Guide to Aircraft Ground Deicing

Issue 6 – January 2018

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This document\(^1\) provides an introduction to aircraft ground deicing, a brief description of the forty-five current\(^2\) documents issued by the SAE G-12 Aircraft Ground Deicing Committee, documents issued by other SAE Committees, guidance issued by regulators, the FAA, Transport Canada, EASA and ICAO, documents issued by airframe manufacturers (e.g., Boeing), a list of abbreviations, an index\(^3\), and flowcharts for the documents and a list of preferred words and expressions.

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\(^1\) To receive updates of this Guide to Aircraft Ground Deicing (Guide) or to send comments, please communicate with Jacques Leroux, jleroux@dow.com. This Guide is available online: &lt;https://www.sae.org/works/committeeHome.do?comtID=TEAG12ADF &gt;.

\(^2\) This document is up-to-date as of January 20, 2018.

\(^3\) Citations and titles are quoted with original spelling but keywords and index words use United States English spelling.
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Preface

This work was initiated subsequent to needs expressed by members of SAE G-12 at the Montreal November 2015 meeting and by encouragement by a family member, JGB, who does similar work in another area.

Indexing is a personal endeavor, more of an art than a science. It reflects the way the underlying concepts of the indexed document organize themselves in the mind, at the time of indexing, and the way I imagine users will seek information. Users will, undoubtedly, think differently about the concepts and certainly would have indexed them differently. Nevertheless, I hope, some will find the work useful. Suggestions to improve the Guide to Aircraft Ground Deicing are welcome.

JL

Savannah, May 7, 2016
Changes in Issue 6

In Issue 6, the following documents were indexed:

- AMS1448B Sand, Airport Snow and Ice Control
- ARP5485B Endurance Time Test Procedures for SAE Type II/III/IV Aircraft Deicing/Anti-icing Fluids
- ARP5718B Qualifications Required for SAE Type II/III/IV Aircraft Deicing/Anti-icing Fluids
- ARP5945A Endurance Time Tests for SAE Type I Aircraft Deicing/Anti-icing Fluids
- ARP6207 Qualification Required for SAE Type I Aircraft Deicing/Anti-icing Fluids
- Arriaga, Michael, Effects of Alkali Metal Runway Deicers on Carbon Brakes, Boeing Aero, Issue 53, Quarter 01, 2014
- EASA AMC1 ADR.OPS.C010 Pavements, Other Ground Surfaces, and Drainage
- EASA Safety Information Bulletin SIB No.: 2018-01 Information on Materials Used for Runway and Taxiway De/Anti-icing
- Oda, Haruiiko et al, Safe Winter Operation, Boeing Aero, Quarter 04, 2010

Documents cancelled, revised or obsolete:

- Transport Canada Advisory Circular AC 700-040 Supplemental Holdover Timetables and Regression Information for Society of Automotive Engineers (SAE) Type II and IV Fluids, September 30, 2016
- ARP5718A Process to Obtain Holdover Times for Aircraft Deicing/Anti-Icing Fluids, SAE AMS1428 Types II, III, and IV
- ARP5485A Endurance Time Tests for Aircraft Deicing/Anti-icing Fluids SAE Type II, III, and IV

A short description of the Royal Air Maroc collision at Montreal (Mirabel) airport and of the Iberia IB 3195 collision at Munich airport and more information on the source of data for holdover time guidelines were added to the introduction.
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FAA Advisory Circular AC 120-112 Use of Liquid Water Equivalent System to Determine Holdover
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FAA Advisory Circular AC 120-60B Ground Deicing and Anti-icing Program, December 20, 2004
FAA Holdover Time Regression Guidelines Information, Winter 2017-2018 – Original Issue: August 9,
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FAA Notice N 8900.431 Revised FAA–Approved Deicing Program Updates, Winter 2017–2018
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Myers, Barry B., Aircraft Anti-icing Fluid Endurance, Holdover, and Failure Times Under Winter
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SAE AMS1424/2 Deicing/Anti-icing Fluid, Aircraft SAE Type I Non-glycol Based
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SAE AMS1435C Fluid, Generic, Deicing/Anti-icing Runways and Taxiways
SAE AMS1448B Sand, Airport Snow and Ice Control
SAE ARP1971C Aircraft Deicing Vehicle - Self-Propelled
SAE ARP4902B Design of Aircraft Deicing Facilities
SAE ARP5058A Enclosed Operator’s Cabin for Aircraft Ground Deicing Equipment
SAE ARP5149B Training Program Guidelines for Deicing/Anti-icing of Aircraft on Ground
SAE ARP5149BDA Digital Annex
SAE ARP5485B Endurance Time Test Procedures for SAE Type II/III/IV Aircraft Deicing/Anti-icing Fluids
SAE ARP5646 Quality Program Guidelines for Deicing/Anti-icing of Aircraft on the Ground
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SAE ARP6207 Qualification Required for SAE Type I Aircraft Deicing/Anti-icing Fluids
SAE ARP6257 Aircraft Ground De/anti-icing Communication Phraseology for Flight and Ground Crews
SAE ARP6852B Methods and Processes for Evaluation of Aerodynamic Effects of SAE-Qualified Aircraft Ground Deicing/Anti-icing Fluids
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SAE AS5635 Message Boards (Deicing Facilities)
SAE AS5681B Minimum Operational Performance Specification for Remote On-Ground Ice Detection Systems
SAE AS5901C Water Spray and High Humidity Endurance Test Methods for SAE AMS1424 and SAE AMS1428 Aircraft Deicing/Anti-icing Fluids
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SAE AS6286/6 Deicing/Anti-Icing Diagrams/No Spray Zones
SAE AS6332 Aircraft Ground Deicing/Anti-icing Quality Management
SAE AS9968 Laboratory Viscosity Measurement of Thickened Aircraft Deicing/Anti-icing Fluids with the Brookfield LV Viscometer
Transport Canada Advisory Circular AC 700-030 electronic Holdover Time (eHOT) Applications, November 18, 2014
Transport Canada Exemption from Sections 1.0, 3.0, 6.0, 6.2 and 7.111 of Standard 622.11 Ground Icing Operations Made Pursuant for Subsection 602.11(4) of the Canadian Aviation Regulations
Transport Canada Guidelines for Aircraft Ground Icing Operations TP 14052E, 2nd ed, April 2005
Transport Canada Holdover Time (HOT) Guidelines Regression Information Winter 2017-2018, Original Issue: August 9, 2017
Transport Canada Holdover Time Guidelines: Winter 2017-2018, Revision 1.0
Acknowledgments

Many, including Michael Arriaga, Randy Baker, Jean-Denis Brassard, Stephanie Bendickson, Yvan Chabot, Kevin Connor, Lynn Davies, John D'Avirro, Ken Eastman, Chuck Enders, Guillermo Felix, Alberto Fernandez-Lopez, Kevin Flick, Mike Hanlon, Jacob Klain, Carlton Lambiasi, George Legarreta, Graham Morgan, Brody Russell, Detlef Schulz, Ian Sharkey, Jacqueline Teres, Alun Williams, and Roger Zbinden made helpful suggestions or provided information to improve this Guide. Thank you.

JL

January 20, 2018
### Abbreviations

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<tr>
<td>A4A</td>
<td>Airlines for America</td>
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<tr>
<td>A4E</td>
<td>Airlines for Europe</td>
</tr>
<tr>
<td>AAF</td>
<td>aircraft anti-icing fluid</td>
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<tr>
<td>AAT</td>
<td>aerodynamic acceptance test</td>
</tr>
<tr>
<td>AC</td>
<td>Advisory Circular (FAA)</td>
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<tr>
<td>ACARS</td>
<td>Aircraft Communications Addressing and Reporting System</td>
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<tr>
<td>ADF</td>
<td>aircraft deicing fluid</td>
</tr>
<tr>
<td>ADF/AAF</td>
<td>aircraft deicing/anti-icing fluid</td>
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<tr>
<td>AEA</td>
<td>Association of European Airlines</td>
</tr>
<tr>
<td>AFM</td>
<td>Aircraft Flight Manual</td>
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<tr>
<td>AFS</td>
<td>Flight Standard Service (FAA)</td>
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<tr>
<td>AIP</td>
<td>Aeronautical Information Publication</td>
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<tr>
<td>AIR</td>
<td>Aerospace Information Report (SAE)</td>
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<td>aka</td>
<td>also known as</td>
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<tr>
<td>AMC</td>
<td>Acceptable Means of Compliance (EASA)</td>
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<td>AMIL</td>
<td>Anti-icing Materials International Laboratory</td>
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<td>AMM</td>
<td>Aircraft Maintenance Manual</td>
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<td>AMS</td>
<td>Aerospace Material Specification (SAE)</td>
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<tr>
<td>AO</td>
<td>anti-oxidant</td>
</tr>
<tr>
<td>AOM</td>
<td>Aircraft Operating Manual</td>
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<tr>
<td>AOS</td>
<td>alkali organic salt</td>
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<td>APU</td>
<td>auxiliary power unit</td>
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<td>app</td>
<td>application (electronic)</td>
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<td>Advisory Rulemaking Committee (FAA)</td>
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<td>ARP</td>
<td>Aerospace Recommended Practice (SAE)</td>
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<td>AS</td>
<td>Aerospace Standard (SAE)</td>
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<td>ASOS</td>
<td>automated surface observing system</td>
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<td>ATC</td>
<td>Air Traffic Control</td>
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<td>ATM</td>
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<td>Air Transportation Oversight System (US)</td>
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<td>AWOS</td>
<td>Automatic Weather Observation System</td>
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<td>BAe</td>
<td>British Aerospace</td>
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<tr>
<td>BFU</td>
<td>Bundsstelle für Flugunfalluntersuchung⁴</td>
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<tr>
<td>BLDT</td>
<td>boundary layer displacement thickness</td>
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<tr>
<td>BOD</td>
<td>biochemical oxygen demand</td>
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<td>C</td>
<td>Celsius</td>
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<tr>
<td>ca</td>
<td><em>circa</em> (approximately)</td>
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<tr>
<td>CAAC</td>
<td>Civil Aviation Administration of China</td>
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<tr>
<td>CAR</td>
<td>Canadian Aviation Regulation</td>
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<tr>
<td>CASI</td>
<td>Civil Aviation Safety Inspector (Transport Canada)</td>
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<tr>
<td>CBDS</td>
<td>computer based deicing simulator</td>
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<tr>
<td>CBT</td>
<td>computer based training</td>
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⁴ German Federal Bureau of Aircraft Accident Investigation.
Abbreviations

CDF  centralized deicing facility
CEPA  Canadian Environmental Protection Act
CFR  Code of Federal Regulations (US)
CLmax  3D maximum lift coefficient
CML  Consumable Materials List (Airbus)
COD  chemical oxygen demand
CSSF  cold soaked fuel frost
CT  check time
CTDS  check time determination system
DAQCP  Deicing/Anti-icing Quality Control Pool (IATA)
DCT  data collection tool (FAA)
DDF  designated deicing facility
DEG  diethylene glycol
EASA  European Aviation Safety Agency
EFB  electronic flight bag
EG  ethylene glycol
eHOT app  electronic holdover time application
eHOT  electronic holdover time
e-learning  electronic learning
EMB  electronic message board
EU  European Union
EUROCAE  European Organisation for Civil Aviation Equipment
FAA  Federal Aviation Administration, United States Department of Transportation
FAS  forced air system
FBO  fixed base operator
FCOM  Flight Crew Operation Manual
FMH-1  Federal Meteorological Handbook No. 1, Surface Weather Observations and Reports (US)
FPD  freezing point depressant
FSDO  Flight Standards District Office (FAA)
FSIMS  Flight Standard Information Management System (FAA)
G-12 ADF  G-12 Aircraft Deicing Fluid Committee (SAE)
G-12 AWG  G-12 Aerodynamics Working Group (SAE)
G-12 DF  G-12 Deicing Facility Committee (SAE)
G-12 E  G-12 Equipment Committee (SAE)
G-12 FG  G-12 Future Technology Committee (SAE)
G-12 HOT  G-12 Holdover Time Committee (SAE)
G-12 M  G-12 Methods Committee (SAE)
G-12 RDF  G-12 Runway Deicing fluid Committee (SAE)
G-12 Steering  G-12 Steering Group (SAE)
G-12 T  G-12 Training and Quality Control Committee (SAE)
GAC  glycerine acetate
GIDS  ground ice detection system
GIP  Ground Icing Program (FAA and Transport Canada)
GM  Guidance Material (EASA)
GOFR  General Operating and Flight Rules (Transport Canada)
<table>
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<td>GRV</td>
<td>glycol recovery vehicle</td>
</tr>
<tr>
<td>GUI</td>
<td>graphical user interface</td>
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<tr>
<td>HHET</td>
<td>high humidity endurance test</td>
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<tr>
<td>HOT</td>
<td>holdover time</td>
</tr>
<tr>
<td>HOTDR</td>
<td>holdover time determination report</td>
</tr>
<tr>
<td>HOTDS</td>
<td>holdover time determination system</td>
</tr>
<tr>
<td>HOWV</td>
<td>highest on-wing viscosity</td>
</tr>
<tr>
<td>HQ</td>
<td>Headquarters (FAA)</td>
</tr>
<tr>
<td>HUPR</td>
<td>highest usable precipitation rate</td>
</tr>
<tr>
<td>IAC</td>
<td>Interstate Aviation Committee</td>
</tr>
<tr>
<td>ICAO</td>
<td>International Civil Aviation Organization</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>JAR</td>
<td>Joint Aviation Authorities (European Union)</td>
</tr>
<tr>
<td>KAC</td>
<td>potassium acetate</td>
</tr>
<tr>
<td>KFOR</td>
<td>potassium formate</td>
</tr>
<tr>
<td>LOUT</td>
<td>lowest operational use temperature</td>
</tr>
<tr>
<td>LOWV</td>
<td>lowest on-wing viscosity</td>
</tr>
<tr>
<td>LUPR</td>
<td>lowest usable precipitation rate</td>
</tr>
<tr>
<td>LWE</td>
<td>liquid water equivalent</td>
</tr>
<tr>
<td>LWES</td>
<td>liquid water equivalent system</td>
</tr>
<tr>
<td>METAR</td>
<td>Meteorological Terminal Aviation Routine Weather Report</td>
</tr>
<tr>
<td>METREP</td>
<td>meteorological report</td>
</tr>
<tr>
<td>MOPS</td>
<td>minimum operational performance specification</td>
</tr>
<tr>
<td>MOWV</td>
<td>maximum on-wing viscosity&lt;sup&gt;5&lt;/sup&gt;</td>
</tr>
<tr>
<td>MSDS</td>
<td>material safety data sheet</td>
</tr>
<tr>
<td>NAA</td>
<td>national aviation authorities</td>
</tr>
<tr>
<td>NAAC</td>
<td>sodium acetate</td>
</tr>
<tr>
<td>NAFO</td>
<td>sodium formate</td>
</tr>
<tr>
<td>NCAR</td>
<td>National Center for Atmospheric Research</td>
</tr>
<tr>
<td>NCG</td>
<td>non-conventional glycol</td>
</tr>
<tr>
<td>NG</td>
<td>non-glycol</td>
</tr>
<tr>
<td>NOTAM</td>
<td>notice to airmen</td>
</tr>
<tr>
<td>NTSB</td>
<td>National Transportation Safety Board (US)</td>
</tr>
<tr>
<td>OACI</td>
<td>Organisation de l’aviation civile internationale (ICAO)</td>
</tr>
<tr>
<td>OAT</td>
<td>outside air temperature</td>
</tr>
<tr>
<td>OEM</td>
<td>original equipment manufacturer</td>
</tr>
<tr>
<td>p</td>
<td>page (plural pp)</td>
</tr>
<tr>
<td>Pa</td>
<td>Pascal</td>
</tr>
<tr>
<td>PANS</td>
<td>Procedure for Air Navigation Services (ICAO)</td>
</tr>
<tr>
<td>par</td>
<td>paragraph</td>
</tr>
<tr>
<td>PG</td>
<td>propylene glycol</td>
</tr>
<tr>
<td>PIC</td>
<td>pilot-in-command</td>
</tr>
<tr>
<td>POI</td>
<td>Principal Operations Inspector (FAA and Transport Canada)</td>
</tr>
</tbody>
</table>

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<sup>5</sup> MOWV stands for maximum on-wing viscosity. HOWV stands for highest on-wing viscosity. There are synonymous. The use of HOWV is preferred because there is a risk of confusion with the MOWV which could erroneously thought of as minimum on-wing viscosity.
### Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>POTW</td>
<td>Publicly Owned Treatment Works (US)</td>
</tr>
<tr>
<td>PRI</td>
<td>Performance Review Institute</td>
</tr>
<tr>
<td>PTO</td>
<td>power takeoff (for deicing units)</td>
</tr>
<tr>
<td>QA</td>
<td>quality assurance</td>
</tr>
<tr>
<td>QC</td>
<td>quality control</td>
</tr>
<tr>
<td>QMS</td>
<td>quality management system</td>
</tr>
<tr>
<td>RDF</td>
<td>runway deicing fluid</td>
</tr>
<tr>
<td>RDP</td>
<td>runway deicing product</td>
</tr>
<tr>
<td>RH</td>
<td>relative humidity</td>
</tr>
<tr>
<td>RI</td>
<td>refractive index</td>
</tr>
<tr>
<td>RMK</td>
<td>remark</td>
</tr>
<tr>
<td>RMSE</td>
<td>root mean square error</td>
</tr>
<tr>
<td>ROGIDS</td>
<td>remote on-ground ice detection systems</td>
</tr>
<tr>
<td>RVR</td>
<td>runway visibility range</td>
</tr>
<tr>
<td>s</td>
<td>second(s)</td>
</tr>
<tr>
<td>s</td>
<td>section (plural ss)</td>
</tr>
<tr>
<td>SAE</td>
<td>Society of Automotive Engineers</td>
</tr>
<tr>
<td>SAIB</td>
<td>Special Airworthiness Information Bulletin (FAA)</td>
</tr>
<tr>
<td>SAS</td>
<td>Safety Assurance System (US)</td>
</tr>
<tr>
<td>SCOUIC</td>
<td>Standing Committee on Operations Under Icing Conditions (Transport Canada)</td>
</tr>
<tr>
<td>SD</td>
<td>Safety Directive (EASA)</td>
</tr>
<tr>
<td>SDS</td>
<td>safety data sheet</td>
</tr>
<tr>
<td>SHRP</td>
<td>Strategic Highway Research Program (US)</td>
</tr>
<tr>
<td>SIAGDP</td>
<td>Standardized International Aircraft Ground Deicing Program</td>
</tr>
<tr>
<td>SIB</td>
<td>Safety Information Bulletin (EASA)</td>
</tr>
<tr>
<td>SLD</td>
<td>supercooled large droplets</td>
</tr>
<tr>
<td>SMI</td>
<td>Scientific Materials International</td>
</tr>
<tr>
<td>SMS</td>
<td>safety management system</td>
</tr>
<tr>
<td>SNOWTAM</td>
<td>snow warning to airmen</td>
</tr>
<tr>
<td>SOP</td>
<td>standard operation procedure</td>
</tr>
<tr>
<td>SPECI</td>
<td>aviation special weather report</td>
</tr>
<tr>
<td>STP</td>
<td>standard teaching plan</td>
</tr>
<tr>
<td>TAF</td>
<td>Terminal Aerodrome Forecast</td>
</tr>
<tr>
<td>TAT</td>
<td>total air temperature</td>
</tr>
<tr>
<td>TC</td>
<td>Transport Canada</td>
</tr>
<tr>
<td>TCCA</td>
<td>Transport Canada Civil Aviation</td>
</tr>
<tr>
<td>TOD</td>
<td>total oxygen demand</td>
</tr>
<tr>
<td>Type I</td>
<td>SAE AMS1424 Type I Aircraft Deicing/Anti-icing Fluid</td>
</tr>
<tr>
<td>Type II</td>
<td>SAE AMS1428 Type II Aircraft Deicing/Anti-icing Fluid</td>
</tr>
<tr>
<td>Type III</td>
<td>SAE AMS1428 Type III Aircraft Deicing/Anti-icing Fluid</td>
</tr>
<tr>
<td>Type IV</td>
<td>SAE AMS1428 Type IV Aircraft Deicing/Anti-icing Fluid</td>
</tr>
<tr>
<td>US</td>
<td>United States of America</td>
</tr>
<tr>
<td>UV</td>
<td>ultraviolet</td>
</tr>
</tbody>
</table>
The abbreviation “v” is used to compare notions; for example, for the index entry “frost point v dewpoint, 139, 159”, one would find information comparing frost point and dewpoint on pages 139 and 159. It is also used in the usual scientific manner meaning “as a function of”, for example, as in “Type I wetting v time”.

6 The abbreviation “v” is used to compare notions; for example, for the index entry “frost point v dewpoint, 139, 159”, one would find information comparing frost point and dewpoint on pages 139 and 159. It is also used in the usual scientific manner meaning “as a function of”, for example, as in “Type I wetting v time”.

v versus 6
V1 takeoff decision speed
V2 takeoff safety speed
Vlof lift-off speed
Vmu minimum unstick speed
Vr rotation speed
VS start up velocity
VS1g 1-g stall speed
VSZ vehicle safety zone
WG Working Group (SAE)
WMO World Meteorological Organization
WSET water spray endurance test
Introduction

Objective. Over the years, documentation on aircraft ground deicing has increased considerably. Those less familiar with the documentation, and even those familiar with the field, sometimes, find it difficult to find specific information in authoritative documentation. The purpose of this document is to index the available current documentation and make it easier to find specific information related to aircraft ground deicing.

Accidents. NASA used to maintain an interactive map with the location of accidents and near misses related to aircraft ground icing. Unfortunately, the information does not appear to be available on the web anymore. Most accidents occur when there is no deicing or improper deicing. Collisions between deicing units and aircraft can have severe consequences. Near misses, such as aborted takeoffs and successful landings, after control problems or engine icing, have been reported. Below are key accidents which changed the way industry deals with ground deicing issues.

Air Florida Flight 90. On January 13, 1982, after a takeoff run with adhering snow and ice to the aircraft, Air Florida Flight 90 hit the 14th Street Bridge near Washington National Airport. It plunged in the Potomac River killing 69. The NTSB conclusions were:

The National Transportation Safety Board determines that the probable cause of this accident was the flightcrew’s failure to use engine anti-ice during ground operation and takeoff, their decision to take off with snow/ice on the airfoil surfaces of the aircraft, and the captain’s failure to reject the takeoff during the early stage when his attention was called to anomalous engine instrument readings. Contributing to the accident were the prolonged ground delay between deicing and the receipt of ATC takeoff clearance during which the airplane was exposed to continual precipitation, the known inherent pitchup characteristics of the B-737 aircraft when the leading edge is contaminated with even small amounts of snow or ice, and the limited experience of the flightcrew in jet transport winter operations.7

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NTSB recommendation A-82-9 read as follows:

Immediately require flightcrews to visually inspect wing surfaces before takeoff if snow or precipitation is in progress and the time elapsed since either deicing or the last confirmation that the surfaces were clear exceeds 20 minutes to ensure compliance with 14 CFR121.629(b) which prohibits takeoff if ice, snow or frost is adhering to the wings or control surfaces.\textsuperscript{8}

FAA’s response to recommendation A-82-9 was that reference to such a time as 20 minutes was “not in the best interest of aviation” as ice could form in shorter period of time.\textsuperscript{9} As a result of the Air Florida accident, R&D effort was accelerated to understand aircraft ground icing.

Two accidents in the late 1980’s and early 1990’s and the following in-depth investigations profoundly changed the way aircraft ground deicing is understood and performed.

\textit{The Dryden Accident}. Air Ontario Flight 1363 Fokker F-28 aircraft crashed shortly after departure near Dryden, Ontario, on March 10, 1989. It was snowing that afternoon. The flightcrew did not request deicing. It attempted to takeoff with frozen contamination on the aircraft. Unable to gain altitude, the aircraft crashed killing 24 and injuring 69 on-board. This accident was the subject of a judicial commission of enquiry led by Justice Virgil P. Moshansky.\textsuperscript{10} Rather than satisfying himself with the immediate cause of the accident, pilot error, Justice Moshansky sought an understanding of the distant but effective causes of the accident.\textsuperscript{11} He launched what was to be a systemic approach to understanding the accident: a thorough analysis of the Canadian aviation system. He attributed the ultimate probable causes of the accident not only to pilot error but a systemic failure of the air transportation system. His recommendation number 167 reads as follows:

\textit{That Transport Canada actively participate in the research and development necessary to establish safety effectiveness measurement systems that will lead to...}
Introduction

the most efficient use of resources in assuring safety. Cooperation with the United States Federal Aviation Administration and other international groups should be encouraged and resourced to obtain the maximum and most expedient benefits from such programs.12

This incited Transport Canada to a) allocate significant resources to research and development, in close cooperation with the FAA, in the area of aircraft ground deicing and b) participate in the SAE G-12 Committees, resulting to the development of authoritative standards and guidance documentation. The report facilitated the use of anti-icing fluids in Canada by encouraging the regulator to provide the necessary technical evaluation and regulatory framework for their use at large airports across the country.

**USAir Flight 405.** Three years after the Dryden accident, on March 22, 1992, another Fokker F-28 crashed at takeoff from LaGuardia Airport killing 27 due to ice accumulation on critical surfaces, 35 minutes following deicing with Type I fluid only. The National Transportation Safety Board, not unlike the Moshansky Inquiry, attributed probable cause of the accident to failure of the airlines industry and regulator to “to provide flightcrews with procedures, requirements, and criteria compatible with departure delays in conditions conducive to airframe icing and the decision by the flightcrew to takeoff without positive assurance that the aircraft wings were free of ice accumulation after 35 minutes of exposure to precipitation following de-icing”.

Since 1993, use of anti-icing fluid has become much more prevalent. FAA, in cooperation with Transport Canada, has pursued vigorously the fundamental understanding of aircraft icing and the development and dissemination of guidance, such as the *Holdover Time Guidelines*, and documentation related to aircraft ground deicing. FAA, like Transport Canada, exercises leadership positions in SAE G-12.

**Royal Air Maroc Collision at Montreal (Mirabel) Airport.** One should not think, that, in ground deicing, the only danger is frozen contamination on the aircraft. The Royal Air Maroc accident is a tragic example of what can go wrong in the deicing process itself. On January 21, 1995, the Royal Air Maroc 747-400 was parked at the deicing pad at Mirabel airport being deiced by a crew of Canadian Airlines International Ltd. The four engine were running. The flightcrew heard “dégivrage terminé” (deicing completed). The message was not intended for the flightcrew but for

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the deicing coordinator. The pilot attempted to communicate with the deicing crew without success. The Transportation Safety Board of Canada\(^\text{13}\) concluded that engine noise probably prevented the deicing crew from hearing the pilot. Radio-communication equipment was not designed for engines-on operations. Communications protocols with the ice crew, apron control and flightcrew were inadequate and engines-on deicing training was lacking. The perimeter of the aircraft was not clear. Two deicing vehicles were in front of the horizontal stabilizer of the aircraft. In the communication confusion, the aircraft started to taxi. It hit the deployed booms of the deicing vehicles. The deicing vehicles were overturned. The two deicing vehicle drivers sustained minor injuries. The three occupants of the deicing baskets fell from a height of 15 meters. The three sustained fatal injuries.

Near-misses have occurred at various airports since the Royal Air Maroc fatal accident.

*Iberia IB 3195 Collision at Munich Airport.* In a sequence of events, uncannily similar to the Royal Air Maroc, a collision occurred at Munich airport, twenty one years later, on January 20, 2016. The Iberia flightcrew was configuring the aircraft for deicing at a deicing pad. The copilot erroneously pushed the DISCH button on the cargo smoke panel discharging fire suppression product in the cargo hold. He should have pushed the DITCHING button on the cabin pressure panel to appropriately set the air conditioning units. With the fire suppressant discharged, the aircraft would not fly and did not need deicing anymore. The pilot conveyed to the deicing crew there was a technical problem and needed “to go back to the stand”. The ground crew understood there was a mechanical problem but did not understand the aircraft would not need deicing. There was communication confusion between the flightcrew and the deicing crew; standard phraseology was not used. Two deicing unit remained in position, ready to start deicing. Their booms were in front of the winglets. The perimeter was not clear. Iberia flight 3195 Airbus 320 began to taxi,

hitting the booms. And almost overturning the deicing units. No one was injured. The German Federal Bureau of Aircraft Accident Investigation (BFU)\textsuperscript{14} called it a serious accident.

\textit{Regulations.} Countries issue regulations prohibiting takeoff of aircraft contaminated with adhering frozen deposits. The regulations are enforced by National Aviation Authorities (NAA, also known as regulators) such as the United States Federal Aviation Administration (FAA)\textsuperscript{15}, Transport Canada (TC)\textsuperscript{16}, the Civil Aviation Administration of China (CAAC) or supra national authorities such as the European Aviation Safety Agency (EASA).\textsuperscript{17}

\textit{Guidance and advisory material.} The regulations prohibiting takeoff with frozen contamination require guidance material for compliance. Guidance and advisory material is issued by the regulators (e.g., EASA, FAA, Transport Canada), ICAO\textsuperscript{18}, IATA, IAC\textsuperscript{19} and airframe manufacturers such as Boeing\textsuperscript{20} and Airbus.\textsuperscript{21}

\textit{Holdover Time Guidelines.} SAE Type I, II, III and IV fluids, during winter operations, provide a limited period of protection against frozen or freezing precipitations while the aircraft is on the

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\textsuperscript{15} United States 14 CFR § 121.629 (b) “No person may take off an aircraft when frost, ice, or snow is adhering to the wings, control surfaces, propellers, engine inlets, or other critical surfaces of the aircraft or when the takeoff would not be in compliance with paragraph (c) of this section. Takeoffs with frost under the wing in the area of the fuel tanks may be authorized by the Administrator.”, online: <https://www.gpo.gov/fdsys/pkg/CFR-2007-title14-vol2/xml/CFR-2007-title14-vol2-sec121-629.xml>.

\textsuperscript{16} Canadian Aviation Regulations SOR/96-433, s. 602.11 (2) “No person shall conduct or attempt to conduct a takeoff in an aircraft that has frost, ice or snow adhering to any of its critical surfaces”, online: <http://laws-lois.justice.gc.ca/eng/regulations/SOR-96-433/section-602.11-20140529.html>.

\textsuperscript{17} EASA CAT.OP.MPA.250 Ice and other contaminants — ground procedures

\begin{enumerate}
\item The operator shall establish procedures to be followed when ground deicing and anti-icing and related inspections of the aircraft are necessary to allow the safe operation of the aircraft.
\item The commander shall only commence take-off if the aircraft is clear of any deposit that might adversely affect the performance or controllability of the aircraft, except as permitted under (a) and in accordance with the AFM. online: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:296:0001:0148:EN:PDF>.
\end{enumerate}


\textsuperscript{19} E. Petrov et al., \textit{Methodical Recommendations: Airplane Protection From Icing Up On the Ground, Revision 3} (Moscow: IAC, September 2017), online: <http://mak-iac.org/upload/iblock/cd3/Methodical%20Recommendations%20Rev.3%202017.pdf>.


