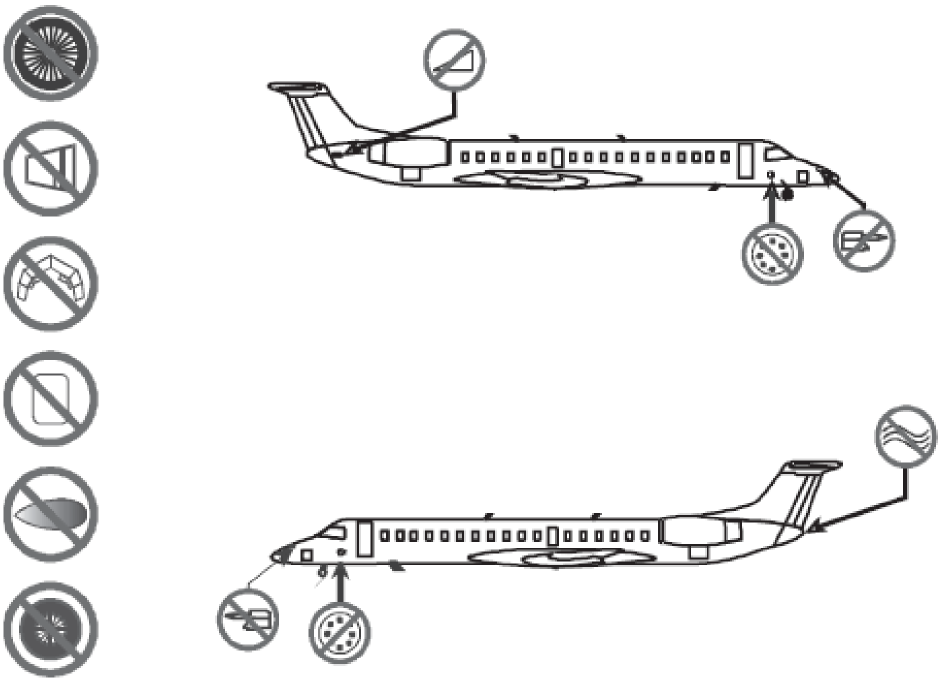


1.2.21 Jetstream 31/41



No Direct Application of De-icing/Anti-icing fluid allowed

1.2.22 Embraer 135/145



No Direct Application of De-icing/Anti-icing fluid allowed

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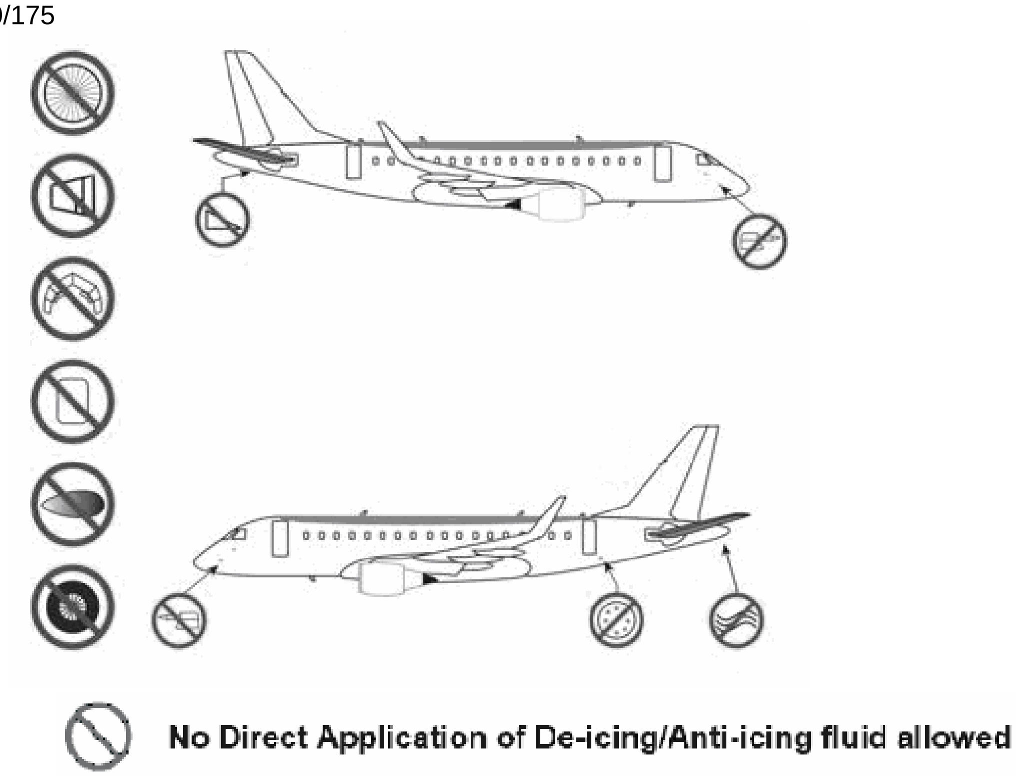
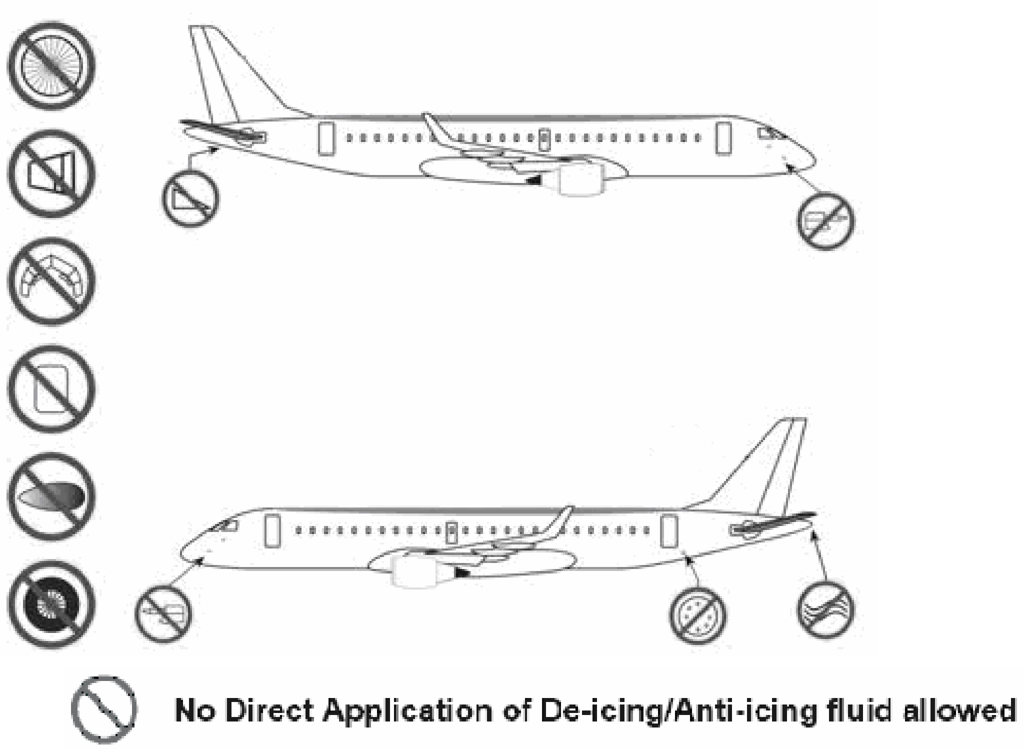


1.2.24 Embraer 190/195



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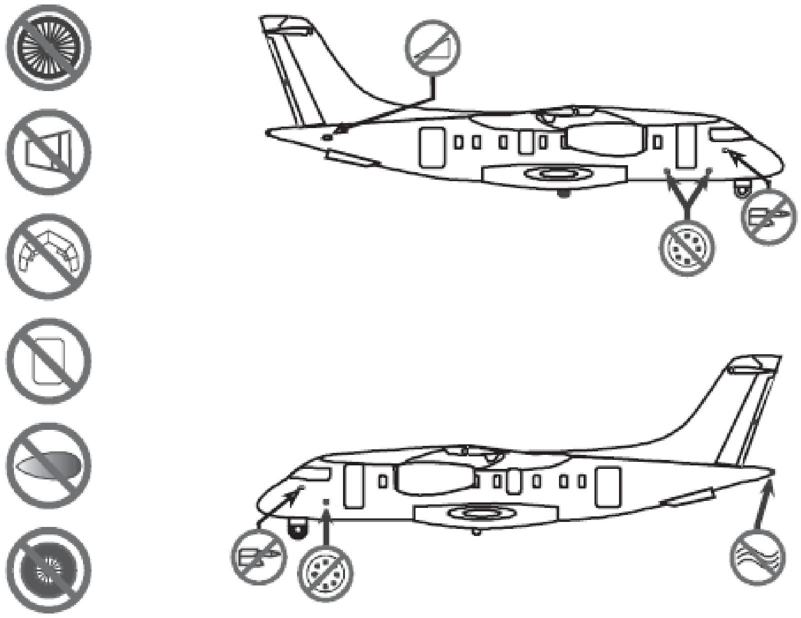

No Direct Application of De-icing/Anti-icing fluid allowed

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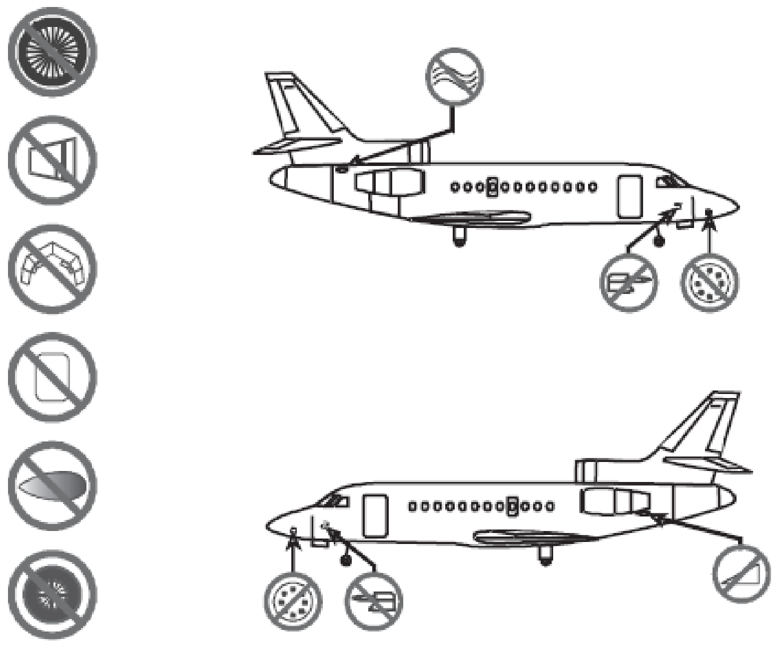

No Direct Application of De-icing/Anti-icing fluid allowed

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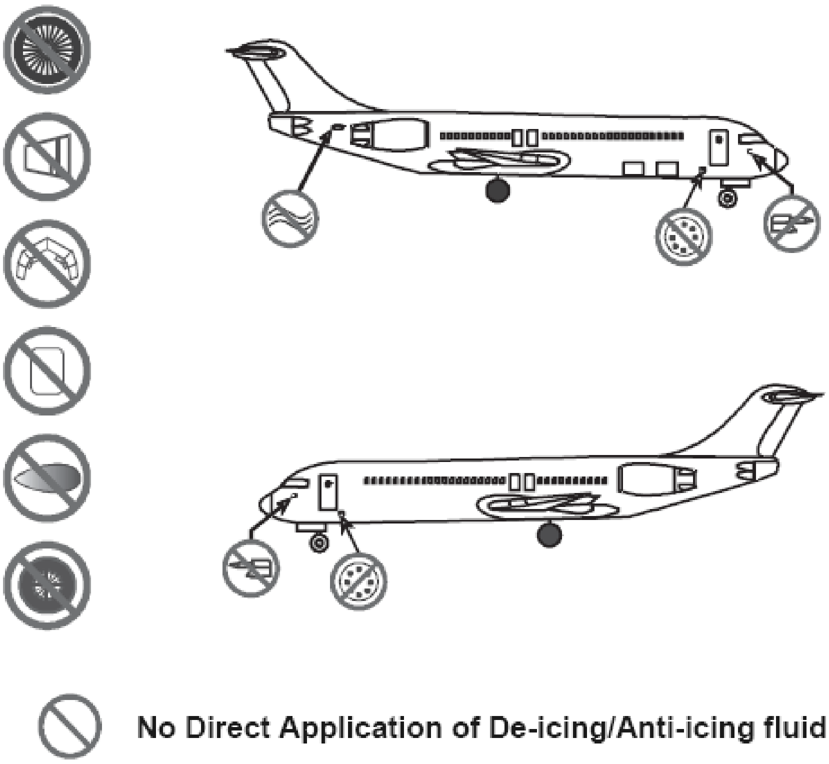

