Guide to Aircraft Ground Deicing

Issue 16 – May 2022

Jacques Leroux, Ph.D.

Dear Reader,

How can you and I make the *Guide* better?

Please:

- tell me when you find errors or omissions;
- make suggestions for new documents to be indexed;
- let me know what you like or don't like about the *Guide*; I do care about what you think;
- send me questions; they may become new topics for the Q&A section;
- tell other people about the *Guide;* they may, hopefully, find it useful.

You can reach me at jleroux@dow.com.

Enjoy the *Guide.*

Jacques Leroux

Jacques Leroux is Chair of the SAE G-12 Steering Group on Aircraft Ground Deicing, Co-chair of the SAE G-12 Aircraft Deicing Fluids and Runway Deicing Products Committees, and Chair of the SAE/ICAO/IATA Council for the Global Aircraft Deicing Standards. He holds a Ph.D. in Chemistry from McGill University and is a member of the Quebec Order of Chemists.

First issue May 2016. Second issue September 2016. Third issue January 2017. Fourth issue April 2017. Fifth issue September 2017. Sixth issue January 2018. Seventh issue May 2018. Eight issue October 2018. Ninth issue February 2019. Tenth issue May 2019. Eleventh issue September 2019. Twelfth issue November 2019. Thirteenth issue October 2020. Fourteenth issue May 2021. Fifteenth issue September 2021. Sixteenth issue May 2022.

Guide to Aircraft Ground Deicing

Issue 16 – May 2022

This *Guide*[1] provides an introduction to aircraft ground deicing, a brief description of the standards published by the SAE G-12 Aircraft Ground Deicing Committee and other SAE Committees, guidance issued by regulators, the FAA, Transport Canada, EASA, and ICAO, documents issued by the Transportation Safety Board of Canada and Boeing, a list of abbreviations, a list of fluid manufacturers, charts of the documents, questions and answers, a list of preferred words and expressions, and an index.

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[1] Available at https://www.sae.org/works/committeeHome.do?comtID=TEAG12ADF. Get updates of this *Guide* by emailing a request at jleroux@dow.com.

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Changes in Issue 16

These revised documents replace the earlier published documents:

- SAE AS6170 Ice Melting Test Method for Runways and Taxiways Deicing/Anti-Icing Chemicals (28 October 2021); replaces AIR6170A;
- SAE AS6172 Ice Undercutting Test Method for Runways and Taxiways Deicing/Anti-Icing Chemicals (28 October 2021); replaces AIR6172A;
- SAE AS6211 Ice Penetration Test Method for Runways and Taxiways Deicing/Anti-Icing Chemicals (16 November 2021); replaces AIR6211A.

The following documents are indexed for the first time:

- SAE AIR7988 Impact of Alkali Metal-Based Runway De-icing Fluids on Aircraft Electrical Systems (21 December 2021);
- Transport Canada, Standard 622.11 Appendix A, "Minimum Assurance Requirement and Performance Specifications for Holdover Time Determination Systems (HOTDS)", Canadian Aviation Regulations (9 December 2020);
- Transport Canada, Standard 622.11, "Ground Icing Operations", Canadian Aviation Regulations (9 December 2020);
- Transportation Safety Board of Canada, *Air Transportation Safety Investigation Report A17C0146* (Gatineau, QC: Transportation Safety Board of Canada, 28 October 2021).

The following documents was deleted:

- 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 (23 February 2017).

The "Frequently Asked Question" section was renamed "Questions and Answers" (Q&A). Several (113) new questions and answers were added related to holdover time, lowest operational use temperature, highest operational use concentration. freezing point, freezing point depression, refraction, viscosity, sampling, nomenclature and short stories–lessons learned. Read a few each day. Some answers may surprise you or may even change the way you think about some deicing concepts.

In these times of pandemic, dear friends and readers, please be well and stay well. I miss not seeing all of you.

Jacques Leroux

May 1st, 2022

List of Indexed Documents

1. Arriaga, Michael, “Effects of Alkali Metal Runway Deicers on Carbon Brakes” (2014) Q1:19 Boeing Aero Magazine.
2. EASA Acceptable Means of Compliance (AMC) and Guidance Material (GM) to Part-CAT GM1 CAT.OP.MPA.250, “Ice and other contaminants – ground procedures: terminology”, revised (23 April 2021).
3. EASA, Acceptable Means of Compliance (AMC) and Guidance Material (GM) to Part-CAT, GM2 CAT.OP.MPA.250, “Ice and other contaminants – ground procedures: de-icing/anti-icing – procedures”, revised (23 April 2021).
4. EASA, Acceptable Means of compliance (AMC) and Guidance Material (GM) to Part-CAT, GM3 CAT.OP.MPA.250, “Ice and other contaminants – ground procedures: de-icing/anti-icing background information”, revised (23 April 2021).
5. EASA, AMC1 ADR.OPS.C010, “Pavements, Other Ground Surfaces, and Drainage” (August 2017).
6. EASA, Safety Information Bulletin No. 2015-27, “Potential Adverse Effect of Alkali Organic Salt-based Aircraft De-Icing Fluids on Anti-Icing Holdover Protection and Potential Aircraft Corrosion” (16 December 2015).
7. EASA, Safety Information Bulletin SIB No. 2008-19R2, “Catalytic Oxidation of Aircraft Carbon Brakes due to Runway De-icers” (23 April 2013).
8. EASA, Safety Information Bulletin SIB No. 2017-11, “Global De-icing Standards” (14 July 2017).
9. EASA, Safety Information Bulletin SIB No. 2018-01, “Information on Materials Used for Runway and Taxiway De/Anti-icing” (9 January 2018).
10. FAA, Advisory Circular AC 120-112, “Use of Liquid Water Equivalent System to Determine Holdover Times or Check Times of Anti-icing Fluids” (14 July 2015).
11. FAA, Advisory Circular AC 120-60B, “Ground Deicing and Anti-icing Program” (20 December 2004).
12. FAA, Advisory Circular AC 150/5200-30D, “Airport Field Condition Assessments and Winter Operations Safety” (29 October 2020).
13. FAA, Advisory Circular AC 150/5300-14D, “Design of Aircraft Deicing Facilities” (17 March 2020).
14. FAA, *Degree-Specific Holdover Time Data, Winter 2021-2022,* original issue (4 August 2021).
15. FAA, *Holdover Time Guidelines, Winter 2021-2022*, original issue (4 August 2021).
16. FAA, *Holdover Time Regression Guidelines Information, Winter 2021-2022*, original issue (4 August 2021).
17. FAA, Notice N 8900.594, “Revised FAA–Approved Deicing Program Updates, Winter 2021–2022” (26 August 2021).
18. FAA, Policy Statement, Policy No: PS-ACE-23-05, PS-ANM-25-10, “Type Certification Policy for Approval of Use of Type II, III, and IV Deicing/Anti-Icing Fluids on Airplanes Certificated Under 14 CFR Parts 23 and 25” (3 May 2015).
19. FAA, Special Airworthiness Information Bulletin SAIB NM-08-27R1, “Landing gear: Catalytic Oxidation of Aircraft Carbon Brakes due to Runway De-icing (RDI) Fluids” (31 December 2008).
20. Hille, Joel, “Deicing and Anti-icing Fluid Residues” (2007) Q1:16 Boeing Aero Magazine.