\textsuperscript{21} \textit{Coming to Grips with Cold Weather Operations}, AI/SRA A007-01/00 (Toulouse: Airbus Industrie, 2000). For more recent information on Airbus procedures and qualified products (allowed materials) apply to Airbus for access to Airbus Aircraft Maintenance Manuals (AMM) and Consumable Materials List (CML) or raise a query with Airbus Support Engineering Department.
ground. The protection time can be estimated using holdover time guidelines that are published by the FAA or Transport Canada. Holdover time guidelines are derived from laboratory test or outdoor test. The holdover time guidelines published by the FAA and Transport Canada differ slightly, usually in capping of the values. Both the FAA and Transport Canada holdover time values are derived from a unique set of endurance time data which is updated every year taking into consideration the latest laboratory and outdoor tests. The FAA and Transport Canada are the only organizations publishing holdover times and they do from that single set of data.

Standards. Detailed standards and recommended practices, including specifications for the fluids used for aircraft deicing and anti-icing, testing procedures, qualification processes, endurance time testing, methods for deicing and anti-icing, training and quality control are published by SAE International. These documents are created, maintained and updated by experts gathering under the auspices of the SAE G-12 Aircraft Ground Deicing Committee which works in close cooperation with the regulators. The FAA, Transport Canada, and more recently EASA, fund and perform icing research. The results are presented to the SAE G-12 members.

SAE G-12. The SAE G-12 Aircraft Ground Deicing Committee (SAE G-12) is comprised of 1) the Steering Group, 2) the Aircraft Deicing Fluid Committee (G-12 ADF), 3) the Holdover Time Committee (G-12 HOT)\textsuperscript{22}, 4) the Methods Committee (G-12 M), 5) the Deicing Facility Committee (G-12 DF), 6) the Training and Quality Control Committee (G-12 T), 7) the Future Technology Committee (G-12 FG), 8) the Equipment Committee (G-12 E), 9) the Runway Deicing Fluid Committee\textsuperscript{23} (G-12 RDF) and 10) various \textit{ad hoc} workgroups reporting to the Committees, such as the Aerodynamics Workgroup (G-12 AWG), the Carbon Brake Oxidation Workgroup, etc. A new Rotorcraft Working Group was added in 2017.

SAE G-12 Meetings. All the committees and workgroups that comprise the SAE G-12 Aircraft Ground Deicing Committee meet every May. Meeting locations change every year. The committees and workgroups often hold more working sessions during the year. Over the last few

\textsuperscript{22} In 2016, having published all the standards it wished to publish and since activity in the field of ice detection equipment development was minimal, the G-12 Ice Detection Committee decided to become a workgroup that reports to the G-12 Holdover Time Committee until such time that ROGIDS development work becomes active again.

\textsuperscript{23} The SAE G-12 Runway Deicing Fluid Committee is responsible for not only for runway deicing fluid standards but for runway deicing solids standards as well. Often the expression runway deicing fluid is meant to include products in liquid and solid form. In this document, we use the expression runway deicing products (RDP) to include the solid and liquid forms.
years, several committees have been meeting in late October or early November in Montreal, for the so-called mid-year meeting.

*SAE Documents.* The documents issued by SAE G-12 fall into four categories: Aerospace Material Specification (AMS), Aerospace Recommended Practice (ARP), Aerospace Information Report (AIR) and Aerospace Standard (AS).

*Global Aircraft Deicing Standards.* ICAO, national aviation authorities, (e.g., FAA, Transport Canada and EASA), SAE, and airline associations (e.g., AEA) have developed recommended practices for aircraft ground deicing/anti-icing with the intention of providing unified standards. Experience has shown that differences are significant enough to prevent operators from adopting any single one of the many standards published.

The issue of multiple standards became more apparent as centralized deicing facilities (CDF) started operating in many countries. For instance, in Toronto, over 80 airlines fly into a centralized facility, each attempting to impose its own standard for deicing on the staff for its own aircraft. Staff would have had to be trained for each procedure resulting in a multitude of procedures, high training costs and a complexity that added to the risk of non-compliance to the multiple procedures. Many CDF faced with impossible tasks of training its staff to many procedures, imposed their own procedures with the approval of the national regulatory authority. Flightcrews have to learn the difference between each CDF, which adds to complexity of their tasks. Service providers are being audited to different standards.

IATA approached the SAE G-12 in San Francisco in May 2011 and explained that IATA had received a mandate from its Operations Committee (OPC) comprised of the major airline members to develop globally harmonized deicing procedures. Safety and costs would be improved by the adoption of such standards.

SAE G-12 welcomed IATA’s request. IATA and SAE agreed to enter into a formal cooperation agreement. SAE and IATA became sponsors of a newly created Council for Globalized Aircraft

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24 The Association of European Airlines (AEA) ceased its operations in December 2016. It is expected that the ex-AEA deicing working group will continue its work under the auspices of the Airlines for Europe (A4E).
Deicing Standards.25 At its first meeting in Montreal, on November 10, 2011, ICAO became a sponsor of the Council and also entered into a formal agreement with SAE.

Necessity for harmonization was stated to be 1) the improvement of safety by reducing the chance of discrepancy between the deicing performed and the deicing expected by the flightcrew as well as simplifying communication, 2) increase in efficiency by reducing the training required by service providers, reducing the costs of airline audits, and simplifying contracts. Areas to be covered by the globalized standards were deicing/anti-icing methods, training and quality assurance.

Rather than attempting to modify the existing SAE documents, it was decided to start from scratch and create new documents, the so-called “global deicing standards”, to replace the existing SAE documents covering 1) deicing/anti-icing processes including flightcrew/ground crew communications, 2) training and 3) quality assurance.

Table 1 lists of the old standards, cancelled or to be cancelled, and corresponding new global deicing standards, all recently issued.

Lexicon. As we move to adopt global standards, it will be important to try to use words with the common understanding and spelling. A lexicon is appended with the aim of standardizing the use of words in the G-12 standards can be found on page 213.

### Table 1 Correspondence of Existing SAE Standards and Global Aircraft Deicing Standards

<table>
<thead>
<tr>
<th>Existing SAE Standards</th>
<th>Global Aircraft Deicing Standards</th>
</tr>
</thead>
</table>
ARP6257 Flight and Ground Crew De/Anti-icing Phraseology (issued Oct., 2016) |
| ARP5149B Training Program Guidelines for Deicing/Anti-Icing of Aircraft on Ground (to be cancelled) | AS6286 Training and Qualification Program for Deicing/Anti-icing of Aircraft on the Ground  
AS6286/1 Processes (issued Nov., 2016)  
AS6286/2 Equipment (issued Nov., 2016)  
AS6286/3 Fluids (issued Dec., 2016)  
AS6286/4 Weather (issued Nov., 2016)  
AS6286/5 Health, Safety and First Aid (issued Sept., 2016)  
AS6286/6 Aircraft Diagram and No-spray Zones (issued Dec., 2016) |
| ARP5646 Quality Program Guidelines for Deicing/Anti-Icing of Aircraft on the Ground (to be cancelled) | AS6332 Aircraft Ground Deicing/anti-icing Quality Management (issued Aug., 2017) |

*Research Reports.* APS Aviation has prepared over 100 reports related to aircraft ground deicing for Transport Canada and the FAA. These reports are not indexed in this *Guide to Aircraft Ground Deicing.*

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26 Several reports can be found online: Rhea Group <https://www.rheagroup.com/aps-holdover-time-testing/aircraft-ground-icing-research>.
Documentation Notification Services. The FAA and Transport Canada offer free email notification services upon publication of aircraft deicing documentation.

FAA:

Transport Canada: http://wwwapps.tc.gc.ca/Comm/5/ListServ/menu.aspx

Members of SAE G-12 receive notification of SAE standard publications. To become a member, please contact Sonal Khunti at skhunti@sae.org or Jacques Leroux at jleroux@dow.com.

There is no cost to be a member of SAE G-12, to receive committee minutes and review document ballots. People are encouraged to become members of SAE at minimal cost, but this is not required to be a member of SAE G-12.

Vocabulary. There is an effort to standardize the vocabulary in SAE G-12 documents. A lexicon of preferred words and expressions can be found under the heading “List of Preferred Words and Expressions” at p 213.
PART ONE: THE AIRCRAFT DEICING DOCUMENTS

Figure 1 (at p 215) provides a visual representation on how the aircraft deicing documents relate to one another.

Documents Issued by SAE

Documents Issued by the SAE G-12 Aircraft Deicing Fluids Committee

AIR6232 Aircraft Surface Coating Interaction with Aircraft Deicing/Anti-Icing Fluids

Issued 2013-08-12 by SAE G-12 ADF.

Aircraft operators in 2012 expressed interest in the use of after-market coatings on aircraft surfaces for various purposes, including appearance enhancement, fuel savings, and ice shedding. The coatings were designed to have hydrophilic or hydrophobic properties that could possibly interfere with the wetting, thickness, holdover time and aerodynamic properties of aircraft deicing/anti-icing fluid. AIR6232 was issued to raise the issue of the potential deleterious effects of these coatings and propose testing to evaluate the aircraft surface coating compatibility with the deicing anti-icing fluids. AIR6232 also provides descriptions of suggested test methods for evaluating aircraft surface coatings with respect to durability, hardness, weathering, aerodynamic drag, ice adhesion, ice accumulation, contact angle, and thermal conductivity. These tests can provide informational data for characterizing the coatings and may be useful to aircraft operators when evaluating the coatings.

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advancing contact angle. See contact angle, advancing
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ARP6852B Methods and Processes for Evaluation of Aerodynamic Effects of SAE-Qualified Aircraft Ground Deicing/Anti-icing Fluids

Revised 2017-01-03 by SAE G-12 AWG and SAE G-12 ADF.

AMS1424 and AMS1428 require aircraft deicing/anti-icing fluids to comply to the aerodynamic acceptance test whose purpose is to ensure that the aerodynamic performance of all fluids are no worse than an established accepted standard; this aerodynamic acceptance test is described in detail in AS5900C. Even with successful aerodynamic acceptance qualification, there can be circumstances which require the evaluation of the aerodynamic effect of fluids on specific aircraft. ARP6852B does provide guidance for such aircraft specific evaluation.

ARP6852B, prepared by the members of the G-12 Aerodynamics Working Group, describes methods known to have been used by aircraft manufacturers to evaluate specific aircraft aerodynamic performance and handling effects following application of glycol based SAE AMS Type I, II, III or IV aircraft deicing/anti-icing fluids. Guidance and insight based upon those experiences are provided, including, similarity analyses, icing wind tunnel tests, flight tests, computational fluid dynamics and other numerical analyses.

ARP6852B further presents an historical account of the evaluation of the aerodynamic effects of fluids, including the initial work done by Boeing in the 1980s and 1990s on high speed aircraft and of de Havilland on commuter type aircraft which led to the development of the aerodynamic acceptance test described in AS5900C. ARP6852B provides an extensive bibliography on the effects of fluids on aircraft aerodynamics and reports on the methods used by Bombardier, Cessna and SAAB to evaluate the effects of fluid on their respective aircraft.

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aerodynamic acceptance test – Boeing history, s 3.4, Appendix A
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\textsuperscript{27} AS6852B appears to use the words “transient” and “transitory” as synonyms when referring to the aerodynamic effects of fluid as in “[t]he aerodynamic effects of fluids are transitory…” (par 3 at p 10) or “[c]urrent data suggests that the fluid transient behavior…” (par 5 at p 11). Here we index under “transient”.

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AS5900C Standard Test Method for Aerodynamic Acceptance of AMS1424 and AMS1428 Aircraft Deicing/Anti-icing Fluids

Revised 2016-10-25 by SAE G-12 ADF.

This standard provides test methods to ensure acceptable aerodynamic characteristics of the deicing/anti-icing fluids as they flow off aircraft lifting and control surfaces during the takeoff ground acceleration and climb. AS5900C establishes the aerodynamic flow-off requirements for SAE AMS1424 Type I and SAE AMS1428 Type II, III and IV fluids used to deice and/or anti-ice aircraft.

Two tests are defined. One to simulate the takeoff of large transport jet aircraft28 with speeds29 at rotation exceeding approximately 100 knots and with time30 from brake release to rotation greater than 20 s. This takeoff is simulated using a “high speed ramp” where the test is performed as 65 m/s (126 knots) and a 25 s acceleration at 2.5 m/s².

The other test simulates the takeoff of commuter turbo-prop aircraft31 with speeds at rotation between 60 and 100 knots and with a time from brake release to rotation between 15 and 20 s. The takeoff is simulated using a “low speed ramp” where the test is performed at 35 m/s (70 knots) and a 17 s acceleration at 2.1 m/s².

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28 Large jet transport aircraft are also known as high speed aircraft.
29 Takeoff rotation speed or rotation speed are also known as VR.
30 Time from brake release to rotation is also known as takeoff run time or ground acceleration time or brake release to VR.
31 Commuter turbo-prop aircraft are colloquially known as low speed aircraft.
Keywords:

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32 The expressions “test facility”, “facility”, “site/facility” “aerodynamic acceptance test facility” appear to be used interchangeably (ss 3.3, 4, 4.5). Section 3.3 defines qualification of the facility, associated staff and resources as technical suitability and competency.

33 There is no elimination set for Type I fluids but there is a maximum “fluid residual thickness” set for the high speed ramp and the low speed ramp.
Aircraft Deicing Documents – Issued by the G-12 Aircraft Deicing Fluid Committee

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AS5901C Water Spray and High Humidity Endurance Test Methods for SAE AMS1424 and SAE AMS1428 Aircraft Deicing/Anti-icing Fluids

Revised 2014-06-24 by SAE G-12 ADF.

The purpose of this standard is to determine the anti-icing endurance, under controlled laboratory conditions, of AMS1424 Type I and AMS1428 Type II, III, and IV fluids. AS5901C establishes a) the minimum requirements for an environmental test chamber and b) the test procedures to carry out anti-icing performance tests according to the current specification for aircraft deicing/anti-icing fluids.

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WSET – fluid temperature, s 6.3
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AMS1424N Fluid, Aircraft Deicing/Anti-Icing, SAE Type I

Revised 2017-06-09 by SAE G-12 ADF.

AMS1424N\textsuperscript{34} sets the technical and environmental requirements and quality assurance provisions for aircraft deicing fluids (SAE Type I) that are used to remove frozen deposits from exterior surfaces of aircraft prior to takeoff. SAE Type I fluids do not contain thickeners.

AMS1424N is defined as the foundation specification for SAE Type I fluids. The SAE Type I fluids are divided into two categories: a) SAE Type I fluids based on Glycol freezing point depressants, which include Conventional Glycols and Non-conventional Glycols and b) SAE Type I fluids based on Non-glycol freezing point depressants.

SAE Type I fluids based on Conventional and Non-conventional Glycol freezing point depressants are defined and identified as AMS1424/1 (read AMS1424 slash one) Type I fluids. The purpose of the AMS1424/1 specification, which is called a category specification, is to identify the SAE Type I fluid as a glycol (conventional or non-conventional) based fluid.

*Conventional Glycols* are defined as ethylene glycol, diethylene glycol and propylene glycol.

*Non-conventional Glycols* are defined as organic non-ionic diols and triols, e.g., 1,3-propanediol, glycerine and mixtures thereof and mixtures with conventional glycols.

SAE Type I fluids based on Non-glycol freezing point depressants are defined and identified as AMS1424/2 (read AMS1424 slash two) Type I fluids. The purpose of the AMS1424/2 specification, which is called a category specification, is to identify the SAE Type I fluid as a Non-glycol based fluid.

\textsuperscript{34} *Type I – compatibility with Type II/III/IV.* When a Type II, III or IV fluid conforming to AMS1428 is used to perform step two in a two-step deicing/anti-icing operation, and the fluid used in step one is often a Type I fluid conforming to AMS1424, section 1.3.6 of AMS1424N explains that users must ensure that the Type I be compatible with the Type II/III/IV. A means of verification is suggested in section 6.3.3.2 of ARP4737H requiring a test be made to confirm that the combination of these fluids does not significantly reduce the WSET performance of the AMS1428 fluid. For some unexplained reason, AS6285 omits to provide the information provided in 6.3.3.2 of ARP4737H. FAA Notice N 8900.431 at s 13.d.(2) tells operators to make sure the Type I and Type IV are compatible by contacting the respective fluid manufacturers.
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*Non-glycol* is defined as all that is not Glycol (Conventional and Non-conventional), such as organic salts, e.g., sodium formate, sodium acetate, potassium formate, potassium acetate and any mixtures thereof.

*Mixtures* of any Glycol with Non-glycol are defined as Non-glycol.

In summary, there is one foundation specification for Type I fluid, AMS1424N, and two category specifications AMS1424/1 and AMS1424/2.

Keywords:
1,3-propanediol. See Glycol, Non-conventional – 1,3-propanediol
alkali metal salts. See also Non-glycol
AMS1424 – performance v composition of matter specification, s 3.1
AMS1424/1, ss 1.1, 1.3.6, 5.1.3
AMS1424/2, ss 1.1, 1.3.6, 5.1.3
Brix, s 3.2.4
color uniformity, s 3.1.4
color, Type I – orange, s 3.1.4.1
colorless. See also Type I – colorless
compatibility, fluid. See fluid compatibility – Type I with Type II/III/IV
Conventional Glycol. See Glycol, Conventional
definition – Glycol, Conventional and Non-conventional, s 3.1.1
definition – Glycol, Conventional, s 3.1.1.1
definition – Glycol, Non-, s 3.1.1.3
definition – Glycol, Non-conventional, s 3.1.1.2
definition – Glycol, s 3.1.1.1
definition – lot, Type I, s 4.3
definition – LOUT, Type I, s 1.2.2.1
definition – Non-glycol, s 3.1.1.2
diethylene glycol. See also Glycol, Conventional – diethylene glycol
ethylene glycol. See also Glycol, Conventional – ethylene glycol; EG v PG
fluid application, two-step – Type I compatibility with Type II/III/IV, s 1.3.6, see footnote 34
fluid compatibility – Type I with Type II/III/IV, s 1.3.6, see footnote 34
fluid manufacturer documentation – aerodynamic acceptance data, ss 1.3.2, 3.5.3
fluid manufacturer documentation – appearance, s 3.1.4
fluid manufacturer documentation – aquatic toxicity, s 3.1.5.4, Appendix A
fluid manufacturer documentation – biodegradability, s 3.1.5.3
fluid manufacturer documentation – BOD, s 3.1.5.1
fluid manufacturer documentation – COD, s 3.1.5.2
fluid manufacturer documentation – color, s 3.1.4.1
fluid manufacturer documentation – flash point, s 3.2.1
fluid manufacturer documentation – fluid stability, s 3.3
fluid manufacturer documentation – freezing point v dilutions, s 1.2.2.1
fluid manufacturer documentation – freezing point, s 3.2.5
fluid manufacturer documentation – glycol, presence of recycled, s 4.4.2.1
fluid manufacturer documentation – hard water stability, s 3.3.3
fluid manufacturer documentation – HHET, s 3.5.2

35 Section 1.2.2.1 refers to ARP4737, it should refer to AS6285.
fluid manufacturer documentation – LOUT for intended dilutions, s 1.2.2
fluid manufacturer documentation – LOUT, s 1.2.2
fluid manufacturer documentation – materials compatibility, 3.4
fluid manufacturer documentation – pH limits, s 3.2.3
fluid manufacturer documentation – recycled glycol, presence of, s 4.4.2.1
fluid manufacturer documentation – refractive index limits, s 3.2.4
fluid manufacturer documentation – safety data sheet, ss 1.3.1, 4.5.2
fluid manufacturer documentation – shear stability, s 3.3.4
fluid manufacturer documentation – specific gravity, s 3.2.2
fluid manufacturer documentation – storage stability, s 3.3.1
fluid manufacturer documentation – surface tension, s 3.2.6
fluid manufacturer documentation – tendency to foam, s 3.3.5
fluid manufacturer documentation – thermal stability, s 3.3.2
fluid manufacturer documentation – trace contaminants, s 3.1.6
fluid manufacturer documentation – viscosity limits, s 3.2.7
fluid manufacturer documentation – WSET, s 3.5.2
freezing point depressant, Glycol, Conventional and Non-Conventional, s 3.1.1
freezing point depressant, Glycol, Conventional, ss 3.1.1, 3.1.1.1
freezing point depressant, Glycol, Non-conventional, ss 3.1.1, 3.1.1.2
freezing point depressant, Non-glycol, ss 3.1.1, 3.1.1.3, 3.1.3
glycerine. See Glycol, Non-conventional – glycerine
Glycol – definition, s 3.1.1.1
Glycol, Conventional – definition, s 3.1.1.1
Glycol, Conventional – diethylene glycol, s 3.1.1.1
Glycol, Conventional – ethylene glycol, s 3.1.1.1
Glycol, Conventional – propylene glycol, s 3.1.1.1
Glycol, Conventional and Non-conventional – definition, s 3.1.1
glycol, Non-. See Non-glycol
Glycol, Non-conventional – 1,3-propanediol, s 3.1.1.2
Glycol, Non-conventional – definition, s 3.1.1.2
Glycol, Non-conventional – glycerine, s 3.1.1.2
Glycol, Non-conventional – organic non-ionic diols and triols, mixtures of, s 3.1.1.2
Glycol, Non-conventional – organic non-ionic diols and triols, mixtures with Conventional Glycol, s 3.1.1.2
Glycol, Non-conventional – organic non-ionic diols and triols, s 3.1.1.2
glycol, recycled. See Type I – recycled glycol
HHET, Type I – 20 minutes minimum, s 3.5.2
lot, Type I – definition, s 4.3
Non-conventional Glycol. See Glycol, Non-conventional
Non-glycol – definition, s 3.1.1.3
Non-glycol – organic salts mixtures with Glycol, s 3.1.1.3
Non-glycol – organic salts, mixtures of, s 3.1.1.3
Non-glycol – potassium acetate, s 3.1.1.3
Non-glycol – potassium formate, s 3.1.1.3
Non-glycol – sodium acetate, s 3.1.1.3
Non-glycol – sodium formate, s 3.1.1.3
propylene glycol. See also Glycol, Conventional – propylene glycol; EG v PG
recycled glycol. See Type I – recycled glycol
specification, category, ss 1.1, 1.1.1
specification, foundation, ss 1.1, 1.1.1
Type I – acrylic plastics, effect on, s 3.4.6
Type I – aerodynamic acceptance – 50/50\textsuperscript{36}, ss 3.5.3, 3.5.3.2
Type I – aerodynamic acceptance – concentrate form, ss 1.3.2, 3.5.3.2
Type I – aerodynamic acceptance – concentrations to test, ss 3.5.3, 3.5.3.2
Type I – aerodynamic acceptance – fluid elimination\textsuperscript{37}, s 3.5.3.1
Type I – aerodynamic acceptance – fluid thickness, final, s 3.5.3.1
Type I – aerodynamic acceptance – fluid thickness, initial, s 3.5.3.1
Type I – aerodynamic acceptance – high speed ramp, s 3.5.3
Type I – aerodynamic acceptance – highest concentration, ss 3.5.3, 3.5.3.2
Type I – aerodynamic acceptance – low speed ramp, s 3.5.3
Type I – aerodynamic acceptance – ready-to-use, ss 3.5.3, 3.5.3.2
Type I – aging, accelerated, s 3.3.2
Type I – aircraft manufacturer maintenance manual, s 1.2.1
Type I – aircraft manufacturer service letters, s 1.2.1
Type I – aircraft type and model restrictions, s 1.2.1
Type I – anti-icing performance – HHET, s 3.5.2
Type I – anti-icing performance – sample sheared, s 3.5.2
Type I – anti-icing performance – WSET, s 3.5.2
Type I – appearance, s 3.1.4
Type I – approval by purchaser, s 4.4.1
Type I – aquatic toxicity, s 3.1.5.4
Type I – biodegradability, s 3.1.5.3
Type I – BOD, s 3.1.5.1
Type I – Brix, s 3.2.4
Type I – cadmium as contaminant, s 3.1.6
Type I – carbon brake compatibility, s 1.3.8
Type I – certificate of analysis, s 4.2.1
Type I – chromium as contaminant, s 3.1.6
Type I – COD, s 3.1.5.2
Type I – color uniformity, s 3.1.4
Type I – color, orange, s 3.1.4.1
Type I – colorless – mitigating procedures, s 3.1.4.1
Type I – colorless – risk assessment, s 3.1.4.1
Type I – colorless – special training, s 3.1.4.1
Type I – commingling, s 1.3.6
Type I – compatibility with Type II/III/IV, s 1.3.6, see footnote 34
Type I – composition – fire hazard inhibitor, ss 1.3.4, 3.1
Type I – composition – thickeners, free from, s 3.1
Type I – composition, s 3.1
Type I – concentrate to be diluted, s 1.3.2
Type I – consistency, s 4.5.1
Type I – containers, ss 5.1.1, 5.1.3, 5.1.5, 8.4
Type I – contaminants – other fluids, s 1.3.6
Type I – contaminants, trace, s 3.1.6
Type I – corrosion – recycled glycol, caused by, s 4.4.2.1
Type I – corrosion, low embrittling cadmium plate, s 3.4.3
Type I – corrosion, sandwich, s 3.4.1

\textsuperscript{36} Dilutions of concentrate SAE Type I aircraft deicing fluid are normally given by volume, the first number being the volume percent of the concentrate fluid and the second number the volume of water. For example a 70/30 mixture would be 70 parts by volume of the concentrate SAE Type I fluid mixed with 30 parts by volume of water.

\textsuperscript{37} AMS1424N refers to initial thickness and final thickness of the fluid in the aerodynamic acceptance test. AMS1428J refers to fluid elimination. The notions are related in that they attempt to quantify the quantity of fluid that is eliminated during the acceleration run.
Type I – corrosion, stress-, s 3.4.4
Type I – crawling, s 1.3.7
Type I – drums, ss 5.1.2, 5.1.5, 8.4
Type I – effect on aircraft materials, s 3.4
Type I – environmental information, s 3.1.5
Type I – exposure, human, s 1.3.1
Type I – field test with deicing unit, s 1.3.7
Type I – film breaks, s 1.3.7
Type I – fire hazard – circuit breakers, s 1.3.4
Type I – fire hazard – direct current, s 1.3.4
Type I – fire hazard – glycol, ss 1.3.4, 3.1
Type I – fire hazard – inhibitor, ss 1.3.4, 3.1
Type I – fire hazard – noble metal coated wiring, ss 1.3.4, 3.1
Type I – fire hazard – silver coated wiring, ss 1.3.4, 3.1
Type I – fire hazard – switches, electrical, s 1.3.4
Type I – fisheyes, s 1.3.7
Type I – flash point, minimum, ss 1.3.3, 3.2.1
Type I – flash point, ss 1.3.3, 3.2.1
Type I – fluid manufacturer to report – all technical requirement results, s 4.5
Type I – fluid manufacturer to report – recycled glycol, presence of, ss 4.4.2.1
Type I – fluid manufacturer to report – recycled glycol, source of, ss 4.4.2.1
Type I – foam, tendency to, s 3.3.5
Type I – foreign matter, free from, s 3.1.4
Type I – freezing point buffer, s 1.2.2.1
Type I – freezing point curve, s 3.5.1
Type I – freezing point depressant, non-glycol, s 3.1.1
Type I – freezing point of 50/50 dilution, ss 3.2.5, 3.5.1
Type I – freezing point of concentrate form, s 3.2.5
Type I – freezing point of ready-to-use form, s 3.5.1.1
Type I – halogens as contaminant, s 3.1.6
Type I – hard water stability, s 3.3.3
Type I – HHET – sample sheared, s 3.5.2
Type I – HHET, s 3.5.2
Type I – hydrogen embrittlement, s 3.4.5
Type I – label – AMS1424/1 or AMS142/2, s 5.1.3
Type I – label – lot number, s 5.1.3
Type I – label – manufacturer’s identification, s 5.1.3
Type I – label – purchase order number, s 5.1.3
Type I – label – quantity, s 5.1.3
Type I – lead as contaminant, s 3.1.6
Type I – lot acceptance tests, ss 4.2.1, 4.3.3
Type I – lot number, s 4.1
Type I – lot rejection, s 4.6
Type I – LOUT – definition, s 1.2.2.1
Type I – LOUT of dilutions, s 1.2.2
Type I – LOUT reporting requirement, s 1.2.2
Type I – LOUT, manufacturer obligation to report, s 1.2.2
Type I – lumps, free from, s 3.1.4
Type I – matter, free from foreign, s 3.1.4
Type I – mercury as contaminant, s 3.1.6
Type I – mixing of fluids from different manufacturers, ss 1.3.6
Type I – mold growth, s 3.1
Type I – nitrate as contaminant, s 3.1.6
Type I – nitrogen as contaminant, total, s 3.1.6
Type I – painted surface, effect on, s 3.4.7
Type I – particulate contamination, s 3.1.4
Type I – performance properties, s 3.5
Type I – pH, s 3.2.3,
Type I – phosphorus as contaminant, s 3.1.6
Type I – physical properties, s 3.2
Type I – polycarbonate, effect on, s 3.4.6.2
Type I – precautions, s 1.3
Type I – qualification results, initial – comparison to subsequent results38, s 4.5.1
Type I – qualification, initial – what: all technical requirement, s 4.2.2
Type I – qualification, initial – when: change in ingredients, s 4.2.2
Type I – qualification, initial – when: change in processes, s 4.2.2
Type I – qualification, initial – when: change in processing, s 4.2.2
Type I – qualification, initial – when: confirmatory testing, s 4.2.2
Type I – qualification, initial – when: prior first shipment, s 4.2.2
Type I – qualification, initial39, s 4.2.2
Type I – qualification, multiple location – different from original location, s 4.4.3.1
Type I – qualification, multiple location – same as original location, s 4.4.3.2
Type I – qualification, multiple location – when: once, s 4.4.3.3
Type I – qualification, multiple location, s 4.4.3
Type I – qualification, periodic re- – what: aerodynamic acceptance, s 4.2.3
Type I – qualification, periodic re- – what: WSET and HHET, s 4.2.3
Type I – qualification, periodic re- – when: 2 years and 4 years thereafter, s 4.2.3
Type I – qualification, periodic re-, s 4.2.3
Type I – quality assurance, s 4
Type I – recycled glycol – obligation to report presence of, s 4.4.2.1
Type I – recycled glycol – obligation to report source of, s 4.4.2.1
Type I – recycled glycol – quality assurance, s 4.4.2.1
Type I – recycled glycol contaminants, s 4.4.2.1
Type I – recycled glycol, source of, s 4.4.2.1
Type I – refraction, s 3.2.4
Type I – refractive index, s 3.2.4
Type I – rejection by purchaser, s 7
Type I – reports by independent facilities, ss 4.1, 4.2.3, 4.5
Type I – Right to Know Regulation (US), s 5.1.4
Type I – runway concrete resistance, s 3.4.9
Type I – safety data sheet, ss 1.3.1, 4.5.2
Type I – same ingredients, s 4.4.2

38 In section 4.5.1 “subsequent reports” are defined as the periodic requalification reports. Presumably, the multiple site qualification reports should also be subject to the product consistency check of section 4.5.1.
39 AMS1424N lists three kinds of qualification (my understanding): 1) initial qualification (s 4.2.2), 2) periodic requalification (s 4.2.3) and 3) multiple site qualification (4.4.3). What tests? Initial qualification – all technical requirements; periodic qualification – aerodynamic acceptance, WSET and HHET; multiple site, if methods, materials and handling is different from original site – all technical requirements; multiple site, if same methods, materials and handling as the original site – aerodynamic acceptance, WSET and HHET. When? Initial qualification – prior to first shipment; periodic qualification – for non-recycled and recycled glycols after two years and every 4 years thereafter [AMS1424M required testing every 2 years for recycled glycol]; multiple site – after the first multiple site qualification, there no requirement for further testing at that site, unless there is a change in method, materials or handling.
Type I – same manufacturing procedures, s 4.4.2
Type I – same methods of inspection, s 4.4.2
Type I – sampling, bulk shipments, s 4.3.1
Type I – sampling, drum shipments, s 4.3.2
Type I – sampling, statistical, s 4.3.5
Type I – sampling, tote shipments40, s 4.3.2
Type I – shear, resistance to, s 3.3.4
Type I – skins, free from, s 3.1.4
Type I – slipperiness, s 1.3.5
Type I – specific gravity, s 3.2.2
Type I – stability, hard water, s 3.3.3
Type I – stability, storage, s 3.3.1
Type I – stability, thermal, s 3.3.2
Type I – storage stability, s 3.3.1
Type I – sulfur as contaminant, s 3.1.6
Type I – surface tension, s 3.2.6
Type I – suspended matter, s 3.1.4
Type I – testing, autonomous facilities, s 4.2.3
Type I – testing, confirmatory, ss 4.1, 4.2.2
Type I – testing, independent facilities, ss 4.1, 4.2.3, 4.5
Type I – testing, independent laboratories41, ss 4.1, 4.2.3, 4.5
Type I – thermal stability, s 3.3.2
Type I – thickeners, free from, s 3.1
Type I – totes, ss 4.3.2, 5.1.2, 5.1.5
Type I – transparent plastics, effect on, s 3.4.6
Type I – unpainted surface, effect on, s 3.4.8
Type I – use of concentrate form, s 1.3.2
Type I – use of dilution, s 1.3.2
Type I – water, composition of hard, s 3.3.3.1
Type I – water, soft, s 3.3.3
Type I – wetting, s 1.3.7
Type I – WSET – 3 minutes minimum, s 3.5.2
Type I – WSET – sample sheared, s 3.5.2
Type I Glycol (Conventional and Non-conventional) based fluid – technical requirements, s 3.1.2.1
Type I Glycol (Conventional and Non-conventional) based fluid, ss 1.1.1, 3.1.1, 3.1.2.1
Type I Glycol (Conventional) based fluid – technical requirements, s 3.1.2.1
Type I Glycol (Conventional) based fluid, ss 1.1.1, 3.1.1, 3.1.1.1, 3.1.2.1
Type I Glycol (Non-conventional) based fluid – technical requirements, s 3.1.2.1
Type I Glycol based fluid, ss 1.1.1, 3.1.1, 3.1.1.1
Type I Non-glycol based fluid – technical requirement, additional, ss 3.1.1.2, 3.1.3
Type I Non-glycol based fluid – technical requirements, s 3.1.2.2
Type I Non-glycol based fluid, ss 1.1.1, 3.1.1, 3.1.1.3, 3.1.2.2, 3.1.3
Type II/III/IV – compatibility with Type I, s 1.3.6, see footnote 34
WSET, Type I – 3 minutes minimum, s 3.5.2

40 Sampling requirements for bulk and drum shipments are defined in AMS1424 and AMS1428 but are undefined for totes. The industry generally considers tote shipments to be a subset of packaged shipments which include drum shipments. In this document, we considered tote shipments to be equivalent to drum shipments.