No Direct Application of De-icing/Anti-icing fluid allowed

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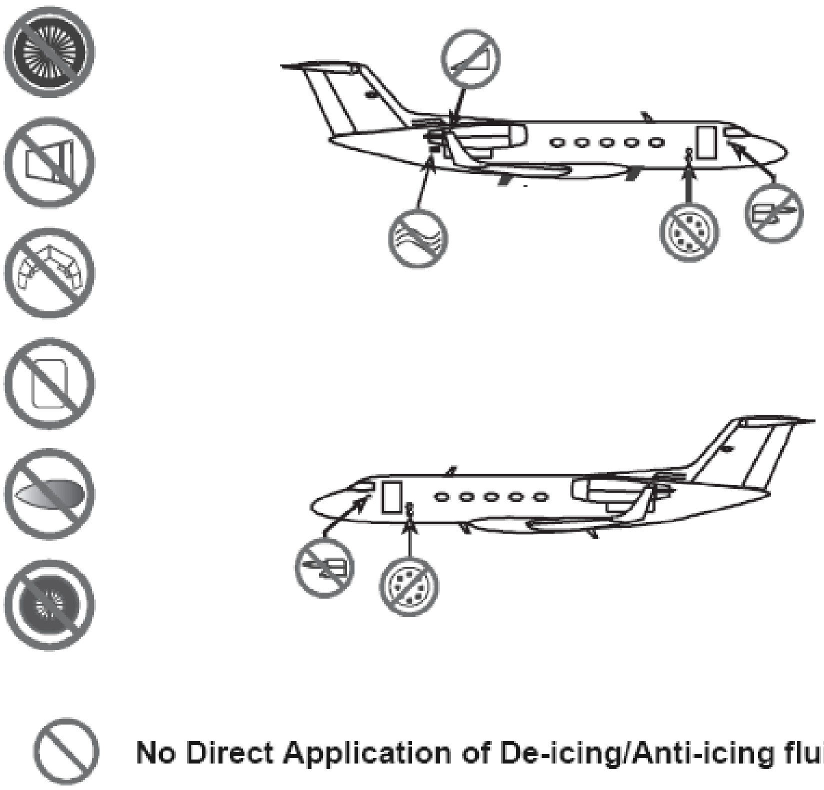

No Direct Application of De-icing/Anti-icing fluid allowed

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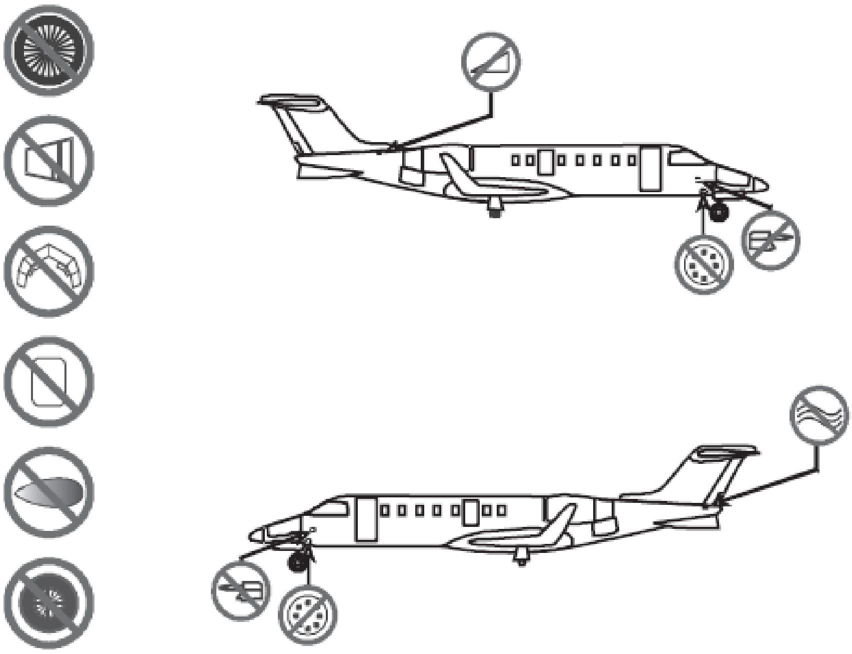
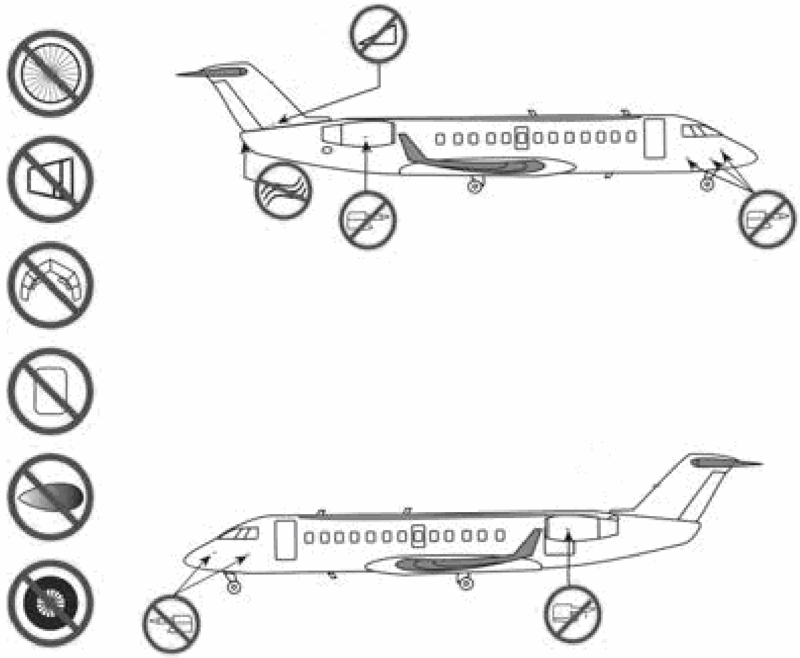


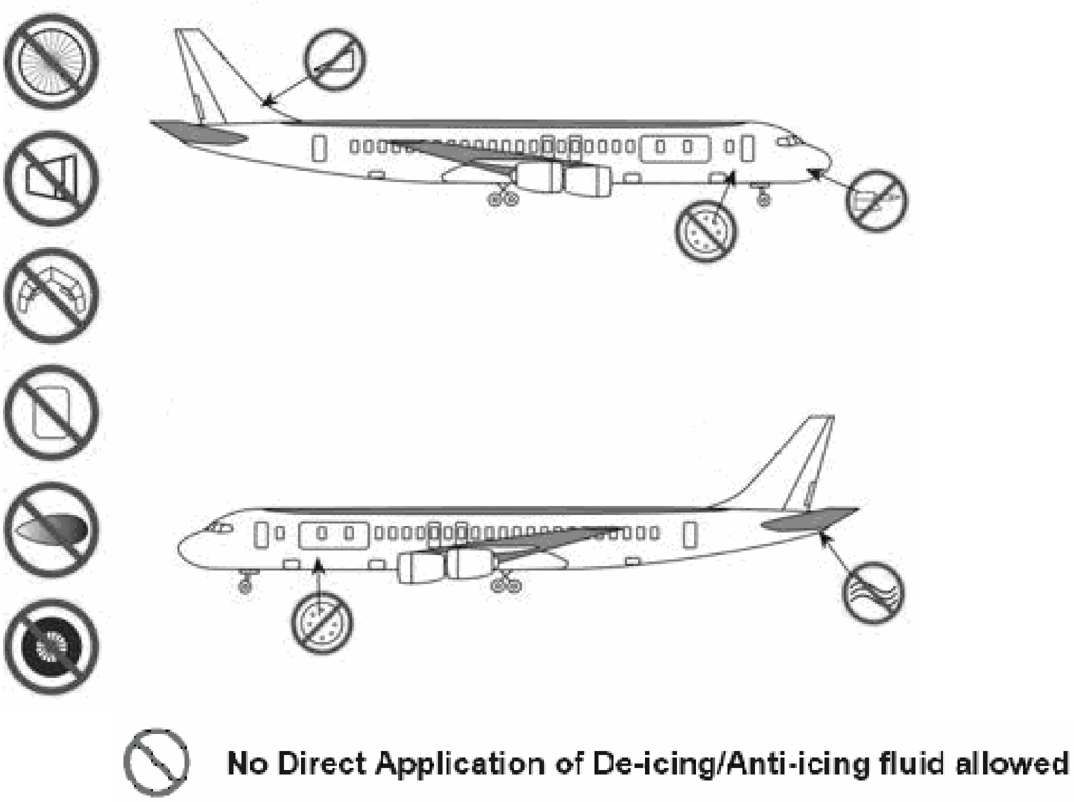
No Direct Application of De-icing/Anti-icing fluid allowed