21. ICAO, Doc 4444, “Procedures for Air Navigation Services, Air Traffic Management”, 16th ed (2016).
22. ICAO, Doc 9640/AN940, “Manual of Aircraft Ground De-icing/Anti-icing Operations”, 3rd ed, advance unedited (2018).
23. Myers, Barry B., *Aircraft Anti-icing Fluid Endurance, Holdover, and Failure Times Under Winter Precipitation Conditions*, TP 13832 (Montreal: Transportation Development Centre, Transport Canada, November 2001).
24. Oda, Haruiko et al, “Safe Winter Operation” (2010) Q4:5 Boeing Aero Magazine.
25. SAE AIR5490A Carbon Brake Contamination (12 April 2016).
26. SAE AIR5567A Test Method for Catalytic Brake Oxidation (17 August 2015).
27. SAE AIR5704 Field Viscosity Test for Thickened Aircraft Anti-Icing Fluids (22 July 2014).
28. SAE AIR6130A Cadmium Plate Cyclic Corrosion Test (18 May 2017).
29. SAE AIR6232 Aircraft Surface Coating Interaction with Aircraft Deicing/Anti-Icing Fluids (issued 12 August 2013, reaffirmed 2 April 2019).
30. SAE AIR6284 Forced Air or Forced Air/Fluid Equipment for Removal of Frozen Contaminants (22 January 2015).
31. SAE AIR7988 Impact of Alkali Metal-Based Runway De-icing Fluids on Aircraft Electrical Systems (21 December 2021).
32. SAE AMS1424/1 Deicing/Anti-Icing Fluid, Aircraft SAE Type I Glycol (Conventional and Non-Conventional) Based (18 April 2016).
33. SAE AMS1424/2 Deicing/Anti-Icing Fluid, Aircraft SAE Type I Non-glycol Based (5 May 2016).
34. SAE AMS1424R Fluid, Aircraft Deicing/Anti-icing, SAE Type I (18 November 2020).
35. SAE AMS1428/1 Fluid, Aircraft Deicing/Anti-icing, Non-Newtonian (Pseudoplastic), SAE Type II, III and IV Glycol (Conventional and Non-Conventional) Based (14 February 2017).
36. SAE AMS1428/2 Fluid, Aircraft Deicing/Anti-Icing, Non-Newtonian (Pseudoplastic), SAE Type II, III and IV Non-Glycol Glycol Based (9 February 2017).
37. SAE AMS1428K Fluid, Aircraft Deicing/Anti-Icing, Non-Newtonian (Pseudoplastic), SAE Types II, III, and IV (24 October 2018).
38. SAE AMS1431E Solid Runway Deicing/Anti-Icing Product (24 October 2018).
39. SAE AMS1435D Liquid Runway Deicing/Anti-Icing Product (2 November 2018).
40. SAE AMS1448B Sand, Airport Snow and Ice Control (5 September 2014).
41. SAE ARP1971D Aircraft Deicing Vehicle - Self-Propelled (13 February 2019).
42. SAE ARP4902C Design of Aircraft Deicing Facilities (15 February 2018).
43. SAE ARP5058A Enclosed Operator’s Cabin for Aircraft Ground Deicing Equipment (21 June 2004).
44. SAE ARP5485B Endurance Time Test Procedures for SAE Type II/III/IV Aircraft Deicing/Anti-Icing Fluids (10 October 2017).
45. SAE ARP5660A Deicing Facility Operational Procedures (6 January 2011).
46. SAE ARP5718B Qualifications Required for SAE Type II/III/IV Aircraft Deicing/Anti-Icing Fluids (7 December 2017).
47. SAE ARP5945A Endurance Time Tests for SAE Type I Aircraft Deicing/Anti-Icing Fluids (10 October 2017).
48. SAE ARP6207 Qualification Required for SAE Type I Aircraft Deicing/Anti-Icing Fluids (10 October 2017).