41 AMS1424N uses the various terms with apparently similar meaning: “independent laboratory” (s 4.1), “independent facility” (s 4.2.3), “autonomous test facility” (s 4.2.3), “independent testing facilities” (s 4.5). The term facility encompasses laboratory.
AMS1424/1 Deicing/Anti-Icing Fluid, Aircraft SAE Type I Glycol (Conventional and Non-Conventional) Based

Issued 2016-04-18 by SAE G-12 ADF.

SAE Type I fluids based on Conventional and Non-conventional Glycol freezing point depressants are defined and identified as AMS1424/1 (read AMS1424 slash one) Type I fluids. The purpose of the AMS1424/1 specification, which is called a category specification, is to identify the SAE Type I fluid as a Glycol (Conventional or Non-conventional) based fluid. For further information read the description for AMS1424N.

Keywords:
AMS1424/1, Title at p 1
category specification, s 1.1.1
foundation specification, s 1.1.1
freezing point depressant – Glycol, Conventional, s.1.1.1
freezing point depressant – Glycol, Non-conventional, s 1.1.1
freezing point depressant – Glycol, s 1.1.1
freezing point depressant – Non-glycol, s 1.1.1
Glycol, Conventional, s 1.1.1
Glycol, Non-conventional, s 1.1.1
specification, category, s 1.1.1
specification, foundation, s 1.1.1
Type I AMS1424/1, Title at p 1
Type I Glycol (Conventional and Non-conventional) based fluid, Title at p 1, s 1.1.1
Type I Glycol (Conventional) based fluid, s 1.1.1
Type I Glycol (Non-conventional) based fluid, s 1.1.1

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

Issued 2016-05-05 by SAE G-12 ADF.

SAE Type I fluids based on Non-glycol freezing point depressants are defined and identified as AMS1424/2 (read AMS1424 slash two) Type I fluids. The purpose of the AMS1424/2 specification, which is called a category specification, is to identify the SAE Type I fluid as a Non-glycol based fluid. For further information read the description for AMS1424N.

Keywords:
AMS1424/2, Title at p 1
category specification, s 1.1.1
foundation specification, s 1.1.1
freezing point depressant – Non-glycol, s 1.1.1
specification, category, s 1.1.1
specification, foundation, s 1.1.1
AMS1428 sets the technical requirements for deicing/anti-icing fluids (SAE Type II, III and IV) that are used to protect aircraft surfaces against freezing or frozen precipitation for a certain but limited period of time prior to takeoff. These fluids contain thickeners giving shear thinning properties to the fluids. In other words, the thickeners selected for these fluids are such that viscosity of the thickened fluid decreases when a shear strain is applied to the fluid. SAE Type II, III and IV are often known as thickened anti-icing fluids.

AMS1428 is defined as the *foundation specification* for SAE Type II, III and IV fluids. The SAE Type II, III and IV fluids are divided into two *category specifications*: a) SAE Type II/III/IV fluids based on Glycol freezing point depressants, which include Conventional Glycols and Non-conventional Glycols and b) SAE Type II/II/IV fluids based on Non-glycol freezing point depressants.

SAE Type II/III/IV fluids based on Conventional and Non-conventional Glycol freezing point depressants are defined and identified as AMS1428/1 (read AMS1428 slash one) Type II/III/IV fluids. The purpose of the AMS1428/1 specification, which is called a *category specification*, is to identify the SAE Type II/III/IV fluid as a Glycol (Conventional or Non-conventional) based fluid.

*Conventional Glycols* are defined as ethylene glycol, diethylene glycol and propylene glycol.

*Non-conventional Glycols* are defined as organic non-ionic diols and triols, e.g., 1,3-propanediol, glycerine and mixtures thereof and mixtures with conventional glycols.

SAE Type II/III/IV fluids based on Non-glycol freezing point depressants are defined and identified as AMS1428/2 (read AMS1428 slash two) Type II/III/IV fluids. The purpose of the AMS1428/2 specification, which is called a *category specification*, is to identify the SAE Type II/III/IV fluid as a Non-glycol based fluid.
Non-glycol is defined as all that is not Glycol (Conventional and Non-conventional), such as organic salts, e.g., sodium formate, sodium acetate, potassium formate, potassium acetate and any mixtures thereof.

Mixtures of any Glycol with Non-glycol are defined as Non-glycol.

In summary, there is one foundation specification for Type II/III/IV fluids, AMS1428J, and two category specifications AMS1424/1 and AMS1424/2.

Holdover Time Guidelines. SAE Type II, III and IV fluids, during winter operations, provide a limited period of protection against frozen or freezing precipitations while the aircraft is on the ground. The protection time can be estimated using fluid-specific holdover time guidelines that are published by the FAA or Transport Canada.

Commercialization Readiness. For fluid manufacturers wishing to commercialize a Type II/II/IV, it should be noted that it is insufficient to meet all the requirements of AMS1428J to be able to use such fluids on aircraft. The fluids must be on the list of qualified fluid published by the FAA or Transport Canada, obtain holdover time guidelines, also published by the FAA and Transport Canada, and preferably, perform full scale spray test. This process to prepare for commercialization of SAE Type II/III/IV fluids is described in ARP5718A.

Keywords:
1,3-propanediol. See Glycol, Non-conventional – 1,3-propanediol
aerodynamic acceptance, s 3.2.5.2
aerodynamic acceptance. See also Type II/III/IV – aerodynamic acceptance
alkali metal salts. See also Non-glycol
AMS1428 – performance v composition of matter specification, s 3.1
AMS1428/1, ss 1.1.1, 2.1.1
AMS1428/2, ss 1.1.1, 2.1.1
anti-icing performance42, s 3.2.4.1
Brix43, s 3.2.1.4
Brookfield LV viscometer. See viscometer, Brookfield LV
Buehler test44, s 3.2.2.4, Appendix A
color, Type II – yellow, s 1.1.2
color, Type III – bright yellow, s 1.1.2
color, Type IV – green, s 1.1.2

42 Anti-icing performance, as defined in AMS1428 (latest version), is comprised of WSET and HHET.
43 Brix is a unit of refraction. A table of conversion from Brix to index of refraction is available in Robert C. Weast, ed, Handbook of Chemistry and Physics, 49th ed (Cleveland OH, Chemical Rubber Co., 1968-1969) at E-225.
44 The successive dry-out and rehydration test is sometimes referred to as the Buehler test after Mr. Rolf Buehler who developed it.
colorless. See Type II/III/IV – colorless
Conventional Glycol. See Glycol, Conventional
definition – fluid, non-Newtonian, s 1.1.3
definition – fluid, pseudoplastic, s 1.1.4
definition – Glycol, s 3.1.1.1
definition – Glycol, Conventional and Non-conventional, s 3.1.1
definition – Glycol, Conventional, s 3.1.1.1
definition – Glycol, Non-, s 3.1.1.3
definition – Glycol, Non-conventional, s 3.1.1.2
definition – HOWV, s 4.2.3.145
definition – lot, Type II/III/IV, s 4.3
definition – LOUT, Type II/III/IV, s 1.3.1
definition – Non-glycol, s 3.1.1.3
definition – pseudoplastic, s 1.1.4
fluid commingling. See Type I – commingling; Type II/III/IV commingling
fluid manufacturer documentation – aerodynamic acceptance data, ss 1.1.2, 3.2.5.2
fluid manufacturer documentation – aquatic toxicity, s 3.1.4
fluid manufacturer documentation – biodegradability, s 3.1.6.3
fluid manufacturer documentation – BOD, s 3.1.6.1
fluid manufacturer documentation – cold storage stability, 3.2.2.10
fluid manufacturer documentation – dry-out exposure to cold dry air, s 3.2.2.3
fluid manufacturer documentation – exposure to dry air, s 3.2.2.2
fluid manufacturer documentation – flash point, s 3.2.1.1
fluid manufacturer documentation – fluid stability, s 3.2.2
fluid manufacturer documentation – hard water stability, s 3.2.2.8
fluid manufacturer documentation – HHET, s 3.2.4.1
fluid manufacturer documentation – LOUT for intended dilutions, s 1.3.1
fluid manufacturer documentation – LOUT, s 1.3.1
fluid manufacturer documentation – materials compatibility, 3.3.2
fluid manufacturer documentation – pavement compatibility, s 3.3.5
fluid manufacturer documentation – pH limits, s 3.2.1.3
fluid manufacturer documentation – physical properties, s 3.2
fluid manufacturer documentation – refractive index limits, s 3.2.1.4
fluid manufacturer documentation – safety data sheet, ss 1.3.2.4.5.2
fluid manufacturer documentation – specific gravity, s 3.2.1.2
fluid manufacturer documentation – storage stability, s 3.2.2.6
fluid manufacturer documentation – successive dry out and rehydration, s 3.2.2.4
fluid manufacturer documentation – surface tension, s 3.2.1.5
fluid manufacturer documentation – tendency to foam, s 3.2.2.9
fluid manufacturer documentation – thin film thermal stability, s 3.2.2.5
fluid manufacturer documentation – TOD or COD, s 3.1.6.2
fluid manufacturer documentation – toxicity information, s 3.1.4
fluid manufacturer documentation – trace contaminants, s 3.1.7
fluid manufacturer documentation – Type I, Type II or Type IV, s 1.1.2
fluid manufacturer documentation – viscosity limits, s 3.2.3.3
fluid manufacturer documentation – WSET, s 3.2.4.1
fluid, neat. See also Type II/III/IV – neat fluid
fluid, non-Newtonian – definition, s 1.1.3
fluid, non-Newtonian, Title at p 1, ss 1.1, 1.1.3, 3.2.3, 3.2.3.1
fluid, pseudoplastic – definition, s 1.1.4

45 See footnote 5
fluid, pseudoplastic, Title at p 1, ss 1.1.4, 3.2.3
fluid, thickened. See Type II/III/IV
freezing point depressant, Glycol, Conventional and Non-Conventional, ss 3.1.1, 3.1.2.1
freezing point depressant, Glycol, Conventional, ss 3.1.1, 3.1.1.1
freezing point depressant, Glycol, Non-conventional, ss 3.1.1, 3.1.1.2
freezing point depressant, Non-glycol, ss 3.1.1, 3.1.1.3, 3.1.2.2, 3.1.3
glycerine. See Glycol, Non-conventional – glycerine
Glycol – definition, s 3.1.1.1
Glycol, Conventional – definition, s 3.1.1.1
Glycol, Conventional – diethylene glycol, ss 3.1.1.1, 3.1.2.1
Glycol, Conventional – ethylene glycol, ss 3.1.1.1, 3.1.2.1
Glycol, Conventional – propylene glycol, ss 3.1.1.1, 3.1.2.1
Glycol, Conventional and Non-conventional – definition, s 3.1.1
glycol, Non-. See Non-glycol
Glycol, Non-conventional – 1,3-propanediol, s 3.1.1.2
Glycol, Non-conventional – definition, s 3.1.1.2
Glycol, Non-conventional – glycerine, s 3.1.1.2
Glycol, Non-conventional – organic non-ionic diols and triols, s 3.1.1.2
Glycol, Non-conventional – organic non-ionic diols and triols, mixtures of, s 3.1.1.2
Glycol, Non-conventional – organic non-ionic diols and triols, mixtures with Conventional Glycol, s 3.1.1.2
HHET, Type II 50/50 – 0.5 hours minimum, s 3.2.4.1
HHET, Type II 75/25 – 5 hours minimum, s 3.2.4.1
HHET, Type II neat – 4 hours minimum, s 3.2.4.1
HHET, Type III 75/25 – determine and report, s 3.2.4.1
HHET, Type III 50/50 – determine and report, s 3.2.4.1
HHET, Type III neat – 2 hours minimum, s 3.2.4.1
HHET, Type IV 50/50t – 0.5 hours minimum, s 3.4.2.1
HHET, Type IV 75/25 – 2 hours minimum, s 3.4.2.1
HHET, Type IV neat – 8 hours minimum, s 3.4.2.1
lot, Type II/III/IV – definition, s 4.3
LOUT, Type II/III/IV – definition, s 1.3.1
maximum on-wing viscosity. See HOWV
neat. See Type II/III/IV – neat fluid
Non-conventional Glycol. See Glycol, Non-conventional
Non-glycol – definition, s 3.1.1.3
Non-glycol – organic salts mixtures with Glycol, ss 3.1.1.3, 3.1.2.2, 3.1.3
Non-glycol – organic salts, mixtures of, ss 3.1.1.3, 3.1.2.2, 3.1.3
Non-glycol – potassium acetate, ss 3.1.1.3, 3.1.2.2, 3.1.3
Non-glycol – potassium formate, ss 3.1.1.3, 3.1.2.2, 3.1.3
Non-glycol – sodium acetate, ss 3.1.1.3, 3.1.2.2, 3.1.3
Non-glycol – sodium formate, ss 3.1.1.3, 3.1.2.2, 3.1.3
non-Newtonian fluid. See fluid, non-Newtonian
propylene glycol. See also Glycol, Conventional – propylene glycol; EG v PG
pseudoplastic fluid. See fluid, pseudoplastic
shear thinning. See Type II/III/IV – shear thinning
Type II 50/50 – HHET 0.5 hours minimum, s 3.2.4.1
Type II 50/50 – WSET 5 minutes minimum, s 3.2.4.1
Type II 75/25 – HHET 2 hours minimum, s 3.2.4.1
Type II 75/25 – WSET 20 minutes minimum, s 3.2.4.1
Type II color – yellow, s 1.1.2
Type II neat – HHET 4 hours minimum, s 3.2.4.1

46 Thickened fluid is a generic term for Type II/III/IV fluids as all these fluids contain thickeners.
Type II neat – WSET 30 minutes minimum, s 3.2.4.1
Type II. See also Type II/III/IV; Type II/IV
Type II/III/IV – aerodynamic acceptance of highest viscosity dilution sample, s 3.2.5.3
Type II/III/IV – aerodynamic acceptance of sheared sample, s 3.2.5.1
Type II/III/IV – aerodynamic acceptance of unsheared sample, s 3.2.5.1
Type II/III/IV – approval by purchaser s 4.4.1
Type II/III/IV – approval, re- ss 4.2.3, 4.4.2
Type II/III/IV – aquatic toxicity, s 3.1.6.4
Type II/III/IV – biodegradability, s 3.1.6.3
Type II/III/IV – BOD, s 3.1.6.1
Type II/III/IV – Brookfield LV viscometer, s 3.2.3.2.1
Type II/III/IV – carbon brake compatibility, s 1.3.6
Type II/III/IV – certificate of analysis, s 4.2.1
Type II/III/IV – change in formulation, ss 4.2.3, 4.4.2
Type II/III/IV – change in ingredients, ss 4.2.3, 4.4.2
Type II/III/IV – change in production method, s 4.3.2, 4.4.2
Type II/III/IV – corrosion, aluminum alloy, s 3.3.2.2
Type II/III/IV – corrosion, low embrittling cadmium plate, s 3.3.2.3
Type II/III/IV – corrosion, sandwich, s 3.3.2.1
Type II/III/IV – corrosion, stress-, s 3.3.2.4
Type II/III/IV – corrosion, total immersion, s 3.3.2.2
Type II/III/IV – corrosion resistance, s 3.3.2.4.1
Type II/III/IV – corrosion, aluminum alloy, s 3.3.2.2
Type II/III/IV – direct current hazard, s 1.3.3
Type II/III/IV – dry-out exposure to cold dry air, s 3.2.2.3
Type II/III/IV – dry-out exposure to dry air, s 3.2.2.3
Type II/III/IV – dry-out, heated leading edge, s 3.2.2.5
Type II/III/IV – dry-out, successive test. See Type II/III/IV – successive dry-out and rehydration test
Type II/III/IV – dry-out, successive. See Type II/III/IV residue; Type II/IV residue
Type II/III/IV – effect on acrylic plastics, s 3.3.2.6
Type II/III/IV – effect on aircraft materials, s 3.3.2
Type II/III/IV – effect on painted surfaces, s 3.3.3
Type II/III/IV – effect on polycarbonate, s 3.3.2.6.1
Type II/III/IV – effect on transparent plastics, s 3.3.2.6
Type II/III/IV – effect on unpainted surfaces, s 3.3.4
Type II/III/IV – electrochemical dehydrolysis, s 1.3.3
Type II/III/IV – environmental information, s 3.1.6
Type II/III/IV – exposure to cold dry air, s 3.2.2.3
Type II/III/IV – exposure to dry air, s 3.2.2.2
Type II/III/IV – exposure, human, s 1.3.2
Type II/III/IV – FAA/TC list of fluids\(^{47}\), s 1.5
Type II/III/IV – fire hazard inhibitor, s 1.3.3
Type II/III/IV – fire hazard, s 1.3.3
Type II/III/IV – flash point , s 3.2.1.1
Type II/III/IV – fluid elimination, s 3.2.5.4
Type II/III/IV – foam, tendency to, s 3.2.2.9
Type II/III/IV – freezing point buffer, s 1.3.1
Type II/III/IV – freezing point, s 3.3.1
Type II/III/IV – friction, s 1.3.5
Type II/III/IV – glycol dehydrolysis, s 1.3.3
Type II/III/IV – halogen reporting requirement, s 3.1.7
Type II/III/IV – hard water composition, s 3.2.2.8.1
Type II/III/IV – hard water stability, s 3.2.2.8
Type II/III/IV – HHET requirements, s 3.4.2.1
Type II/III/IV – high viscosity sample\(^{48}\), ss 3.2.5, 4.2.3.1
Type II/III/IV – highest viscosity dilution, s 3.2.5.3
Type II/III/IV – HOWV, s 4.2.3.1
Type II/III/IV – HOWV, s 4.2.3.1
Type II/III/IV – HOWV, s 4.2.3.1\(^{49}\)
Type II/III/IV – hydrogen embrittlement , s 3.3.2.5
Type II/III/IV – lead reporting requirement, s 3.1.7
Type II/III/IV – leading edge dry-out, heated, s 3.2.2.5
Type II/III/IV – licensee manufacturing, s 4.4.3
Type II/III/IV – list of fluids, FAA/TC, s 1.5. See also list of fluids, FAA/TC; list of fluids (FAA); list of fluids (TC)
Type II/III/IV – list of qualified fluids\(^{50}\), s 1.5
Type II/III/IV – lot acceptance, s 4.2.1
Type II/III/IV – lot, s 4.3
Type II/III/IV – lot, ss 4.1, 4.2.1, 4.3, 4.5.1.1, 5.1.1.1, 5.1.2
Type II/III/IV – LOUT , s 1.3.1
Type II/III/IV – LOUT, obligation to report, s 1.3.1
Type II/III/IV – low embrittling cadmium plate, s 3.3.2.3
Type II/III/IV – Low Viscosity sample, s 4.2.3.2
Type II/III/IV – magnesium alloy, corrosion of, s 3.3.2.2
Type II/III/IV – materials compatibility, s 3.3.2
Type II/III/IV – maximum on-wing viscosity. See Type II/III/IV – HOWV
Type II/III/IV – mercury reporting requirement, s 3.1.7

\(^{47}\)Both the FAA and Transport Canada issue a list of fluids. If a document refers to both, it will be indexed as “list of fluids, FAA/TC”. If the document refers to only one list, it will be indexed as “list of fluids, FAA” or “list of fluid, TC”, as the case may be.

\(^{48}\)ARP5718B recommends to fluid manufacturers to carefully select the viscosities of the high viscosity sample and low viscosity sample before submitting to the testing laboratories, as these viscosities will be used to establish to set the quality control limits for the fluid delivered. The viscosity of the high viscosity sample will become the highest on-wing viscosity (HOWV), also known as the maximum on-wing viscosity (MOWV).

\(^{49}\)See footnote 5

\(^{50}\)Section 1.5 of AMS1428J refers to the FAA’s and Transport Canada’s list of qualified fluids. FAA and Transport Canada no longer use the term “qualified” for the list of fluids published in their holdover time guidelines.
Type II/III/IV – mixing with fluid from different manufacturers, s 1.3.4
Type II/III/IV – mixture with other fluids, s 1.3.4
Type II/III/IV – multiple location manufacturing, s 4.4.3
Type II/III/IV – neat, ss 1.3.1, 3.2.1
Type II/III/IV – nitrate reporting requirement, s 3.1.7
Type II/III/IV – noble metal coated wiring, s 1.3.3
Type II/III/IV – non-glycol based fluids, ss 3.1.1, 3.1.1.3, 3.1.3
Type II/III/IV – non-Newtonian, ss 1.1, 1.1.3
Type II/III/IV – overnight exposure to dry air, s 3.2.2.2
Type II/III/IV – packaging, s 5.1
Type II/III/IV – pavement compatibility, s 3.3.5
Type II/III/IV – periodic tests, s 4.2.2
Type II/III/IV – pH, s 3.2.1.3
Type II/III/IV – phosphate reporting requirement, s 3.1.7
Type II/III/IV – polycarbonate, effect on. See Type II/III/IV – effect on transparent plastics
Type II/III/IV – preproduction tests, ss 3.2.2.2.2, 3.2.5.3.1, 4.2.3, 4.2.3.1, 4.5.2, A.4, A.5.1, A.6.4
Type II/III/IV – pseudoplastic, s 1.1.4
Type II/III/IV – qualification reports, s 4.5.1
Type II/III/IV – qualification, initial, ss 4.2.3.1, 4.5.1
Type II/III/IV – qualification, periodic re-, ss 4.5.1, 4.5.1.2
Type II/III/IV – quality assurance, s 4
Type II/III/IV – reaction, exothermic, s 1.3.3
Type II/III/IV – re-approval, ss 4.2.3, 4.4.2
Type II/III/IV – refractive index, s 3.2.1.4
Type II/III/IV – rejection, s 4.6
Type II/III/IV – resampling, s 4.6
Type II/III/IV – residue. See Type II/III/IV residue; Type II/IV residue
Type II/III/IV – retesting, s 4.6
Type II/III/IV – rheological properties, s 3.2.3
Type II/III/IV – runway concrete scaling, s 3.3.5.1
Type II/III/IV – sales specification, s 3.2.3.3
Type II/III/IV – same ingredients, s 4.4.2
Type II/III/IV – sample selection. See also HOT, process to obtain – sample selection
Type II/III/IV – sample selection, ss 4.2.3, 4.2.3.1, 4.2.3.2
Type II/III/IV – shear stability, s 3.2.2.7
Type II/III/IV – shear stress, effect on apparent viscosity, ss 1.1.3, 1.1.4
Type II/III/IV – shear thinning\(^{52}\), s 1.1.4
Type II/III/IV – silver coated wiring, s 1.3.3
Type II/III/IV – slipperiness, s 1.3.5
Type II/III/IV – specific gravity, s 3.2.1.2
Type II/III/IV – storage stability waived, s 4.2.3
Type II/III/IV – storage stability, s 3.2.2.6
Type II/III/IV – storage stability, cold, s 3.2.2.10
Type II/III/IV – storage, long term, s 3.2.2.1
Type II/III/IV – stress-corrosion resistance, s 3.3.2.4
Type II/III/IV – subcontractor manufacturing, s 4.4.3
Type II/III/IV – successive dry out and rehydration test, s 3.2.2.4, Appendix A
Type II/III/IV – sulfur reporting requirement, s 3.1.7

\(^{51}\) Several sections refer to preproduction samples or tests. It should be understood that the initial qualification tests of ss 4.2.3, 4.2.3.1, 4.2.3.2 are performed on preproduction samples. This is made explicit in ss A.4, A.5.1, A.6.4

\(^{52}\) Shear thinning is generally considered a synonym of pseudoplastic, that is a fluid whose viscosity is decreased when subjected to shear strain (excluding time dependent effects).
Type II/III/IV – surface tension, s 3.2.1.5
Type II/III/IV – switches, defective, s 1.3.3
Type II/III/IV – technical requirements, s 3
Type II/III/IV – temperature cycling, s 3.2.2.10
Type II/III/IV – thermal stability, accelerated aging, s 3.2.2.1
Type II/III/IV – thermal stability, thin film, s 3.2.2.5
Type II/III/IV – thickened fluid, s 3.2.3
Type II/III/IV – titanium corrosion resistance, s 3.3.2.2
Type II/III/IV – TOD, s 3.1.6.2
Type II/III/IV – toxicity, s 3.1.4
Type II/III/IV – trace contaminants, s 3.1.7
Type II/III/IV – U.S Military procurement, s 4.2.3.3
Type II/III/IV – uncolored, s 3.1.5
Type II/III/IV – undiluted fluid, ss 1.3.1, 3.2.1
Type II/III/IV – viscosity limits, s 3.2.3.3
Type II/III/IV – viscosity measurement, s 3.2.3.2
Type II/III/IV – wiring, defective, s 1.3.3
Type II/III/IV – WSET limits, s 3.2.4.1
Type II/III/IV residue formation – first step application of Type II/III/IV in two-step application, s 1.3.7
Type II/III/IV residue formation – one-step application of Type II/III/IV, s 1.3.7
Type II/III/IV residue formation test. See Type II/III/IV – successive dry out and rehydration test
Type II/III/IV residue formation, s 3.2.2.4
Type II/III/IV residue formation. See also Type II/IV residue formation
Type II/III/IV residue in aerodynamically quiet areas, s 1.3.7
Type II/III/IV residue in cavities, s 1.3.7
Type II/III/IV residue in gaps, s 1.3.7
Type II/III/IV residue, effect of – flight safety, s 1.3.7
Type III 50/50 – HHET determine and report, s 3.2.4.1
Type III 50/50 – WSET determine and report, s 3.2.4.1
Type III 75/25 – HHET determine and report, s 3.2.4.1
Type III 75/25 – WSET determine and report, s 3.2.4.1
Type III color – bright yellow, s 1.1.2
Type III neat – HHET 2 hours minimum, s 3.2.4.1
Type III neat – WSET 20 minutes minimum, s 3.2.4.1
Type III. See also Type II/III/IV
Type IV 50/50 – HHET 0.5 hours minimum, s 3.2.4.1
Type IV 50/50 – WSET 5 minutes minimum, s 3.2.4.1
Type IV 75/25 – HHET 2 hours minimum, s 3.2.4.1
Type IV 75/25 – WSET 20 minutes minimum, s 3.2.4.1
Type IV color – green, s 1.1.2
Type IV neat – HHET 8 hours minimum, s 3.2.4.1
Type IV neat – WSET 80 minutes minimum, s 3.2.4.1
Type IV. See also Type II/III/IV; Type II/IV
viscometer, Brookfield LV – cold storage stability, s 3.2.2.10
viscometer, Brookfield LV – highest viscosity dilution, s 3.2.5.3.1
viscometer, Brookfield LV – small sample adapter, ss 3.2.3.2, 3.2.5.1
viscometer, Brookfield LV – Type II/III/IV viscosity measurement, ss 3.2.3.2, 3.2.3.2.1
WSET, Type II 50/50 – 5 minutes minimum, s 3.2.4.1
WSET, Type II 75/25 – 20 minutes minimum, s 3.2.4.1
WSET, Type II neat – 30 minutes minimum, s 3.2.4.1
WSET, Type III 50/50 – determine and report, s 3.2.4.1
WSET, Type III 75/25 – determine and report, s 3.2.4.1
WSET, Type III neat – 20 minutes minimum, s 3.2.4.1
WSET, Type IV 50/50 – 5 minutes minimum, s 3.2.4.1
WSET, Type IV 75/25 – 20 minutes minimum, s 3.2.4.1
WSET, Type IV neat – 80 minutes minimum, s 3.2.4.1

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

Issued 2017-02-14 by SAE G-12 ADF

SAE Type II, II and IV fluids based on Conventional and Non-conventional Glycol freezing point depressants are defined and identified as AMS1428/1 (read AMS1428 slash one) Type II, III and IV fluids. The purpose of the AMS1428/1 specification, which is called a category specification, is to identify the SAE Type I fluid as a Glycol (Conventional or Non-conventional) based fluid. For further information, read the definition of Glycol Conventional and Non-Conventional in AMS1428J, which is defined as the base specification.