1.2.30 Global Express

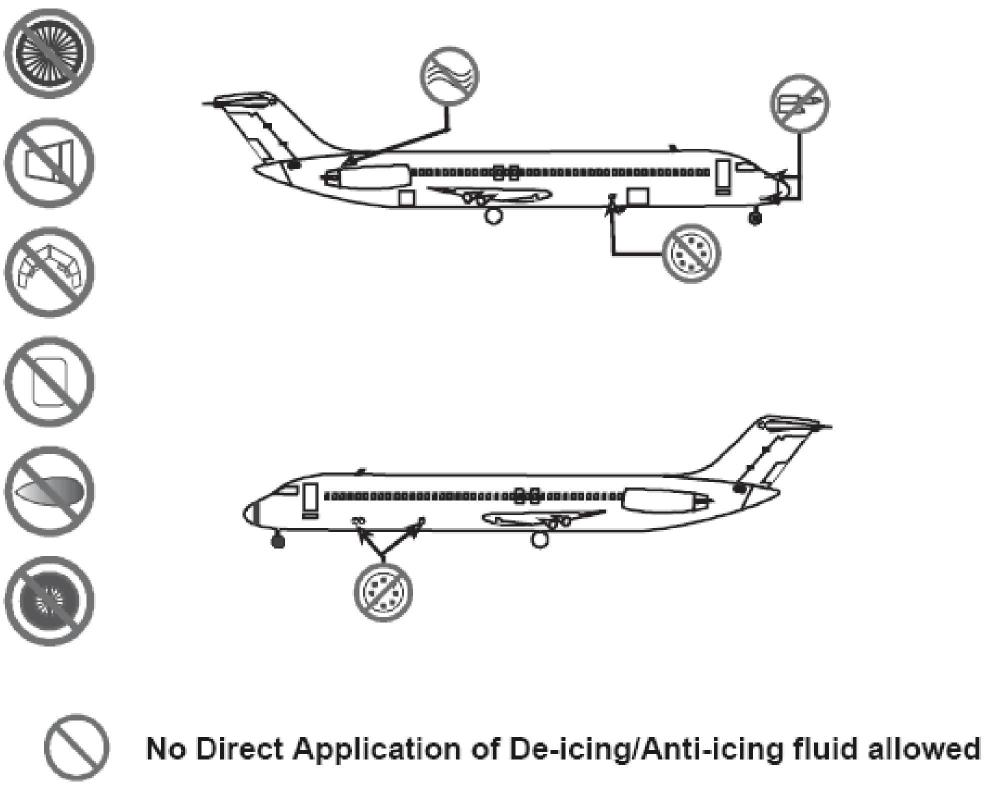


No Direct Application of De-icing/Anti-icing fluid allowed

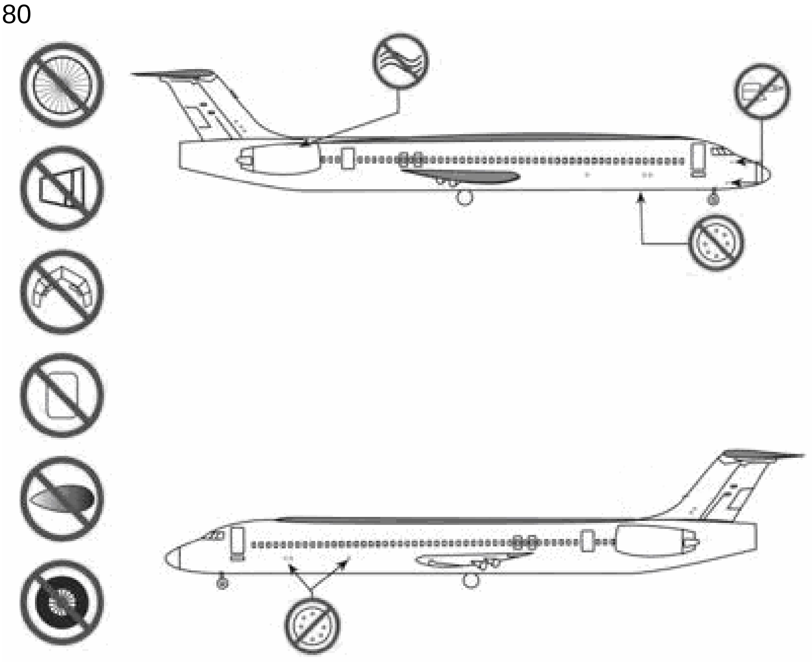
1.2.31 DC-8



1.2.32 DC-9-30/40

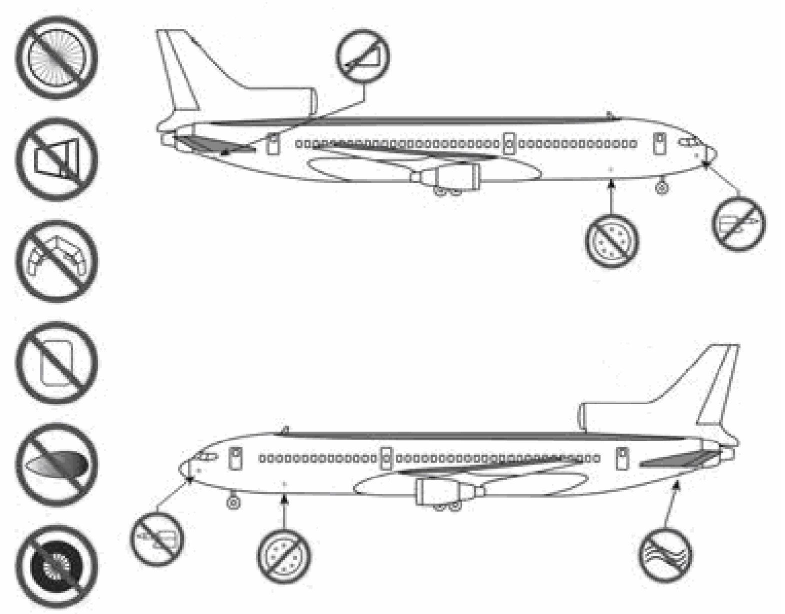


1.2.33 MD 80



No Direct Application of De-icing/Anti-icing fluid allowed

1.2.34 L-1011



No Direct Application of De-icing/Anti-icing fluid allowed

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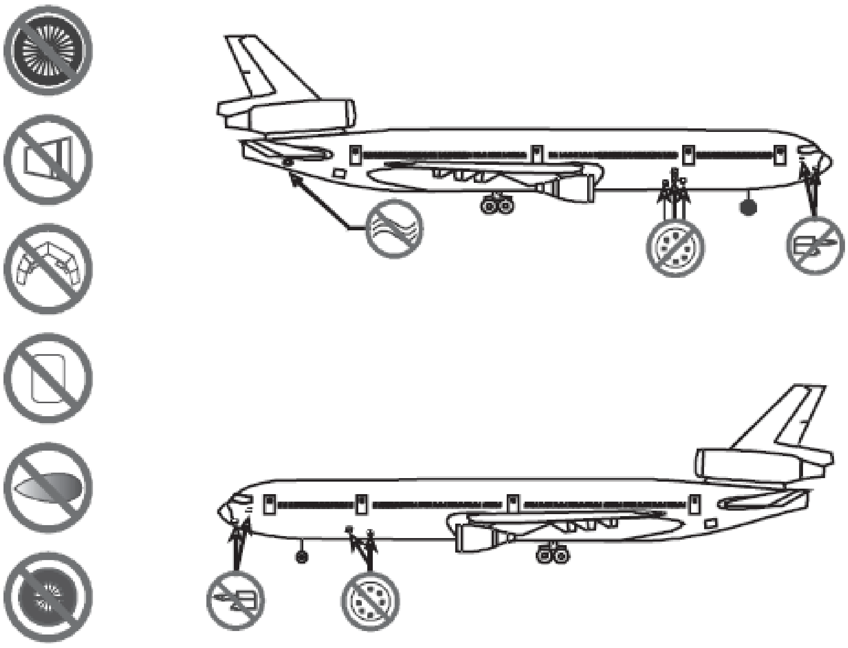
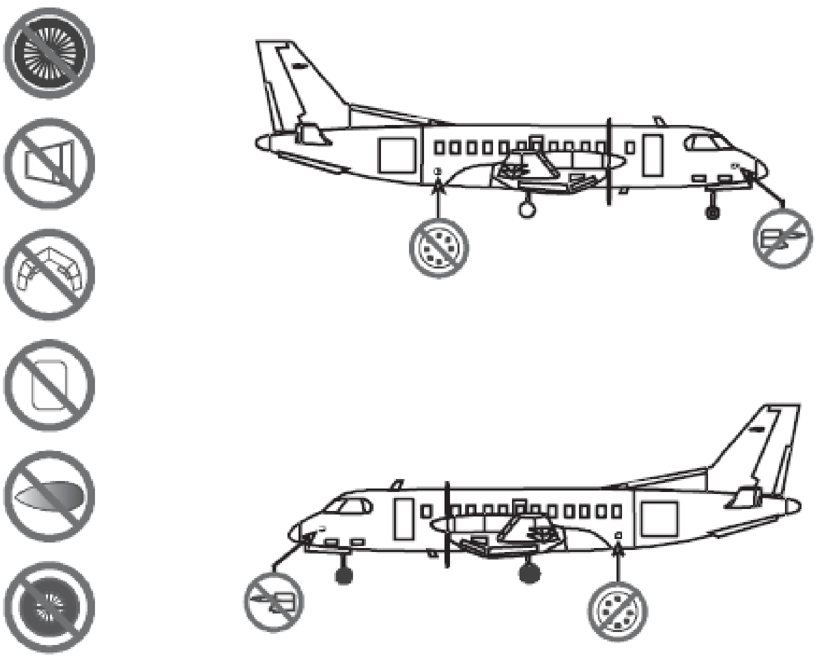
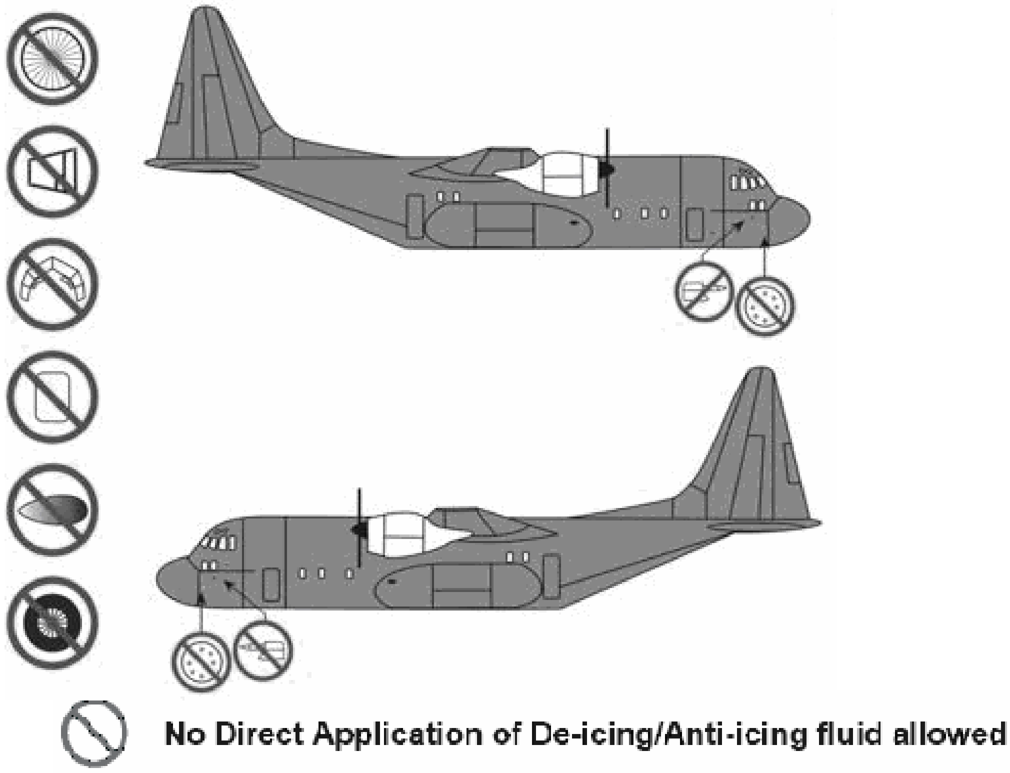