49. SAE ARP6257 Aircraft Ground De/Anti-icing Communication Phraseology for Flight and Groundcrews (25 October 2016).
50. SAE ARP6852C Methods and Processes for Evaluation of Aerodynamic Effects of SAE-Qualified Aircraft Ground Deicing/Anti-Icing Fluids (24 October 2018).
51. SAE AS5537A Weather Support to Deicing Decision Making (WSDMM) Winter Weather Nowcasting System (10 February 2021).
52. SAE AS5635 Message Boards (Deicing Facilities) (16 February 2005).
53. SAE AS5681B Minimum Operational Performance Specification for Remote On-Ground Ice Detection Systems (17 May 2016).
54. SAE AS5900E Standard Test Method for Aerodynamic Acceptance of SAE AMS1424 and SAE AMS1428 Aircraft Deicing/Anti-Icing Fluids (3 August 2020).
55. SAE AS5901D Water Spray and High Humidity Endurance Test Methods for SAE AMS1424 and SAE AMS1428 Aircraft Deicing/Anti-Icing Fluids (4 September 2019).
56. SAE AS6170 Ice Melting Test Method for Runways and Taxiways Deicing/Anti-Icing Chemicals (28 October 2021).
57. SAE AS6172 Ice Undercutting Test Method for Runways and Taxiways Deicing/Anti-Icing Chemicals (28 October 2021).
58. SAE AS6211 Ice Penetration Test Method for Runways and Taxiways Deicing/Anti-Icing Chemicals (16 November 2021).
59. SAE AS6285D Aircraft Ground Deicing/Anti-Icing Processes (18 May 2021).
60. SAE AS6286B Training and Qualification Program for Deicing/Anti-Icing of Aircraft on the Ground (11 June 2020).
61. SAE AS6332 Aircraft Ground Deicing/Anti-Icing Quality Management (29 August 2017).
62. SAE AS9968A Laboratory Viscosity Measurement of Thickened Aircraft Deicing/Anti-Icing Fluids with a Viscometer (23 July 2021).
63. *Standardized International Aircraft Ground Deicing Program (SIAGDP)*, revision July 2020.
64. Transport Canada, Advisory Circular AC 700-030, “electronic Holdover Time (eHOT) Applications” (18 November 2014).
65. Transport Canada, Advisory Circular AC 700-061, “Degree-Specific Holdover Times”, issue 01 (16 July 2021).
66. Transport Canada, Aircraft Certification Test Division, Working Note No. 38, “Transport Canada Guidelines for Aeroplane Testing Following Deicing/Anti-Icing Fluid Application”, initial issue (5 October 2010).
67. Transport Canada, Civil Aviation Safety Alert CASA 2019-09, “Use of SAE Type I Fluids as an Anti-icing Fluid”, issue 1 (15 November 2019).
68. Transport Canada, *Commercial and Business Aviation Inspection and Audit (Checklists) Manual*, TP 13750E, 1st ed (October 2000).
69. Transport Canada, *Degree-Specific Holdover Times, Winter 2021-2022,* original issue (4 August 2021).
70. Transport Canada, *Holdover Time (HOT) Guidelines Regression Information, Winter 2021-2022*, original issue (4 August 2021).
71. Transport Canada, *Holdover Time (HOT) Guidelines Winter 2021-2022*, original issue (4 August 2021).
72. Transport Canada, Service Difficulty Advisory AV-2009-03, “Catalytic Oxidation of Aircraft Carbon Brakes due to Runway De-icing (RDI) Fluids” (26 June 2009).

73. Transport Canada, Standard 622.11, “Ground Icing Operations”, Canadian Aviation Regulations (9 December 2020).
74. Transport Canada, Standard 622.11 Appendix A, “Minimum Assurance Requirement and Performance Specifications for Holdover Time Determination Systems (HOTDS)”, Canadian Aviation Regulations (9 December 2020).
75. Transport Canada, TP 14052E, “Guidelines for Aircraft Ground Icing Operations”, issue 6 (August 2021).
76. Transportation Safety Board of Canada, *Air Transportation Safety Investigation Report A17C0146* (Gatineau, QC: Transportation Safety Board of Canada, 28 October 2021).

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Abbreviations and Acronyms

A4A	Airlines for America
A4E	Airlines for Europe
AAF	aircraft anti-icing fluid
AARTF	Transport Canada, Standards Branch, Commercial Flight Standards
AAT	aerodynamic acceptance test
AC	Advisory Circular (FAA and Transport Canada)
ACARS	aircraft communications addressing and reporting system
ACS	American Chemical Society
ADF	aircraft deicing fluid or aircraft deicing/anti-icing fluid
ADF/AAF	aircraft deicing/anti-icing fluid
AEA	Association of European Airlines
AFM	Aircraft Flight Manual
AFS	Flight Standard Service (FAA)
AGIP	approved ground icing program (Transport Canada)
AGL	above ground level
AIA	Aerospace Industries of America
AIP	Aeronautical Information Publication
AIR	Aerospace Information Report (SAE)
AIRMET	airman's meteorological information or aviation weather advisory
aka	also known as
ALP	airport layout plan
AMC	Acceptable Means of Compliance (EASA)
AMIL	Anti-icing Materials International Laboratory
AMM	Aircraft Maintenance Manual
AMS	Aerospace Material Specification (SAE)
AO	air operator (Transport Canada)
AO	anti-oxidant
AOA	angle-of-attack
AOC	air operator certificate (Transport Canada)
AOM	Aircraft Operating Manual or Aircraft Operations Manual
AOS	alkali organic salt
app	application (electronic)
APS	APS Aviation Inc.
APU	auxiliary power unit
AR	activity recording (FAA)
ARC	Advisory Rulemaking Committee (FAA)
ARP	Aerospace Recommended Practice (SAE)
AS	Aerospace Standard (SAE)
ASDE	airport surface detection equipment
ASOS	automated surface observing system
ASR	airport surveillance radar
AST	above ground storage tank
ASTM	American Society for Testing Materials
ATC TWR	air traffic control tower

ATC	air traffic control
ATCT	air traffic control tower
ATM	Air Traffic Management (ICAO)
ATOS	Air Transportation Oversight System (US)
ATR	Avions de transport régional
ATS	air traffic services
AWOS	automated weather observation system
°Brix	Brix degrees
BAe	British Aerospace
BFU	Bundsstelle für Flugunfalluntersuchung[2]
BLDT	boundary layer displacement thickness
BOD	biochemical oxygen demand
°C	Celsius degrees
C of C	certificate of conformance
ca	*circa* (approximately)
CAA	Civil Aviation Authority
CAAC	Civil Aviation Administration of China
CAC	clean aircraft concept
CAP	comprehensive assessment plan (FAA)
CAR	Canadian Aviation Regulation
CASA	Civil Aviation Safety Alert (Transport Canada)
CASI	Civil Aviation Safety Inspector (Transport Canada)
CASS	Commercial Air Service Standard (Transport Canada)
CAT.OP.MPA	Commercial Air Transport Operating Procedure Motor-Powered Aircraft (EASA)
CBA	Canadian Business Aviation
CBDS	computer based deicing simulator
CBT	computer-based training
CCME	Canadian Council of Ministers of the Environment
CD	coefficient of drag
CDF	centralized deicing facility
CEPA	Canadian Environmental Protection Act
C_f	coefficient of friction
CFD	computational fluid dynamics
CFR	Code of Federal Regulations (US)
CFS	Commercial Flight Standards (Transport Canada)
CG, cg	center of gravity
CH	certificate holder (FAA)
cl	2D lift coefficient
CL	3D lift coefficient
clmax	2D maximum lift coefficient
CLmax	3D maximum lift coefficient
CML	consumable materials list (Airbus)
COD	chemical oxygen demand
COHSR	Canadian Occupational Health and Safety Regulations

[2] German Federal Bureau of Aircraft Accident Investigation.