Keywords:
AMS1428/1, Title at p 1
category specification, s 1.1.1
foundation specification, s 1.1.1
freezing point depressant – Glycol, Conventional, s.1.1.1
freezing point depressant – Glycol, Non-conventional, s 1.1.1
freezing point depressant – Glycol, s 1.1.1
freezing point depressant – Non-glycol, s 1.1.1
Glycol, Conventional, s 1.1.1
Glycol, Non-conventional, s 1.1.1
specification, category, s 1.1.1
specification, foundation, s 1.1.1
Type II/III/IV AMS1428/1, Title at p 1
Type II/III/IV Glycol (Conventional and Non-conventional) based fluid, Title at p 1, s 1.1.1
Type II/III/IV Glycol (Conventional) based fluid, s 1.1.1
Type II/III/IV Glycol (Non-conventional) based fluid, s 1.1.1
Type II/III/IV purchase documents, ss 2, 9.2

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

Issued 2017-02-09 by SAE G-12 ADF

SAE Type II, II and IV fluids based on Non-Glycol freezing point depressants are defined and identified as AMS1428/2 (read AMS1428 slash two) Type II, III and IV fluids. The purpose of the AMS1428/2 specification, which is called a category specification, is to identify the SAE Type II,
III and IV fluids as a Non-Glycol based fluid. For further information, read the definition of Glycol Conventional and Non-Conventional in AMS1428J, which is called the base specification.

Keywords:
AMS1428/2, Title at p 1
category specification, s 1.1.1
foundation specification, s 1.1.1
freezing point depressant – Glycol, Conventional, s.1.1.1
freezing point depressant – Glycol, Non-conventional, s 1.1.1
freezing point depressant – Glycol, s 1.1.1
freezing point depressant – Non-glycol, s 1.1.1
Glycol, Conventional, s 1.1.1
Glycol, Non-conventional, s 1.1.1
specification, category, s 1.1.1
specification, foundation, s 1.1.1
Type II/III/IV AMS1428/2, Title at p 1
Type II/III/IV Glycol (Conventional and Non-conventional) based fluid, Title at p 1, s 1.1.1
Type II/III/IV Glycol (Conventional) based fluid, s 1.1.1
Type II/III/IV Glycol (Non-conventional) based fluid, s 1.1.1
Type II/III/IV purchase documents, ss 2, 9.2

AS9968 Laboratory Viscosity Measurement of Thickened Aircraft Deicing/Anti-icing Fluids with the Brookfield LV Viscometer

Issued 2014-07-22 by SAE G-12 ADF.

AS9968 describes a standard laboratory method (as opposed to a field method) for viscosity measurements of thickened (SAE Type II, III and IV) anti-icing fluids. Many fluid manufacturers publish alternate methods for their fluids. In case of conflicting results between the two methods, the manufacturer method takes precedence. To compare viscosities, exactly the same measurement elements (including spindle size, speed of rotation, time after beginning of rotation, container size and temperature) must have been used to obtain those viscosities.

Keywords:
fluid manufacturer documentation – viscosity measurement method, s 1
Type II/III/IV viscosity measurement method, Title at p 1, Rationale at p 1
viscometer, Brookfield LV, Title at p 1, Rationale at p 1, ss 3.1, 3.3.8.1
viscosity measurement method – air bubble free sample s 3.3.2

53 Viscosity measurement methods and viscosity field check. There are three ways of verifying that an SAE Type II/III/IV is above its lowest on-wing viscosity (LOWV): a) viscosity measurement method provided by the fluid manufacturer (the “manufacturer method”), b) viscosity measurement method described in AS9968 (the “AS9968 method”) and c) “viscosity” field check (or field test) as described in AIR5704 or provided by the fluid manufacturer, such as a falling ball method. Here, we attempt to make a distinction between the laboratory viscosity measurement methods which use a Brookfield LV viscometer where the result is a numerical viscosity value in mPa·s and viscosity field checks where the result is generally a pass/fail result without a numerical viscosity value.
AIR5704 Field Viscosity Test for Thickened Aircraft Anti-Icing Fluids

Reaffirmed 2016-06-09 by SAE G-12 ADF.

AIR5704 provides a description of a field screening method (or field “viscosity” check) for verifying an SAE Type II, III or IV anti-icing fluid is above its minimum low shear viscosity as published with holdover time guidelines. The test will determine if the fluid is (a) satisfactory, (b) unsatisfactory, or (c) borderline needing more advanced viscometry testing. Other field tests may be required to determine if an anti-icing fluid is useable, such as refractive index, pH, appearance or other tests as may be recommended by the fluid manufacturer.

Keywords:
air bubble removal by centrifugation, s 3.2
Stony Brook apparatus for viscosity field check, s 3.3
viscosity field check – air bubble removal by centrifugation, s 3.2
viscosity field check – air bubbles, s 3.2
viscosity field check – screening method, Rationale at p 1
viscosity field check – Stony Brook apparatus, s 3.3
viscosity field check for Type II/III/IV, Title at p 1
viscosity field check v fluid manufacturer method, Foreword at p 1, see footnote 53
viscosity field check, Title at p 1
viscosity field test. See viscosity field check
viscosity measurement method v field check see footnote 53
The purpose of ARP6207 is to explain to fluid manufacturers and users, at a high level, the steps required for an experimental fluid i) to become a commercially useable fluid, ii) to be allowed to use the generic Type holdover times, and iii) to be listed on the FAA and Transport Canada list of fluids.

Meeting all of the technical requirements of AMS1424N is insufficient for a Type I deicing fluid to be used on an aircraft. ARP56207 explains that there are four conditions to commercialize an SAE Type I fluid, the first three are mandatory, the fourth one is highly recommended: 1) meet the technical requirements of AMS1424, 2) be identified on the FAA/Transport Canada list of fluids and 3) have a performance such that it can be used with generic Type I holdover time guidelines published by the FAA/Transport Canada and 4) running a field spray test to demonstrate operational performance

ARP6207 a) describes the preparatory steps to test an experimental fluid according to AMS1424, b) advises fluid manufacturers on sample selection issues for experimental fluids, c) provides a suggested protocol for field spray testing, d) details the protocol to demonstrate that an experimental Type I can be used with the FAA/Transport Canada generic Type I holdover time guidelines, e) explains the process for inclusion and exclusion of fluids on the FAA/Transport Canada list of fluids, f) describes the role of the SAE G-12 ADF and HOT Committees and g) the publication process for Type I holdover time guidelines.

Its sister document for AMS1428 fluids, is ARP5718B whose title is Qualifications Required for SAE Type II/III/IV aircraft Deicing/Anti-Icing Fluid.

Keywords:
aerodynamic acceptance – definition, s 2.3
aircraft manufacturer documentation – list fluid types allowed on aircraft, footnote 1 at p 1
alkali organic salt based Type I – exclusion from FAA/Transport Canada list of fluids, s 3.2
alkali organic salt based Type I – effect on Type II/III/IV protection time, s 3.2
alkali organic salt based Type I – HOT – invalid, s 3.2
allowance time – definition, s 2.3
allowance time – failure mode – aerodynamic and visual, s 2.3
allowance time – wind tunnel testing, s 3.5
allowance time, Type I – none, s 3.5
allowance time, Type II – none, s 3.5
allowance time. See also wind tunnel testing
AMS1424, purpose of – minimum requirements for Type I, s 3.3.1
AMS1424/1, purpose of – identity of freezing point depressant, s 3.2
AMS1424/2, purpose of – identity of freezing point depressant, s 3.2
AOS. See alkali organic salt
color intensity, evaluation of – field spray test, s 4.3d
definition – aerodynamic acceptance, s 2.3
definition – allowance time, s 2.3
definition – endurance time, s 2.3
definition – FAA/Transport Canada list of fluids. See definition – list of fluids, FAA/Transport Canada
definition – HOT guideline, s 2.3
definition – HOT guideline, fluid-specific, s 2.3
definition – HOT guideline, generic, ss 2.3, 5.5
definition – HOT table. See definition – HOT guideline
definition – HOT, s 2.3
definition – list of fluids, FAA/Transport Canada, s 2.3
definition – LOUT, Type I, s 2.3
definition – WSET, s 2.3
endurance time – definition, s 2.3
endurance time tests, Type I – glycol based – none, s 3.4.1
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FAA/Transport Canada list of fluids. See list of fluids, FAA/Transport Canada
failure mode, allowance time – aerodynamic and visual, s 2.3
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field spray test. See spray test, field
fluid manufacturer – obligation to provide to FAA/TC – Type I (licensee location) – initial qualification test report – aerodynamic acceptance, ss 5.7.2, 5.7.2
fluid manufacturer – obligation to provide to FAA/TC – Type I (licensee location) – original qualification test data, ss 5.7.2, 5.7.2
fluid manufacturer – obligation to provide to FAA/TC – Type I (new) – initial qualification test report – aerodynamic acceptance, ss 5.6.3, 5.6.3.1
fluid manufacturer – obligation to provide to FAA/TC – Type I – periodic requalification test report – aerodynamic acceptance, ss 5.6.3, 5.6.3.1
fluid manufacturer – obligation to provide to FAA/TC – Type I – periodic requalification test report – anti-icing performance, ss 5.6.3, 5.6.3.1
fluid manufacturer – obligation to provide to FAA/TC – Type I – restrictions on use of, ss 5.2.1
fluid manufacturer – obligation to provide to FAA/TC – Type I (licensee location) – initial qualification test report – WSET, ss 5.7.2
fluid manufacturer – obligation to provide to FAA/TC – Type I (new) – initial qualification test report – aerodynamic acceptance, high speed and or low speed, ss 5.6.2, 5.6.2.1a
fluid manufacturer – obligation to provide to FAA/TC – Type I (new) – initial qualification test report – anti-icing performance, ss 5.6.2, 5.6.2.1a
fluid manufacturer – obligation to provide to FAA/TC – Type I (new) – freezing point data, ss 5.6.2, 5.6.2.1c
fluid manufacturer – obligation to provide to FAA/TC – Type I (new) – endurance time data, ss 3.4.1

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fluid manufacturer – obligation to provide to FAA/TC – Type I (new) EG based – endurance time data not required, s 3.4.1
fluid manufacturer – obligation to provide to FAA/TC – Type I (new) PG based – endurance time data not required, s 3.4.1
fluid manufacturer – obligation to provide to FAA/TC – Type I (new) DEG based – endurance time data not required, s 3.4.1
fluid manufacturer – obligation to provide to FAA/TC – Type I (new) – final name by May 01, s 5.3
fluid manufacturer – obligation to provide to FAA/TC – Type I (new) – unique name, s 5.3
fluid manufacturer – sample selection considerations, Type I, ss 3.3.2, 3.4.2
fluid manufacturer licensee – Type I HOT guideline, s 5.7.2
fluid name – final commercial name, s 5.3
fluid name – formulation change, upon, s 5.3
fluid name – new unique name, s 5.3
fluid name – reformulation, s 5.3
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fluid, new – data required for use with generic HOT, s 5.7
fluid, new – new unique name, mandatory, s 5.3
fluid, new – obligation to provide information to FAA/TC, s 5.6.2
fluid-specific HOT guidelines. See HOT, fluid-specific
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generic HOT guidelines. See HOT, generic
HOT – definition, s 2.3
HOT – failure mode – visual, s 2.3
HOT guideline – definition, s 2.3
HOT guideline, fluid specific Type I – none, s 2.3
HOT guideline, fluid-specific – definition, s 2.3
HOT guideline, generic – definition, s 2.3
HOT guideline, publication date for, ss 8, 9
HOT guideline, publication timeline for, s 9
HOT table synonym for HOT guideline, s 2.3
HOT values, capping of. See HOT, preparation of Type I – HOT values, capping of
HOT values, rounding of. See HOT, preparation of Type I – HOT values, rounding of
HOT, preparation of Type I – cautions – HOT reduced – aircraft skin temperature lower than OAT, s 5.1.4a
HOT, preparation of Type I – cautions – no inflight-protection, s 5.1.4b
HOT, preparation of Type I – cautions – protection time shortened – jet blast, s 5.1.4a
HOT, preparation of Type I – cautions – protection time shortened – high winds, s 5.1.4a
HOT, preparation of Type I – cautions – protection time shortened – heavy weather, 5.1.4a
HOT, preparation of Type I – cautions – protection time shortened – heavy precipitation rates, s 5.1.4a
HOT, preparation of Type I – cautions – protection time shortened – high moisture content, s 5.1.4a
HOT, preparation of Type I – cells, s 5.1.2
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HOT, preparation of Type I – date of revision, s 5.1.5
HOT, preparation of Type I – fluid product names, s 5.3
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HOT, preparation of Type I – format, s 5.1
HOT, preparation of Type I – generic – unchanging, s 2.3
HOT, preparation of Type I – generic, ss 2.3, 5.1
HOT, preparation of Type I – HOT values from R&D, s 2.3
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Transport Canada/FAA list of fluids. See list of fluids, FAA/Transport Canada
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Type I – sample selection. See also HOT, process to obtain – sample selection
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Type I commercialization condition – AMS1424 technical requirements, meet the, Foreword at p 1
Type I commercialization condition – FAA/Transport Canada list of fluids, be on the, Foreword at p 1
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**ARP5945A Endurance Time Tests for SAE Type I Aircraft Deicing/Anti-icing Fluids**

Revised 2017-10-10 by SAE G-12 HOT.

ARP5945A provides sample selection criteria and test procedures for SAE Type I aircraft deicing/anti-icing fluids, required for the generation of endurance time data of acceptable quality for review by the SAE G-12 HOT. Specifically, ARP5945A describes laboratory endurance procedure testing for freezing fog, freezing drizzle, light freezing rain, rain on cold soaked wing, and snow (two methods, NCAR/APS method and the AMIL method). It describes natural outdoor procedures for snow and frost.

A significant body of previous research and testing has indicated that all Type I fluids formulated with propylene glycol, ethylene glycol, and diethylene glycol perform in a similar manner from an endurance time perspective. Type I deicing/anti-icing fluids whose freezing point depressant is one of those three glycols do not require testing for endurance times. Fluids formulated with 1)

\textsuperscript{54} Field spray trial (p 1) and field spray test (s 4.1) appear to be used interchangeably in ARP6207.
glycol freezing point depressants other than those listed above, and 2) all non-glycol freezing point
depressants, must be tested for endurance times using the methods described in this ARP5945A.

Its sister document for AMS1428 Type II/III/IV fluids is ARP5485B whose title is *Endurance
Time Test Procedures for SAE Type II/III/IV Aircraft Deicing/Anti-Icing Fluids.*

**Keywords:**
- crystallization, delayed, s 4.7.3
- definition – endurance time, Foreword at p 1
- diethylene glycol based Type I – endurance time tests not required, ss 1.1, 3.1
- endurance time – definition, Foreword at p 1
- endurance time tests, Type I – crystallization, delayed, s 4.7.3
- endurance time tests, Type I – data examination by SAE G-12 HOT, Rationale at p 1, ss 1.1, 1.2
- endurance time tests, Type I – data validation by SAE G-12 HOT, Rationale at p 1, ss 1.1, 1.2
- endurance time tests, Type I – delayed crystallization, s 4.7.3
- endurance time tests, Type I – diethylene glycol based fluid – test not required, s 1.1
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- endurance time tests, Type I – failure mode, snow – dilution – more prevalent, s 10.4.6
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- endurance time tests, Type I – failure mode, snow – snow-bridging, s 10.4.6
- endurance time tests, Type I – failure, frozen contamination – 30% area, s 4.7.2
- endurance time tests, Type I – failure, frozen contamination – appearance, s 4.7.2
- endurance time tests, Type I – failure, snow – 30% area or non-absorption over 5 crosshairs, s 10.4.6
- endurance time tests, Type I – fluid manufacturer documentation – aerodynamic acceptance data, s 3.4.2
- endurance time tests, Type I – fluid manufacturer documentation – freezing point data, s 3.2.5b
- endurance time tests, Type I – fluid manufacturer documentation – freezing point v dilution data, s 3.2.5a
- endurance time tests, Type I – fluid manufacturer documentation – freezing point v refractive index data, s
  3.2.5a
- endurance time tests, Type I – fluid manufacturer documentation – LOUT, s 3.4.2
- endurance time tests, Type I – fluid manufacturer documentation – safety data sheet, s 3.2.5c
- endurance time tests, Type I – fog, freezing, s 6
- endurance time tests, Type I – freezing drizzle, s 7
- endurance time tests, Type I – freezing fog, s 6
- endurance time tests, Type I – frost, laboratory s 5
- endurance time tests, Type I – frost, natural, s 12
- endurance time tests, Type I – glycol based fluid, other – test required, s 1.1
- endurance time tests, Type I – ice crystal seeding, s 4.7.3
- endurance time tests, Type I – icing intensity measurements by regression analysis, s 4.6.2.2
- endurance time tests, Type I – icing intensity measurements with reference ice-catch plates, s 4.6.2.1
- endurance time tests, Type I – icing intensity measurements, s 4.6.2
- endurance time tests, Type I – light freezing rain, s 8
- endurance time tests, Type I – manufacturer’s mandatory documentation, s 3.2.5
- endurance time tests, Type I – non-glycol based fluid – test required, ss 1.1, 3.1
- endurance time tests, Type I – plate cleanliness, ss 7.4.1, 11.4.1
- endurance time tests, Type I – propylene glycol based fluid – test not required, ss 1.1, 3.1
- endurance time tests, Type I – purpose, p 1
- endurance time tests, Type I – rain on cold soaked wing, s 9
- endurance time tests, Type I – regression analysis, ss 4.6.2.2, 6.2.1.3, 11.4.5
- endurance time tests, Type I – relation to HOT, Foreword at p 1, s 1.2

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endurance time tests, Type I – snow form excludes: soft hail (graupel), s 11.4.6
endurance time tests, Type I – snow form includes: capped columns, s 11.4.6
endurance time tests, Type I – snow form includes: columns, s 11.4.6
endurance time tests, Type I – snow form includes: irregular particles, s 11.4.6
endurance time tests, Type I – snow form includes: needles, s 11.4.6
endurance time tests, Type I – snow form includes: plates, s 11.4.6
endurance time tests, Type I – snow form includes: snow grains, s 11.4.6
endurance time tests, Type I – snow form includes: spatial dendrites, s 11.4.6
endurance time tests, Type I – snow form includes: stellar crystals, s 11.4.6
endurance time tests, Type I – snow grains, s 11.4.6
endurance time tests, Type I – snow, laboratory – shorter time than natural snow, Foreword at p1
endurance time tests, Type I – snow, laboratory – snow distribution systems, ss 10.1.5, 10.1.6, 10.1.7
endurance time tests, Type I – snow, laboratory – snow sources, ss 10.4.1, 10.4.2
endurance time tests, Type I – snow, laboratory, s 10
endurance time tests, Type I – snow, natural, s 11
endurance time tests, Type I – temperature, lowest test, ss 3.4.2, 12.3
endurance time tests, Type I – test facility, ss 1.5.1, 4.4, 4.6.2.4, 4.7.4
endurance time tests, Type I – test facility/site – independence from fluid manufacturer, s 1.5.1
endurance time tests, Type I – test facility/site, role of, s 1.4.2
endurance time tests, Type I – test plate cleanliness, s 4.7.1
endurance time tests, Type I – testing agent – independence from fluid manufacturer, s 1.4.1
endurance time tests, Type I – testing agent duties, ss 1.4.2, 3.2, 3.3
endurance time tests, Type I – testing agent, role of, ss 1.4.2, 3.2, 3.3,
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endurance time tests, Type I – water droplet size – laser diffraction method, s 4.6.5c
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failure, plate. See also frozen contamination – appearance
fluid manufacturer documentation. See also endurance time tests, Type I – fluid manufacturer documentation
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frozen contamination – appearance – ice crystals, disseminated, s 4.7.2
frozen contamination – appearance – ice front, s 4.7.2
frozen contamination – appearance – ice pieces imbedded in fluid, s 4.7.2
frozen contamination – appearance – ice pieces partially imbedded in fluid, s 4.7.2
frozen contamination – appearance – ice sheet, s 4.7.2
frozen contamination – appearance – slush front, s 4.7.2
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frozen contamination – appearance – snow bridges, s 4.7.2
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propylene glycol based Type I – endurance time tests not required, ss 1.1, 3.1
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water droplet size – laser diffraction method, s 4.6.5e
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water droplet size – slide impact method with oil, s 4.6.5a

**ARP5718B Qualifications Required for SAE Type II/III/IV Aircraft Deicing/Anti-icing Fluids**

Revised 2017-12-07 by SAE G-12 HOT.

In its version B, the document name changed. The version A name was ARP5718A Process to Obtain Holdover Times for Aircraft Deicing/Anti-Icing Fluids, SAE AMS1428 Types II, III, and IV.

The purpose of ARP5718B is to explain to fluid manufacturers and users, at a high level, the steps required for an experimental fluid i) to become a commercially useable fluid, ii) to obtain allowance and holdover times, and iii) to be listed on the FAA and Transport Canada list of fluids.

Meeting all of the technical requirements of AMS1428 is insufficient for a Type II, III or IV de/anti-icing fluid to be used on an aircraft. For such a fluid to be used commercially, it must be associated to holdover time guideline and be identified on a list of fluids published by the FAA and Transport Canada. It is further recommended that a field spray trial be conducted with the fluid to demonstrate acceptable operational performance.

ARP5718B a) describes the preparatory steps to test an experimental fluid according to AMS1428, b) advises fluid manufacturers on sample selection issues, particularly in selecting viscosity parameters for experimental fluids, c) offers a short description of wind tunnel testing for obtaining data to generate allowance times, d) provides a suggested protocol for field spray testing, e) details the protocol used to generate holdover time guidelines form endurance time data, including the format of the holdover time tables, e) explains the process for inclusion and exclusion of fluids on the FAA/Transport Canada list of fluids, f) describes the role of the SAE G-12 ADF and HOT
Committees and g) the publication process for the Type III/IV allowance and Type II/III/IV holdover time guidelines.

Its sister document for AMS1424 Type I fluids is ARP6207 Qualifications Required for SAE Type I Aircraft Deicing/Anti-icing Fluids.

Keywords:
aerodynamic acceptance – definition, s 2.3
aircraft manufacturer documentation – list fluid types allowed on aircraft, footnote 1 at p 1
allowance time – definition, s 2.3
allowance time – failure mode – aerodynamic and visual, s 2.3
allowance time – wind tunnel testing, ss 3.4.1, 3.4.2, 3.4.3
allowance time. See also wind tunnel testing
allowance time, preparation of Type II/IV – sample selection, s 3.4.3
allowance time, preparation of Type III/IV – precipitation categories – ice pellets and small hail, s 5.1.1f
allowance time, preparation of Type III/IV – precipitation categories – mixed ice pellets, s 5.1.1f
AMIL gel residue tables55, s 3.2.3
AMIL residue tables. See AMIL gel residue tables
AMS1428, purpose of – minimum requirements for Type II/II/IV fluids, s 3.2.1
AMS1428/1, purpose of – identity of freezing point depressant, s 3.2.1
AMS1428/2, purpose of – identity of freezing point depressant, s 3.2.1
bleed-through. See color bleed-through
color bleed-through – definition, s 4.3
color bleed-through, evaluation of, s 4.3
color intensity, evaluation of – field spray test, s 4.3c
definition – aerodynamic acceptance, s 2.3
definition – allowance time, s 2.3
definition – bleed-through, s 4.3c
definition – endurance time, s 2.3
definition – FAA/Transport Canada list of fluids. See definition – list of fluids, FAA/Transport Canada
definition – highest useable precipitation rate. See definition – HUPR
definition – HOT guideline, s 2.3
definition – HOT guideline, fluid-specific, s 2.3
definition – HOT guideline, generic, ss 2.3, 5.8
definition – HOT table. See definition – HOT guideline
definition – HOT, s 2.3
definition – HUPR, s 2.3
definition – list of fluids, FAA/Transport Canada, s 2.3
definition – LOUT, Type II/III/IV, s 2.3
definition – lowest useable precipitation rate. See definition – LUPR
definition – LOWV, ss 2.3, 3.3.2
definition – LUPR, s 2.3
definition – precipitation rate, highest useable. See definition – HUPR

55 AMIL, “Anti-icing Fluids Gel Residue Testing Results”, online: <http://amillaboratory.ca/aircraft-deanti-icing-fluids/aaa/>. Type II/III/IV upon evaporation may leave residue on aircraft surface, particularly in aerodynamically quiet areas. The residues may upon rehydration form gels that are susceptible to freezing and which may hinder the movement of critical parts of the aircraft. Different Type II/III/IV fluids have different propensity to form such residues. AMIL conducted a study where several fluids were tested for the propensity for form rehydrated residues. The results are published online.
definition – precipitation rate, lowest useable. See definition – LUPR
definition – viscosity limit, lower sales specification, s 2.3
definition – WSET, s 2.3
endurance time – definition, s 2.3
endurance time – limits in natural snow, s 5.5
endurance time – LUPR and HUPR analysis, s 5.5.2
endurance time tests, Type II/III/IV – sample selection, s 3.3.2
FAA/Transport Canada list of fluids. See list of fluids, FAA/Transport Canada
failure mode, allowance time – aerodynamic and visual, s 2.3
failure mode, endurance time – visual, s 2.3
failure mode, HOT – visual, s 2.3
field spray test. See spray test, field
fluid manufacturer – obligation to provide to FAA/TC – Type II/III/IV (licensee location) – initial qualification test report – aerodynamic acceptance, s 5.7.5
fluid manufacturer – obligation to provide to FAA/TC – Type II/III/IV (licensee location) – initial qualification test report – WSET, s 5.7.5
fluid manufacturer – obligation to provide to FAA/TC – Type II/III/IV (licensee location) – original qualification test data, s 5.7.5
fluid manufacturer – obligation to provide to FAA/TC – additional requested data, s 5.9.4
fluid manufacturer – obligation to provide to FAA/TC – data – general obligation, s 5.9
fluid manufacturer – obligation to provide to FAA/TC – deadlines, ss 5.6, 5.9.2, 5.9.3, 9
fluid manufacturer – obligation to provide to FAA/TC – Type II/III/IV – list of fluids to be commercialized by June 01, ss 5.9.1, 9
fluid manufacturer – obligation to provide to FAA/TC – Type II/III/IV – periodic requalification test report – aerodynamic acceptance, ss 5.9.3, 5.9.3.1, 5.9.3.2
fluid manufacturer – obligation to provide to FAA/TC – Type II/III/IV – periodic requalification test report – anti-icing performance, ss 5.9.3, 5.9.3.1, 5.9.3.2
fluid manufacturer – obligation to provide to FAA/TC – Type II/III/IV – restrictions on use of, s 5.2
fluid manufacturer – obligation to provide to FAA/TC – Type II/III/IV – periodic requalification test report – multiple locations56
fluid manufacturer – obligation to provide to FAA/TC – Type II/IV (new) – initial qualification test report – aerodynamic acceptance, high speed, ss 5.9.2, 5.9.2.1
fluid manufacturer – obligation to provide to FAA/TC – Type II/IV (new) – initial qualification test report – anti-icing performance, ss 5.9.2, 5.9.2.1
fluid manufacturer – obligation to provide to FAA/TC – Type II/IV (new) – freezing point data, 5.9.2, 5.9.2.1
fluid manufacturer – obligation to provide to FAA/TC – Type II/IV (new) – endurance time data, s 3.3
fluid manufacturer – obligation to provide to FAA/TC – Type II/IV (new) – unique name, s 5.6
fluid manufacturer – obligation to provide to FAA/TC – Type II/IV (new) – final name by May 01, s 5.6
fluid manufacturer – obligation to provide to FAA/TC – Type III (new) – initial qualification test report – aerodynamic acceptance, low speed, ss 5.9.2, 5.9.2.2
fluid manufacturer – obligation to provide to FAA/TC – Type III (new) – initial qualification test report – aerodynamic acceptance, high speed (optional), ss 5.9.2, 5.9.2.2
fluid manufacturer – obligation to provide to FAA/TC – Type III (new) – initial qualification test report – anti-icing performance, ss 5.9.2, 5.9.2.2
fluid manufacturer – obligation to provide to FAA/TC – Type III (new) – endurance time data, s 3.3
fluid manufacturer – obligation to provide to FAA/TC – Type III (new) – initial qualification test report – freezing point data 5.9.2, 5.9.2.2

56 The requirement for fluid manufacturers to provide data for each manufacturing location was an explicit requirement of s 5.7.3 of ARP5718A. The section 5.7.3 became section 5.9.3 in ARP5718B but the sentence requiring the provision of data for each manufacturing location is no longer present in that section. We believe it is an implicit obligation as there is not statement excluding multiple sites from reporting.
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fluid manufacturer – obligation to provide to FAA/TC – Type III (new) – to be used heated, not heated or both, s 5.2
fluid manufacturer – obligation to provide to FAA/TC – Type III (new) – unique name, s 5.6
fluid manufacturer – obligation to provide to FAA/TC – Type III (new) – final name by May 01, s 5.6
fluid manufacturer – option not to publish fluid-specific HOT, s 5.7.1
fluid manufacturer – sample selection considerations, Type II/III/IV, ss 3.2.2, 3.3.2
fluid manufacturer licensee – fluid-specific HOT guideline, s 5.7.5
fluid name – final commercial name, s 5.6
fluid name – formulation change, upon, s 5.6
fluid name – new unique name, s 5.6
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57 Field spray trial (p 1) and field spray test (s 4.1) appear to be used interchangeably in ARP5718B.
58 There are four conditions to commercialize an SAE Type II/III/IV fluid, the first three are mandatory, the fourth one is highly recommended: 1) meet the technical requirements of AMS1428, 2) be identified on the FAA/Transport Canada list of fluids and 3) have a holdover time guideline published by the FAA/Transport Canada and 4) running a field spray test to demonstrate operational performance (see ARP5718B p 1).
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ARP5485B Endurance Time Test Procedures for SAE Type II/III/IV Aircraft Deicing/Anti-icing Fluids

Revised 2017-10-10 by SAE G-12 HOT.

ARP5485B provides the sample selection and endurance time test procedures, for SAE Type II, III, and IV aircraft deicing/anti-icing fluids, required for the generation of endurance time data of acceptable quality for review by the SAE G-12 HOT. Specifically, ARP5945B describes laboratory endurance procedure testing for freezing fog, freezing drizzle, light freezing rain, rain on cold soaked wing, and snow (two methods, NCAR/APS Aviation method and the AMIL method). It describes natural outdoor procedures for snow and frost.