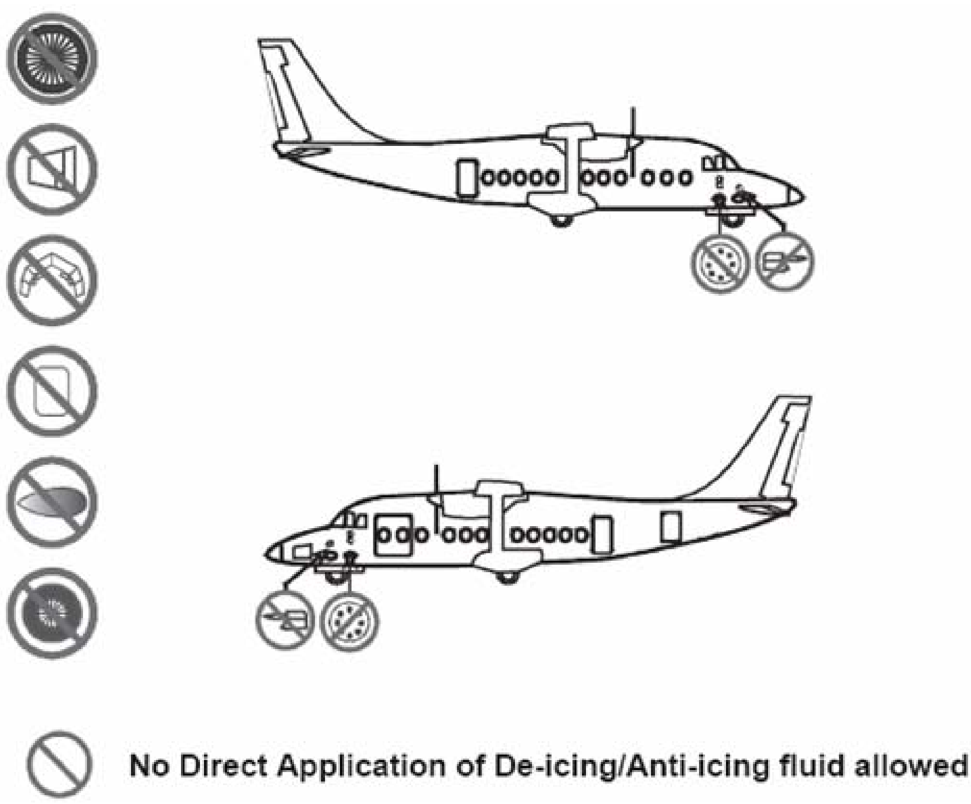
1.2.36 Saab SF-340



1.2.37 C-130 Hercules



1.2.38 Shorts 360



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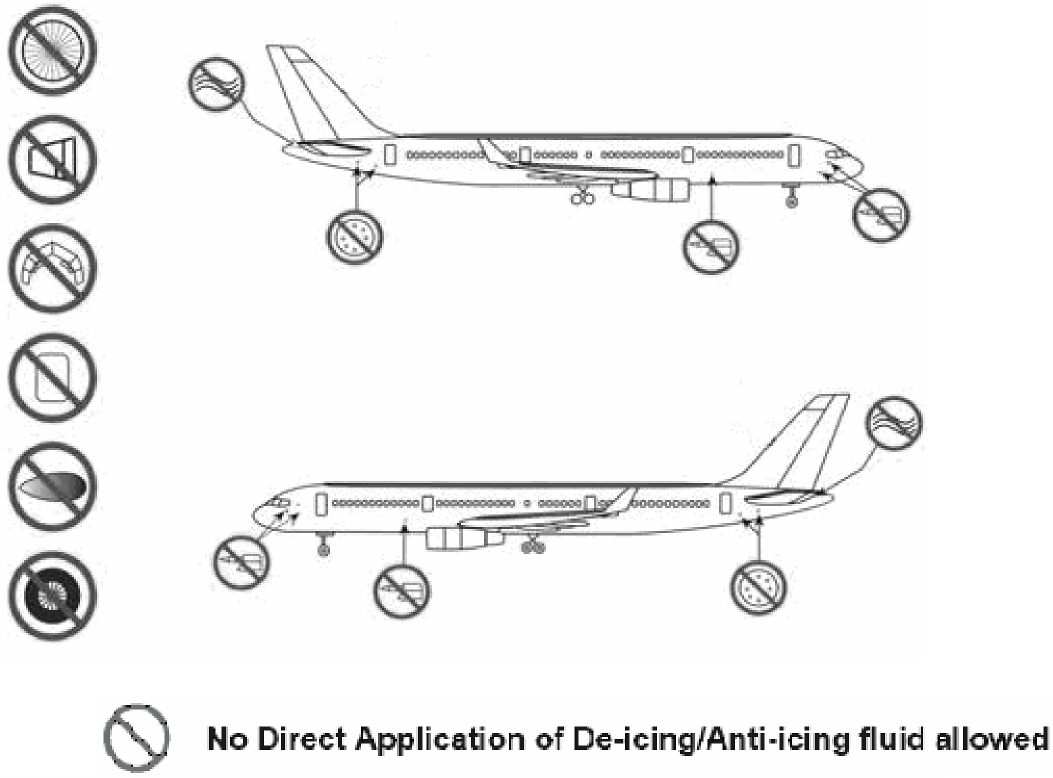
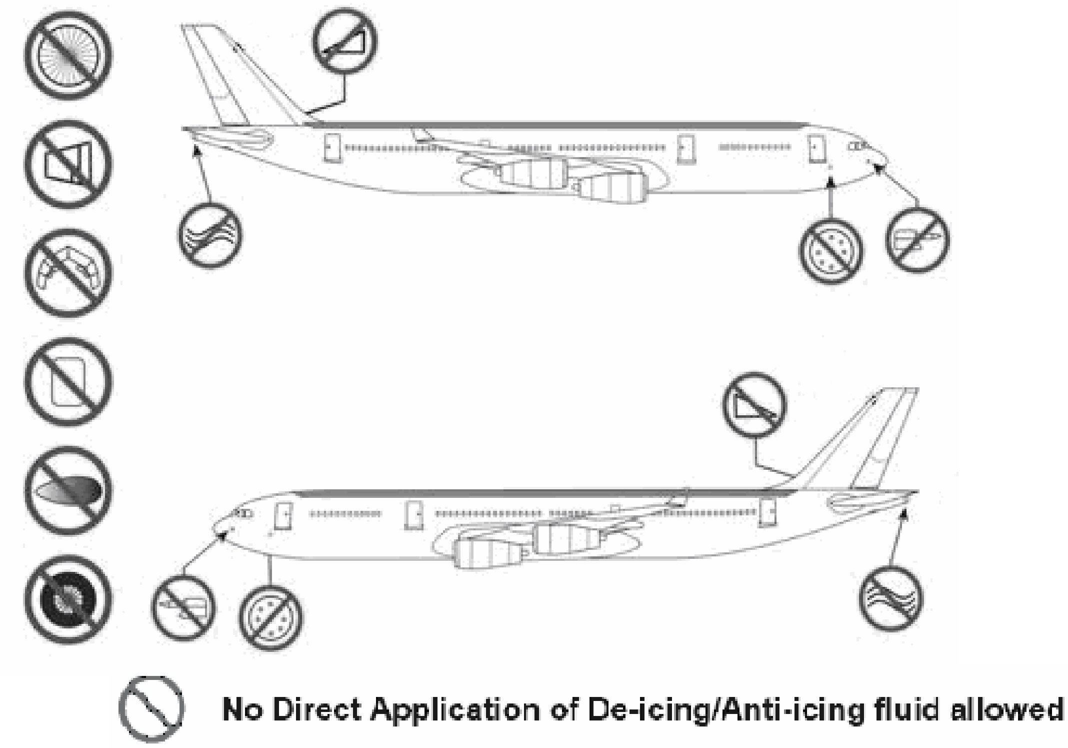
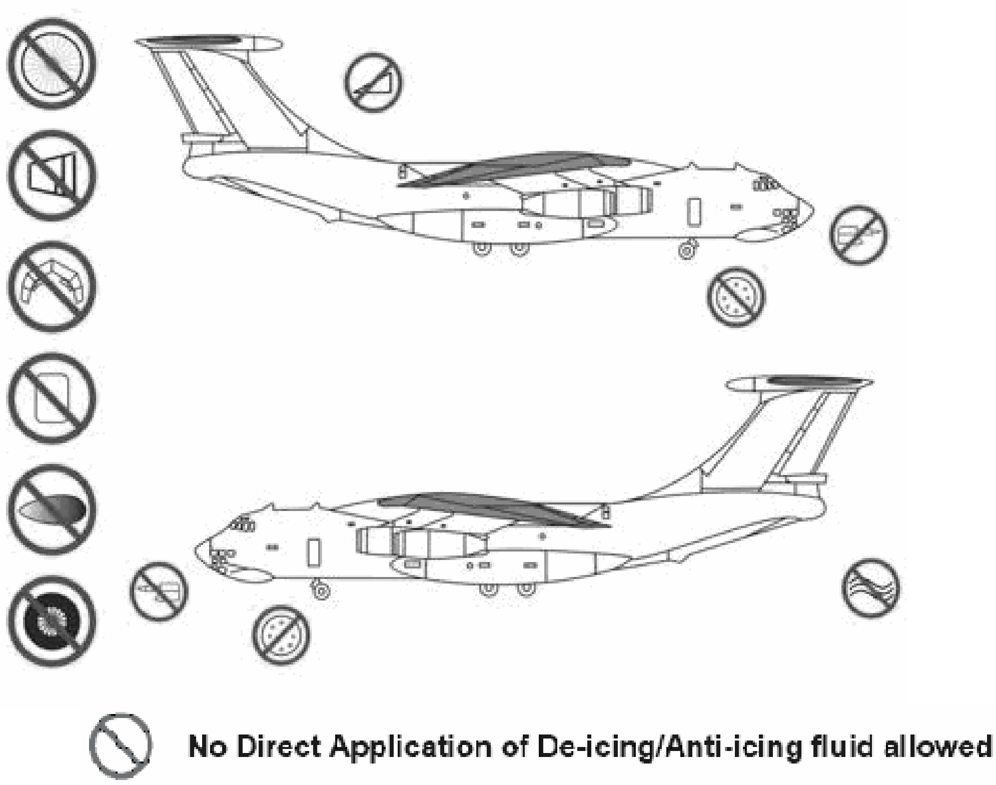


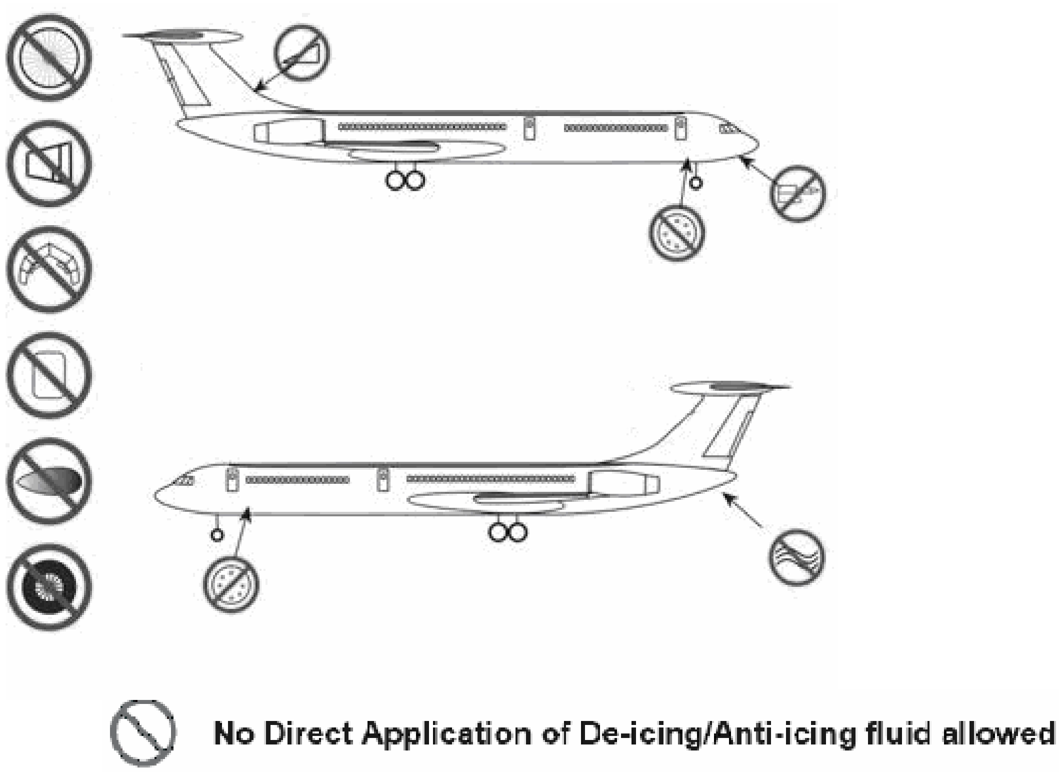
1.2.40 Ilyushin 96



1.2.41 Ilyushin 76



1.2.42 Ilyushin 62



ANNEX B

Abbreviations

5th Edition
September 2008

Association of
European Airlines

1 ANNEX B

1.1 Abbreviations, General

A

A/S	Airspeed
AAA	Amended meteorological message (or AAB, AAC, etc., in sequence)
AAS	Airport Advisory Service
A/C	Aircraft
AC	Advisor Circular
AC	Altocumulus (cloud genera)
ACC	Area Control Center or Area Control
ACI	Airports Council
AD	Advisory Directive
AD	Airworthiness Directive
ADF	Aircraft De-icing Facility
AEA	Association of European Airlines
AECMA	The European Association of Aerospace Industries
AFIS	Aerodrome Flight Information Service
AFTN	Aeronautical Fixed Telecommunication Network
AIC	Aeronautical Information Circular
AIM	Aeronautical Information Message (Manual)
AIP	Aeronautical Information Publication
AIS	Aeronautical Information Service
ALT	Alternate, Altitude
ALT	Altitude
AMD	Amended Meteorological Message
AMIL	Anti-icing Material International Laboratory
AMM	Aircraft Maintenance Manual
AMSL	Above Mean Sea Level
ANT	Antenna
AO	Aircraft Operator
AOA	Angle of Attack
AP	Autopilot
APP	Approach Control (office)
APS	
APU	Auxilary Power Unit
ARP	Aerodrome Reference Point
ARR	Arrival
AS	Altostratus (cloud genera)
ASN	Aviation Safety Network
ASR	Airport Surveillance Radar
ASRS	Aviation Safety Reporting System
ASSW	Associated with
ATA	Actual Time of Arrival
ATAG	Air Transport Action Group
ATC	Air Traffic Control
ATCT	Air Traffic Control Tower
ATFM	Air Traffic Flow Management
ATD	Actual Time of Departure
ATIS	Automated Terminal Information Service
ATS	Air Traffic Services

B

BARO	Barometric
BASE	Cloud base
BAT	Battery
BKN	Broken (5/8-7/8)
BLDT	Boundary layer displacement thickness
BLO	Below clouds
BLW	Below...
BRK	Brake
BTL	Between layers
BTN	Between...

C

C	Centigrade
CA	Cabin Attendant
CAA	Civil Aviation Administration
CAA	Civil Aviation Authorities
CANSO	Civil Air Navigation Services Organisation
CAPT	Captain
CASA	Computer Assisted Slot Allocation
CAT	Clear Air Turbulence
CB	Cumulonimbus (cloud genera)
CC	Cirrocumulus (cloud genera)
CCA	Corrcted Meteorological Message (or CCB, CCC, etc..., in sequence)
CDF	Centralized De-icing Facility
CEN	Committé Europeén de Normalisation (European Committee for Standardization)
CG	Center of Gravity
CI	Cirrus (cloud genera)
CLD	Cloud
CLR	Clear
CM	Centimeter
CNL	Cancelled
CNS	Continuous
COM	Communication
COMPT	Compartment
COR	Corrected, Correct
COORD	Coordination, Coordinator
COT	At the coast
COV	Covered
CP	Control Panel
CS	Cirrostratus (cloud genera)
CTOT	Calculated Takeoff Time
CU	Cumulus (cloud genera)
CUF	Cumuliform
CWR	Cockpit Voice Recorder

D

DAILY	Daily Check
DEG	Degrees
DENEB	Fog dispersal operations
DEV	Deviation
DEP	Departure

DEST	Destination
DGAC	Direction Générale de l'Aviation Civile
DIF	Diffuse
DIR	Direction
DP	Dewpoint temperature
DUC	Dense upper cloud

E

EA	Each
EASA	European Aviation Safety Agency
EBAA	European Business Aviation Association
EC	European Commission
ECAC	European Civil Aviation Conference
EEA	European Express Association
ELEV	Elevator
EMBD	Embedded in a layer
EMER	Emergency
EPA	Environmental Protection Agency
ERAA	European Regions Airline Association
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
EU	European Union
EU	European Union
EUROCONTROL	European Organisation for the Safety of Air Navigation
EXT PWR	External power

F

FAA	Federal Aviation Administration
FADS	Forced Air Deicing Systems
FBL	Light
FBO	Fixed Base Operator
FCST	Forecast
FIC	Flight Information Centre
FIDS	Flight Information Display System
FIR	Flight Information Region
FIS	Flight Information Service
FL	Flight Level
FLT	Flight
FLUC	Fluctuating, Fluctuation
FO	First Officer
FOD	Foreign Object Damage
FP	Freezing Point
FPD	Freezing Point Depressant
FRONT	Weather Front
FRQ	Frequent
FSF	Flight Safety Foundation
FT	Feet
FWD	Forward
FZ	Freezing