COM	company operations manual (Transport Canada)
CRC	cyclic redundancy check
CRM	crew resource management
CSA	Canadian Standard Association
CSFF	cold-soaked fuel frost
CT	check time
CTDS	check time determination system
CTOT	certain takeoff time
d-	*dextro* (rotatory); the opposite of *l-*
DA	design assessment (FAA)
DAQCP	Deicing/Anti-Icing Quality Control Pool (IATA)
DCT	data collection tool (FAA)
DDF	designated deicing facility
DEG	diethylene glycol
DEVA	de/anti-icing vendor audit
DGPS	differential global positioning system
DIS	deicing supervisor
dl-	racemic
DME	distance measuring equipment
DO	dissolved oxygen
DSHOT	degree-specific holdover time
DSHOTDA	degree-specific holdover time data administrator (Transport Canada)
EASA	European Aviation Safety Agency
ECD	estimated completion date
ECS	environmental control system
EFB	electronic flight bag
e.g.	*exempli gratia* (for example)
EG	ethylene glycol
eHOT app	electronic holdover time application
eHOT	electronic holdover time
e-learning	electronic learning
EMB	electronic message board
ERP	emergency response plan
ET	endurance time
EU	European Union
EU-OPS	EASA Operations Regulations
EUROCAE	European Organization for Civil Aviation Equipment
EWIS	electrical wiring interconnection system
FA	flight attendant
FAA	Federal Aviation Administration, United States Department of Transportation
FADS	forced air deicing systems
FAQ	frequently asked questions
FAS	forced air system
FBO	fixed base operator
FCOM	Flight Crew Operation Manual

ff	folio (and following)
FMH-1	Federal Meteorological Handbook No. 1, Surface Weather Observations and Reports (U.S.)
FMS	flight management system
FMVSS	Federal Motor Vehicle Safety Standard
FO	first officer
FOD	foreign object damage or foreign object debris
fp	freezing point
FPD	freezing point depressant
FSAT	Flight Standards Information Bulletins for Air Transportation (FAA)
FSDO	Flight Standards District Office (FAA)
FSIMS	Flight Standard Information Management System (FAA)
FSR	full scale range (viscometry)
FWP	flight working paper
g	gravitational constant
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 RDP	G-12 Runway Deicing Product Committee (SAE)
G-12 RWG	G-12 Rotorcraft Ground Deicing Working Group (SAE)
G-12 Steering	G-12 Steering Group (SAE)
G-12 T	G-12 Training and Quality Control Committee (SAE)
GAC	glycerine acetate
GID	ground ice detector
GIDS	ground ice detection system
GIP	Ground Icing Program (Transport Canada)
GM	Guidance Material (EASA)
GMP	glycol management plan
GOFRS	General Operating and Flight Rules Standards (Transport Canada)
GosNII GA	State Institute of Civil Aviation (Russia)
GPU	ground power unit
GRV	glycol recovery vehicle
GTAA	Greater Toronto Airport Authority
GUI	graphical user interface
h	hour
HHET	high humidity endurance test
HOT	holdover time
HOTDR	holdover time determination report
HOTDS	holdover time determination system
HOUC	highest operational use concentration
HOUR	highest operational use refraction
HOWV	highest on-wing viscosity
HP	pressure altitude

HQ	Headquarters (FAA)
HRDC	Human Resources Department Canada
HSR	high speed ramp
HUPR	highest usable precipitation rate
IAC	Interstate Aviation Committee
IBC	intermediate bulk container (aka tote)
ICA	Instructions for Continued Airworthiness (FAA)
ICAO	International Civil Aviation Organization
i.e.	*id est* (that is)
in fine	at the end
in limine	at the beginning
ISO	International Organization for Standardization
ITT	interstage turbine temperature
JAA	Joint Aviation Authorities (European Union)
JAR	Joint Aviation Requirements (European Union)
JCAB	Japan Civil Aviation Bureau
KAC	potassium acetate
KCAS	knots calibrated airspeed
KFOR	potassium formate
KIAS	knots indicated airspeed
k_s	sand grain roughness
kts	knots
l-	*levo* (rotatory); the opposite of *d*-
L	liter(s)
LAAT	lowest acceptable aerodynamic temperature
LOUT	lowest operational use temperature
LOWV	lowest on-wing viscosity
LSR	low-speed ramp
LUPR	lowest usable precipitation rate
LV	low viscosity (viscometry)
LWE	liquid water equivalent
LWES	liquid water equivalent system
MAC	mean aerodynamic chord
MANOBS	Manual of Surface Weather Observations (Environment Canada)
MARPS	Minimum Assurance Requirements and Performance Specifications (Transport Canada)
METAR	meteorological terminal aviation routine weather report or meteorological terminal air report
METREP	meteorological report
MLIT	Ministry of Land, Infrastructure, Transportation and Tourism (Japan)
MOC	means of compliance (EASA)
mol wt	molecular weight
MOPS	minimum operational performance specification

MOWV	maximum on-wing viscosity[3]
MSDS	material safety data sheet[4]
MSR	middle speed ramp
NAA	national aviation authorities
NAAC	sodium acetate
NAE	National Aeronautical Establishment
NAFO	sodium formate
NASA IRT	NASA Icing Research Tunnel, Glenn Research Center, Cleveland OH
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCG	non-conventional glycol
NDT	non-destructive testing
NG	non-glycol
no.	number (plural nos.)
NOTAM	notice to airmen
NS2D	2-dimensional Navier-Stokes CFS Code
NTO	no technical objection
NTSB	National Transportation Safety Board (U.S.)
NWS	National Weather Service (U.S.)
OACI	Organisation de l'aviation civile internationale (ICAO)
OAT	outside air temperature or outdoor ambient temperature
OEI	one engine inoperative
OEM	original equipment manufacturer
OFA	object free area
OFZ	obstacle free zone
OOS	out-of-service
OSH	occupational safety and health
p	page (plural pp)
Pa	Pascal
PA	performance assessments (FAA)
PANS	Procedure for Air Navigation Services (ICAO)
par	paragraph
PG	propylene glycol
pH	acid base scale; log of the reciprocal of the hydrogen ion concentration
PI	principal inspector (FAA)
PIB	product information bulletin
PIC	pilot-in-command
PNF	pilot not flying
POI	Principal Operations Inspector (FAA and Transport Canada)
POTW	Publicly Owned Treatment Works (U.S.)
PPE	personal protective equipment
PRI	Performance Review Institute

[3] 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 be thought of as minimum on-wing viscosity.
[4] The preferred expression is now safety data sheet (SDS).