Snow tests can be performed by three methods: 1) outdoors with natural snow, 2) indoors with artificial snow or collected natural snow, storing the artificial snow or collected natural snow, and distributing either systematically over the test plates or 3) indoors with artificial snow made as the test is being performed. Artificial snow is made by a) spraying fine water droplets in a cold chamber resulting in fine solid ice crystals that are collected on the cold chamber floor (used in method 2) or b) shaving ice cores into ice shavings with a so-called snowmaker (used in method 3). Outdoor tests are performed under uncontrolled weather conditions, which means all desired temperature/snow precipitation rate combinations may not be tested during a given winter; indoor tests are performed under controlled conditions.

59 See footnote 5
60 The collected snow and subsequent distribution method was developed at AMIL.
61 The instantaneous shaving core snowmaker method was developed at NCAR and extensively used by APS Aviation.
Its sister document for AMS1424 Type I fluids is ARP5945A whose title is *Endurance Time Test Procedures for SAE Type I Aircraft Deicing/Anti-Icing Fluids*.

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AS5681B Minimum Operational Performance Specification for Remote On-Ground Ice Detection Systems

AS5681B issued 2016-05-17 by SAE G-12 Ice Detection, now part of SAE G-12 HOT.

AS5681B specifies the minimum operational performance specification (MOPS) of remote on-ground ice detection systems (ROGIDS). ROGIDS are ground-based systems that indicate whether frozen contamination is present on aircraft surfaces.

ROGIDS are intended to be used during aircraft ground deicing operations to inform ground crews or flight crews about the condition of the aircraft.

AS5681B presents a functional description of ROGIDS, design requirements, minimum performance requirements, laboratory tests conditions to evaluate the ROGIDS, recommended test procedure to demonstrate compliance with the minimum requirements and operational evaluation requirements to verify the performance of in-service ROGIDS.

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62 Frozen contaminants and frozen contamination are generally used as synonyms.
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Documents Issued by the SAE G-12 Methods Committee

ARP4737J Aircraft Deicing/Anti-Icing Methods

Cancelled 2017-08-02 by SAE G-12 M.

As ARP4737J is a cancelled document, its indexing was removed from the Guide to Aircraft Ground Deicing. ARP4737H (the last active version of ARP4737) was replaced by AS6285 which was issued on August 19, 2016. The intent is for AS6285 is to become a standard adopted by all countries, ICAO, and IATA as the new global standard for processes for aircraft ground deicing.

AS6285 Aircraft Ground Deicing/Anti-Icing Processes

Issued 2016-08-19 by SAE G-12 M.

This is the first of the global standards to be issued. It provides the procedures to perform deicing and anti-icing of aircraft that are subject any form of ice, snow and frost.

Keywords:
aircraft deicing/anti-icing methods, Foreword at p 1  
aircraft ground deicing methods, Foreword at p 1  
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63 AS6285 is not explicit about the need to communicate with the flightcrew if deicing/anti-icing is performed in its absence. See s 13.a. of FAA Notice N 8900.431 for more information.
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\(^{64}\) Correct expression is “freezing” point, not “freeze” point, as spelled in AS6285.
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65 The three minute rule of ARP4737H has been replaced in AS6285 by rule whereby the second step fluid has to be applied before the fluid of the first step freezes, s 8.7.1, Tables 1–2.
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67 Section 4.3.1 calls for a “visual examination for color and foreign body contamination” in other words, the person performing this visual test must verify for color and the presence of foreign matter (aka as suspended matter). Section only refers to “visual examination” which includes an assessment of appearance (color and form, e.g., green liquid) and suspended matter. In this guide we index “visual examination” as “visual check” which should probably be broken down as appearance test and suspended matter test.

68 Although not covered in AS6285, a complete sampling procedure should cover safety precautions, personal protective equipment, special hazards at airport such as movement of trucks and aircraft, specific procedure for sampling delivery trucks, storage tanks, deicing unit tanks, drums, totes, warning about the possible high temperature of fluid, disposal of excess fluid taken during sampling, site clean up after sampling, specific sampling equipment (e.g., zone sampler). specific type of sample bottle.
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post deicing/anti-icing check – incorporated in deicing/anti-icing operation or as separate check, s 7.3
post deicing/anti-icing check – repetition, s 7.3c
post deicing/anti-icing check – responsibility to conduct, s 5.5
post deicing/anti-icing check excludes clear ice check, s 7.3
post deicing/anti-icing check, ss 5.5, 7.3
pre-deicing process – brooms, s 8.2
pre-deicing process – forced air with fluid, s 8.2
pre-deicing process – forced air, s 8.2
pre-deicing process – heat, s 8.2
pre-deicing process – heavy frozen contaminant accumulation, s 8.4.3
pre-deicing process – hot air, s 8.2
pre-deicing process – hot water, s 8.2
pre-deicing process – infrared, s 8.2
pre-deicing process – negative freezing point buffer hot fluid, s 8.2
pre-deicing process, s 8.2
preflight check – by flightcrew, s 7
preflight check – by ground crew, s 7
pretakeoff check – assessment by flightcrew if HOT is still appropriate, s 7.4
pretakeoff check, ss 7.4, 7.5, 8.5.3
pretakeoff contamination check – alternative is re-deicing, s 7.5
pretakeoff contamination check – when critical surface conditions cannot be determined by flightcrew, s 7.5
pretakeoff contamination check – when HOT exceeded, s 7.5
pretakeoff contamination check, s 7.5
program, ground deicing and anti-icing, s 3.5
proximity sensor – definition, s 2.2.2b
proximity sensor activation – communications with flightcrew, ss 5.10, 8.7.19
proximity sensor activation – reporting procedure, s 8.7.19
proximity sensor activation, deicing unit, s 5.10
quality assurance – audit, s 4.1
quality assurance subset of quality program, s 4
quality assurance, s 4.1
quality control program, s 4.2
quality control subset of quality program, s 4
quality program superset of quality assurance and quality control, s 4
refractive index – definition, s 2.2.2b
refractometer – definition, s 2.2.2b
regulator – responsibilities, s 3.5
regulator – responsibility for regulations and guidance material, s 3.5
regulator – responsibility for airline to have a deicing program, s 3.5
regulator – responsibility for policies and standards supporting the clean aircraft concept, s 3.5
regulator – responsibility for regulations and guidance material on clean aircraft concept, s 3.5
residue. See Type II/III/IV residue
residue/gel – definition, s 2.2.2b
rime ice – definition, s 2.2.2b
sample bottle label – concentration [e.g., 100/0, 75/25, 50/50], s 4.3.6c
sample bottle label – date sample taken, s 4.3.6c
sample bottle label69 – hazard category
sample bottle label – name of airline or company sending the sample, see footnote 69
sample bottle label – name of vessel [e.g., deicing unit 5, storage tank B, tote 57], s 4.3.6c
sample bottle label – origin [airport code, city], s 4.3.6c
sample bottle label – product name, s 4.3.6c
sample bottle label – where the sample was taken from [e.g., nozzle, bottom valve, top of tank, middle of tank], s 4.3.6c
sampling frequency, ss 4.3.2.1, 4.3.2.2, 4.3.3
sampling, nozzle. See fluid sampling, nozzle
service provider – responsibilities, s 3.3
shall (SAE) – definition, s 2.2.2a
should (SAE) – definition, s 2.2.2a
slipperiness, s 10.1
slush – definition, s 2.2.2b
snow – definition, s 2.2.2b
snow grains – definition, s 2.2.2b
snow grains subset of snow [for HOT], s 2.2.2b
snow pellets – definition, s 2.2.2b
snow, removal of, s 8.4.3
snowflake formation, s 2.2.2b
staff, qualified – definition, s 2.2.2b
storage – annual inspection, s 10.1
storage – contamination check, s 10.1
storage – corrosion at vapor space, s 10.1
storage – corrosion check, s 10.1
storage – corrosion in vapor space, s 10.1
storage – dedicated, s 10.1
storage – degradation check – frequency, s 10.1
storage – degradation check, s 10.1
storage – dissimilar metals, s 10.1

69 Although not listed in section 4.3.6c of AS6285, the following should appear on a sample label: name of the airline or company sending the sample and hazard category of the fluid, a mandatory requirement for shipping chemicals.
storage – effect of prolonged heating, s 4.3.4
storage – galvanic couple, s 10.1
storage – label, s 10.1
storage – labeling, conspicuous, s 10.1
storage – prolonged heating, s 10.3
storage – sampling frequency s 10.1
storage – temperature, s 10.1
storage – viscosity test, s 4.3.2.3
storage – water loss, s 10.3
storage tank – definition, s 2.2.2b
sublimation, frost formation by, s 2.2.2b
temperature at nozzle, Tables 1–2
training, s 11
two-step deicing/anti-icing, 8.7.2
Type I – acetate based, s 8.5
Type I – application guidelines. See fluid application
Type I – compatibility with Type II/III/IV\textsuperscript{70}
Type I – formatted based, s 8.5
Type I – functional description, s 8.5.3
Type I – LOUT, s 2.2.2b, Table 1
Type I – maximum concentration, ss 4.3.3.1, 8.6.1
Type I – use of concentrate form, no, s 8.6
Type II/III/IV – application guidelines. See fluid application
Type II/III/IV – fluid transfer system – dedicated, s 10.2
Type II/III/IV – fluid transfer system – labeling, s 10.2
Type II/III/IV – fluid transfer system, s 10.2
Type II/III/IV – functional description, s 8.5.3
Type II/III/IV – LOUT differs for dilutions, Table 2
Type II/III/IV – minimum quantity (1 liter/m²), s 8.5.1
Type II/III/IV – removal from cockpit windows, 8.7.11
Type II/III/IV – thickness application, sufficient, s 8.5, 8.5.1
Type II/III/IV – use as deicing fluid – residue inspection and cleaning program required, ss 8.7.1, 8.7.2
Type II/III/IV – use in first-step of two-step process – residue inspection and cleaning program required, s 8.7.2
Type II/III/IV – use in one-step deicing – residue inspection and cleaning program required, s 8.7.2
Type II/III/IV – water loss, ss 8.5, 10.3
Type II/III/IV 50/50 – cold soaked wing, do not used for, Table 2
Type II/III/IV 50/50 – tolerance on fluid/water mixtures, s 4.3.3.3
Type II/III/IV 75/25 – tolerance on fluid/water mixtures, s 4.3.3.3
Type II/III/IV degradation – heating, s 10.3
Type II/III/IV degradation – water loss s 10.3
Type II/III/IV dehydration. See Type II/III/IV degradation – water loss
Type II/III/IV residue cleaning program, s 8.7.1
Type II/III/IV residue cleaning, s 8.7.16
Type II/III/IV residue detection, ss 8.7.1, 8.7.2
Type II/III/IV residue detection. See also Type II/IV residue detection
Type II/III/IV residue formation – conditions conducive to, ss 8.6.2, 8.7.1, 8.7.2, 8.7.16
Type II/III/IV residue formation – no takeoff and no precipitation after fluid application, s 6.9

\textsuperscript{70} The following sentence, present in ARP4737H, is missing from AS6285: “When a fluid conforming to AMS1428 is used to perform step two in a two step (sic) deicing/anti-icing operation, and the fluid used in step one is a Type I fluid conforming to AMS1424, a test shall be made to confirm that the combination of these fluids does not significantly reduce the WSET performance of the AMS1428 fluid.”
Type II/III/IV residue formation – Type I to alleviate, s 8.7.1
Type II/III/IV residue formation – use of Type II/III/IV without Type I, s 8.7.2
Type II/III/IV residue inspection, ss 8.7.1, 8.7.2, 8.7.16
Type II/III/IV residue, effect of – flight control restrictions, s 8.7.1, 8.7.2
Type II/III/IV residue, s 8.7.16
water loss – Type I – undesirable aerodynamic effects, s 10.3
water loss – Type II/III/IV – degradation and lower HOT, s 10.3
water loss due to heating s 10.3
windows with wipers, cockpit – removal of Type II/III/IV, s 6.8
windows, cockpit – removal of Type II/III/IV, s 6.8
wing skin temperature lower than OAT, ss 8.5.3, 8.7.2, Tables 1–2

ARP6257 Aircraft Ground De/Anti-icing Communication Phraseology for Flight and Ground Crews

ARP6257 issued 2016-10-25 by SAE G-12 M.

AS6287 contains standardized scripts for communication between aircraft flight and ground crews during aircraft deicing operations. It covers contact protocols, aircraft configuration, de/anti-icing treatment needed and post deicing reporting requirements.

Keywords:
anti-icing code, s. 3.2.1
communication with flightcrew – aircraft configuration confirmation, s 3.2.1
communication with flightcrew – all clear signal, s 3.2.1
communication with flightcrew – anti-icing code, s 3.2.1
communication with flightcrew – before starting deicing/anti-icing, s 3.2.1
communication with flightcrew – deicing unit proximity sensor activation s 3.2.2.1a
communication with flightcrew – emergency, s 3.2.2.1b
communication with flightcrew – interrupted operations, s 3.2.2.2a
communication with flightcrew – phraseology, need for standard, s 1.1, 1.2
communication with flightcrew – phraseology, Rationale at p 1, ss 1, 3
communication with flightcrew – post deicing/anti-icing check completion, s 3.2.1
communication with flightcrew – proximity sensor activation s 3.2.2.1a
emergency – communications, s 3.2.2.1b
phraseology, Rationale at p 1, ss 1, 3
phraseology, use of standard, ss 1.1, 1.2

AS5537 Weather Support to Deicing Decision Making (WSDMM) Winter Weather Nowcasting System

AS5537 issued 2004-05-04 by SAE G-12 M.

AS5537 provides guidelines for the deployment of WSDMM nowcasting weather system which is a form of holdover time determination system (HOTDS). This system converts real-time snow
data and other precipitation data into liquid water equivalent data which is matched to endurance
time data using appropriate regression equation. The system provides a check time for an aircraft
treated with Type I/II/II/IV fluids. The check time is used to determine the fluid protection
capability in varying weather conditions.

Keywords:
GEONOR, s 4
HOTDS – WSDMM, Foreword at p 1
LWES, Foreword at p 1
METAR snowfall intensity underestimation. See snowfall intensity, METAR – underestimation.
nowcasting, Title at p 1
snow gauge – hotplate, s 4
snow gauge – precipitation, s 4
snow gauge, Foreword at p 1, s 4
snowfall intensity, METAR – underestimation in heavily rimed snow, Foreword at p 2, s 1.2
snowfall intensity, METAR – underestimation in snow containing single crystals of compact shape, Foreword
at p 2, s 1.2
snowfall intensity, METAR – underestimation in wet snow, Foreword at p 2, s 1.2
snowfall rate – liquid water equivalent, Foreword at p 2, s 1.2
weather support to deicing decision making, Title at p 1
wind shield – single alter, s 4.1
WSDMM, Title at p 1

**AIR1335A Ramp De-icing**

Issued 2000-03-01 by SAE G-12 M.

To be cancelled, as it was replaced by ARP4737. It is not indexed.
Documents Issued by the SAE G-12 Deicing Facilities Committee

ARP5660A Deicing Facility Operational Procedures

ARP5660A issued 2011-01-06 by SAE G-12 DF.

ARP5660A provides guidelines for the standardization of safe operating procedures to be used in performing the services and maintenance at designated deicing facilities (DDF), centralized deicing facilities (CDF) or remote deicing facilities. AIR5660A should be used by regulators and airport authorities to develop and standardize approvals and permits for the establishment and operation of a DDF. The coordination of stakeholders is required prior to the approval of design plans for a deicing facility. Operating procedures must be agreed to, in writing, by all air operators, airport authorities, regulators and service providers prior to commencing deicing operations.

Keywords:
- ACARS – definition, s 2.3
- CDF – definition, s 2.3
- CDF subset of DDF, Foreword at p 1
- CDF. See also DDF
- central deicing facility. See CDF
- centralized deicing facility. See CDF
- control point – definition, s 2.3
- control point. See also transfer point
- DDF – approval, s 14
- DDF – control boundaries, s15.2
- DDF – definition, s 2.3
- DDF – design of, s 1.2
- DDF – documentation, s 11
- DDF – emergency action plans, s 7
- DDF – emergency communications protocol, Table A3
- DDF – engines-on deicing, Rationale at p 1, ss 3.2, 4.1.4, 4.2.5.1
- DDF – environmental considerations, s 5
- DDF – fluid acceptance, ss 12.2.3, 12.2.4
- DDF – fluid management, s 12
- DDF – fluid testing, ss 12.2.5, 12.2.6
- DDF – operational procedure, ss 1.1, 3
- DDF – phraseology, Appendix A
- DDF – pilot brief sheet, Appendix B
- DDF – pre-storm planning, s 15.1, Table 1
- DDF – quality control, s 13
- DDF – safety, s 9
- DDF – service provider, single, s 4.3.1
- DDF – service providers, several, s 4.3.2
- DDF – snow removal, s 8
- DDF – spent fluid, s 5.9
- DDF superset of centralized deicing facility, s 1.1
DDF superset of remote deicing facility, s 1.1
definition – ACARS, s 2.3
definition – CDF, s 2.3
definition – control point, s 2.3
definition – DDF, s 2.3
definition – deicing bay, s 2.3
definition – deicing coordinator, s 2.3
definition – deicing crew, s 2.3
definition – deicing facility, s 2.3
definition – deicing lead, s 2.3
definition – deicing operator, s 2.3
definition – deicing pad, s 2.3
definition – deicing vehicle operator, primary, s 2.3
definition – ground coordinator, s 2.3
definition – ice house, s 2.3
definition – iceman, s 2.3
definition – pad control point, s 2.3
definition – pad control, s 2.3
definition – pad leadership, s 2.3
definition – pink snow, s 2.3
definition – primary deicing vehicle operator, s 2.3
definition – remote deicing facility, s 2.3
definition – slot management, s 2.3
definition – snow desk, s 2.3
definition – snow, pink, s 2.3
definition – staging area, s 2.3
definition – transfer point, s 2.3
definition – windrows, s 2.3
deicing bay – definition, s 2.3
deicing coordinator – definition, s 2.3
deicing crew – definition, s 2.3
deicing facility – definition, s 2.3
deicing facility – operational procedure, Title at p 1
deicing facility, designated. See DDF
deicing facility, remote subset of DDF p 1
deicing lead – definition, s 2.3
deicing operator – definition, s 2.3
deicing operator – definition, s 2.3
deicing pad – definition, s 2.3
deicing vehicle operator, primary – definition, s 2.2
designated deicing facility. See DDF
engines-on deicing, Rationale at p 1, ss 3.2, 4.1.4, 4.2.5.1
fluid acceptance – DDF, ss 12.2.3, 12.2.4
frozen contamination, removal of – with forced air at DDF, s 3.3
frozen contamination, removal of – with infrared at DDF, s 3.3
frozen contamination, removal of – with steam at DDF, s 3.3
glycol mitigation, s 5.11
ground coordinator – definition, s 2.3
hand signals, ss 4.2.1, 4.2.6
ice house – definition, s 2.3
iceman – definition, s 2.3
message boards – use at DDF, s 4.1.4
pad control – definition, s 2.3
pad control point – definition, s 2.3
pad leadership – definition, s 2.3
pink snow – definition, s 2.3
primary deicing vehicle operator – definition, s 2.3
remote deicing facility – definition, s 2.3
remote deicing facility subset of DDF, s 15.2
remote deicing facility. See also DDF (designated deicing facility)
slot management – definition, s 2.3
snow desk – definition, s 2.3
snow removal – DDF, s 9
snow, pink – definition, s 2.3
staging areas\(^7\) – definition, s 2.3
transfer point – definition, s 2.3
windrows – definition, s 2.3

ARP4902B Design of Aircraft Deicing Facilities

Issued 2013-03-28 by SAE G-12 DF.

ARP4902B provides guidance material to assist in assessing the need for and feasibility of developing deicing facilities, the planning (size and location) and design of deicing facilities including environmental and operational considerations.

Keywords:
ADF, spent. See also deicing facility – spent ADF
aircraft deicing facility. See deicing facility
aircraft deicing pad. See deicing pad
common fluid, s 6.1.3
definition – deicing facility, remote, s 2.2.1.2
definition – deicing facility, s 2.2.1
definition – deicing facility, terminal, s 2.2.2.1
definition – deicing pad, s 2.2.2
definition – remote deicing facility, s 2.2.1.2
deicing facility – aircraft failure, s 6.5.1.5
deicing facility – aircraft marshaling plan, s 6.5.1.1
deicing facility – aircraft parking area, s 2.2.2
deicing facility – apron perimeter, s 4.5.2
deicing facility – ATC, coordination with, s 6.2
deicing facility – BOD, s 5.2
deicing facility – COD, s 5.2
deicing facility – common fluid, s 6.1.3
deicing facility – construction, Foreword p 1, s 4
deicing facility – definition, s 2.2.1
deicing facility – deicing pad safety, s 6.7.1
deicing facility – deicing vehicle maneuvering area, s 2.2.2
deicing facility – design, Title at p 1, s 4

\(^7\) Section 2 of ARP4902B defines staging area, yet the deicing pad definition refers to staging bay.
deicing facility – disabled aircraft, ss 3.2.2.2, 6.5.1.2
deicing facility – drainage and collection, ss 4.6, 5.3.2
deicing facility – drainage, ss 3.2.1.4, 3.5.3.1, 4.1, 4.5, 5.3.2
deicing facility – effect on water quality, s 5.1.2
deicing facility – emergency evacuation, s 6.5.1.5
deicing facility – emergency response, s 6.9.2
deicing facility – engine shutdown/restart, s 6.5.1.2
deicing facility – environmental considerations, s 5
deicing facility – environmental reporting, s 6.9.6
deicing facility – equipment failures, s 6.5.1.2
deicing facility – facility activation, s 6.4.4
deicing facility – FBO, s 6.1.1.4
deicing facility – fluid segregation, s 5.3.3
deicing facility – gate hold procedure, s 6.2.2
deicing facility – glycol – oxygen depleting potential, s 5.1.1
deicing facility – glycol recovery vehicle, ss 5.3.3, 5.5.2
deicing facility – grooved pavements, s 4.5.1
deicing facility – ground power unit, s 6.6.6
deicing facility – ground water protection, s 5.3.5
deicing facility – GRV, s 5.3.3, 5.5.2
deicing facility – jet blast, s 4.3.3, 6.8
deicing facility – location considerations, s 3
deicing facility – nighttime lighting systems, s 4.4.2
deicing facility – oil/water separator, s 5.3.2.2
deicing facility – pad configuration, s 4.3
deicing facility – passenger emergency, s 6.5.1.5
deicing facility – pavement lighting, s 4.4.1.2
deicing facility – pavement markings, s 4.4.1.1
deicing facility – pavement system, s 4.5
deicing facility – pH, s 5.2
deicing facility – piping, s 5.3.1
deicing facility – planning, Foreword at p 1
deicing facility – prevailing winds, s 4.3.5
deicing facility – recycling ADF, s 5.4.2
deicing facility – secondary containment, s 5.3.1
deicing facility – security requirements, s 6.9.5
deicing facility – signage, s 6.5.1.4
deicing facility – snow removal, ss 4.6.3, 6.5.2.1
deicing facility – spent ADF – above ground storage tanks, s 5.3.4.3
deing facility – spent ADF – biological degradation, s 5.4.2
deing facility – spent ADF – detention pond, ss 4.6.5.2, 5.3.4.1
deing facility – spent ADF – disposal, s 5.4.1
deing facility – spent ADF – photochemical oxidation, s 5.4.4
deing facility – spent ADF – recycling, s 5.4.3
deing facility – spent ADF – storage size, s 5.3.4
deing facility – spent ADF – underground storage tanks, s 5.3.4.2
deing facility – spent ADF – waste water treatment plant, s 5.4.2
deing facility – storage, s 5.3.1
deing facility – storm drain system, s 5.3.2.2
deing facility – storm water, s 4.6.5
deing facility – surface water, s 5.3.2.1
deing facility – taxi routes, s 6.2.3
deing facility – throughput demand, s 6.6.1
AS5635 Message Boards (Deicing Facilities)

AS5635 issued 2005-02-16 by SAE G-12 DF.

AS5635 establishes the minimum standard requirements for message boards deicing facilities including the minimum content and appearance of the display, functional capabilities, design, inspection, and testing requirements

Keywords:
decing facility – message boards, Title at p 1
message boards – aircraft entry, s 3.4.3.1
message boards – aircraft exit, s 3.4.3.4
message boards – aircraft positioning, s 3.4.3.2
message boards – deicing/anti-icing information, s 3.4.3.3
message boards – design requirements, s 3
message boards – inspection and testing, s 4
message boards – minimum design requirement, s 3.5
message boards – precedence of verbal communications, s 3.4.3
message boards – purpose, s 3.2
message boards – safety requirements, s 3.6
message boards – system malfunction, s 3.6.2
message boards – technical requirements, s 3.3
message boards, Title at p 1
Documents Issued by the SAE G-12 Equipment Committee

ARP1971C Aircraft Deicing Vehicle - Self-Propelled

Revised 2011-05-06 by SAE G-12 E.

ARP1971C covers requirements for a self-propelled, boom type aerial device, equipped with an aircraft deicing/anti-icing fluid spraying system.

Keywords:
aircraft deicing vehicle – self-propelled. See deicing unit
anti-icing truck. See deicing unit
basket. See deicing unit – basket
boom. See deicing unit – boom
deicing truck. See deicing unit
deicing unit – acceptance, s 4
deicing unit – aerial basket, ss 3.1, 3.2.3, 3.4
deicing unit – aerial device, s 3.4
deicing unit – aircraft inspection, use for, s 1
deicing unit – aircraft maintenance, use for, s 1
deicing unit – basket capacity, s 3.2.3
deicing unit – basket, ss 3.1, 3.2.3, 3.4
deicing unit – blower, s 3.2.9
deicing unit – boom, s 3.4
deicing unit – chassis, s 3.3.9
deicing unit – combustion heaters, s 3.2.7
deicing unit – controls and instrumentation, s 3.6
deicing unit – fast heating system, s 3.2.7
deicing unit – fill ports – different sizes, s 3.9.19
deicing unit – fill ports, s 3.9.19
deicing unit – fluid contamination, s 3.5.6
deicing unit – fluid delivery pressure, s 3.2.4
deicing unit – fluid delivery rate, s 3.2.4
deicing unit – fluid delivery temperatures, s 3.2.4
deicing unit – fluid fill couplings, s 3.9.19
deicing unit – fluid fill ports, s 3.9.19
deicing unit – fluid heating system ss 3.2.7, 3.5.15-17, 3.9.25
deicing unit – fluid heating system, electric 3.9.25
deicing unit – fluid labeling, s 3.5.1
deicing unit – fluid level gauges, s 3.6.8
deicing unit – fluid mixing system, ss 3.9.2, 3.9.3
deicing unit – fluid pressure gauge, s 3.9.20
deicing unit – fluid proportioning system, ss 3.2.5, 3.9.2, 3.9.3

72 ARP1971C does not offer an exhaustive list of potential sources of chemical contamination, for example when new equipment is placed into service, it may have been shipped with an antifreeze solution in the pump and piping system. This antifreeze solution is an unwanted contaminant and needs to be cleaned off. Rain can enter through covers, so can melted snow. Often deicing trucks tanks are filled with water in the summertime for training purpose; care should be taken to drain the water before the deicing truck is put back into service.
deicing unit – fluid pumps – circulating/mixing, s 3.9.1
deicing unit – fluid pumps – on demand, s 3.9.1
deicing unit – fluid pumps – positive displacement, s 3.9.1
deicing unit – fluid pumps – rotary diaphragm, s 3.9.1
deicing unit – fluid pumps – test for fluid shear degradation, s 3.9.1
deicing unit – fluid pumps – Type II/III/IV, s 3.9.1
deicing unit – fluid pumps, s 3.9.1
deicing unit – fluid spray pattern, s 3.5.11
deicing unit – fluid system, s 3.5
deicing unit – fluid tank capacity, s 3.5.2
deicing unit – fluid tank fittings, s 3.5.5
deicing unit – fluid tank, s 3.9.1
deicing unit – fuel capacity, s 3.2.10
deicing unit – hose couplings, s 3.9.19
deicing unit – hot water deicing system, ss 3.5.4, 3.9.2, 3.9.27
deicing unit – inspection of aircraft, s 1
deicing unit – labeling of, s 3.2.12
deicing unit – maintenance manuals, s 5
deicing unit – markings on, s 3.2.12
deicing unit – mixing system. See deicing unit – fluid mixing system
decing unit – modifications, s 6.4
decing unit – nozzle – ground level – Type I only, s 3.5.2
decing unit – nozzle – pressure gauge, s 3.9.23
decing unit – nozzle – rate of flow adjustment, s 3.5.11
decing unit – nozzle – spray patterns, s 3.5.11
decing unit – nozzle – test for degradation, s 3.9.1
decing unit – nozzle – Type II/III/IV, ss 3.9.1–3.9.3
decing unit – nozzle, adjustable, s 3.5.11
decing unit – nozzle, ss 3.5.10, 3.5.12, 3.9.1 - 3.9.3
decing unit – on-board fluid mixing system, ss 3.9.2, 3.9.3
decing unit – parts, ss 5.2, 6.1
decing unit – personnel basket. See deicing unit – basket
decing unit – product support, s 6
decing unit – proportioning mix system, ss 3.9.2, 3.9.3, 3.9.27
decing unit – pumps. See deicing unit – fluid pumps, s 9.1
decing unit – speed control device, s 3.8.9
decing unit – speed, s 3.2.1
decing unit – spray nozzle See deicing unit – nozzle
decing unit – tank capacity, s 3.2.5
decing unit – tank covers, s 3.5.6
decing unit – tank rain entry prevention, s 3.5.6
decing unit – technical requirements, s 3
decing unit – training by manufacturer, s 6.3
decing unit – Type II, III and IV system, ss 3.9.1–3.9.3
decing unit – use for aircraft maintenance, s 1
decing unit – use for inspection, s 1
decing/anti-icing truck. See deicing unit
decing unit
hone couplings, s 3.9.19
hot water deicing system, ss 3.5.4, 3.9.2, 3.9.27
hot water deicing. See also deicing unit – hot water deicing
nozzle. See also deicing unit – nozzle
pump. See also deicing unit – fluid pump

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AIR6284 Forced Air or Forced Air/Fluid Equipment for Removal of Frozen Contaminants

Issued 2015-01-22 by SAE G-12 E.

Forced air is a process by which an air stream is utilized to remove accumulation of frozen contamination from the aircraft. Forced air can be used with or without deicing fluid, heated or unheated. AIR6284 provides information on equipment, safety, operation, and methodology for use of deicing vehicles equipped with forced air.

Keywords:
air stream, Rationale at p 1, ss 3, 4.3.2, 5.1.3
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ARP5058A Enclosed Operator’s Cabin for Aircraft Ground Deicing Equipment

Revised 2004-06-21 by SAE G-12 E.

ARP5058A sets guidelines and design requirements for an enclosed cabin for both mobile deicers and fixed deicing equipment.