G

G	Gram (g)
GA	General Aviation

GMT	Greenwich Mean Time
GND	Ground
GRID	Processed meteorological data in the form of grid point values
GSE	Ground Support Equipment
GVC	General Visual Check
H	
H	Hours
H24	Continuous day and night service
HHET	High Humidity Endurance Test
HLD	Hold
HO	Service available to meet operational requirements
HOT	Holdover Time
HS	Service available during hours of scheduled operations
HURCN	Hurricane
HVY	Heavy
Hz	Herz
I	
IACA	International Air Carrier Association
IAO	In and out of clouds
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
ICE	Icing
IFA	International Federation of Airworthiness
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
IMPR	Improve, Improving
INBD	Inboard
INC	In cloud
INOP	Inoperative
INTL	International
INTSF	Intensifying
IR	Infrared
ISA	International Standard Athmosphere
ISO	International Organisation for Standardization
ISO	International Standardization Organisation
ISOL	Isolated
J	
JAA	Joint Aviation Authorities
JAR	Joint Aviation Requirements
JTST	Jet stream
K	
KG	Kilogram
KM	Kilometer
L	
L	Litre (l)
L/G	Landing Gear
LAN	Inland
LBS	Pounds

LH	Lefthand
LOC	Locally
LOUT	Lowest Operational Use Temperature
LSQ	Line Squall
LV	Light and Variable (relating to wind)
LYR	Layered

M

M	Meter
MAC	Mean Aerodynamic Chord
MAR	At sea
MECH	Mechanic
MEL	Minimum Equipment List
MG	Milligram (mg)
MHz	Megaherz
MIN	Minutes (min)
MISC	Miscellaneous
MLG	Main Landing Gear
MM	Maintenance Manual
MM	Millimeter
MOD	Moderate
MON	Above Mountains
MOV	Moving
MSL	Mean Sea Level
MT	Mountain
MTOW	Maximum Takeoff Weight
MTW	Mountain Waves

N

NA	Not available, Not applicable
NACA	National Aviation Committee for Aeronautics
NASA	National Aeronautics and Space Administration
NC	No Change
NDT	Non Destructive Testing
NIL	No, None
NLG	Nose Landing Gear
NM	Nautical Miles
NOAA	National Oceanic and Atmospheric Administration
NS	Nimbostratus (cloud genera)
NSC	No Significant Clouds
NSW	No Significant Weather
NTP	National Toxiology Program
NTSB	National Transportation Safety Board

O

OAT	Outside Air Temperature
OBS	Observed
OBT	Off Block Time
OCNL	Occasionally
OJT	On Job Training
OPC	Operational Check
OPMET	Operational Meteorological Information
OTP	On Top

OVC	Overcast
P	
P/N	Part number
PAX	Passengers
PFC	Phase Check
PH	Potential of Hydrogen
PIC	Pilot in Command
PPM	Parts Per Million
PROB	Probability
PROP	Propeller
PSI	Pounds per Square Inch
PWR	Power
Q	
QC	Quality Control
QFE	Atmospheric pressure at aerodrome elevation (or at runway threshold)
QNH	Sea level pressure
QTS	Quarts
R	
RAG	Ragged
RAT	Ram Air Turbine
RCC	Rescue Coordination Centre
RDP	Remote De-icing Pad
REF	Reference
REG	Registration
RH	Righthand, Relative Humidity
ROBT	Revised Off Block Time
RPM	Revolutions Per Minute
RRA	Delayed meteorological message (or RRB, RRC, etc..., in sequence)
RT/E	Radio Telephony/English
RVR	Runway Visual Range
RWY	Runway
S	
SAE	Society of Automotive Engineers
SAR	Search And Rescue
SC	Stratocumulus (cloud genera)
SCT	Scattered
SEV	Severe
SFC	Surface
SIGWX	Significant Weather
SKC	Sky Clear
SLW	Slow
SMI	Scientific Material International
SPC	Special Check
ST	Stratus (cloud genera)
STA	Station
STD	Standard
STD	Stand
STF	Stratiform
STNR	Stationary

SWC	Significant Weather Chart
T	
TC	Transport Canada
TCU	Towering cumulus
TDO	Tornado
TEMP	Temperature
T/O	Take Off
TOP	Cloud Top
TROP	Tropopause
TURB	Turbulence
TVC	Thorough Visual Check
TWR	Aerodrome Control, Control Tower
TYPH	Typhoon
U	
U/S	Unserviceable
UNL	Unlimited
UTC	Coordinated Universal Time
V	
V_1	Takeoff decision speed
V_2	Minimum takeoff safety speed
VC	Vicinity of the aerodrome
VER	Vertical
VHF	Very High Frequency
VIS	Visibility
VMC	Visual Meteorological Conditions
V_r	Rotation speed
VRB	Variable
W	
WAC	Walk Around Check
WDSPR	Widespread
WKN	Weaken, Weakening
WS	Wind Shear
WSET	Water Spray Endurance Test
WSI	Weather Service International
WTSPT	Waterspout
WX	Weather
WXR	Weather Radar

1.2 Abbreviations, Weather

A	
ATIS	Air traffic information service
AUTOMETAR	Aerodrome observation made by the wind to a height of 6 feet or more above the ground
B	
BLSN	Snow storm/snow raised by the wind to a height of 6 feet or more above the ground

C	
C	Celsius (°C Degrees Celsius)
CNS	Continuous
D	
DEG	Degrees
DENEB	Fog dispersal operations
DP	Dew point temperature
DRSN	Snow raised by the wind to less than 6-ft. above ground level
DZ	Drizzle
F	
F	Fahrenheit (°F Degrees Fahrenheit)
FCST	Forecast
FG	Fog
FP	Freezing point
FRONT	Weather front
FRQ	Frequent
FZ	Freezing
FZRA	Freezing/super cooled rain
FZDZ	Freezing/super cooled drizzle
G	
GR	Grain
GR/GS	Hail/small hail or snow pellets
H	
H24	Continuous day and night service
HVY	Heavy
I	
IC	Ice crystal (diamond dust)
ICE	Icing
IMPR	Improve, improving
INTSF	Intensifying
ISA	International standard atmosphere
ISOL	Isolated
L	
LOC	Locally
M	
METAR	Routine aerodrome observation in the METAR code
METREP	Local routine aerodrome observation
MOD	Moderate
MOV	Moving
MSL	Mean Sea level
N	
NC	No change
NIL	No, none
NSW	No significant weather

O	
OAT	Outside air temperature
OBS	Observed
OCNL	Occasionally
P	
PL	Ice pellets
PROB	Probability
R	
RA	Rain
RASN	Rain and snow mixed, sleet (slush)
S	
SADIS	Satellite distribution system of meteorological data
SEV	Severe
SFC	Surface
SG	Snow grain
SH	Shower
SIGWX	Significant weather
SKC	Sky clear
SLW	Slow
SN	Snow
SNRA	Snow and rain mixed, sleet (slush)
SPECIAL	Special aerodrome observation in METAR code
STNR	Stationary
SWC	Significant weather chart
T	
TAF	Aerodrome forecast
TREND	TREND-type landing forecast
TS	Thunderstorm
U	
UNL	Unlimited
UTC	Coordinated Universal time
V	
VRB	Variable
W	
WKN	Weaken, weakening
WX	Weather

ANNEX C

Bibliography and Links

5th Edition
September 2008

Association of
European Airlines

1 ANNEX C

1.1 Bibliography

The reference material mentioned here is intended for the reader as sources for further study in relevant subjects. There are different publications for different areas of operation and all of this material mentioned here is not intended to be acquired for de-icing operations and training. There is a large amount of material not mentioned here and this can be found via major organisations and their own publications. This material referenced below is not necessarily up-to-date and it is up to the reader to use only current standards and recommendations.

AEA	Recommendations for De-icing/Anti-icing of Aircraft on the Ground
Boeing	BW 2001-12, McDonnel Douglas Airworthiness Directive Correction Large Aircraft, 2001-06-16 McDonnel Douglas: Amendment 39-12163, Docket 98-NM-326-AD, Applicability: All Model DC9-81, -82, -83 and –87 series airplanes and Model MD-88 airplanes; certified in any category
Boeing	Winter Operations - Keep It Clean, Boeing Airliner magazine, Oct.-Dec. 1983. Cold Weather Operation, Boeing Airliner magazine, Oct.-Dec. 1982. PT-2 Engine Inlet Probe Icing, Boeing Airliner magazine, Oct.-Dec. 1982
CEN	EN 1915-1:2001, Aircraft Ground Support Equipment-General Requirements-Part 1:Basic Safety Requirements
CEN	EN 12312-6:2001, Aircraft Ground Support Equipment - Specific Requirements - Part 6: Deicers, Deicing Equipment
CEN	EN 30011-1:1993, Guidelines for Auditing Quality Systems-Part 1:Auditing (identical with ISO 10011-1:1990)
CEN	EN ISO 9004, Quality Management Systems-Guidelines for Performance Improvements (ISO 9004:2000)
DGAC	Flight In Icing Conditions, On behalf of French DGAC
EPA	Preliminary Data Summary, Airport De-icing Operations, United States Environmental Protection Agency
FAA	AC 120-117, Hazards Following Ground De-icing and Ground Operations in Conditions Conducive to Aircraft Icing
FAA	AC 120-58, Large Aircraft Ground De-icing, Pilot Guide
FAA	AC 120-60, Ground De-icing Anti-icing Program
FAA	AC 135-16, Ground De-icing and Anti-icing Training and Checking
FAA	AC 135-17, Small Aircraft Ground De-icing, Pilot Guide
FAA	AC 150/5300-14, Change 2, Design of Aircraft De-icing Facilities
FAA	AC 23.1419-2B, Certification of Part 23 Airplanes for Flight in Icing Conditions

FAA AC 23.143-1, Ice Contaminated Tailplane Stall (ICTS)

FAA AC 91-51A, Effect of Icing on Aircraft Control and Airplane De-ice and Anti-ice Systems

FAA FAR 121.629, Operation in Icing Conditions

FAA Federal Aviation Administration, William J. Hughes Technical Center, DOT/FAA/AR-00/37, Report of the 12A Working Group on Determination of Critical Ice Shapes for the Certification of Aircraft

FAA Federal Aviation Administration, William J. Hughes Technical Center, DOT/FAA/AR-00/40, Hot Water De-icing of Aircraft

FAA Federal Aviation Administration, William J. Hughes Technical Center, DOT/FAA/AR-00/55, History, Processing, and Usage of Recycled Glycol for Aircraft De-icing and Anti-icing

FAA Federal Aviation Administration, William J. Hughes Technical Center, DOT/FAA/AR-01/13, Anti-icing Endurance Time Tests of Two Certified SAE Type I Aircraft De-icing Fluids

FAA Federal Aviation Administration, William J. Hughes Technical Center, DOT/FAA/AR-01/91, A History and Interpretation of Aircraft Icing Intensity Definitions and FAA Rules for Operating in Icing Conditions

FAA Federal Aviation Administration, William J. Hughes Technical Center, DOT/FAA/AR-02/107, Outdoor Testing of Type I Fluids in Snow

FAA Federal Aviation Administration, William J. Hughes Technical Center, DOT/FAA/AR-02/68, Effect of Residual and Intercycle Ice Accretion on Airfoil Performance

FAA Federal Aviation Administration, William J. Hughes Technical Center, DOT/FAA/AR-99/18, Survey of Nonglycol and Reduced Glycol Aircraft De-icing Methods

FAA Federal Aviation Administration, William J. Hughes Technical Center, DOT/FAA/AR-00/14, Effects of Large-Droplet Ice Accretion on Airfoil and Wing Aerodynamics and Control

FAA Order 8400.10, FAA-Approved De-icing Program Updates

FAA AC-00-6A, Aviation Weather

FAA AC-60-14, Aviation Instructor's Handbook

FAA AC-00-45C, Aviation Weather Services

FSF Flight Safety Digest, Protection Against Icing: A Comprehensive Overview, Flight Safety Foundation

IATA IATA, AHM, Airport Handling Manual

IATA IATA, IOSA, IATA Operational Safety Audit

IATA IATA, DAQCP, De-icing/Anti-icing Quality Control Pool

ICAO ICAO, Doc 9640-AN/940, Manual of Aircraft Ground De-icing/Anti-icing Operations