PTO	power takeoff (for deicing units)
PTOCC	pretakeoff contamination check (FAA)
PTCOI	pretakeoff contamination inspection (Transport Canada)
PTRS	program tracking and reporting subsystem (FAA)
Q&A	question and answer (plural Q&As)
QA	quality assurance
QAP	quality assurance program
QC	quality control
QMS	quality management system
R&D	research and development
RDF	runway deicing fluid
RDIMS	records, documents, and information management system (Canada)
RDP	runway deicing product
RH	relative humidity
RI	refractive index
RMK	remark
RMSE	root mean square error
RMT	rule-making task (EASA)
ROGIDS	remote on-ground ice detection systems
RPZ	runway protection zone
RSA	runway safety area
RVR	runway visibility range
s	second(s)
s	section (plural ss)
SAE	Society of Automotive Engineers
SAIB	Special Airworthiness Information Bulletin (FAA)
SARPs	Standard and Recommended Practices (ICAO)
SAS	Safety Assurance System (FAA)
SCOUIC	Standing Committee on Operations Under Icing Conditions (Transport Canada)
SD	Safety Directive (EASA)
SDS	safety data sheet
SHRP	Strategic Highway Research Program (U.S.)
SI	Le système international d’unités – The International System of Units
SIAGDP	Standardized International Aircraft Ground Deicing Program (U.S.)
SIB	Safety Information Bulletin (EASA)
sic	*sic erat scriptum* (thus was it written)
SIGMET	significant meteorological information
SLD	supercooled large droplets
SM	statute mile
SMI	Scientific Materials International
SMS	safety management system
SNOWTAM	snow warning to airmen
SOP	standard operation procedure or standard operating procedure
SOR	Statutory Orders and Regulations (Canada)
SP	service provider

SPECI	aviation special weather report
SRM	safety risk management
SSA	small sample adapter (viscometry)
STP	standard teaching plan
sub verbo	under the word (plural *sub verbis*)
SWAMP	severe wind and moisture prone
TAF	terminal aerodrome forecast
TAT	total air temperature
TC	Transport Canada
TCCA	Transport Canada Civil Aviation
TDC	Transportation Development Centre (Transport Canada)
TEM	threat and error management
TOD	total oxygen demand
TODR	takeoff distance required
TP	teaching plan
TP	Transport Canada publication
TSA	taxi safety area
TSS	total suspended solids
Type I	SAE AMS1424 Type I Aircraft Deicing/Anti-Icing Fluid
Type II	SAE AMS1428 Type II Aircraft Deicing/Anti-Icing Fluid
Type III	SAE AMS1428 Type III Aircraft Deicing/Anti-Icing Fluid
Type IV	SAE AMS1428 Type IV Aircraft Deicing/Anti-Icing Fluid
UF	upper fuselage
ULA	ultra-low adapter (viscometry)
UQAC	Université du Québec à Chicoutimi
U.S. or US	United States of America
USC	United States Code of Federal Regulations
UST	underground storage tank
UV	ultraviolet
v	*versus*
V_1	takeoff decision speed
V_2	takeoff safety speed
VCS	very cold snow
V_{lof}	lift-off speed
V_{mc}	minimum control speed
V_{mu}	minimum unstick speed
VOR	very high frequency omni range
V_r	rotation speed
V_S	start up velocity
V_{S1g}	1-g stall speed
VSR	vehicle service road
VSZ	vehicle safety zone
VTP	vertical tail plane
VVFCS	very very cold snow
WG	Working Group (SAE)
WHMIS	Workplace Hazardous Materials Information System (Canada)

WMO	World Meteorological Organization
WSDMM	weather support to deicing decision making
WSET	water spray endurance test

Aircraft Deicing Fluid Manufacturers

Abbreviated name	Name
ABAX	ABAX Industries
ADDCON	ADDCON EUROPE Gmbh
ALAB	ALAB Industries
AllClear	AllClear Systems
ARCO	ARCO Chemical Co. [acquired by Lyondell Chemical Co. in 1998]
Arcton	Arcton Ltd.
ASG	ASG LLC [renamed ASGlobal in 2021]
ASGlobal	ASG Global Aviation Chemicals Ltd
AVIAFLUID	AVIAFLUID International Ltd.
Aviation Shaanxi	Aviation Shaanxi Hi-Tech Physical Chemical Co. Ltd.
Aviation Xi'an	Aviation Xi'an High-Tech Physical Co. Ltd.
BASF	BASF AG
Baltic	Baltic Ground Services
Battelle	Battelle Memorial Institute
Beijing C.J.	Beijing C.J. Aviation Chemical Co. Ltd.
Beijing Phoenix	Beijing Phoenix Air Traffic Product Development and Trading Co.
Beijing Wangye	Beijing Wangye Aviation Chemical Product Co.
Beijing Yadilite	Beijing Yadilite Aviation Chemical Product Co. Ltd.
Boryszew	Boryszew S.A.
Chemco	Chemco Inc.
Chemical Specialists	Chemical Specialists Development Inc.
Clariant	Clariant Produkte (Deutschland) GmbH
Cryotech	Cryotech Deicing Technology
Deicing Solutions	Deicing Solutions, LLC (HOC Industries)
Delta Petroleum	Delta Rocky Mountain Petroleum
DR Energy	DR Energy Group Ltd.
Dow	The Dow Chemical Company
Ely Chemical	Ely Chemical Co. Ltd.
Gansu	Gansu Xiexin Huineng Science and Technology Development Co., Ltd.
Harbin	Harbin Aeroclean Aviation Tech Co. Ltd. [now Heilongjiang Hangjie Aero-chemical Technology Co. Ltd.]
HOC	HOC Industries
Heilongjiang	Heilongjiang Hangjie Aero-chemical Technology
Hoechst	Hoechst AG [acquired by Clariant Produkte (Deutschland) GmbH in 1997]
Hokkaido	Hokkaido NOF Corporation
Home Oil	Home Oil [HOC Industries; Deicing Solutions LLC)]
Inland	Inland Technologies Ltd. or Inland Technologies Canada Inc.
Jarchem	Jarchem Industries Ltd.
JSC	JSC RCP Nordix [formerly Oksayd Co. Ltd.]
Kilfrost	Kilfrost Limited
LNT	LNT Solutions Ltd.