Keywords:
decing boom – variable height, s 3.2.1
decing boom, s 3.1
decing unit – cabin design requirements, s 1
decing unit – enclosed cabin. See enclosed cabin
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closed cabin – controls, s 3.3.5
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ARP5149B Training Program Guidelines for Deicing/Anti-Icing of Aircraft on Ground

Revised 2013-11-06 by SAE G-12 T.

ARP5149B is expected to be cancelled soon as it was replaced by AS6286, AS6286/1, AS6286/2, AS6286/3, AS6286/4, AS6286/5 and AS6286/6 which were all issued in late 2016.

ARP5149B establishes the minimum criteria for effective training of air carrier and service provider personnel to deice/anti-ice aircraft to ensure the safe operation of aircraft during ground icing conditions. It includes recommendations for trainer qualification, for train-the-trainer in order to ensure training is performed by competent and qualified individuals, provision for the use of computer based training/e-learning/distant learning and computer based deicing simulators, recommendations for language proficiency and qualification and competency for personnel involved in deicing/anti-icing communications. It presents aircraft diagrams with spray and no-spray zones.

Keywords:
Airbus A300 spray area diagram, Appendix D
Airbus A310 spray area diagram, Appendix D
Airbus A318/319 spray area diagram, Appendix D
Airbus A320 spray area diagram, Appendix D
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ARP5149BDA (Digital Annex for ARP5149B)

Revised 2014-08-05 by SAE G-12 T.

ARP5149BDA is the Digital Annex (DA) of ARP5149B. It contains the full-PDF version of ARP5149B, Training Program Guidelines for Deicing/Anti-Icing of Aircraft on Ground, as well as jpeg format files of Appendix D, Application Guidelines Configuration, Critical Component,
and Spray Area Diagrams for Aircraft. The .jpeg diagram files may be used by purchasers in accordance with the terms of the included license agreement.

**ARP5646 Quality Program Guidelines for Deicing/Anti-Icing of Aircraft on the Ground**

Issued 2008-08-19 by SAE G-12 T.

ARP5646 provides a form, whose format is a checklist, to perform audits of aircraft ground deicing/anti-icing programs. An auditor may use this form, at a given location where deicing is performed, by an airline or service provider, to determine if the aircraft ground deicing program at that location meets applicable standards, recommended practices, and the regulatory requirements.

The form has five parts

1. *Audit Data.* The audit data identifies the parties involved in the audit and the standards against which the audit is performed.
2. *Audit Results.* This sections compiles the number of findings, lists corrective actions, if follow-up audits are required, recommended intervals for future audits, and provides a place for the auditor and approver to sign.
3. *Checklist.* This section provides a list of items to be audited in the form of questions and space for the auditor to list comments and recommendations.
4. *Comments.* This section provides space for extra comments.
5. *Findings.* This is where the auditor lists findings, their status and date due.

It is the objective of SAE G-12 E to replace ARP5646 by AS6332, in draft form at this time, at the earliest opportunity. The intent is for AS6332 is to become a global standard adopted by all countries, ICAO, and IATA as a new global standard for aircraft ground deicing quality program.

**Keywords:**
AEA recommendations, s 3
aircraft ground deicing program audit, Foreword p 1, s 1
audit – definition, Foreword at p 1
audit checklist – airline personnel access to deicing site, s 5.07
audit checklist – availability of ground deicing program manuals, s 5.03
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AS6286 Training and Qualification Program for Deicing/Anti-icing of Aircraft on the Ground

Issued 2016-11-29 by SAE G-12 T.

This document sets the standard for the qualification and training programs as well as examinations for personnel involved in aircraft ground deicing.

Keywords:
- computer based deicing simulator – minimum requirement, s 3.21
- ICAO language proficiency rating scale, s 3.22
- fluid manufacturer documentation – safety data sheet, s 3.20.8
- training – aircraft manufacturer recommendations, s 1.1
- training – computer based training simulator, ss 3, 3.20
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74 Clear ice is a deicing/anti-icing condition that should be added to section 3.23.3.
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75 Section 3.2 appears to be missing a training qualification level for dispatch personnel, yet section 3 call for training of dispatch personnel.
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training fundamentals – training methods, s A.5.4
training fundamentals – training process, ss A.5.1, A.5.2
training fundamentals – unsafe habits, s A.5.1
training fundamentals – what if scenarios, s A.5.4

AS6286/1 Processes Including Methods

Issued 2016-11-01 by SAE G-12 T.

This document sets the standard for training of personnel with respect to processes and methods of deicing/anti-icing aircraft on the ground.

Keywords:
check, flight control. See flight control check
check, gate departure. See gate departure check
check, pretakeoff. See pretakeoff check
clear ice, conditions conducive to, s 3.2
clear ice, detection of, s 3.2
clear ice, difficulty to detect, s 3.2
definition – pre-deicing process, s 3.14.6
deicing/anti-icing decision – after flightcrew is on board, s 3.5
deicing/anti-icing decision – contamination check by flightcrew, s 3.5
deicing/anti-icing decision – contamination check by ground crew, s 3.5
deicing/anti-icing decision – overnight aircraft prior to flightcrew arrival, s 3.5
flight control check, s 3.17.1
fluid manufacturer documentation – recycling, s 6.9.4
foam confused as snow, s 3.14.4
gate departure check — APU free of contamination, s 3.6
gate departure check – critical sensing devices free of contamination, s 3.6
gate departure check – doors and door seals free of contamination, s 3.6

76 Gate departure check is the series of steps and checks to be made at the gate before an aircraft taxies to the off-gate deicing area.
gate departure check – cockpit windows clean, s 3.6
gate departure check – passengers informed of remote deicing, s 3.6
gate departure check – tires not frozen to ramp, s 3.6
heat loss, ss 3.14.2, 6.1.2.1, 6.5, 8.4.1
ICAO alphabet, s 6.8.7
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preflight check – by flightcrew, s 3.3
preflight check – by ground crew, s 3.3
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snow, foam confused as, s 3.14.4
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training – aerodynamics – angle of attack, s 6.1.3
training – aerodynamics – contamination, effect of, ss 6.1.6, 6.1.9
training – aerodynamics – critical surfaces, s 6.1.5
training – aerodynamics – failed fluids, effect of, s 6.1.10
training – aerodynamics – flaps and slats, s 6.1.5
training – aerodynamics – fluids, effects of, s 6.1.10
training – aerodynamics – frost, effect of, ss 6.1.7, 6.1.8
training – aerodynamics – fundamentals, s 6.1
training – aerodynamics – fuselage, s 6.1.5
training – aerodynamics – laminar and turbulent flow, s 6.1.3
training – aerodynamics – stall, 6.1.8
training – aerodynamics, s 6.1
training – all clear signal, s 3.17.5
training – anti-icing code, ss 3.17.3, 3.17.4, 6.8.2, 6.8.3
training – clean aircraft concept, ss 6.2.1, 6.4
training – clear ice, s 3.2
training – communications with flightcrew – English language, s 3.7
training – communications with flightcrew, ss 3.7, 3.17.2, 3.17.3, 4.3, 6.8.1, 6.8.4, 6.8.5
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training – critical surface – airstream direction detector probes, s 10.1.2
training – critical surface – angle of attack sensors, s 10.1.2
training – critical surface – engine fan blades, s 3.1.3
training – critical surface – engine inlets, ss 3.1.2, 6.8.2
training – critical surface – flaps, s 3.1.1
training – critical surface – fuel tank vents, s 3.1.6
training – critical surface – fuselage, s 10.1.7
training – critical surface – landing gear doors, s 3.1.5
training – critical surface – landing gear, s 3.1.5
training – critical surface – pitot heads, s 3.1.2
training – critical surface – static ports, s 3.1.2
training – critical surface – wing, tail and control surfaces, s 3.1.1
training – critical surface inspection, s 3.1
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training – deicing/anti-icing decision – contamination check by flightcrew, s 3.5
training – deicing/anti-icing decision – contamination check by ground crew, s 3.5
training – deicing/anti-icing decision – overnight aircraft prior to flightcrew arrival, s 3.5
training – engine ingestion hazard, ss 3.11, 3.12
training – engines-off deicing, s 3.9
training – engines-on deicing – center mounted engine aircraft, s 3.13
training – engines-on deicing – jet aircraft, s 3.11
training – engines-on deicing – propeller aircraft, s 3.10
training – engines-on deicing – wing mounted aircraft, s 3.12
training – engines-on deicing, s 3.9
training – environmental considerations, s 5
training – environmental impact, s 5
training – environmental protection, ss 5, 6.9.1, 6.9.2, 6.9.3
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training – flight control check, s 3.17.1
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training – fluid application – airframe manufacturer requirements, s 3.8
training – fluid application – APU bleed air off, s 3.8
training – fluid application – brakes and wheels, s 3.8
training – fluid application – cabin windows, s 3.8
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training – fluid application – cockpit windows, s 3.8
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training – fluid application – control surface hinge areas, s 3.8
training – fluid application – engine manufacturer requirements, s 3.8
training – fluid application – engines, s 3.8
training – fluid application – exhausts, s 3.8
training – fluid application – guidelines, use of, s 3.16.3
training – fluid application – intakes, s 3.8, 3.11
training – fluid application – landing gears, s 3.8
training – fluid application – maximum pressure, s 3.14.5
training – fluid application – no spray zones, s 3.8
training – fluid application – one-step, s 3.16.1
training – fluid application – outlets, s 3.8
training – fluid application – sensors, s 3.8
training – fluid application – slipperiness, s 3.8
training – fluid application – strategy, ss 3.15.3, 3.15.3.1
training – fluid application – symmetrical, s 3.8
training – fluid application – thrust reversers, s 3.8
training – fluid application – two-step, s 3.16.2
training – fluid application – wheel bays, s 3.8
training – fluid recovery, s 6.9.3
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training – freezing point depressant, identity of, s 5
training – frost, removal of, s 3.14.3
training – gate departure check, s 3.6
training – HOT, use of, s 3.8
training – ICAO alphabet, s 6.8.7
training – ice, light, removal of, s 3.14.3
training – ice, removal of, s 3.14.5
training – jet blast hazard, ss 3.11, 3.12
training – landing gear, deicing of, s 3.8
training – no spray zones, s 3.8
training – post deicing/anti-icing check, s 3.17
training – preflight check, s 3.3
training – pretakeoff check, s 4
training – pretakeoff contamination check, s 4.2
training – radio communications, ss 6.8.6, 6.8.7, 6.8.7.1
training – recycling, s 6.9.4
training – representative surfaces, s 4.1
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training – slipperiness hazard, s 3.8, 6.3
training – snow, removal of, s 3.14.4
training – windows, flightcrew, care of, s 3.8

AS6286/2 Equipment

Issued 2016-11-22 by SAE G-12 T.

This document sets the standard for training of personnel involved in aircraft ground deicing with respect to deicing/anti-icing equipment.

Keywords:
training – deicing unit – boom operation from lower control station, s 8
training – deicing unit – braking test, s A.1.2
training – deicing unit – closed cabin layout, s 5.2
training – deicing unit – communication system, s A.1.6
training – deicing unit – communications between driver and sprayer, s A.1.2
training – deicing unit – communications monitoring, s A.1.3
training – deicing unit – deicing data collection, s A.1.8
training – deicing unit – emergency hydraulic pump, s 8
training – deicing unit – emergency lowering of boom, s A.1.3
training – deicing unit – emergency shut off, s A.1.3
training – deicing unit – emergency stop switch, s 8
training – deicing unit – emergency stop, s A.1.3
training – deicing unit – filling of, s A.1.2
training – deicing unit – filling station, s A.1.5
training – deicing unit – fire suppression systems, s 8
training – deicing unit – fluid concentration monitoring, s A.1.7
training – deicing unit – fluid flow rate, s A.1.7
training – deicing unit – fluid overfilling prevention system, s A.1.3
training – deicing unit – fluid pressure monitoring, ss A.1.3, A.1.4, A.1.7
training – deicing unit – fluid temperature monitoring, s A.1.3
training – deicing unit – labelling, ss A.1.4, A.1.5
training – deicing unit – load capacity of basket/cabin, s A.1.4
training – deicing unit – maximum speed with boom raised 6 km/h, s 4
training – deicing unit – maximum velocity of boom, s A.1.4
training – deicing unit – maximum wind with boom elevated, s .A1.4
training – deicing unit – nozzle, use of, s A.1.7
training – deicing unit – open basket layout, s 5.1
training – deicing unit – underwing spraying, s A1.1.1
training – deicing unit – walk-around pre-operation check – basket/cabin, s 7
training – deicing unit – walk-around pre-operation check – boom, s 7
training – deicing unit – walk-around pre-operation check – emergency and safety equipment, s 7
training – deicing unit – walk-around pre-operation check – engine, s 7
training – deicing unit – walk-around pre-operation check – fuel, s A.1.2
training – deicing unit – walk-around pre-operation check – nozzle, s 7
training – deicing unit – walk-around pre-operation check – windshield washer fluid, s A.1.2
training – deicing unit auxiliary engine – asphyxiation hazard in poorly ventilated areas, s 4
training – deicing unit combustion heaters – asphyxiation hazard in poorly ventilated areas, s 4
training – deicing unit engine – asphyxiation hazard in poorly ventilated areas, s 4
AS6286/3 Fluids

Issued 2016-12-06 by SAE G-12 T.

This document sets the standard for training of personnel involved in aircraft ground deicing with respect to deicing/anti-icing fluids.

Keywords:
AMIL, s 5.1
APS Aviation, s 5.1
fluid manufacturer documentation – acceptance field tests, s 3.7.1
fluid manufacturer documentation – aerodynamic acceptance data, s 5.1.2
fluid manufacturer documentation – certificate of analysis, s 3.7.1
fluid manufacturer documentation – color, ss 3.7.1, 5.1, 5.1.4, 5.1.5
fluid manufacturer documentation – concentration limits, s 5.1.4
fluid manufacturer documentation – field viscosity check, ss 3.7.2, 5.1.6.2
fluid manufacturer documentation – fluid transfer system requirements, s 3.3, 3.4, 5.1.7
fluid manufacturer documentation – fluid, heating of, ss 3.5, 5.1.7
fluid manufacturer documentation – freezing point data, s 3.7.1
fluid manufacturer documentation – LOUT, s 5.1.2
fluid manufacturer documentation – pH limits, s 3.7.2
fluid manufacturer documentation – refractive index limits, ss 3.7.1, 3.7.2
fluid manufacturer documentation – storage tank requirements, ss 3.1, 5.1.6.2
fluid manufacturer documentation – viscosity limits, ss 3.7.2, 4.3
fluid manufacturer documentation – visual check test, s 3.7.1
refractometer – dual scale caution, s 3.7.1
SMI, s 5.1
training – aerodynamics acceptance test, s 5.1.2
training – certificate of analysis, s 3.7.1
training – deicing unit, new – cleaning of, s 3.3
training – field tests, s 3.7.1
training – fluid blending – water quality, s 3.8
training – fluid blending, s 3.8
training – fluid concentration check, ss 3.5, 3.7.3
training – fluid contamination, s 5.1.6
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training – fluid heating, ss 3.2, 3.5
training – fluid hoses, s 3.3
training – fluid manufacturer recommendations – fluid handling system, s 3.2
training – fluid manufacturer recommendations – fluid heating, ss 3.5, 5.1.6.2
training – fluid manufacturer recommendations – fluid reception, s 3.7.1
training – fluid manufacturer recommendations – fluid transfer system, s 3.4
training – fluid manufacturer recommendations – particles, s 3.7.1
training – fluid manufacturer recommendations – samples, s 3.6.5
training – fluid manufacturer recommendations – sampling, ss 3.6.5, 3.7.1
training – fluid manufacturer recommendations – storage container materials, ss 3.1, 5.1.6.2
training – fluid manufacturer recommendations – storage temperature limits, s 3.1
training – fluid manufacturer recommendations – test frequency, s 3.7.2
training – fluid shear degradation, ss 3.2, 3.3
training – fluid storage – fluid manufacturer recommendations, s 3.1
training – fluid storage – labelling, s 3.1, 5.1.6
training – fluid storage – regulatory requirements, s 3.1
training – fluid storage – tank level, s 3.1
training – fluid storage – temperature, maximum, ss 3.1, 3.5
training – fluid storage – temperature, minimum, s 3.1
training – fluid storage – totes, s 3.3
training – fluid storage – UV light, effect of, s 3.1
training – fluid storage, ss 3.1, 5.1.6, 5.1.6.2
training – fluid testing – appearance, ss 5.1.6.1, 5.1.6.2
training – fluid testing – field viscosity check, s 5.1.6.2
training – fluid testing – fluid manufacturer specification, ss 3.7.1, 3.7.2
training – fluid testing – pH, ss 5.1.6.1, 5.1.6.2
training – fluid testing – refraction, ss 5.1.6.1, 5.1.6.2
training – fluid testing frequency – fluid manufacturer recommendations, s 3.7.2
training – fluid testing frequency, ss 3.7, 3.7.2
training – fluid testing, ss 3.5, 5.1.6.1, 5.1.6.2
training – fluid transfer system – labels, s 3.3
training – fluid transfer system, dedicated, s 3.3
training – fluid transfer system, ss 3.3, 5.1.6
training – fluid, reception of, ss 5.1.6, 5.1.6.2
training – freezing point buffer, s 3.8
training – frost prevention, local, s 5.4
training – galvanic couples, s 5.1.6.2
training – HHET, s. 5.1.1
training – HOT, use of, ss 4, 5.1.10, 5.2, 5.3, 5.3.1
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training – LOUT relationship to OAT, s 3.8
training – LOUT, s 3.8
training – materials compatibility, s 5.1.3
training – refractometer – dual scale caution, s 3.7.1
training – refractometer, use of, s 3.7.1
training – sample bottles, s 3.6.1
training – sample label, s 3.6.4
training – sample labelling, ss 3.6.1, 3.6.4
training – samples, care of, s 3.6.5

\textsuperscript{77} Relationship of LOUT to OAT is described in section 3.8. Relationship of LOUT to type of aircraft (high speed/low speed) should be part of training as well.
This document sets the standard for training of personnel involved in aircraft ground deicing with respect to weather.

It is important for personnel performing deicing to understand weather. Weather determines how freezing or frozen precipitation will affect the process of deicing, the protection time of deicing/anti-icing fluids and the failure of fluids. This standard list topics related to weather that should be covered in training, such as precipitation types including frost formation, fluid failure recognition, and weather reports (METAR and TAF).

Keywords:
clear ice – definition, s 4.1.3.3
clear ice, conditions conducive to, ss 4.1.3.3, 4.1.3.4
cold front. See front, cold
cold soaking – definition, s 4.1.3.4
cold soaking – fuel caused, s 4.1.3.4
cold soaking, conditions conducive to, ss 4.2.3.4, 4.3
cold soaking, fueling, s 4.1.3.4
cold soaking, refueling, s 4.1.3.4
condensation – definition, s 4.1.3.2
definition – clear ice, s 4.1.3.3
definition – cold soaking, s 4.1.3.4
definition – condensation, s 4.1.3.2
definition – dewpoint, s 4.1.3.6
definition – drizzle, s 4.1.3.7
definition – evaporation, s 4.1.3.2
definition – freezing drizzle, s 4.1.3.8
definition – freezing fog, s 4.1.3.9
definition – freezing rain, heavy, s 4.1.3.15
definition – freezing rain, light, s 4.1.3.13
definition – freezing rain, moderate, s 4.1.3.15
definition – freezing, s 4.1.3.2
definition – front, cold, s 4.1.3.5
definition – front, warm, s 4.1.3.24
definition – frost, s 4.1.3.10
definition – frost, active, s 4.1.3.1
definition – hail, small, s 4.1.3.12
definition – high humidity on cold soaked wing, s 4.1.3.16
definition – hoarfrost, s 4.1.3.10
definition – humidity, relative, 4.1.3.18
definition – ice pellets, s 4.1.3.12
definition – LOUT, s 4.1.3.14
definition – melting, s 4.1.3.2
definition – rain and snow, s 4.1.3.17
definition – rain on cold soaked wing, s 4.1.3.16
definition – saturation, s 4.1.3.19
definition – slush, s 4.1.3.23
definition – snow grains, s 4.1.3.21
definition – snow pellets, 4.1.3.22
definition – snow, s 4.1.3.20
definition – sublimation, s 4.1.3.2
definition – water vapor, 4.1.3.25
dewpoint – definition, s 4.1.3.6
drizzle – definition, s 4.1.3.7
evaporation – definition, s 4.1.3.2
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fluid failure description – graying of surface reflectivity, s 3
fluid failure description – no absorption of precipitation, s 3
fluid failure description – presence of frozen contamination on the fluid, s 3
fluid failure description – snow accumulation, random s 3
fluid failure description – snow accumulation, s 3
fluid failure recognition, s 3
fluid failure, initial – downwind wing in crosswind, s 3
fluid failure, initial – leading and trailing edges, s 3
fluid manufacturer documentation – freezing point data, s 4.1.3.14
fluid manufacturer documentation – LOUT, s 4.1.3.14
fluid manufacturer documentation – refractive index limits, s 4.1.3.14
FOD, s 4.3.2
freezing – definition, s 4.1.3.2
freezing drizzle – definition, s 4.1.3.8
freezing fog – definition, s 4.1.3.9
freezing rain, heavy – definition, s 4.1.3.15
freezing rain, light – definition, s 4.1.3.13
freezing rain, moderate – definition, s 4.1.3.15
front, cold – definition, s 4.1.3.5
front, warm – definition, s 4.1.3.24
frost – definition, s 4.1.3.10
frost formation conditions, s 4.3.3
frost on fuselage, s 4.3
frost on lower horizontal stabilizer surface, s 4.3
frost on lower wing surface, s 4.3
frost, active – definition, s 4.1.3.1
frost, local, s 4.3
hail, small – definition, s 4.1.3.12
hazards of ice, snow and frost, s 4.3.2
high humidity on cold soaked wing – definition, s 4.1.3.16
hoarfrost – definition, s 4.1.3.10
hoarfrost, s 4.3
humidity, relative – definition, 4.1.3.18
ice pellets – definition, s 4.1.3.12
LOUT – definition, s 4.1.3.14
melting – definition, s 4.1.3.2
METAR, s 4.2.1
rain and snow – definition, s 4.1.3.17
rain on cold soaked wing – definition, s 4.1.3.16
rime, s 4.1.3.3
roughness, effect of, s 4.3.3
saturation – definition, s 4.1.3.19
slush – definition, s 4.1.3.23
snow – definition, s 4.1.3.20
snow grains – definition, s 4.1.3.21
snow pellets – definition, 4.1.3.22
sublimation – definition, s 4.1.3.2
TAF, s 4.2.2
training – clear ice, s 3
training – fluid failure recognition, s 3
training – weather, s 4
warm front. See front, warm
water vapor – definition, 4.1.3.25

AS6286/5 Health, Safety and First Aid

Issued 2016-09-22 by SAE G-12 T.

This document sets the standard for training of personnel involved in aircraft ground deicing in areas related to health, safety and first aid.

It is important for personnel performing deicing to understand the hazards that could affect them personally in deicing operations, the precautions and equipment to prevent accidents, human factors related to accidents and the reporting of accidents/incidents. This standard list topics that should be covered in training to ensure safety of the personnel involved in deicing.

Keywords:
fluid manufacturer documentation – safety data sheet, s 3.1
training – accident/incident reporting, s 4.5
training – aircraft movement hazard, s 4.4
training – APU blast hazard, s 4.4
training – communications, s 3.1
training – eye/face protection, use of, s 3.2
AS6286/6 Deicing/Anti-icing Diagrams/No Spray Zones

Issued 2016-12-05 by SAE G-12 T.

This documents provides aircraft diagrams with showing zones where deicing/anti-icing fluids may be applied, areas where fluids should be applied indirectly and where fluid should not be applied (no-spray zones). It also provides wing surface area, horizontal surface area, wingspan, aircraft category and suggested anti-icing fluid quantities for several commonly used aircraft.

Keywords
Airbus A300 spray area diagram, s 3.1.1
Airbus A310 dimensions, s 4.2.1.5
Airbus A310 spray area diagram, s 3.1.2
Airbus A318/319 spray area diagram, s 3.1.3

78 Jet suction hazard and engine ingestion hazard appear to be used synonymously.
79 See footnote 78.
Airbus A318/319/320/321 dimension, s 4.2.1.6
Airbus A320 spray area diagram, s 3.1.4
Airbus A321 spray area diagram, s 3.1.5
Airbus A330 dimensions, s 4.2.1.2
Airbus A330 spray area diagram, s 3.1.6
Airbus A340 dimensions, s 4.2.1.1
Airbus A340 spray area diagram, 3.1.7
Airbus A350 dimensions, s 4.2.1.8
Airbus A350 spray area diagram, s 3.1.8
Airbus A380 dimensions, s 4.2.1.3
Airbus A380 spray area diagram, s 3.1.9
Airbus A400M spray area diagram, s 3.1.10
aircraft category. See category, aircraft
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aircraft left-hand, s 4.1.4
aircraft right-hand, s 4.1.4
Antonov AN-12 dimensions, s 4.2.4.1
Antonov AN-124 dimensions, s 4.2.4.4
Antonov AN-70 dimensions, s 4.2.4.2
Antonov AN-74/AN-74T dimensions, s 4.2.4.3
APU fluid ingestion, s 4.1.3
APU glycol ingestion, s 4.1.3
area, wetted – definition, s 4.2
ATR ATR42/ATR72 dimensions, s 4.2.3.8,
ATR ATR42/ATR72 spray area diagram, s 3.1.11
Avro RJ dimensions, s 4.2.3.3
Avro RJ spray area diagram, s 3.1.12
BAe 146/Avro RJ dimensions, s 4.2.3.3
BAe 146/Avro RJ spray area diagram, s 3.1.12
BAe 748/HS 748 spray area diagram, s 3.1.13
BAe ATP dimensions, s 4.2.3.1
BAe Jetstream 31 dimensions, s 4.3.2.2
BAe Jetstream 41 spray area diagram, s 3.1.1
BAe Jetstream 41 dimensions, s 4.3.2.2
Beech 1900D dimensions, s 4.2.5.2
Beech Beechjet 400A dimensions, s 4.2.5.3
Beech King Air 350 dimensions, s 4.2.5.1
Beech King Air B200 dimensions, s 4.2.5.5
Beech King Air C90B/C90SE dimensions, s 4.2.5.4
Beechcraft B1900 spray area diagram, s 3.1.5
Boeing B707 dimensions, s 4.2.2.1
Boeing B717 dimensions, s 4.2.2.2
Boeing B717 spray area diagram, s 3.1.16
Boeing B727 dimensions, s 4.2.2.3
Boeing B727 spray area diagram, s 3.1.17
Boeing B737 dimensions, s 4.2.2.4
Boeing B737 spray area diagram, s 3.1.18
Boeing B747 dimensions, s 4.2.2.5
Boeing B747 spray area diagram, s 3.1.19
Boeing B757 dimensions, s 4.2.2.6
Boeing B757 spray area diagram, s 3.1.20
Boeing B767 dimensions, s 4.2.2.7
Boeing B767 spray area diagram, s 3.1.21
Boeing B777 dimensions, s 4.2.2.8
Boeing B777 spray area diagram, s 3.1.22
Boeing B787 dimensions, s 4.2.2.13
Boeing B787 spray area diagram, s 3.1.23
Boeing C-17 dimensions, s 4.2.2.12
Boeing C-17 spray area diagram, s 3.1.24
Boeing Douglas DC-8 dimensions, s 4.2.2.9
Boeing Douglas DC-8 spray area diagram, s 3.1.25
Boeing McDonnell Douglas DC-10/MD-10/MD-11 dimensions, s 4.2.2.11
Boeing McDonnell Douglas DC-10/MD-10/MD-11 spray area diagram, s 3.1.27
Boeing McDonnell Douglas DC-9 dimensions, s 4.2.2.10
Boeing McDonnell Douglas DC-9 spray area diagram, s 3.1.26
Boeing McDonnell Douglas MD-80/MD-90 dimensions, s 4.2.2.10
Boeing McDonnell Douglas MD-80/MD-90 spray area diagram, s 3.1.28
Bombardier 130-100 Continental dimensions, s 4.2.5.7
Bombardier Challenger CL600 dimensions, s 4.2.5.8
Bombardier CL 100/200 dimensions, s 4.2.5.6
Bombardier CRJ dimensions, s 4.2.5.4
Bombardier Global Express dimensions, s 4.2.3.7
Bombardier Global Express spray area diagram, s 3.1.33
Bombardier Shorts 330 spray area diagram, s 3.1.35
Canadair RJ100/200 spray area diagram, s 3.1.29
Canadair RJ700/900/1000 spray area diagram, s 3.1.30
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Cessna 680 Citation Sovereign dimensions, s 3.2.5.18
Cessna 750 Citation X dimensions, s 4.2.5.17
Cessna Caravan C208 spray area diagram, s 3.1.36
Cessna Citation 525 CJ2 dimensions, s 4.2.5.13
Cessna Citation 550 Bravo dimensions, s 4.2.5.14
Cessna Citation 560 Encore dimensions, s 4.2.5.15
Cessna Citation CJ1 dimensions, s 4.2.5.12
configuration, aircraft deicing – elevator, s 4.1.7
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Dassault Falcon 50 dimensions, s 4.2.5.19
Dassault Falcon 900 dimensions, s 3.2.5.20
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AS6332 Aircraft Ground Deicing/Anti-icing Quality Management

Issued 2017-08-29 by SAE G-12 T.

This document sets the requirements for aircraft deicing/anti-icing quality management system. It comprises quality system, documentation, control of records, management responsibility, resource management, measurement and analysis of results, and process for continuous improvement.

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The FAA and Transport Canada publish yearly holdover time guidelines, extensive guidance material, a list of fluids that have qualified themselves for anti-icing performance and aerodynamic acceptance and their respective lowest aerodynamic acceptance temperature. The FAA and Transport Canada do not verify that the fluids meet all the technical requirements of AMS1424 (latest version) and AMS1428 (latest version) other than anti-icing performance and aerodynamic acceptance. Users must verify if the fluids to be used meet all other technical requirements of AMS1424 (latest version), AMS1424/1, AMS1428 (latest version) and AMS1428/1.

EASA and ICAO also publish guidance material.

**Documents Issued by the Federal Aviation Administration**

**FAA Notice N 8900.431 Revised FAA–Approved Deicing Program Updates, Winter 2017–2018**

Effective date: 2017-08-11; cancellation date: 2018-08-11. Issued by the FAA.

This notice is meant to provide FAA inspectors information on holdover time and guidance on various several operational issues related to aircraft ground deicing. It is revised every year is to be used in conjunction with the FAA *Holdover Time Guidelines*, also issued annually.

It provides information and guidance, not only to the FAA inspectors, but to airlines seeking FAA approval of ground deicing/anti-icing programs.