ICAO ICAO, Doc 8643, Aircraft Type Designators

ICAO	ICAO Annex 10 Vol. II, PANS-RAC Doc 4444, Doc 9432-A/925, Manual of Radiotelephony
ICAO	ICAO 9835, Manual on the Implementation of ICAO Language Proficiency Requirements
ISO	11075, Aerospace-Aircraft De-icing/Anti-icing Newtonian Fluids
ISO	11076, Second Edition, Aerospace-Aircraft De-icing/Anti-icing Methods with Fluids
ISO	11077, First Edition, Aerospace-Self Propelled De-icing/Anti-icing Vehicles-Functional Requirements
ISO	11078, Aerospace-Aircraft De-icing/Anti-icing Non-Newtonian Fluids
ISO	9001, Third Edition, Quality Management Systems-Requirements
JAA	JAR-OPS 1 Subpart D – 1.345, Ice and other contaminants-[ground procedure]
JANE'S	Jane's All the World's Aircraft
JP	JP Airline-Fleets International
NASA	Addy, Jr,. H.E., Ice Accretions and Icing Effects for Modern Airfoils, NASA TP-2000-210031
NASA	Bernstein, B.C., Ratvasky, T.P., Miller, D.R., and McDonough, F., Freezing Rain as an In-Flight Icing Hazard, NASA TM-2000-210058
NASA	NASA Glenn Research Center, A Pilots Guide to In-Flight Icing
NASA	NASA Glenn Research Center, Icing for General Aviation Pilots
NASA	NASA Glenn Research Center, Icing for Regional and Corporate Pilots
NASA	NASA Glenn Research Center, Tailplane Icing
NASA	Ratvasky, T.P., Van Zante, J.F., and Sim, A., NASA/FAA Tailplane Icing Program:Flight Test Report, NASA TP-2000-209908, DOT/FAA/AR-99/85
NTP	NTP-CERHR-PG-03, NTP-CERHR Expert Panel Report on the Reproductive and Developmental Toxicity of Propylene Glycol, National Toxicology Program U.S. Department of Health and Human Services
SAE	AMS 1424, Deicing/Anti-Icing Fluid, Aircraft SAE Type-I
SAE	AMS 1425, Deicing Fluid, Aircraft, Ethylene Glycol Base
SAE	AMS 1426, Fluid, Deicing/Anti-Icing, Runways and Taxiways Glycol Base
SAE	AMS 1427, Deicing/Anti-Icing Fluid, Aircraft, Propylene- Glycol Base
SAE	AMS 1428, Fluid, Aircraft Deicing/Anti-Icing, Non-Newtonian (Pseudoplastic), SAE Types II, III and IV, October 1998
SAE	AMS 1431, Compound, Solid Runway and Taxiway Deicing/Anti-Icing
SAE	AMS 1435, Fluid, Generic, Deicing/Anti-Icing Runways and Taxiways

SAE	ARP 1247, General Requirements for Aerospace Ground Support Equipment Motorized and Nonmotorized
SAE	ARP 1971, Aircraft Deicing Vehicle – Self Propelled, Large and Small Capacity
SAE	ARP 4737, Aircraft Deicing/Anti-Icing Methods
SAE	ARP 4806, Aerospace – Deicing/Anti-Icing Self-Propelled Vehicle Functional Requirements
SAE	ARP 4902, Design and Operation of Aircraft Deicing Facilities
SAE	ARP 5058, Enclosed Operators Cabin for Aircraft Ground Deicing Equipment
SAE	ARP 5149, Training Program Guidelines for Deicing/Anti-Icing of Aircraft on Ground
SAE	AIR 1335, Ramp Deicing
SAE	AIR 9968, Field Viscosity Test of Thickened Aircraft Deicing/Anti-Icing Fluids
SAE	AS 5537, Weather Support to De-icing Decision Making (WSDDM) Winter Weather Nowcasting System
SAE	AS 5635, Message Boards (Deicing Facilities)
SAE	AS 5681, Minimum Operational Performance Specification for Remote On-Ground Ice Detection Systems
SAE	AS 5900, Standard Test Method for Aerodynamic Acceptance of SAE AMS 1424 and SAE AMS 1428 Aircraft Deicing/Anti-Icing Fluid
SAE	AS 5901, Water Spray and High Humidity Endurance Test Methods for SAE AMS 1424 and SAE AMS 1428 Aircraft Deicing/Anti-Icing Fluid
SAE	AS 8243, Anti-icing and Deicing-Defrosting Fluids

1.2 Internet links

The links mentioned here are intended for the reader as a source for further study in relevant subjects. No stand is taken on behalf of any company or organisation.

AEA	http://www.aea.be
ACI	http://www.airports.org/
AMIL	http://www.uqac.ca/amil/amil/amil.htm
APS	http://www.adga.ca/aps/index.asp
ASN	http://aviation-safety.net/index.shtml
ASRS	http://asrs.arc.nasa.gov/
ASTM	http://www.astm.org/
ATAG	http://www.atag.org/content/default.asp
ATI	http://www.rati.com/
Aviation Web Guide	http://aeroflt.users.netlink.co.uk/guide/avweb.htm
CEN	http://www.cenorm.be/
DAQCP	http://www.daqcp.info
DFT	http://www.dft.gov.uk/
DGAC	http://www.dgac.fr/
EADS	http://www.eads.net/
EASA	http://www.easa.eu.int/
EC	http://europa.eu.int/index_en.htm
ECAC	http://www.ecac-ceac.org/
EPA	http://www.epa.gov/fedrgstr/index.html
ERAA	http://www.eraa.org/
EUROCONTROL	http://www.eurocontrol.fr/
FAA	http://www1.faa.gov/
FSF	http://www.flightsafety.org/
GOFIR	http://www.gofir.com/
IATA	http://www.iata.org/index.htm
ICAO	http://www.icao.int/
IFA	http://www.ifairworthy.org/
IHS	http://www.ihserc.com/
International CAA	http://www.intl.faa.gov/civilauths.cfm
ISO	http://www.iso.ch/iso/en/ISOOnline.openerpage
JAA	http://www.jaa.nl/
JRC	http://www.jrc.cec.eu.int/
NASA	http://www.nasa.gov/
NLR	http://www.nlr.nl/public/index.html
NOAA	http://www.nws.noaa.gov/
NTP	http://cerhr.niehs.nih.gov/
NTSB	http://www.ntsb.gov/default.htm
SAE	http://www.sae.org/servlets/index
SMI	http://www.smiinc.com/
SRC	http://www.eurocontrol.int/src/index.html
TC	http://www.tc.gc.ca/

ANNEX D

Training Syllabus

5th Edition
September 2008

TABLE OF CONTENTS

1 ANNEX D

1.1 Standard Teaching Plan (STP)

The following pages contain a generic Standard Teaching Plan. The STP is a guide to de-icing/anti-icing training and includes all of the required minimum elements that should be included in a training session, as detailed in the AEA De-icing / Anti-icing Training Recommendations. The STP is in two parts, part 1 covers the theoretical elements of training and part 2 covers the practical training. The STP is not designed to be a training syllabus but as a high level guide from which individual, detailed lesson plans can be developed, and should be used for both initial and refresher training. The STP is made up as follows:

1.1.1 Subject

This column contains all of the main subject headers that should be included in all de-icing / anti-icing training. The STP represents what is considered to be the minimum required content and operators / providers can include additional elements into the training as required.

1.1.2 Objective

This column is self-explanatory and indicates the aims of the teaching.

1.1.3 Content

This column represents the minimum subject content of each main subject heading. Operators/providers are free to include any additional content as required.

1.1.4 Reference

The reference column gives an indication where subject information can be found in the background information

1.1.5 Teaching Aid

Items shown in this column are only representative of what can be used as a teaching aid; they do not represent a minimum requirement. Operators/providers are free to use any other medium available to them. It is accepted that for most operators, having the use of an aircraft for practical training purposes is very limited. Some examples of how this can be overcome are, firstly, 'use cones to mark out the shape of an aircraft on the ground'. This can be invaluable when practicing driving around an aircraft. Secondly, in the absence of an aircraft for spraying practice, a flat bed truck or a row of empty baggage containers could be used to simulate a wing surface.

1.1.6 Timescale

The times shown in this column are the minimum recommended times and are based on a representative de-icing/anti-icing operation (e.g. an airport with 90 winter operation days/2000 de-icing/anti-icing frost and snow events per year). There are a wide variety of winter seasons and winter operations, and the length of the training should be adjusted accordingly. The operator/provider is free to increase the time allowed for training in each or all of the elements as required. (E.g. to further enhance practical experience in equipment handling, in reducing amounts of fluid sprayed, to include a variety of winter conditions etc.). However, the minimum level of training should be covered in all cases.

1.1.7 Who

This column lists the persons to whom each element is aimed as a minimum. For ease, operators / providers may choose to include all categories of persons in all of the training. The codes used are in line with those listed in the AEA De-icing / Anti-icing Training Recommendations.

1.2 Theoretical Element

SUBJECT	OBJECTIVE	CONTENT (to include as minimum)	REFERENCE	TEACHING AID	TIMESCALE	WHO
Introduction	To state	Introduce self How you qualify to train subject, knowledge and experience etc. Overview of course content Requirement for validation exam and pass mark			15mins	
Standards, regulations and recommendations	To identify	Industry bodies AEA SAE ISO Regulations EASA, EU Ops, EASA Part-66 Recommendations AEA – Training Recommendations and Background Information for De-icing / Anti-icing of Aircraft on the Ground SAE – ARP 4737 / 5149 – Methods / Training Programme Guidelines for De-icing / Anti-icing of Aircraft on the Ground ISO – 11076 – Aircraft De-icing / Anti-icing methods with fluids	Section 1	AEA / SAE Documents JAR-Ops statement	30mins	DI-L10 DI-L20 DI-L30 DI-L30B DI-L40 DI-L50 DI-L60 DI-L70 DI-L80
Basic knowledge of aircraft performance	To list To explain	Aerodynamic forces: Lift – Weight - Thrust - Drag How each is achieved and how they can work against each other / with each other to achieve and maintain steady level flight.	Sections 3.1.1 – 3.1.5	Model aircraft wing	30mins	DI-L10 DI-L30 DI-L30B DI-L40 DI-L50 DI-L70

SUBJECT	OBJECTIVE	CONTENT (to include as minimum)	REFERENCE	TEACHING AID	TIMESCALE	WHO
Effects of frozen contaminants on aircraft performance	To explain	How frozen contaminants can cause; Loss of Lift Increased stall speed Increased Weight Increased Drag Reduce aircraft performance	Section 3.1.4 – 3.1.4.3	DVD / Video (e.g. Ice Aware)	30mins	DI-L10 DI-L30 DI-L30B DI-L40 DI-L50 DI-L70 DI-L80
What are frozen contaminants	To list and describe each of;	Types Frost / Hoar Frost Freezing Fog Freezing Drizzle Freezing Rain Rain and snow Snow Slush Rime Ice Hail Rain on a cold soaked wing	Section 4.1.2	Handout	30mins	DI-L10 DI-L30 DI-L30B DI-L40 DI-L50 DI-L70 DI-L80
Weather terminology and causes of icing conditions	To list and describe each of;	Weather terminology Temperature Precipitation Cold front Warm front Dew point Relative humidity Cold soak effect Describe how certain weather phenomena can cause the formation of ice and/or other frozen deposits.	Sections 4.1 - 4.1.1 4.1.3 – 4.1.8 Annexe B	Handout	30mins	DI-L10 DI-L30 DI-L30B DI-L40 DI-L50 DI-L70 DI-L80 DI-L80B

SUBJECT	OBJECTIVE	CONTENT (to include as minimum)	REFERENCE	TEACHING AID	TIMESCALE	WHO
Make-up and characteristics of fluids, causes of fluid degradation and consequences of fluid residues'	To describe To explain	Fluid Types Type I fluid Type II fluid Type III fluid Type IV fluid Manufacturers safety data sheets (MSDS) Characteristics Fluid content / colours Thickening agents Viscosity 'Shear Off' of fluids Fluid residues and problems resulting from them Fluid degradation (e.g. storage, handling, shelf life etc.) Reference should also be made to 'water' as a de-icing medium.	Sections 5.1.1 6.1 – 6.1. 6.3 10.1 – 10.3	Fluid samples MSDS's	90mins	DI-L10 DI-L30 DI-L40 DI-L50 DI-L60 DI-L70 DI-L80
Instruments used for fluid measurements (e.g. Refractometer)	To describe To demonstrate To explain	Components of instrument How it is used (including student participation) Fluid / water mixes Refractive index Frequency of checks /Documentation	Sections 6.1.6.3 13.2.1 – 13.2.1.1	Sample Instrument (e.g. Refractometer)	15mins	DI-L10 DI-L30 DI-L40 DI-L50 DI-L60 DI-L70 DI-L80

SUBJECT	OBJECTIVE	CONTENT (to include as minimum)	REFERENCE	TEACHING AID	TIMESCALE	WHO
Specific critical aircraft areas	To identify	Critical surfaces Wings – leading edge, upper and lower surfaces Ailerons Flaps Horizontal and vertical stabilisers	Sections 7.2.2	Diagrams / Photos Aircraft Model	60mins	DI-L10 DI-L20 DI-L30 DI-L30B DI-L40 DI-L50 DI-L70 DI-L80
Specific critical aircraft areas (cont.)	To identify	Other critical areas Engines/APU's Undercarriage Pitot tubes Static ports Angle of attack sensors Fuselage Reference should also be made to other 'no-spray' areas such as windows and brakes.	Section 7.3.1.1		60mins	
General De-icing and Anti-icing Procedures and Checks	To define To describe To explain	De-icing / Anti-icing What is de-icing? What is anti-icing? Process Single step process Two-step process Mechanical methods (brushes, squeegees etc.) Checks Determination of the need for de-icing Visual and tactile post de-icing checks Pre take-off checks	Sections 7 & 8	Handout	120mins	DI-L10 DI-L20 DI-L30 DI-L40 DI-L50 DI-L70 DI-L80