Lyondell	Lyondell Chemical Company
Metss	Metss Corp.
Newave	Newave Aerochemical Co. Ltd.
Octagon	Octagon Process Inc. [acquired by Clariant Produkte (Deutschland) GmbH in 2011]
Oksayd	Oksayd Co. Ltd. [now JSC RCP Nordix]
Oslo Airport	Oslo Airport
Romchim	Romchim Protect SRL
Sanshin	Sanshin Kagaku Kogyo Co.
Shaanxi	Shaanxi Cleanway Aviation Chemical Co. Lt.
SPCA	SPCA Ltd. [renamed ABAX Industries in 2008]
Union Carbide	Union Carbide Corporation [acquired by Dow in 1999] or Union Carbide Canada Ltd.
Velvana	Velvana a.s.
Viterbo	Viterbo S.A.
Xinjiang	Xinjiang Zhongtian

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. Accidents occur when there is a) undetected contamination, b) detected contamination but ignored, c) undetected contamination after deicing, d) fluid failure after deicing, e) engine icing after deicing (very costly), f) improper procedures and g) systemic errors. "Improper procedures" is a catch all category encompassing, for example, miscommunications. For instance, if strict communication protocols between flightcrew and groundcrew are not implemented, an aircraft can start to taxi with its perimeter not clear resulting in collision with deicing vehicles. This appears innocuous, but fatalities have occurred upon collision between aircraft and deicing vehicles. Below is short description of selected 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.[5]

[5] United States, National Transportation Safety Board, *Aircraft Accident Report: Air Florida Inc., Boeing 737-222, N62AF, Collision with 14th Street Bridge, Near Washington National Airport, Washington D.C., January 13, 1982* (Washington DC: Government of the United States, 10 August 1982) Report NTSB AAR-82-8 at p 82, http://libraryonline.erau.edu/online-full-text/ntsb/aircraft-accident-reports/AAR82-08.pdf. [*Air Florida*]

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.[6]

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.[7] 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.

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.[8] 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.[9] 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:

> That Transport Canada actively participate in the research and development necessary to establish safety effectiveness measurement systems that will lead to the most efficient use of resources in assuring safety. Cooperation with the United

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[6] *Ibid* at p 83.
[7] *Ibid* at p 84.
[8] The Honorable Virgil P. Moshansky, *Commission of Inquiry into the Air Ontario Crash at Dryden, Ontario: Final Report* (Ottawa: Minister of Supply and Services of Canada, 1992), http://lessonslearned.faa.gov/ll_main.cfm?TabID=1&LLID=31&LLTypeID=3. [*Dryden*]
[9] The Honorable Virgil P. Moshansky & Donald L. Van Dyke, *The Role of the Judiciary in Aviation Safety: The Inside Story and Legacy of Dryden*, (Montreal: Royal Aeronautical Society, Montreal Branch Lecture, presented at ICAO, 16 October 2007), http://www.system-safety.org/chapters/sites/canada/meetings/presentations/RAeSLecture_JudicialRolesE.pdf.

> States Federal Aviation Administration and other international groups should be encouraged and resourced to obtain the maximum and most expedient benefits from such programs.[10]

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 aircraft 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.

West Wind Flight 282, Fond-du-Lac, Saskatchewan. On December 13, 2017, West Wind ATR 42 encountered icing upon descent. The aircraft was contaminated. Before takeoff, one of the pilots advised the other pilot that the aircraft had residual ice. No deicing was done. It took-off from Fond-du-Lac Airport and collided with trees 1400 feet from departure. One death. Ten serious injuries. A letter[11] from the Transportation Safety Board of Canada to the Minister of Transport

[10] *Dryden*, *supra* note 8 Vol. III at 1235.
[11] Letter from Kathleen Fox, Chair of the TSB of Canada to The Honorable Marc Garneau, Minister of Transport, December 14, 2018, http://www.tsb.gc.ca/eng/recommandations-recommendations/aviation/2018/rec-a1802-a1803.asp.

explains that even though deicing equipment was available at Fond-du-Lac, the deicing equipment was inadequate to effectively deicing an aircraft the size of an ATR-42. The letter recommends, *inter alia*, to identify locations with inadequate deicing/anti-icing equipment and take corrective action at Canadian northern remote airports. The final report issued on October 28, 2021.[12] It is well worth reading.

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 engines were running. The flightcrew heard "*dégivrage terminé*" (deicing completed). The message was not intended for the flightcrew but for the deicing coordinator. The pilot attempted to communicate with the deicing crew without success. The Transportation Safety Board of Canada[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

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[12] Transportation Safety Board of Canada, *Air Transportation Safety Investigation Report A17C0146* (Gatineau, QC: Transportation Safety Board of Canada, 28 October 2021), http://www.tsb.gc.ca/eng/rapports-reports/aviation/2017/a17c0146/a17c0146.pdf.

[13] Transportation Safety Board of Canada, *Aviation Occurrence Report, Collision with Vehicle, Royal Air Maroc Boeing 747-400 CN-RGA, Montreal (Mirabel) International Airport, Quebec, 21 January 1995*, Report Number A95Q0015, http://www.bst-tsb.gc.ca/eng/rapports-reports/aviation/1995/a95q0015/a95q0015.asp.

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 groundcrew 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, almost overturning the deicing units. No one was injured. The German Federal Bureau of Aircraft Accident Investigation (BFU)[14] called it a serious accident.

Aeroflot flight SU158 Airbus 350-900 had a collision with a deicing unit at Sheremetyevo on December 16, 2021. The deicing unit driver was admitted to hospital with internal injuries.[15]

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)[16], Transport Canada (TC)[17], the Civil Aviation Administration of China (CAAC), the Japan Civil Aviation Bureau (JCAB) or supra national authorities such as the European Aviation Safety Agency (EASA).[18]

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[14] Jens Friedemann, Hans W. Hempelmann and Norman Kretschmer, *Investigation Report BFU16-0055-EX*, (Braunschweig: Bundsstelle für Flugunfalluntersuchung (BFU), 4 December 2017), https://www.bfu-web.de/EN/Publications/Investigation%20Report/2016/Report_16-0055-EX_A320_MUC_DeIcing.html.