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\textsuperscript{81} It may be useful for users under FAA jurisdiction to consider that FAA appears to make distinction between 4 kinds of conditions conducive to icing: 1) \textit{conditions with holdover time}, e.g., freezing fog, ice crystals, very light snow, very light snow grains, very light snow pellets, light snow, light snow grains, light snow pellets, moderate snow, moderate snow grains, moderate snow pellets, freezing drizzle, light freezing rain, rain on cold soaked wing, very light snow mixed with light rain, light snow mixed with light rain, active frost, 2) \textit{conditions without holdover time but with an allowance time}, e.g., light ice pellets, light ice pellets mixed with light snow, light ice pellets mixed with moderate snow, light ice pellets mixed with light or moderate freezing drizzle, light ice pellets mixed with light freezing rain, light ice pellets mixed with light rain, light ice pellets mixed with moderate rain, moderate ice pellets or small hail, moderate ice pellets or small hail mixed with moderate freezing drizzle, moderate ice pellets or small hail mixed with moderate rain, and 3) \textit{conditions without holdover time but where, with special dispatch procedures, takeoff can occur}, e.g., heavy snow and 4) \textit{conditions without holdover time}, e.g. moderate freezing rain, heavy freezing rain, hail, heavy ice pellets.

\textsuperscript{82} The generic HOT table for Type II is derived from the worst case of all Type II only and not of Type II and Type IV. Section 7.b.(8) is not clear on this point. The FAA HOT Guidelines Regression Information Winter 2017-2018 makes it clear at p 7.

\textsuperscript{83} There is no Type III generic HOT table. There was a mention to that effect in N 8900.326, but the note does not appear in N 8900.431.
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\(^4\) Strictly speaking the approved visual and/or tactile check to allow takeoff in heavy snow is not a pretakeoff contamination check, but it is very similar in nature.

\(^5\) Section 8.e.(1)(c) refers to “pretakeoff contamination inspection (check)”. In the section related to allowance time (section 8.e), it is as if pretakeoff contamination inspection is a synonym for pretakeoff contamination check.
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86 Heating Type I is necessary but will result in some water loss and corresponding increase in glycol concentration. One must take care not to exceed the highest glycol concentration that was tested and passed aerodynamic acceptance. If Type I is repeatedly or continuously heated without replenishment of fresh material or heated at extreme temperatures, there can be oxidation of the glycol, usually the color will fade and pH will decrease below the its accepted specification range.

87 Color should be looked at when checking for appearance. Suspended matter is a form of contamination. It is virtually impossible to exclude all suspended matter. Small amounts of iron particles (not rust) are generally thought to be acceptable. The criterion of acceptability is sometimes formulated as “substantially free from suspended matter”.

88 Neat fluid. The user of a Type II, III or IV HOT guideline needs to know the concentration of the fluid. Guidance material found in section 7.b.(2) of FAA Notice N 8900.431 reads as follows: “For Types II, III, and IV fluids, the fluid concentration (percent mixture) is the amount of undiluted (neat) fluid in water. Therefore, a 75/25 mixture is 75 percent FPD fluid and 25 percent water.” The following may be less prone to misinterpretation: “For Types II, III, and IV fluids, the fluid concentration is expressed as the volume ratio of neat (undiluted) fluid to water. Therefore, a 75/25 fluid concentration is a mixture by volume of 75 parts neat fluid and 25 parts water.” More examples: “100/0 fluid concentration” means neat fluid; a “50/50 fluid concentration” means a mixture by volume of 50 parts neat fluid and 50 parts water. “Neat” means as-delivered by the fluid manufacturer, without added water by the user. Type II/III/IV fluids, as-delivered by the manufacturer, always contain a freezing point depressant and water. The 100 in “100/0” and the 75 in “75/25” do not refer to the weight or volume concentration of the freezing point depressant in the fluid. By analogy, when a drinker says “I drink my Scotch neat”. It means she wants her Scotch served without added water. It does not mean that there is 100% alcohol (the freezing point depressant) in the Scotch.
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89 See footnote 88
90 For example, contamination with other fluids, silicone oil, rust, RDP, jet fuel, diesel fuel, rain water, melted snow, etc.
91 Repeated or prolonged heating of Type II/III/IV can lead to a) water evaporation causing significant viscosity reduction or increase and b) thermal oxidation of the thickener system resulting in viscosity loss.
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Revised 2017-10-12 by the FAA.

This document provides the holdover time guidelines and allowance times for generic and specific fluids. It is considered by the FAA to be official guidance on the use of the holdover time guidelines and allowance times. It includes a list of fluid tested for anti-icing performance and aerodynamic acceptance. It is designed to be used with FAA N 8900.431 Revised FAA-Approved Deicing Program Updates, Winter 2017-2018.

On October 12, 2017, the FAA (and Transport Canada) issued a revision of the 2017-2018 Holdover Time Guidelines. Optional additional holdover time guidelines in the temperature range of -3°C to -8°C for snow, snow grains, and snow pellets and their adjusted equivalents for slats and flaps deployed prior to deicing.

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92 US, Federal Aviation Administration, “FAA Holdover Time Guidelines Winter 2017-2018 – Revision 1.0: October 12, 2017”, online:
<https://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/media/FAA_2017-18_HoldoverTablesR1.pdf>
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visibility, surface, Table 40 note 4
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FAA Holdover Time Regression Guidelines Information, Winter 2017-2018 – Original Issue: August 9, 2017

Issued 2017-08-09 by the FAA

93 None published.
94 Snowfall intensity v snowfall rate. Snowfall intensity is expressed as very light snow, light snow, moderate snow and heavy snow whereas snowfall rates are expressed in g/dm^2/h or liquid water equivalent rates in mm/h or in/h.
This document, updated every year, provides the regression coefficients to calculate holdover times under various weather conditions.

Typically, real-time weather data is fed to a holdover time determination system (HOTDS) which uses the real time weather data and best-fit power law curves with the appropriate regression coefficients to calculate holdover times.

A similar document is issued by the Transport Canada.

Keywords:
- check time determination system
- HOT 76% adjusted – regression calculations
- HOT regression information – changes in 2017-2018
- HOT regression limitations – caution outside precipitation rate limits
- HOT regression limitations – no allowance times
- HOT regression limitations – no interpolation for Type II/III/IV non-standard dilutions
- HOT regression limitations – no regression coefficients for frost
- HOT regression limitations – use at > 0°C
- HOT regression limitations – use of LUPR
- HOT regression limitations – use of snow precipitation rate ≤ 50g/dm²/h
- HOT regression limitations – use with CTDS/HOTDS conforming to Advisory Circular (FAA)
- HOT regression limitations
- HOT, Type I generic – regression calculations
- HOT, Type I generic – regression coefficients
- HOT, Type II – regression grandfathered data obsolete
- HOT, Type II fluid specific – regression calculations
- HOT, Type II fluid specific – regression coefficients
- HOT, Type II generic – HOT minimum (worst case) values of all Type II
- HOT, Type II generic – regression calculations
- HOT, Type II generic – regression coefficients
- HOT, Type III fluid specific – regression calculations
- HOT, Type III fluid specific – regression coefficients
- HOT, Type IV fluid specific – regression calculations
- HOT, Type IV fluid specific – regression coefficients
- HOT, Type IV generic – HOT minimum (worst case) values of all Type IV
- HOT, Type IV generic – regression calculations
- HOT, Type IV generic – regression coefficients
- HOTDS
- HUPR, snow
- LUPR, snow
- regression coefficient tables, interpretation of
- regression coefficients – best fit power law

95 The Transport Canada HOT Regression Information document does not mention check time determination systems.
Aircraft Deicing Documents – Issued by the FAA

FAA Advisory Circular AC 120-60B Ground Deicing and Anti-icing Program

Issued 2004-12-20 by the FAA.

This document provides guidance to obtain FAA approval of ground deicing/anti-icing programs in accordance to Title 14 of the Code of (US) Federal Regulations (14 CFR) part 12, section 121.629.

Keywords:
14 CFR § 121.629, s 1
AC 120-60B, Title at p 1
anti-icing – definition, s 3.a.
anti-icing fluid – definition ss 3.a.(1–5)
check, icing. See preflight check; post deicing/anti-icing check; pretakeoff check; pretakeoff contamination check
check, post application. See post deicing/anti-icing check
critical aircraft surfaces. See critical surface
critical surface – airframe manufacturer defined, s 6.d.(1)
critical surface – control surface, s 6.d.(a)
critical surface – empennage, s 6.d.(a)
critical surface – engine inlets, s 6.d.(a)
critical surface – fuel vents, s 6.d.(a)
critical surface – wings, s 6.d.(a)
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definition – anti-icing fluid, ss 3.a.(1–5)
definition – deicing fluid, ss 3.b.(1–6)
definition – deicing , s 3.b.
definition – frozen contaminants, s 3.c.
definition – hard wing, s 6.e.(2)(a)
definition – HOT range, s 6.c.(3)
definition – HOT, s 3.d.
definition – post deicing/anti-icing check (FAA), ss 3.g., 6.e.(3)
definition – pretakeoff check (FAA), s 3.e.


97 The appears to be four kinds of icing checks: 1) preflight check (aka contamination check) performed by the flightcrew or ground crew to establish the need to deicing/anti-icing), 2) post deicing/anti-icing check (aka post deicing check, post application check), an integral part of the deicing/anti-icing process, 3) pretakeoff check performed within the holdover time and 4) the pretakeoff contamination check performed after the holdover time has expired.
definition – pretakeoff contamination check (FAA), s 3.f.
deicing – definition, s 3.b.
deicing fluid – definition, s 3.b.(1–6)
FAA AC 120-60, Title at p 1
frost, acceptable amount underwing (FAA), s 6.d.
frozen contaminants – definition, s 3.c.
frozen contamination – effect on (rapid) pitch up and roll-off during rotation, s 6.g.(2)(a)
frozen contamination – effect on control, s 6.g.(2)(a)
frozen contamination – effect on drag, s 6.g.(2)(a)
frozen contamination – effect on engine foreign object damage, s 6.g.
frozen contamination – effect on instrument pick up points, s 6.g.(2)(a)
frozen contamination – effect on lift, s 6.g.(2)(a)
frozen contamination – effect on ram air intakes, s 6.g.(2)(a)
frozen contamination – effect on stall at lower-than-normal angle of attack, s 6.g.(2)(a)
frozen contamination – effect on weight, s 6.g.(2)(a)
frozen contamination – effect on winglets s 6.g.(2)(a)
frozen contamination – effect on buffet or stall before activation of stall warning s 6.g.(2)(a)
frozen contamination – effect on hard wing aircraft (without leading edge device) s 6.g.(2)(a)
ground deicing/anti-icing program (FAA) – approval, ss 1., 5.
ground deicing/anti-icing program (FAA) – program elements, s 6.
ground deicing/anti-icing program (FAA), approved – operations in lieu of, s 7.
hard wing – definition, s 6.e.(2)(a)
HOT – definition, s 3.d.
HOT range – definition, s 6.c.(3)
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HOT, start of, s 6.c.(3)
HOT, variables affecting, s 6.c.
ice accretion, in-flight, s 6.g.(2)(b)
phraseology, use of standard s 6.f.
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post deicing check. See post deicing/anti-icing check
post deicing/anti-icing check (FAA)\(^98\) – definition, s 3.g., 6.e.(3)
post deicing/anti-icing check (FAA) – integral part of deicing/anti-icing process, ss 6.e., 6.e.(3)
post deicing/anti-icing check (FAA) – recordkeeping mandatory, s 6.f.(3)D
program, ground deicing/anti-icing (FAA)
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pretakeoff check (FAA) – flightcrew situational awareness, s 6.e.(1)
pretakeoff check (FAA) – guidance, s 6.e.(1)
pretakeoff check (FAA) – regulation 14 CFR § 121.629(c)(3), s 6.e.(1)
pretakeoff check (FAA) – within HOT, ss 3.e., 6.e.(1)
pretakeoff contamination check (FAA) – definition, s 3.f.
pretakeoff contamination check (FAA) – guidance ss 3.f., 6.e.(2)
pretakeoff contamination check (FAA) – regulation 14 CFR § 121.629(c)(3)(i), ss 3.f., 6.e.(2)
pretakeoff contamination check (FAA) – when HOT exceeded, ss 3.f., 6.e.(2)
pretakeoff contamination check (FAA) – within 5 minutes of takeoff, ss 3.f., 6.e.(2)
representative surface, ss 3.e., 6.d.
training – FAA requirements s 6.g.

\(^{98}\) AC 120-60 appears to use different terms for the check that is an integral part of the deicing/anti-icing process:
SAE documents usually call is “post deicing/anti-icing check” such as in ARP4737H s 8.1.2, AS6285 s 7.3,
ARP5149B s 10.12.7.
FAA Advisory Circular AC 120-112 Use of Liquid Water Equivalent System to Determine Holdover Times or Check times of Anti-icing Fluids

Issued 2015-07-14 by the FAA.

Although the FAA does not certify or approve specific liquid water equivalent system (LWES), some US aircraft operators (§ 121.629(c) category) may be required by US law to seek FAA authorization to rely on the use of LWES. This document provides the FAA minimum standard for use of LWES and guidance to those proposing to design, procure, construct, install, activate or maintain LWES. An LEWS is an automated system that measures the liquid water equivalent rate of freezing or frozen precipitation. The LEWS system, using the measured LWE rate and endurance time regression equations, calculates holdover time (HOT) or check time (CT).

Keywords:
anti-icing fluid – definition, Appendix 2
check time – definition, Appendix 2
check time determination system – definition, Appendix 2
check time determination system guidance (FAA), s 1-1
check time determination system subset of LWES, s 1-1
definition – anti-icing fluid, Appendix 2
definition – check time determination system, Appendix 2
definition – check time, Appendix 2
definition – deicing fluid, Appendix 2
definition – endurance time regression analysis, Appendix 2
definition – endurance time, Appendix 2
definition – glycol pan measurement, Appendix 2
definition – HOT, Appendix 2
definition – HOT tables, appendix 2
definition – LWE rate, Appendix 2
definition – LWE sampling time, Appendix 2
definition – LWES, s 1-1, Appendix 2
definition – regression analysis, endurance time, Appendix 2
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endurance time – definition, Appendix 2
endurance time regression analysis – definition, Appendix 2
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freezing rain subset of supercooled large droplets, s 3-11
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HOT – definition, Appendix 2
HOT tables – definition, Appendix 2
HOTDS – guidance (FAA), s 1-1
HOTDS subset of LWES, s 1-1
LWE rate – definition, Appendix 2
LWE sampling time – definition, Appendix 2
LWES – authorization for freezing drizzle (FAA), s 3-9
FAA Advisory Circular AC 150/5300-14C Design of Aircraft Deicing Facilities

Revised 2013-08-07 by the FAA.

This document provides guidance and recommendations of the designing of deicing facilities. It covers the sizing, siting, environmental considerations and operational requirements to maximize


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deicing capacity while maintaining safety and efficiency. There is particular emphasis on centralized deicing facilities and the particular issues associates with such facilities. Design considerations for infrared deicing facilities are discussed.100

Keywords:
14 CFR § 139, s 2. at p i, s 4.b. at p i101
AC 150/5300-14C, Title at p i
ADF, spent – use as RDP, s 6.6a.
ADF, spent. See also CDF runoff mitigation – spent ADF; deicing facility, terminal gate – spent ADF collection
aircraft deicing facility. See deicing facility
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aircraft parking area, deicing pad – definition, s 1.2c.(1)
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Airport Improvement Program (US), s 2. at p i
airport, certificated (FAA), s 2. at p i
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CDF air traffic control tower line-of-sight, s 2.2c.
CDF aircraft access routes, s 4.
CDF benefits – aircraft retreatment near departure runway, s 2.1b.
CDF benefits – avoiding changing weather along long taxiing routes, s 1.1b.(2)
CDF benefits – improved airfield flow, s 2.1b.
CDF benefits – reduced taxing time, s 1.1b.(2)
CDF capacity, s 2.3
CDF common deicing procedures for all users, s 1.1
CDF common deicing procedures– safety benefits, s 1.1
CDF components – bypass taxiing capability for aircraft not needing deicing, ss 2.1c., 2.8
CDF components – control enter, s 2.1c.
CDF components – crew shelter, s 2.1c.
CDF components – deicing pads ss 2.1c., 2.9
CDF components – deicing unit ss 2.1c., 2.5b.
CDF components – environmental runoff mitigation ss 2.1c., 2.5e.
CDF components – fluid storage and handling ss 2.1c., 2.6
CDF components – lighting system ss 2.1c., 2.7
CDF control center, ss 4.c. at p i, 2.1c.
CDF deicing pad, factors affecting number of – deicing procedure, s 2.4a.
CDF deicing pad, factors affecting number of – peak hour departure rate, s 2.4
CDF deicing pad, factors affecting number of – preflight inspection, s 2.4a.(1)
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CDF deicing pad, factors affecting number of – type of deicing units, s 2.4a.(4)
CDF deicing pad, factors affecting number of – variation in meteorological conditions, s 2.4a.(2)
CDF deicing pad, factors affecting number of, s 2.4
CDF environmental considerations – receiving water aquatic communities quality, s 6.1
CDF environmental considerations – receiving water quality, s 6.1

100 Infrared deicing facilities were built at JFK airport in NY, Buffalo NY, Newark NJ, Rhinelander NY, and Oslo, Norway. Buffalo, Newark, and Oslo facilities were dismantled. JFK and Rhinelander is not operational. The builder of infrared facilities is no longer offering them for sale [FAA private communications. June 2016].
101 AC 150/5300-14C has an introductory section at pp i to iv that uses the same section numbering as the main document. When the referring to a section in the introductory part, the pages are indicated.
CDF environmental considerations. See also CDF runoff mitigation
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CDF location and sizing, factors affecting – airport layout, s 2.12
CDF location and sizing, factors affecting – airport safety programs, s 2.5f
CDF location and sizing, factors affecting – deicing queues, s 2.9
CDF location and sizing, factors affecting – environmental considerations, s 2.5e
CDF location and sizing, factors affecting – HOT and time to takeoff clearance time, s 2.5
CDF location and sizing, factors affecting – lighting, s 2.7
CDF location and sizing, factors affecting – restriction of type of deicing fluid, s 2.5a
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CDF runoff mitigation – mechanical aeration of detention basins, ss 6.2c., 6.7
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102 AC 150/5300-14C defines all off-gate deicing facilities as centralized deicing facilities, see s 1.1.
103 In AC 150/5300-14C, the term “centralized aircraft deicing facility” includes “remote aircraft deicing facility” and the expression “remote deicing facility” was dropped from the definition (s 4a at p i). In the Guide, we abbreviate centralized deicing facility as CDF.
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Documents Issued by Transport Canada

Transport Canada Holdover Time Guidelines: Winter 2017-2018. Revision 1.0

Revision 2017-10-12 by Transport Canada.

This document, updated every year, provides the holdover time guidelines as published by Transport Canada and changes to the Transport Canada Guidelines of Aircraft Ground-Icing Operations TP 14052E. The Transport Canada Holdover Time Guidelines are meant to be used in conjunction with TP 14052E where additional guidance on aircraft ground deicing can be found.

On October 12, 2017, Transport Canada (and the FAA) issued a revision of the 2017-2018 Holdover Time Guidelines. Optional additional holdover time guidelines in the temperature range of -3°C to -8°C for snow, snow grains, and snow pellets and their adjusted equivalents for slats and flaps deployed prior to deicing.

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105 Negative buffer. The Transport Canada Holdover Time Guidelines Winter 2015-2016 allowed for a negative buffer of 3°C in the first step of a two-step application procedure (Table 9 at p 63, Table 10 at p 64). The 2016-2017 version only allows for a 0°C buffer (Tables 9–11U at pp 69–71). This appeared inconsistent with sub-paragraph 10.13.3 on p 7 which refers to the negative buffer of Tables 9, 10, 11-H and 11-U. The problem was resolved in the 2017-2018 HOT Guidelines where sub-paragraph 10.13.3 was modified and no longer allows for negative buffer.

106 FAA uses the expression “lower wing surface”, Transport Canada “wing underside”.

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HOT, Type IV fluid-specific, Tables 21–37, Tables C-1 and C-2
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107 Transport Canada Holdover Time Guidelines Winter 2015-2016 spelled out clearly that there was no Type III generic HOT guidelines. There is no Type III generic HOT guideline in the 2017-2018 version but it is not specified as such.
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Transport Canada Holdover Time (HOT) Guidelines Regression Information Winter 2017-2018, Original Issue: August 9, 2017

Issued 2017-08-09 by Transport Canada.

This document, updated every year, provides the regression coefficients to calculate holdover times under various weather conditions.

Typically, real-time weather data is fed to a holdover time determination system (HOTDS) which uses the real time weather data and best-fit power law curves with the appropriate regression coefficients to calculate holdover times.

A similar document is issued by the FAA.

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HOT regression limitations – no allowance times, p 8
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Transport Canada Advisory Circular AC 700-030 Electronic Holdover Time (eHOT) Applications

Issued 2014-11-18 by Transport Canada.

This document provides guidance regarding 1) the implementation and use of eHOT applications in electronic flight bags, 2) the process to obtain authorization from Transport Canada to incorporate eHOT in deicing and anti-icing programs and 3) recommendations to principal operations inspectors and civil aviation safety inspectors when reviewing submission for incorporation of eHOT apps.

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Revised 2005-04 by Transport Canada.
This document provides guidance to those who are involved in aircraft ground deicing. It is meant to be used in conjunction with the Transport Canada *Holdover Time Guidelines* which are issued every year. Even though TP 14052E itself has not be reissued since April 2005, some of its sections have revised and those revision are found in the current version of the Transport Canada *Holdover Time Guidelines*.

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- aerodynamic effect of contamination – guidance (TC), s 12.6.8
- aerodynamic effect of contamination. *See also* frozen contamination – effect on
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108 Here we index TP 14052E, not the revisions thereof. Its revised sections are indexed as part of the Transport Canada *Holdover Time Guidelines*. The revisions of TP 14052E are extensive. Users should incorporate the revisions before attempting to rely on TP 14052E.
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110 The note in s 11.2.4 states that the “pre-take-off contamination [inspection] must be conducted from outside if the aircraft if the Air Operator does not use the HOT guidelines”, yet s 11.4.2 says the “procedure should only be applied to Type II, III and IV anti-icing fluids and then only when the pertinent minimum holdover time exceeds 20 minutes.” If the air operator does not use HOT guidelines, how is the pilot to know what the holdover time is?
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Issued 2014-02-28 by Transport Canada.

This regulatory exemption authorizes air operators to use HOT generated by HOTDS using best-fit power law equations and regression coefficients as part of their ground icing operations program. The documents sets the minimum standards for use of the HOTDS.

Keywords:
anti-icing fluid – definition, Appendix B
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definition – deicing fluid, Appendix B
definition – glycol pan measurement, Appendix B
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Barry B. Myers, Aircraft Anti-icing Fluid Endurance, Holdover, and Failure Times Under Winter Precipitations Conditions, Transportation Development Centre, Transport Canada, TP 13832, November 2001

This document is a glossary prepared by Mr. Barry Myers, an aerodynamicist and Transportation Development Centre (Transport Canada) subject matter expert on matters related to aircraft ground deicing. Mr. Myers for a long time headed research and development on aircraft ground deicing and anti-icing for Transport Canada.

This document (TP 13832) was his effort to clarify definitions related to the hazards of ice, snow and frost on aircraft surfaces and the use to anti-icing fluids to protect against frozen and freezing
precipitation His glossary is particularly interesting as it differentiates between visual, adhesion and aerodynamic failures.

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Issued 2015-12-16 by EASA.

Advisory information explaining the potentially deleterious effects of alkali metal organic salt salts (non-glycol based) as freezing point depressants in the formulation of Type I aircraft deicing fluids. These alkali salt based deicing fluids can have two adverse effects: 1) when used in the first step of a two-step deicing anti-icing, the organic slat based Type I fluid can interfere with the thickener system of Type II/II/IV fluids and reduce expected holdover time, with consequences affecting safety and 2) can facilitate galvanic corrosion of aircraft parts or the catalytic oxidation of aircraft carbon brakes.

Keywords:
- alkali organic salt based Type I fluid – EASA guidance, pp 1–2
- non-glycol based Type I – EASA guidance, pp 1–2
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- Type I Non-Glycol based fluid – effect on Type II/III/IV – EASA guidance, pp 1–2
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- Type I Non-Glycol based fluid – need for inspections – EASA guidance, pp 1–2


Issued 2017-11-14 by EASA.

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- FAA Notice N 8900.xxx FAA-Approved Deicing program Updates, Winter 20xx-20yy – EASA recommendation to use, pp 2–3
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EASA GM1 CAT.OP.MPA.250 Ice and Other Contaminants – Ground Procedures: Terminology

Issued 2012-10-25 by EASA.

Guidance Material (GM) issued by EASA consists of three sections labeled GM1, GM2 and GM3 of the Annex to Executive Director Decision ED 2012/018/R: Acceptable Means of compliance (AMC) and Guidance Material (GM) to Part-CAT.

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112 See footnote 111.

111 EASA uses the term GIDS (ground ice detection system), SAE uses the term ROGIDS (remote on-ground ice detection system for what appears to be the same reality.

112 See footnote 111.
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Issued 2012-10-25 by EASA.

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113 EASA uses “commander”. FAA and Transport Canada tend to use the expression pilot-in-command or captain. Here we use pilot, pilot-in-command or flightcrew, as appropriate. Scripts in section 5.8 pf AS6285 states that pilot-in-command is a synonym of commander.
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EASA GM3 CAT.OP.MPA.250 Ice and Other Contaminants – Ground Procedures: De-icing/Anti-icing Background Information

Issued 25 October 2012 by EASA.

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114 AEA recommendations are no longer published (as of December 2016). EASA now recommends to use the global aircraft deicing standards and FAA documentation. See EASA Safety Information Bulletin 2017-11.
115 The expression “loss of fluid effectiveness” and “fluid failure” appears to be used interchangeably; however, there is a distinction to be made between visual failure and aerodynamic failure.
Documents Issued by ICAO

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

Revised 2000 by ICAO.

Doc 9640-AN/940 provides high level information on aircraft deicing/anti-icing. It summarizes the history of deicing, develops the notion of the clean aircraft concept, informs on deicing fluids, holdover time, on the various deicing checks to be done during deicing operations, distinguishes the responsibilities of the regulators and those of operators, discusses facility design, explains the necessity of air traffic control winter operations plan, summarizes deicing and anti-icing methods, and insists on the need for training and quality assurance. It recommends to maintain information updated and provides web links and bibliography to do such.

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Revised 2016-11-10 by ICAO.

This document has a short section\textsuperscript{116} that describes the standard phraseology to be used by flightcrew and ground crew in deicing/anti-icing operations. Only the section (12.7.2) dealing with deicing/anti-icing operations was indexed in the \textit{Guide}.

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Documents Issued by Boeing

Haruiko Oda\textsuperscript{117} et al, Safe Winter Operations

Issued by Boeing 2010-10.

Provides airline engineering, maintenance, flight personnel and service providers with procedures and tips for safe winter operations.

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Type II/III/IV residue, dried, p 6
Type II/III/IV residue, effect of – flight control restrictions, p 6
Type II/III/IV residue, guidance, Boeing, p 6
Type II/III/IV residue, p 6
Type II/III/IV residue, rehydrated, p 6
wing anti-ice system – not a substitute for ground deicing, p 12
winter operations, guidance (Boeing) – for flightcrews, pp 12–13
winter operations, guidance (Boeing) – for maintenance crews, p 11
winter operations, guidance (Boeing), pp 5–13
PART TWO: THE RUNWAY DEICING DOCUMENTS

A chart with the runway deicing documents can be found in Figure 2 at p 216.

Documents Issued by the SAE G-12 Runway Deicing Fluid Committee

**AMS1431D Compound, Solid Runway and Taxiway Deicing/Anti-Icing**

Revised 2012-06-08 by SAE G-12 RDF.

AMS1431D sets the technical requirements for runway deicing and anti-icing products in the form of a solid.\(^{118}\) Runway deicing products (RDP) are used typically at airports on aircraft maneuvering areas, such as aprons, runways, and taxiways, for the prevention and removal of frozen deposits of snow, frost, and ice.

Keywords:
aircraft maneuvering area deicing product. See RDP
airfield deicing fluid. See RDP
apron deicing product. See RDP
cadmium plate corrosion – reporting requirement p 1, s 3.2.9.3.1
carbon brake oxidation – reporting requirement, Rationale at p 1
definition – RDP, solid – lot, s 4.3
RDP nomenclature see footnote 118
RDP, solid – acceptance tests, s 4.2.1
RDP, solid – AIR6130 reporting, s 3.2.9.3.1
RDP, solid – airfield use label, s 5.1.2
RDP, solid – approval by purchaser, s 4.4
RDP, solid – aquatic toxicity, s 3.1.1.4
RDP, solid – asphalt concrete degradation resistance, s 3.8.2.2
RDP, solid – biodegradation, s 3.1.1.3
RDP, solid – BOD, s 3.1.1.1
RDP, solid – chloride content, s 3.2.3
RDP, solid – composition, s 3.1

\(^{118}\) Use of words to design runway deicing products in solid and liquid form is not systematic in the SAE documents and even within a document. AMS1431D uses “Solid Runway and Taxiway Deicing/Anti-icing Compound” in its title. Section 1.3.1 refers to “deicers/anti-icers”, s 3.1 “product”, s 3.1.1 “compound”, s 3.1.1.4 “formulated compound”. AMS1435C: title “Deicing/Anti-icing Runways (sic) and Taxiways (sic) Generic Fluid”, s 1.1 “deicing and anti-icing materials”, s 1.3.4 “fluid product”, s 1.4 “deicing anti-icing formulations”, s 3.1 “fluid”. AIR6130 rationale section “runway deicing/anti-icing compounds”, “runway deicers”, “deicing compound”, s 1 “runway deicing compound”. AIR6170, AIR6172 and AIR6211 use in their titles “… Runways (sic) and Taxiways (sic) Deicing/Anti-icing Chemicals”. The following nouns are used almost interchangeably: fluid, compound, deicer, chemical, material and product. Fluid does not encompass solids and vice versa. Compound, in chemistry, is a substance formed by a combination of elements in fixed proportions – not what we have here. Deicer can be a chemical, a person or a vehicle – too imprecise. Material is usually referred to as a substance to make things. Chemical, unfortunately, is oft perceived negatively. For lack of a better term, in this document, the runway deicing fluid (RDF) and solids (no abbreviation) are indexed as runway deicing product (RDP): RDF, liquid and RDP, solid.
RDP, solid – ecological behavior, s 3.1.1.4
RDP, solid – effect on aircraft materials, s 3.2.9
RDP, solid – effect on painted surfaces, s 3.2.6
RDP, solid – effect on transparent plastics, s 3.2.5
RDP, solid – effect on unpainted surfaces, s 3.2.7
RDP, solid – Federal (US) Supply Classification 6850, s 8.4
RDP, solid – flash point, s 3.2.2
RDP, solid – friction evaluation, s 1.3.2
RDP, solid – hydrogen embrittlement, s 3.2.9.4
RDP, solid – ice melting, s 3.2.10
RDP, solid – ice penetration, s 3.1.10
RDP, solid – ice undercutting, s 3.2.10
RDP, solid – independent laboratory testing, ss 4.1, 4.5
RDP, solid – labels, s 5
RDP, solid – lot – definition, s 4.3
RDP, solid – lot number, s 5.1.2
RDP, solid – low embrittling cadmium plate, s 3.2.9.3
RDP, solid – safety data sheet, s 4.5.1
RDP, solid – periodic tests, s 4.2.2
RDP, solid – pH, s 3.2.1
RDP, solid – physical properties, s 3.2
RDP, solid – preproduction tests, s 4.2.3
RDP, solid – rejection, s 7
RDP, solid – reports, s 4.5
RDP, solid – resampling, s 4.6
RDP, solid – runway concrete surface scaling resistance, s 3.2.8.1
RDP, solid – sampling plan, s 4.3
RDP, solid – sampling, s 4.3
RDP, solid – sandwich corrosion, s 3.2.9.1
RDP, solid – storage stability, s 3.2.4
RDP, solid – stress corrosion resistance, s 3.2.9.5.1
RDP, solid – TOD, s 3.1.1.2
RDP, solid – total immersion corrosion
RDP, solid – total water content, s 3.1.3
RDP, solid – trace contaminants, s 3.1.2
runway deicer. See RDP
runway deicing chemical. See RDP
runway deicing compound. See RDP
runway deicing fluid. See RDP, liquid
runway deicing product. See RDP
runway deicing solid. See RDP, solid
runway deicing/anti-icing compound. See RDP
solid runway and taxiway deicing/anti-icing compound. See RDP, solid
taxiway deicing compound. See RDP
taxiway deicing product. See RDP
AMS1435C sets the technical requirements for runway deicing and anti-icing products in the form of a liquid. Runway deicing products are used typically at airports on aircraft maneuvering areas, such as aprons, runways, and taxiways, for the prevention and removal of frozen deposits of snow, frost, and ice. Runway deicing products (RDP) in liquid form, also known as runway deicing fluids, must never be used as aircraft deicing fluid.
AIR6130A Cadmium Plate Cyclic Corrosion Test

Revised 2017-05-18 by SAE G-12 RDF.