SUBJECT	OBJECTIVE	CONTENT (to include as minimum)	REFERENCE	TEACHING AID	TIMESCALE	WHO
Fluid application techniques and holdover	To explain To explain To demonstrate	Application Hot fluid Cold fluid No-spray areas Spraying techniques Spray patterns Heat retention Holdover time / calculations What is meant by holdover time? How holdover time is determined Generic tables vs Brand name	Sections 6.1.1 7.3.2 – 7.3.2.3 7.5	Aircraft Model Diagrams / Photos DVD / Video Holdover Chart	60mins	DI-L10 DI-L30 DI-L40 DI-L50 DI-L70 DI-L80
Fluid checks and record keeping	To define	Fluid checks Refractive Index checks Delivery checks Laboratory checks Documentation Fluid quality results	Sections 6.1.6 - 6.1.6.3 13.2.1 – 13.2.1.1	Examples of data recording sheets Copies of Lab test reports	20mins	DI-L10 DI-L20 DI-L30 DI-L40 DI-L50 DI-L60 DI-L70 DI-L80

SUBJECT	OBJECTIVE	CONTENT (to include as minimum)	REFERENCE	TEACHING AID	TIMESCALE	WHO
Anti-icing code and communications	To explain	Anti-icing code Communication Communication to flight crew Operator / driver communication, two-way communication Remote operations, multiple truck operations	Section 7.4.1.1	Demonstrate communication process Copy of post De-icing information sheets	45mins	DI-L10 DI-L20 DI-L30 DI-L30B DI-L40 DI-L50 DI-L70 DI-L80
Safety considerations and precautions, emergency procedures, and environmental considerations	To define To define To explain To define To outline	Human Factors Lessons learned Safety consideration Personal safety (contamination, working at height etc.) Safety of others (contamination, struck by vehicle etc.) Aircraft safety (damage prevention) Safety Precautions Personal Protective Equipment (gloves, visors, clothing etc.) Safety harnesses Vehicle positioning Slippery surfaces (steps, ramp etc.) Emergency Procedures What to do! Who to call! Reporting and investigation of incidents Environmental considerations Spill reporting Waste control (excessive fluid use)	Sections 5 8.1.1 8.2.2 11.1.1 12.2.3	Example PPE Demonstrate use of a Harness Accident reporting forms	60mins	DI-L10 DI-L20 DI-L30 DI-L30B DI-L40 DI-L50 DI-L60 DI-L70 DI-L80

SUBJECT	OBJECTIVE	CONTENT (to include as minimum)	REFERENCE	TEACHING AID	TIMESCALE	WHO
Airline and Aircraft specific procedures (if applicable)		Any airline specific procedures should be imparted		Copy of airline de-icing procedures manual	OPEN	DI-L10 DI-L20 DI-L30 DI-L30B DI-L40 DI-L50 DI-L70 DI-L80
Company and Customer procedures		Local procedures, permits, requirements, documentation and operations		Copy of airline de-icing procedures manual	(30 mins.)	DI-L10 DI-L20 DI-L30 DI-L30B DI-L40 DI-L50 DI-L60 DI-L70 DI-L80 DI-L80B
Theoretical validation test		Validation shall cover all subjects included in the training. Minimum pass mark shall be 75%.			60mins	DI-L10 DI-L20 DI-L30 DI-L30B DI-L40 DI-L50 DI-L60 DI-L70 DI-L80

SUBJECT	OBJECTIVE	CONTENT (to include as minimum)	REFERENCE	TEACHING AID	TIMESCALE	WHO
Theoretical validation test feedback		Test feedback and wrong answers corrected to 100%			10 mins	DI-L10 DI-L20 DI-L30 DI-L30B DI-L40 DI-L50 DI-L60 DI-L70 DI-L80

1.3 Practical Element

SUBJECT	OBJECTIVE	CONTENT (to be included as a minimum)	TEACHING AID	TIMESCALE	WHO
Overview of De-icing / Anti-icing equipment and its operation, and facilities (e.g. storage tanks)	To describe	De-icing/Anti-Icing equipment Vehicle description (type, make etc.) Vehicle equipment (nozzles, guns, tanks etc.) Vehicle operation Safety features Manual vs. proportional mixing Facilities Storage requirements Filling	De-icing truck Filling Station	60mins	DI-L10 DI-L20 DI-L40 DI-L70
Cab Layout and Operation	To explain	Pre-operation checks Seat and mirror adjustment Gear shift selection Park brake Heater / Pump controls Boom controls (if fitted) Communication and connections (headset) Start / Stop Procedures Driving controls (wipers, lights and indicators etc.)	De-icing truck	OPEN	DI-L10 DI-L20 DI-L40 DI-L70
De-icing Unit Control Panel	To describe	Start / Restart / Stop / Emergency Stop Procedures System Indicators Switches	De-icing truck	OPEN	DI-L10 DI-L20 DI-L40 DI-L70

SUBJECT	OBJECTIVE	CONTENT (to be included as a minimum)	TEACHING AID	TIMESCALE	WHO
Basket Operation	To describe To demonstrate	Emergency stop procedures Emergency boom lowering procedures Harness attachment point(s) / Harness use Communications and connections (Headset) Worklight switches Pump delivery selection / pump override / pump delivery Anti-ice / De-ice & Snow gun operation Boom Controls Extend / Retract Raise / Lower / Rotate Personal Protective Equipment	De-icing truck	OPEN	DI-L10 DI-L20 DI-L40 DI-L70
Auxiliary Engine Operation (if fitted)	To explain	Start / restart / stop / emergency stop procedures Manual accelerator control Fire extinguisher operation	De-icing truck	OPEN	DI-L10 DI-L20 DI-L40 DI-L70
Fluid Heater Operation (if fitted)	To demonstrate	Start / Shut down procedures High flame / low flame indicators No flow indicator Low fluid indicator Pump pressure gauge	De-icing truck	OPEN	DI-L10 DI-L20 DI-L40 DI-L70
Ground Hose Operation	To demonstrate	Position of hose Operation of ground gun Fluid flow rate	De-icing truck	10 min (per person)	DI-L10 DI-L20 DI-L40 DI-L70

SUBJECT	OBJECTIVE	CONTENT (to be included as a minimum)	TEACHING AID	TIMESCALE	WHO
Pre-Spray Checks	To explain	All doors / hatches closed All personnel clear Aircraft Configuration	De-icing truck Aircraft (if available)	OPEN	DI-L10 DI-L20 DI-L40 DI-L70
Communication	To define To explain To demonstrate	Communication with Flight Deck / Engineering (i.e. Aircraft Configuration) Anti-icing code Communication between driver and sprayer Multiple vehicle operations, vehicle to vehicle Centralized operation Coordination	De-icing truck Communication tools	10 min (per person)	DI-L10 DI-L20 DI-L30 DI-L30B DI-L50 DI-L40 DI-L70
Vehicle Positioning	To demonstrate	Optimum positioning for spraying Communication with operative Driving safely around the aircraft	De-icing truck Aircraft (if available)	60 min (per person)	DI-L10 DI-L20 DI-L40 DI-L70
Vehicle Safety around Aircraft	To explain	Approaching aircraft (i.e. engines / anti-coll lights) Vehicle brake check Vehicle height Vehicle speed Awareness of other ramp users Accident/Incident reporting and safety reporting	De-icing truck Aircraft (if available)	10 min (per person)	DI-L10 DI-L20 DI-L40 DI-L70
Fluid Spraying	To define To explain To demonstrate	Critical Surfaces No-spray areas Fluid temperature Spraying distance (heat retention) Spray patterns (nozzle settings)	De-icing truck Aircraft (if available), suitable substitute for spraying if a/c not available	1 independent successful event (per person under supervision)	DI-L10 DI-L20 DI-L40 DI-L70

SUBJECT	OBJECTIVE	CONTENT (to be included as a minimum)	TEACHING AID	TIMESCALE	WHO
Other de-/anti-icing procedures	To explain To demonstrate	Pre-de-icing treatments Local frost prevention Related checks	De-icing truck Aircraft (if available)	OPEN	DI-L10 DI-L20 DI-L30B DI-L40 DI-L70
Driving the de-icing truck	To demonstrate	Manoeuvring the vehicle Handling characteristics Emergency situations Fault situation	De-icing truck	30 min (per person)	DI-L10 DI-L20 DI-L40 DI-L70
De-icing scenarious (where applicable)	To explain To demonstrate	Gate de-icing Remote/centralized de-icing Multiple vehicle de-icing	De-icing truck Aircraft (if available)	OPEN	DI-L10 DI-L20 DI-L40 DI-L70
Emergency situations (clarify theoretical elements in practice)	To define To explain To demonstrate	Safety at work Collisions and other accidents Procedures and situations Human Factor situations Environmental control	De-icing truck	OPEN	DI-L10 DI-L20 DI-L30 DI-L40 DI-L70
Quality checks (if applicable)	To explain To demonstrate	Fluids, limits and reporting Sampling Measurement instruments, use of Filling station, fluid quality Fluid delivery	De-icing truck De-/Anti-icing fluids	30 min (per person)	DI-L10 DI-L20 DI-L40 DI-L60 DI-L70
Contamination check	To explain To demonstrate	Different contaminations on the A/C A/C types Clear ice checks, hands on check Reporting/communication Final release, anti-icing code Safety elements, Human Factors	De-icing truck, ladders, stairs or similar equipment Aircraft	OPEN	DI-L10 DI-L20 DI-L30 DI-L30B DI-L40 DI-L70

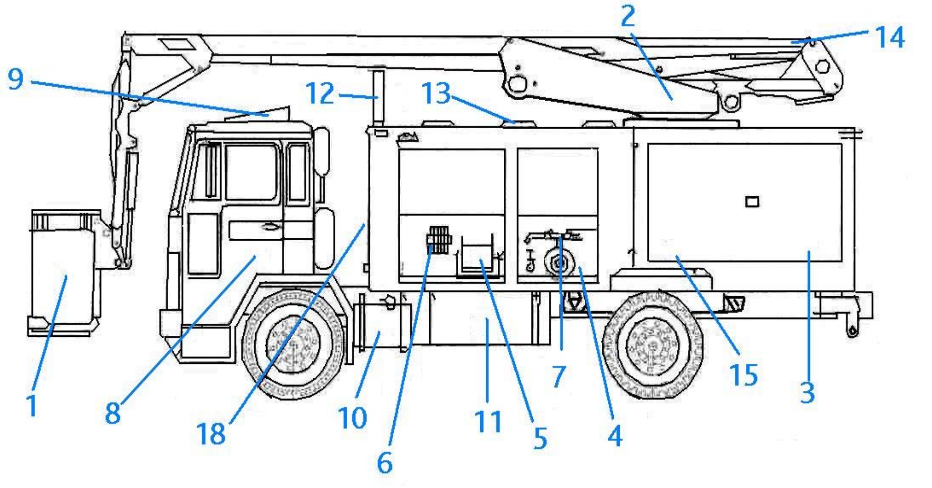
SUBJECT	OBJECTIVE	CONTENT (to be included as a minimum)	TEACHING AID	TIMESCALE	WHO
Spraying and using hot air (Practice as needed)	To explain To demonstrate	Fuselage, underwing, wing and tail Engine/propeller ice Landing gear and instruments	De-icing truck Heater Aircraft (if available)	OPEN	DI-L10 DI-L20 DI-L30 DI-L40 DI-L70
Practical Validation test and feedback		Each student should be able to demonstrate competence in driving / positioning equipment / quality control / communication / reporting and/or spraying (as applicable). Students should also be tested on the operation of the vehicle, in particular, safety aspects and features (as applicable). Actual de-icing/anti-icing operations may be evaluated over a period of time (i.e. events).	De-icing truck Aircraft (if available)	OPEN	DI-L10 DI-L20 DI-L30 DI-L40 DI-L70

1.4 **ICAO LANGUAGE PROFICIENCY RATING SCALE,** Manual on the Implementation of ICAO Language Proficiency Requirements", 9835, International Civil Aviation Organization (2004)

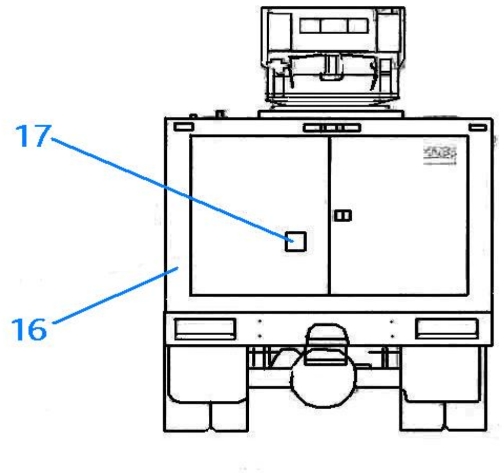
LEVEL	PRONUNCIATION *Assumes a dialect and/or accent intelligible to the aeronautical community.*	STRUCTURE *Relevant grammatical structures and sentence patterns are determined by language functions appropriate to the task.*	VOCABULARY	FLUENCY	COMPREHENSION	INTERACTIONS
Expert 6	Pronunciation, stress, 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. Paraphases 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 occassional 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.
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.