[15] https://www.airlive.net/incident-an-a350-900-collided-with-a-de-icing-truck-at-moscow-sheremetyevo-airport/.

[16] 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.", https://www.gpo.gov/fdsys/pkg/CFR-2007-title14-vol2/xml/CFR-2007-title14-vol2-sec121-629.xml.

[17] Canadian Aviation Regulations SOR/96-433, s. 602.11 (2) "No person shall conduct or attempt to conduct a take-off in an aircraft that has frost, ice or snow adhering to any of its critical surfaces", http://laws-lois.justice.gc.ca/eng/regulations/SOR-96-433/section-602.11-20140529.html.

[18] EASA CAT.OP.MPA.250 Ice and other contaminants — ground procedures

(a) 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.

Guidance and advisory material. The regulations prohibiting takeoff with frozen contamination require guidance material for compliance. Guidance and advisory material are issued by the regulators (e.g., EASA, FAA, Transport Canada), ICAO[19], IATA, IAC[20] and aircraft manufacturers such as Boeing[21] and Airbus.[22]

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 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.

(b) 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, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:296:0001:0148:EN:PDF.

[19] *ICAO Manual of Aircraft Ground De-icing/Anti-icing Operations (Doc 9640)*, 2nd ed (Montreal: ICAO, 2000).

[20] E. Petrov et al., *Methodical Recommendations: Airplane Protection from Icing Up on the Ground, Revision 3* (Moscow: IAC, September 2017), http://mak-iac.org/upload/iblock/cd3/Methodical%20Recommendations%20Rev.3%202017.pdf.

[21] Haruiko Oda et al., “Safe Winter Operations”, (2010) Q4 Boeing Aeromagazine 6, http://www.boeing.com/commercial/aeromagazine/articles/2010_q4/pdfs/AERO_2010_Q4.pdf .

[22] *Coming to Grips with Cold Weather Operations*, AI/SR 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.

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)[23], 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 Product Committee (G-12 RDP) and 10) various *ad hoc* workgroups reporting to the Committees, such as the Aerodynamics Workgroup (G-12 AWG), the Carbon Brake Oxidation Workgroup, etc. A Rotorcraft Ground Deicing Working Group (G-12 RWG) 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 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[24]) 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

[23] 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.
[24] The Association of European Airlines (AEA) ceased its operations in December 2016. The ex-AEA deicing working group continues its work under the auspices of the Airlines for Europe (A4E).

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 must 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 the Global Aircraft Deicing Standards.[25] At its first meeting in Montreal, on November 10, 2011, ICAO became a sponsor of the Council and 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/groundcrew communications, 2) training and 3) quality assurance.

Table 1 lists cancelled standards and corresponding new global deicing standards.

[25] "SAE ICAO IATA Council for the Global Deicing Standards: Charter and Terms of Reference", https://www.sae.org/servlets/works/committeeHome.do?comtID=TEAG12.

Table 1 Correspondence of Obsolete SAE Standards and Global Aircraft Deicing Standards

Obsolete SAE Standards	Global Aircraft Deicing Standards
ARP4737H Aircraft Deicing/Anti-Icing Methods (cancelled August 2, 2017)	AS6285D Aircraft Ground Deicing/Anti-Icing Processes (revised May 2021, effective August 2021) ARP6257 Flight and Groundcrew De/Anti-icing Phraseology (issued Oct. 2016)
ARP5149C Training Program Guidelines for Deicing/Anti-Icing of Aircraft on Ground (cancelled June 19, 2019)	AS6286B Training and Qualification Program for Deicing/Anti-Icing of Aircraft on the Ground (revised June 2020)
ARP5646A Quality Program Guidelines for Deicing/Anti-Icing of Aircraft on the Ground (cancelled June 19, 2019)	AS6332A Aircraft Ground Deicing/anti-icing Quality Management (revised July 2021)

Research Reports. APS Aviation has prepared over 180 reports[26] related to aircraft ground deicing for Transport Canada and the FAA. These reports are not indexed in this *Guide to Aircraft Ground Deicing*.

Documentation Notification Services. The FAA and Transport Canada offer free email notification services upon publication of aircraft deicing documentation.

FAA: https://public.govdelivery.com/accounts/USAFAA/subscriber/new?topic_id=USAFAA_459

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 Rhonda Joseph at rhonda.joseph@sae.org or Jacques Leroux at jleroux@dow.com.

[26] https://www.rheagroup.com/insights/reports/?sort_order=date+desc.

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 in this *Guide* under the heading "Preferred Words and Expressions".

PART ONE: THE AIRCRAFT DEICING DOCUMENTS

Figure 1 (p 337) provides a visual representation on how the aircraft deicing documents relate to each 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 August 12, 2013, and reaffirmed April 2, 2019, by SAE G-12 ADF.

Sponsor: Marco Ruggi.

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.

Keywords

advancing contact angle. *See* contact angle, advancing
Airbus AIMS 09-00-002, s 5
aircraft coating. *See* aircraft surface coating
aircraft surface coating – after-market, s Foreword at p 1
aircraft surface coating – AMS3090 weathering, s 5.1.2
aircraft surface coating – comparative endurance time test, s 3
aircraft surface coating – compatibility with aircraft surfaces, ss 5.1, 5.1.1, 5.1.2
aircraft surface coating – compatibility with cleaners, s 5.1.1
aircraft surface coating – compatibility with polishes, s 5.1.1
aircraft surface coating – compatibility with waxes, s 5.1.1

wetting test, Type I, s 3.4

ARP6852C Methods and Processes for Evaluation of Aerodynamic Effects of SAE-Qualified Aircraft Ground Deicing/Anti-Icing Fluids

Revised October 24, 2018, by SAE G-12 AWG and SAE G-12 ADF.

Sponsor: Paulo Santos.

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 is no worse than an established accepted standard; this aerodynamic acceptance test is described in detail in AS5900. Even with successful aerodynamic acceptance qualification, there can be circumstances which require the evaluation of the aerodynamic effect of fluids on specific aircraft. ARP6852 does provide guidance for such aircraft specific evaluation.