AIR6130A describes a 14-day material test to determine the cyclic effects of runway deicing products on aircraft cadmium plated parts. Some runway and taxiway deicing/anti-icing products, have been found to cause severe corrosion on aircraft components with cadmium plating. There is a need for users to understand the effect of these products on aircraft components when they are
exposed repeatedly in a normal winter operating environment. The existing test in the AMS1431D and AMS1435C specifications for runway deicing products is a one-time 24 hour immersion test for cadmium corrosion, which does not accurately reflect how aircraft and airport equipment are affected by runway deicers. AIR6130 with its 14-day cyclic test is intended to provide better information to the end user/purchaser of the deicing products regarding the cyclic effects on cadmium plated aircraft parts or airport equipment. The document is intended to be referred to by the AMS1431 and AMS1435 specifications, which will then provide more useful information to the end-users in the test report.

Keywords:
cadmium plate cyclic corrosion test – AMS1431 sample, s 3c
cadmium plate cyclic corrosion test – AMS1435 sample, s 3b
cadmium plate cyclic corrosion test – cleaning of test specimens, s 5b
cadmium plate cyclic corrosion test – criterion for undesirable corrosion effects, s 6
cadmium plate cyclic corrosion test – gravimetric results, ss 5i., 5l.
cadmium plate cyclic corrosion test – procedure, s 5
cadmium plate cyclic corrosion test – runway deicing compound sample, s 3
cadmium plate cyclic corrosion test – sample preparation, s 4
cadmium plate cyclic corrosion test – steel substrate, s 3
cadmium plate cyclic corrosion test – test coupons, s 3
cadmium plate cyclic corrosion test – test results, s 6
cadmium plate cyclic corrosion test – test specimen, s 3
cadmium plated aircraft parts – RDP caused corrosion, s 1
cadmium plated aircraft parts corrosion test. See cadmium plate cyclic corrosion test
corrosion of cadmium plated aircraft parts – undesirable corrosion criterion, s 6
corrosion of cadmium plated aircraft parts, s 1
corrosion, undesirable – criterion for, s 6
RDP – cadmium plate cyclic corrosion test, Title at p 1, s 1
RDP – undesirable corrosion criterion, s 6
RDP caused corrosion – undesirable corrosion criterion, s 6
runway deicing fluid. See RDP, liquid
runway deicing/anti-icing compound. See RDP
taxiway deicing/anti-icing compound. See RDP
undesirable corrosion criterion, s 6

AIR6170A Ice Melting Test Method for Runways and Taxiways Deicing/Anti-icing Chemicals

Revised 2017-01-21 by SAE G-12 RDF.

AIR6170A describes a quantitative test method for liquid and solid deicing/anti-icing products, to evaluate the amount of ice melted as a function of the time and temperature.
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Keywords:
AMS1431 RDP ice melting test. See RDP ice melting test
AMS1435 RDP ice melting test. See RDP ice melting test
ice melting test for RDP. See RDP ice melting test
ice melting test. See RDP ice melting test
RDP comparative melting capability, s 3.2
RDP ice melting capability, comparative, s 3.2
RDP ice melting relative capacity, s 1
RDP ice melting test ice preparation, s 3.3.5
RDP ice melting test procedure, s 3.4
RDP ice melting test reference control solution, ss 3.5.3, 3.5.3.1, 3.5.3.2
RDP ice melting test report, s 3.8
RDP ice melting test sample preparation, ss 3.5.1, 3.5.2
RDP ice melting test significance, s 1
RDP ice melting test significance, ss 1, .2
RDP ice melting test temperatures ss 3.6, 3.7
RDP ice melting test, Title at p 1
RDP ice melting v temperature, ss 1, 3.8
RDP ice melting v time, ss 1, 3.8
RDP use on taxiways, s 1
RDP, liquid – ice melting test. See RDP ice melting test
RDP, solid – ice melting test. See RDP ice melting test
SHRP H-332, s 2

AIR6172A Ice Undercutting Test Method for Runways and Taxiways Deicing/Anti-icing Chemicals

Revised 2017-03-15 by SAE G-12 RDF.

AIR6172A describes a quantitative test method, for liquid and solid runway deicing/anti-icing products (RDP), to evaluate the ice undercut as a function of the time and temperature.

Keywords:
AMS1431 RDP ice undercutting test. See RDP ice undercutting test
AMS1435 RDP ice undercutting test. See RDP ice undercutting test
ice undercutting test, RDP. See RDP ice undercutting test, Title at p 1
ice undercutting test. See RDP ice undercutting test
RDP ice undercutting test description, s 3.1
RDP ice undercutting test dye, ss 3.3.1, 3.4.4
RDP ice undercutting test dye – rhodamine, s 3.3.3
RDP ice undercutting test dye – fluorescein, s 3.3.3
RDP ice undercutting test equipment, s 3.3
RDP ice undercutting test ice cavity preparation, s 3.3.6
RDP ice undercutting test ice preparation, s 3.3.5
RDP ice undercutting test procedure, s 3.4
RDP ice undercutting test reference control solution, ss 3.4.3, 3.4.3.1, 3.4.3.2
RDP ice undercutting test reference control solution – 25% w/w potassium acetate solution, s 3.4.3.2
RDP ice undercutting test report, s 3.7
RDP ice undercutting test sample preparation, ss 3.4.1, 3.4.2
RDP ice undercutting test significance, s 3.2
AIR6211A Ice Penetration Test Method for Runways and Taxiways Deicing/Anti-Icing Chemicals

Revised 2017-05-08 by SAE G-12 RDF.

AIR6211A describes a quantitative method, for liquid and solid runway deicing/anti-icing products (RDP), to evaluate the ice penetration as a function of the time and temperature.

Keywords:
AMS1431 RDP ice penetration test. See RDP ice penetration test
AMS1435 RDP ice penetration test. See RDP ice penetration test
ice penetration test. See RDP ice penetration test
RDP ice penetration test – description, s 3.1
RDP ice penetration test dye, s 3.4.4
RDP ice penetration test ice preparation, s 3.3.4
RDP ice penetration test procedure, s 3.4
RDP ice penetration test reference control solution – potassium acetate 50%, s 3.4.3.1
RDP ice penetration test reference control solution – potassium acetate 25%, s 3.4.3.2
RDP ice penetration test reference control solution,
RDP ice penetration test reference control solution, s 3.4.3
RDP ice penetration test significance – reporting, s 3.7
RDP ice penetration test significance, s 3.2
RDP ice penetration test temperature, ss 3.6, 3.7
RDP ice penetration test time, s 3.7
RDP ice penetration test, Title at p 1
RDP, liquid – ice penetration test. See RDP ice penetration test
RDP, solid – ice penetration test. See RDP ice penetration test
SHRP H-332, s 2.4

Documents Issued by the SAE A-5A Wheels, Brakes and Skid Control Committee

AIR5490A Carbon Brake Contamination and Oxidation

Revised 2016-04-12 by SAE A-5A.

This document provides information on the susceptibility of aircraft carbon brake discs to contamination and oxidation. Carbon used in the manufacture of aircraft brake discs is porous, and can absorb liquids and contaminants, such as runway deicing products (RDP), aircraft deicing
fluids (ADF), sea water, aircraft hydraulic fluid, aircraft wash fluids, sea water, cleaning solvents, etc. Some of the contaminants can negatively impact the intended performance of the brakes, particularly through catalytic oxidation of the carbon.

Although aircraft carbon brakes had been operating for many years with the occasional oxidative degradation issues, the introduction of environmentally-friendly, low BOD, alkali organic salt based runway deicing products in the 1990s resulted in significant increases in the frequency of occurrences and severity of carbon brake disk degradation. The catalytic oxidative action is attributed to the alkali moiety of the organic salts.

This document intends to raise awareness of the effects of carbon brake contamination and present information on the chemicals promoting catalytic oxidation, the mechanism of oxidation, and inspection technique on and off the aircraft.\(^\text{119}\)

Keywords:
aircraft carbon brake. See carbon brake
aircraft deicing fluid. See deicing fluid
aircraft hydraulic fluid – definition, s 2.2
aircraft lubricant – definition, s 2.2
airplane. See aircraft
antioxidant (AO) treatments, s 2.2
carbon brake – definition, s 2.2
carbon brake antioxidant treatment – barrier coating, s 5.2.4a
carbon brake antioxidant treatment – barrier coating, self-healing, s 5.2.4a
carbon brake antioxidant treatment – chemical vapor infiltration, s 5.2.5
carbon brake antioxidant treatment – densification of the polyacrylonitrile fibers, s 5.2.5
carbon brake antioxidant treatment – disk soaking, s 5.2.4a
carbon brake antioxidant treatment – oxidation inhibitor, s 5.2.4b
carbon brake antioxidant treatment – oxidation inhibitor, phosphate based, s 5.2.4b
carbon brake antioxidant treatment – oxidation resistance of the carbon, s 5.2.5
carbon brake antioxidant treatment – phosphate solution, s 5.2.4b
carbon brake antioxidant treatment – porosity of the carbon, s 5.2.5
carbon brake catalytic oxidation, Rationale at p 1
carbon brake contamination – decontamination method, s 8
carbon brake contamination – effects of humidity on friction coefficient of contaminated brakes, s 6.2
carbon brake contamination – prevention – phosphate solutions\(^\text{120}\), s 5.2.4b
carbon brake contamination, detection of – chromatography, s 5.4

\(^{119}\) SAE Committee A-5A appears to use the word airplane rather than aircraft in the following expressions: airplane anti-icing/deicing fluids, airplane hydraulic fluids, airplane lubricants, and airplane wash fluids. In this Guide to Aircraft Ground Deicing, we index the word “aircraft” rather than the word “airplane”. Specifically, Committee A-5A refers to airplane anti-icing/deicing fluids. SAE G-12 refers to them as aircraft deicing/anti-icing fluids. Here we follow SAE G-12 usage.

\(^{120}\) Section 8 of AIR5490 stated that brake manufacturers had used phosphate or boron solutions to protect against oxidation. Boron solution was deleted from AIR5490A; no explanation was given.
carbon brake contamination, detection of – conductivity measurement, s 5.4
carbon brake contamination, detection of – discoloration, s 5.4.1
carbon brake contamination, detection of – hardness probes, with, s 5.4
carbon brake contamination, detection of – odor, s 5.4
carbon brake contamination, detection of – off-aircraft inspection, s 5.4.4
carbon brake contamination, detection of – on-aircraft inspection, s 5.4.3
carbon brake contamination, detection of – smoke, s 5.4
carbon brake contamination, detection of – spectrometry, s 5.4
carbon brake contamination, detection of – staining, s 5.4
carbon brake contamination, detection of – visual means, by, ss 5.4, 5.4.1, 5.4.2, 5.4.3.1
carbon brake contamination, effects of – aircraft runway over-runs, s 6.2
carbon brake contamination, effects of – brake disk lug rupture, s 5.3.1
carbon brake contamination, effects of – brake disk rupture, s 6.1
carbon brake contamination, effects of – brake overheating, s 6.2
carbon brake contamination, effects of – brake torque, s 4.2.2
carbon brake contamination, effects of – brake vibrations, ss 4.2.2, 6.1
carbon brake contamination, effects of – brake wear, s 4.2.2
carbon brake contamination, effects of – brake wear, ss 3b, 6.3
carbon brake contamination, effects of – catalytic oxidation, s 3a
carbon brake contamination, effects of – complete loss of braking capability, s 5.3.1
carbon brake contamination, effects of – friction coefficient, increase and decrease, s 6.2
carbon brake contamination, effects of – increased aircraft braking distance in rejected takeoff, s 5.3.1
carbon brake contamination, effects of – loss in braking performance, ss 3a, 5.3.1
carbon brake contamination, effects of – loss of brake disc reuse capability, s 5.3.3
carbon brake contamination, effects of – loss of friction area, s 3a
carbon brake contamination, effects of – loss of mechanical strength, s 3a
carbon brake contamination, effects of – loss of rubbed area, s 3a
carbon brake contamination, effects of – mass loss, s 5.1.2
carbon brake contamination, effects of – over heating of other brakes, s 6.2
carbon brake contamination, effects of – partial loss of braking capability, s 5.3.1
carbon brake contamination, effects of – premature brake removal, s 5.3.2
carbon brake contamination, effects of – runway over-runs, s 6.2
carbon brake contamination, effects of – structural brake disc failure, ss 3a, 5.3
carbon brake contamination, effects of – temporary or permanent change in friction level, ss 3b, 6.2
carbon brake contamination, effects of – torque reduction, s 3
carbon brake contamination, effects of – uneven braking, s 6.2
carbon brake contamination, effects of – vibration, squeal, s 6.1
carbon brake contamination, effects of – vibration, whirl, s 6.1
carbon brake contamination, effects of – p 1
carbon brake contamination, prevention of – use of wheel covers, s 7
carbon brake degradation, Rationale at p 1
carbon brake friction and wear modifier – definition, s 4.2.2
carbon brake inspection, Rationale at p 1
carbon brake operating temperature v steel brake operating temperature, s 3a
carbon brake oxidation – oxidation effects v cumulative thermal load, s 5.3
carbon brake oxidation temperature in absence of contamination [ca 400 °C], s 5.1.1
carbon brake oxidation, effect of. See also carbon brake contamination, effects of
carbon brake oxidation, factors influencing – aircraft deicing fluids, s 5.2.7
carbon brake oxidation, factors influencing – airline route structure, s 5.2.6
carbon brake oxidation, factors influencing – airport selection of RDP, s 5.2.6
carbon brake oxidation, factors influencing – alcohols based RDP, s 5.2.6
carbon brake oxidation, factors influencing – alkali metal acetate based RDP, s 5.2.6
carbon brake oxidation, factors influencing – alkali metal formate based RDP, s 5.2.6
carbon brake oxidation, factors influencing – ambient temperature, s 5.2.1
carbon brake oxidation, factors influencing – antioxidant coatings, s 5.2.4
carbon brake oxidation, factors influencing – antioxidant treatment, s 5.2.4
carbon brake oxidation, factors influencing – brake wear, s 5.2.1
carbon brake oxidation, factors influencing – cleaners, s 5.2.8
carbon brake oxidation, factors influencing – cooling air, s 5.2.2
carbon brake oxidation, factors influencing – cooling ducts in wheel bay, s 5.2.2
carbon brake oxidation, factors influencing – cooling fans, s 5.2.2
carbon brake oxidation, factors influencing – energy absorbed during braking, s 5.2.1
carbon brake oxidation, factors influencing – length of winter, s 5.2.6
carbon brake oxidation, factors influencing – mass of carbon heat sink, s 5.2.1
carbon brake oxidation, factors influencing – number of landings per overhaul, s 5.2.3
carbon brake oxidation, factors influencing – number of thermal cycles, s 5.2.3
carbon brake oxidation, factors influencing – peak temperature ss 5.1.1, 5.2.1
carbon brake oxidation, factors influencing – peak temperature, time at ss 5.1.1, 5.2.1
carbon brake oxidation, factors influencing – ram air cooling, s 5.2.2
carbon brake oxidation, factors influencing – time of exposure to contaminant, s 5.2.10
carbon brake oxidation, factors influencing – urea based RDP, s 5.2.6
carbon brake oxidation, factors influencing – wheel brake structure, s 5.2.1
carbon brake oxidation, factors influencing – wind, s 5.2.1
carbon brake oxidation, Rationale at p 1
carbon brake removal criteria, s 5.4.3.2
carbon brake return-to-service criteria, s 5.4.4.2
carbon brake, smoke from, s 4.2.1 note
carbon brake, sources of contamination – acetate v formate, s 4.2.1b
carbon brake, sources of contamination – aircraft deicing fluids, s 4.1b
carbon brake, sources of contamination – aircraft hydraulic fluids, s 4.1e
carbon brake, sources of contamination – aircraft hydraulic fluids, phosphate ester based, s 4.1c
carbon brake, sources of contamination – aircraft lubricants, s 4.1d
carbon brake, sources of contamination – aircraft wash fluids, s 4.1c
carbon brake, sources of contamination – alkali organic salts, s 4.2.1b
carbon brake, sources of contamination – alkali metal salts, s 4.2.1b
carbon brake, sources of contamination – automatic aircraft washing systems, s 7
carbon brake, sources of contamination – calcium salts, s 4.2.1c
carbon brake, sources of contamination – catalyst – alkali metal based RDP, s 4.2.1b
carbon brake, sources of contamination – catalyst – anti-viral agent, s 4.2.1f
carbon brake, sources of contamination – catalyst – calcium from cleaning agents, s 4.2.1c
carbon brake, sources of contamination – catalyst – disinfectants, ss 4.2.1f, 5.2.9
carbon brake, sources of contamination – catalyst – potassium acetate, s 4.2.1b
carbon brake, sources of contamination – catalyst – potassium formate, s 4.2.1b
carbon brake, sources of contamination – catalyst – potassium from cleaning agents, s 4.2.1c
carbon brake, sources of contamination – catalyst – potassium in Purple K fire extinguishers, s 4.2.1k
carbon brake, sources of contamination – catalyst – RDP, s 4.2.1b
carbon brake, sources of contamination – catalyst – sodium acetate, s 4.2.1b
carbon brake, sources of contamination – catalyst – sodium formate, s 4.2.1b
carbon brake, sources of contamination – catalyst – sodium from cleaning agents, ss 4.2.1a, 4.2.1c
carbon brake, sources of contamination – catalyst – sodium from sea water, s 4.2.1a
carbon brake, sources of contamination – catalyst – sodium hypochlorite, ss 4.2.1f, 5.2.9
carbon brake, sources of contamination – catalyst – temperature indicating crayon marks, s 4.2.1e
carbon brake, sources of contamination – catalyst, s 4.2.1
carbon brake, sources of contamination – cleaning solvents, ss 4.1g, 5.2.8
carbon brake, sources of contamination – disinfectants, bleach containing, ss 4.1h, 5.2.9
carbon brake, sources of contamination – disinfectants, calcium containing, s 4.1h
carbon brake, sources of contamination – disinfectants, chlorine\(^{121}\) containing, ss 4.1h, 5.2.9
carbon brake, sources of contamination – disinfectants, citric acid containing, s 4.1h
carbon brake, sources of contamination – disinfectants, hypochlorite containing, ss 4.1h, 5.2.9
carbon brake, sources of contamination – disinfectants, potassium containing, s 4.1h
carbon brake, sources of contamination – disinfectants, sodium containing, s 4.1h
carbon brake, sources of contamination – fire extinguishing agent, ss 4.1f, 4.2.2
carbon brake, sources of contamination – formate v acetate, s 4.2.1b
carbon brake, sources of contamination – hydraulic fluid leaks, s 4.2.2
carbon brake, sources of contamination – hydraulic system servicing, s 4.2.2
carbon brake, sources of contamination – RDP, s 4.1a
carbon brake, sources of contamination – sea water, s 4.1j
carbon brake, sources of contamination – solvents, cleaning, ss 4.1g, 5.2.8
carbon brake, sources of contamination – temperature indicator crayon marks, s 4.1i

carbon friction material, s 3
catalytic oxidation – definition, s 2.2
cleaning solvent – definition, s 2.2
contamination, carbon brake. See carbon brake contamination
definition – aircraft deicing fluid. See definition – deicing fluid
definition – aircraft hydraulic fluid, s 2.2
definition – aircraft lubricant, s 2.2
definition – carbon brake friction and wear modifier, s 4.2.2
definition – carbon brake, s 2.2
definition – catalytic oxidation. See definition – oxidation, catalytic
definition – cleaning solvent, s 2.2
definition – deicing fluid, s 2.2
definition – disinfectant, s 2.2
definition – fire extinguishing agent, s 2.2
definition – hygroscopic, s 2.2
definition – lubricant, aircraft, s 2.2
definition – oxidation [of carbon], s 2.2
definition – oxidation, thermal, s 2.2.
definition – oxidation, catalytic, s 2.2
definition – runway anti-icing/deicing solids and fluids, s 2.2
definition – temperature indication markers, s 2.2
definition – thermal oxidation, s 2.2.
definition – tribology, s 2.2
deicing fluid – definition, s 2.2
disinfectant – definition, s 2.2
fire extinguishing agent – definition, s 2.2
hydraulic fluid – effect on carbon brake, s 4.2.1 note
hygroscopic\(^{122}\) – definition, s 2.2
lubricant, aircraft – definition, s 2.2
oxidation [of carbon] – definition, s 2.2
oxidation, thermal, s 2.2
RDP – catalytic oxidation of carbon brakes, Rationale at p 1, s 1
RDP – effect on carbon brakes, Rationale at p 1
RDP – market introduction history, Rationale at p 1, s 5.2.6

\(^{121}\) ARP5490A, in section 4.1h, lists chlorine containing disinfectants as potential source of carbon brake contamination. Chlorine is meant to include hypochlorite and bleach (see section 5.2.9).

\(^{122}\) AIR5490A, in section 2.2, defines hygroscopic as absorbs liquid. Hygroscopic is usually defined as the property of a substance that takes up and retains moisture.
AIR5567A Test Method for Catalytic Brake Oxidation

Issued 2015-08-17 by SAE A-5A.

This test method provides stakeholders including fluid manufacturers, brake manufacturers, aircraft constructors, aircraft operators and airworthiness authorities with a relative assessment of the effect of runway deicing products on carbon brake oxidation. This simple test is only designed to assess the relative effects of runway deicing products by measuring mass change of contaminated and bare carbon samples tested under the same conditions. It is not possible to set a general acceptance threshold oxidation limit based on this test method because carbon brake oxidation is a function of heat sink design and the operating environment.

Keywords:
- aircraft carbon brake. See carbon brake
- alkali metal salts – effect on carbon brakes, p 1
- alkali organic salts – catalyst for carbon brake oxidation, p 1
- carbon brake antioxidant treatment, generic, s 3.2
- carbon brake oxidation – catalysis by alkali salts, s 1
- carbon brake oxidation – catalysis by RDP, s 1
- carbon brake oxidation test method – antioxidant formulation, generic, s 3.2
- carbon brake oxidation test method – antioxidant, application of, s 3.3
- carbon brake oxidation test method – carbon coupon selection, s 3.1
- carbon brake oxidation test method – coupon oxidation procedure, s 3.5
- carbon brake oxidation test method – mean normalized carbon weight loss %, s 4.2
- carbon brake oxidation test method – potassium acetate normalized results, s B.3
- carbon brake oxidation test method – potassium formate normalized results, s B.3
- carbon brake oxidation test method – RDP application to coupon, s 3.4
- carbon brake oxidation test method – round robin testing, s B.3
- carbon brake oxidation test method – sodium acetate normalized results, s B.3
- carbon brake oxidation test method – test result for liquid RDP, s 4.2
- carbon brake oxidation test method – test result for solid RDP, s 4.2
- carbon brake oxidation test method – test results, s 4
- carbon brake oxidation test method – test temperature (550 °C), s 3.5d.
- carbon brake oxidation test method – test time (24 h), s 3.5 e.
- carbon brake oxidation test method – urea normalized results, s B.3
- carbon brake oxidation test method – weight loss %, mean normalized, s 4.2
- carbon brake oxidation test method, Title at p 1
- carbon brake oxidation threshold limit – not possible to measure, s 1
- carbon brake oxidation, effect of – mass change, s 1
- carbon brake oxidation, effect of – weight loss, s 1
- RDP – carbon brake oxidation test method, p 1
- RDP – catalysis of carbon brakes, p 1
RDP – effect on carbon brakes p 1, s 1
Documents Issued by SAE G-15 Airport Snow and Ice Control

AMS1448B Sand, Airport Snow and Ice Control


This is a stabilized document meaning it is no longer updated by SAE G-15 and is not known to be used actively by air carriers or operators.

It is included in this Guide as, from time to time, questions are asked on the effects of sand upon aircraft components which are discussed briefly in AMS1448B.

Keywords:
sand – aircraft engine, detrimental to, s 1.3
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sand – chlorides as contaminant, s 3.2.1
sand – containers, s 5
sand – effect on aircraft engines, s 1.3
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sand – use on taxiway, s 1.2
sand – washed, s 3.1
sand – washed, s 3.1

Documents Issued by the FAA

FAA Special Airworthiness Information Bulletin SAIB NM-08-27R1 Landing gear: Catalytic Oxidation of Aircraft Carbon Brakes due to Runway De-icing (RDI) Fluids

Issued 2008-12-31 by the FAA.
This bulletin informs aircraft owners and operators of the deleterious effect of alkali organic salts based runway deicing products on aircraft with carbon brakes. The alkali moiety of the organic salts are known to catalyze oxidation of the carbon with accompanying possible brake failure. The FAA recommends detailed visual inspection of carbon brake stators and rotors, looking for obvious damage. Depending on wheels removal frequency and findings, more frequent inspections may be appropriate to prevent reduction of brake effectiveness or brake failure.

Keywords:
carbon brake contamination process, pp 1-2
carbon brake contamination, detection of – visual means – carbon chips, p 2
carbon brake contamination, detection of – visual means – crushed carbon, p 2
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Documents Issued by Transport Canada

Transport Canada, Catalytic Oxidation of Aircraft Carbon Brakes due to Runway Deicing (RDI) Fluids, Service Difficulty Advisory AV-2009-03

Issued 2009-06-26 by Transport Canada.

This advisory informs aircraft owners and operators of the deleterious effect of alkali organic salts based runway deicing products on aircraft with carbon brakes. The alkali moiety of the organic salts are known to catalyze oxidation of the carbon with accompanying possible brake failure or
dragged bake and subsequent overheat. Transport Canada recommends detailed visual inspection of carbon brake stators and rotors at each landing gear wheel removal, looking for obvious damage.

Keywords:
carbon brake contamination process, p 1
carbon brake contamination, detection of – visual means – carbon chips, p 2
carbon brake contamination, detection of – visual means – crushed carbon, p 2
carbon brake contamination, detection of – visual means – damaged carbon, p 2
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Documents Issued by EASA

EASA Safety Information Bulletin SIB No.: 2018-01 Information on Materials Used for Runway and Taxiway De/Anti-icing

Issued 2018 01 09 by EASA

Alkali organic salts based runway deicing products have deleterious effects on aircraft carbon brakes. The alkali organic salts penetrate carbon brakes lowering the oxidation temperature of the carbon resulting in structural deterioration of carbon discs, reducing efficiency and long-term efficiency of the brakes. EASA believes aircraft operators should be aware of the nature of the runway deicing products used at airports to assess exposure of the brakes to the alkali organic salts and adjust maintenance programs. This information should be noted in SNOWTAM or in the Aeronautical Information Publication (AIP).
Keywords
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alkali organic salts – aircraft maintenance program, p 1
alkali organic salts – effect on carbon brakes, p1
alkali organic salts – oxidation of carbon brakes, p 1
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RDP – oxidation of carbon brakes, p 1
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EASA Safety Information Bulletin SIB No.: 2008-19R2 Catalytic Oxidation of Aircraft Carbon Brakes due to Runway De-icers

Revised 2013 04 23 by EASA.

This bulletin informs aviation stakeholders of the deleterious effect of alkali organic salts based runway deicing products on aircraft with carbon brakes. The alkali moiety of the organic salts are known to catalyze oxidation of the carbon with accompanying possible brake failure or dragged bake and subsequent overheat. EASA recommends detailed visual inspection of carbon brake stators and rotors at each landing gear wheel removal, looking for obvious damage. EASA further raises issues of cadmium and aluminum corrosion of landing gear joints and of electrical wire bundles, particularly those using Kapton®123 insulation, caused by alkali organic salts.

Keywords:
alkali organic salts – effect on aluminum, p 1
alkali organic salts – effect on cadmium, p 1
alkali organic salts – effect on carbon brakes, p 1
alkali organic salts – effect on Kapton insulation, p 2
alkali organic salts – effect on landing gear, p 2
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123 Trademark of E. I. du Pont de Nemours and Company.
Runway Deicing Documents – Issued by the FAA, Transport Canada and EASA

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EASA AMC1 ADR.OPS.C010 Pavements, Other Ground Surfaces, and Drainage

Issued 2017 by EASA

This short document recommends to airport operators to maintain the good friction of paved runway. Specifically it recommends to remove dust, sand, oil, rubber deposits as rapidly and as completely as possible.

Keywords:
aprons, s (a)
dust, s (a)
friction, runway, ss (a), (d)
mud, s (a)
pavement, Title
rubber deposits, s (a)
runway friction, ss (a), (d)
sand, s (a)
taxiways, s (a)
Alkali organic salts used in runway deicing products (RDP), catalytically reduce the temperature at which aircraft brakes undergo oxidation. Catalytic oxidation of the carbon brakes discs results in the mechanical and structural degradation of the brakes. This leads to a reduced service life of the brakes and in some instances could result in brake fires or failures. The author recommends that airlines, airports, regulators and legislators engage in discussions to change the current practice of using alkali organic salts to maintain and improve aviation safety.

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alkali organic salts – effect on carbon brakes, pp 19–24
carbon brake contamination process, p 19
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\(^{125}\) Aerodrome is used in the expression “Terminal Aerodrome Forecast” (TAF).

\(^{126}\) See footnote 5.
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  - AIR6211A Ice Penetration Method

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  - AMS1435C Liquid RDP

- Related Specification
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  - EASA, FAA, Transport Canada, Boeing
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This Guide to Aircraft Ground Deicing (Issue 6 – January 2018) replaces all previously issued versions of the Guide to Aircraft Ground Deicing. Please destroy all previously issued versions.

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