1.5 Typical de-anti-icing vehicle layout

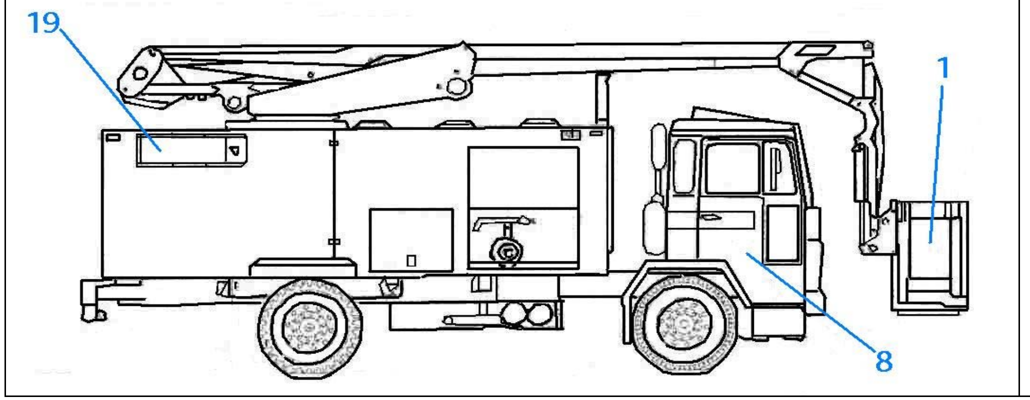
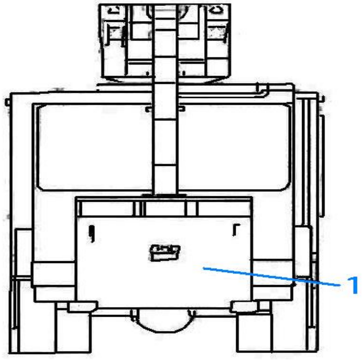
LEFT VIEW



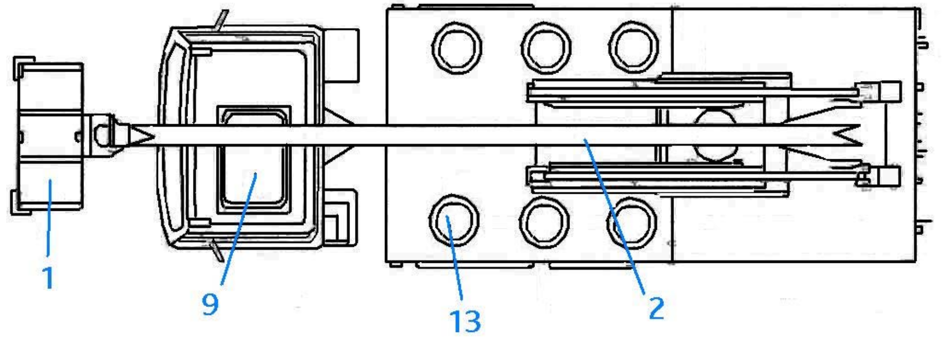
REAR VIEW



1. Operators basket (containing spray guns, communication connections, basket controls, harness point and lights)
2. Hydraulic boom
3. Compartment (containing Donkey Engine, heater and hydraulics)
4. Fluid pump
5. Side gun (under wing nozzle)
6. Emergency boom controls
7. De-icing fluid refill point
8. Truck cab (containing heater controls, gauges, communication connections and driving controls etc)
9. Roof window
10. Truck fuel tank
11. De-icing fuel tank
12. Boom locating point
13. Inspection hatches
14. Beacon light
15. Fluid type (mix)
16. Fire control
17. Fire access point
18. Fluid level gauges
19. Heater exhaust outlet

RIGHT VIEW	FRONT VIEW
	

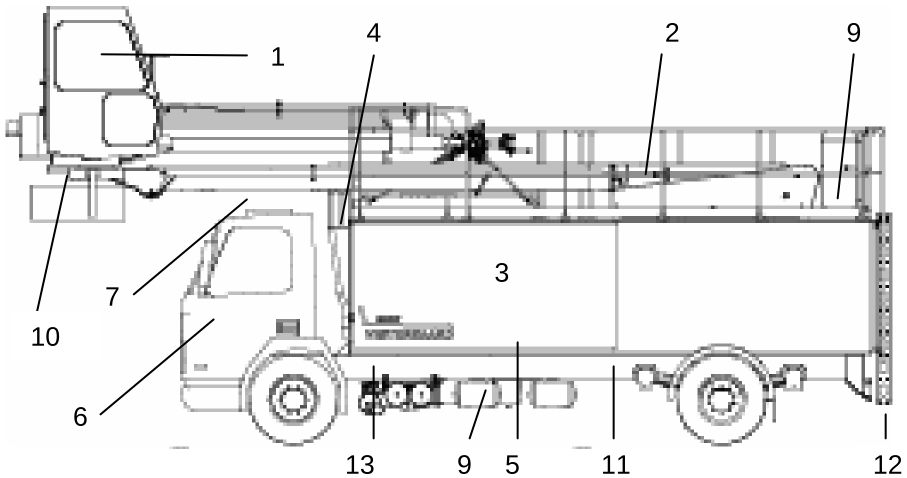
1. Operators basket (containing spray guns, communication connections, basket controls, harness point and lights)
8. Truck cab (containing heater controls, gauges, communication connections and driving controls etc)
19. Heater exhaust outlet

OVERHEAD VIEW


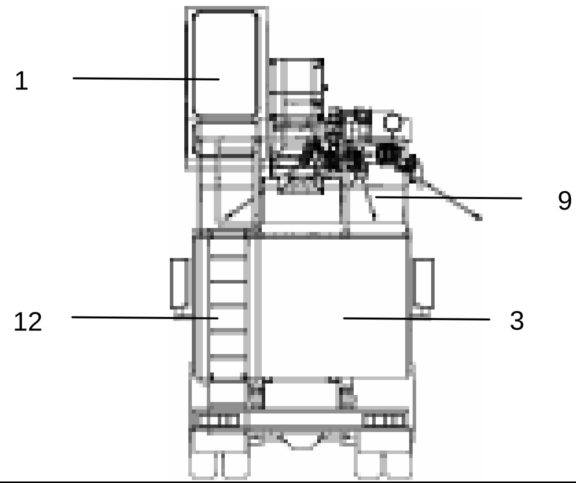
1. Operators basket (containing spray guns, communication connections, basket controls, harness point and lights)
2. Hydraulic boom
9. Roof window
13. Inspection hatches

1.6 Typical de-anti-icing closed cabin vehicle layout

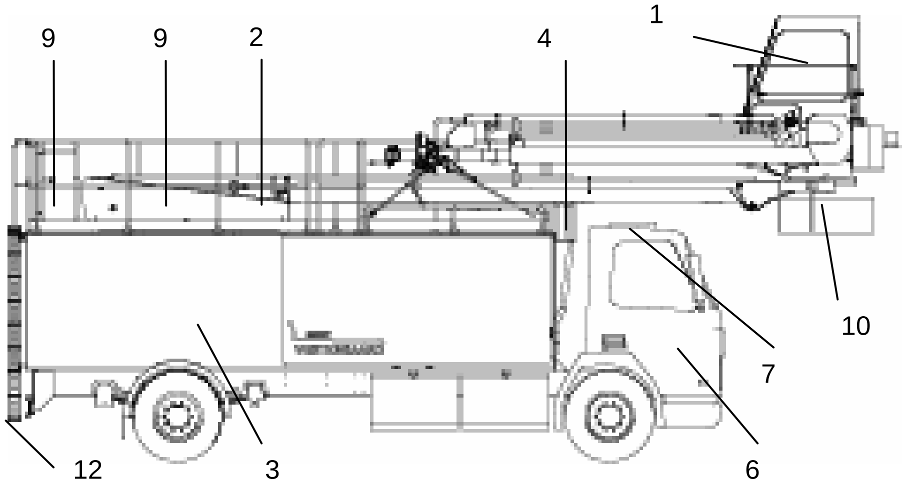
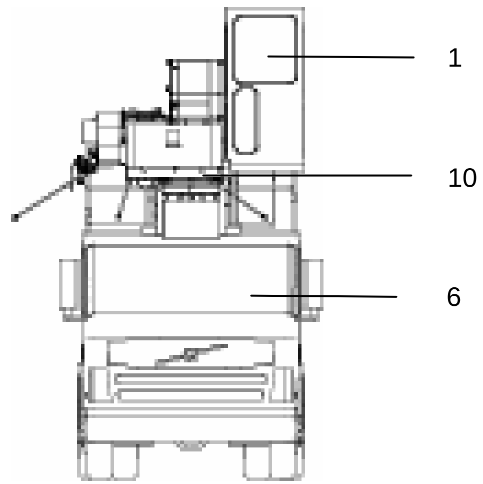
LEFT VIEW



REAR VIEW

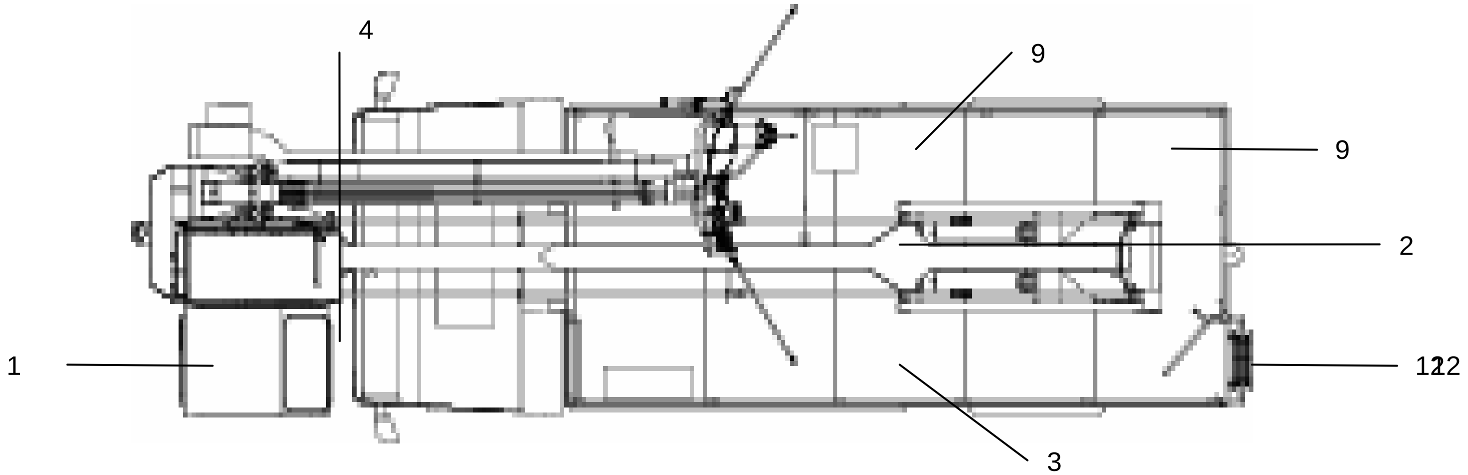


1. Operators enclosed basket (containing nozzle and boom controls, communication equipment, cabin movement controls, optional truck movement controls (1-man-operation))
2. Hydraulic boom
3. Compartment (containing optional Donkey Engine, heater, tanks, fluid pumps and valves, emergency cabin/boom controls and hydraulics)
4. Side gun (under wing nozzle)
5. ADF refill points
6. Truck cabin (containing heater controls, gauges, communication connections, printer and driving controls etc)
7. Roof window
8. Truck fuel tank
9. Inspection hatches
10. Beacon light
11. Fluid level gauges
12. Ladder
13. External power connection and main switch

RIGHT VIEW	FRONT VIEW
	

1. Operators enclosed basket (containing nozzle and boom controls, communication equipment, cabin movement controls, optional truck movement controls (1-man-operation))
2. Hydraulic boom
3. Compartment (containing optional Donkey Engine, heater, tanks, fluid pumps and valves, emergency cabin/boom controls and hydraulics)
4. Side gun (under wing nozzle)
6. Truck cabin (containing heater controls, gauges, communication connections, printer and driving controls etc)
7. Roof window
9. Inspection hatches
10. Beacon light
12. Ladder

OVERHEAD VIEW



1. Operators enclosed basket (containing nozzle and boom controls, communication equipment, cabin movement controls, optional truck movement controls (1-man-operation))
2. Hydraulic boom
3. Compartment (containing optional Donkey Engine, heater, tanks, fluid pumps and valves, emergency cabin/boom controls and hydraulics)
4. Side gun (under wing nozzle)
9. Inspection hatches
12. Ladder