ARP6852, 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.

ARP6852 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 AS5900. ARP6852 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.

Keywords
aerodynamic acceptance test – Boeing history, s 3.4, Appendix A
aerodynamic acceptance test – Bombardier (de Havilland) history, Appendix B
aerodynamic acceptance test – development by Boeing, s 3.4, Appendix A
aerodynamic acceptance test – development by de Havilland, Appendix B
aerodynamic acceptance test – general description, s 3.3.2
aerodynamic acceptance test – high and low speed ramp on Type I and Type III, s 3.3.2
aerodynamic acceptance test – high speed ramp – description, s 3.3.2

[27] ARP6852C 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…” (s 4.4.3.2.2) or “[c]urrent data suggests that the fluid transient behavior…” (s 3.2.1). Here we index under “transient”.

AS5900E Standard Test Method for Aerodynamic Acceptance of AMS1424 and AMS1428 Aircraft Deicing/Anti-Icing Fluids

Revised August 19, 2021, by SAE G-12 ADF.

Sponsor: Éric Villeneuve.

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. AS5900 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.

Three aerodynamic acceptance tests are thus defined:

1- The *high speed test* simulates the takeoff of large transport jet aircraft[28] with speeds[29] at rotation exceeding approximately 100 knots and with time[30] 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 2.6 m/s^2.

2- The *middle speed test* simulates the takeoff of large commuter turbo-prop aircraft[31] with speeds at rotation between 80 and 100 knots and with a time from brake release to rotation between 16 and 20 s. The takeoff is simulated using a *middle speed ramp* where the test is performed at 46 m/s (90 knots) and an 18 s acceleration at 2.6 m/s^2.

3- The *low speed test* simulates the takeoff of commuter turbo-prop aircraft[32] 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/s^2.

In this AS5900E, the most significant changes are: 1) the addition of a middle speed ramp for large turbo-prop aircraft, 2) a detailed justification in Appendix C for the middle speed ramp, 3) interpolation is used to measure the lowest acceptable temperature (LAAT) for Type I when LAAT are below -38°C for improved reproducibility and accuracy and 4) replacement of the percent elimination requirement by a final thickness requirement for AMS1428 fluids.

Keywords

[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 large turbo-prop aircraft are colloquially known as middle speed aircraft.
[32] Commuter turbo-prop aircraft are colloquially known as low speed aircraft.

[33] 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.

AS5901D Water Spray and High Humidity Endurance Test Methods for SAE AMS1424 and SAE AMS1428 Aircraft Deicing/Anti-Icing Fluids

Revised September 4, 2019, by SAE G-12 ADF.

Sponsor: Marc-Mario Tremblay.

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. AS5901D 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.

Keywords

AMS1424R Fluid, Aircraft Deicing/Anti-Icing, SAE Type I

Revised November 18, 2020, by SAE G-12 ADF.

Sponsors: Jim Greaney; Melissa Copeland for the next version.

AMS1424[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.

AMS1424 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

[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 AMS1424R 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. AS6285D compatibility requirement is set in section 8.7.2. FAA Notice N 8900.594 at s 14.e.(2) tells operators to make sure the Type I and Type IV are compatible by contacting the respective fluid manufacturers.

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.

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, AMS1424, and two category specifications AMS1424/1 and AMS1424/2.

This revision of SAE AMS1424 (AMS1424R) provides clarification for the fluid initial qualification and for requalification expiration dates.

Keywords
1,3-propanediol. *See* glycol, non-conventional – 1,3-propanediol
aerodynamic acceptance test – Type I requirements, s 3.5.3
aircraft manufacturer documentation – fluid restrictions for aircraft type and model, s 1.2.1
alkali organic 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
commingling. *See* Type I – commingling; Type II/III/IV – commingling; fluid manufacturer documentation – fluid commingling
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

[35] 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.

[36] AMS1424 refers to initial thickness and final thickness of the fluid in the aerodynamic acceptance test. AMS1428 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.

[37] 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.

[38] AMS1424R 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

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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 – 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 laboratories[39], ss 4.1, 4.2.3, 4.5
Type I – testing, user approved, s 4.2.3
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 – transportation, s 5.1.5
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, ss 1.1.1, 3.1.1, 3.1.2.1
Type II/III/IV – compatibility with Type I, s 1.3.6, footnote 34
WSET – Type I – 3 minutes minimum, s 3.5.2

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

Issued April 18, 2016, by SAE G-12 ADF.

Sponsor: Alun Williams.

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 AMS1424.

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

[39] AMS1424R 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.

glycol, non-conventional, s 1.1.1
specification, category, s 1.1.1
specification, foundation, s 1.1.1
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
Type I – specification – AMS1424/1, Title at p 1

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

Issued May 5, 2016, by SAE G-12 ADF.

Sponsor: Alun Williams.

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 AMS1424.

Keywords
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
Type I – non-glycol based, Title at p 1, s 1.1.1
Type I – specification – AMS1424/2, Title at p 1

AMS1428K Fluid, Aircraft Deicing/Anti-Icing, Non-Newtonian (Pseudoplastic), SAE Types II, III, and IV

Revised October 24, 2018, by SAE G-12 ADF.

Sponsor: Alex Meyers.

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 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/III/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, AMS1428K, and two category specifications AMS1424/1 and AMS1424/2.

Holdover Time Guidelines. SAE Type II, III and IV fluids 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/III/IV, it should be noted that it is insufficient to meet all the requirements of AMS1428K 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

[40] Anti-icing performance, as defined in AMS1428 (latest version), is comprised of WSET and HHET.
[41] 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.
[42] The successive dry-out and rehydration test is sometimes referred to as the Buehler test after Mr. Rolf Buehler who developed it.
[43] *See* footnote 3.

[44] Thickened fluid is a generic term for Type II/III/IV fluids as all these fluids contain thickeners.

[45] Both the FAA and Transport Canada issue a list of fluids. If a document refers to both, it is indexed as “fluid list (FAA/TC)”. If the document refers to only one list, it will be indexed as “fluid list (FAA)” or “fluid list (TC)”, as the case may be.

[46] 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).
[47] *See* footnote 3
[48] 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 fluid list published in their holdover time guidelines.
[49] Several sections refer to preproduction samples or tests. 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.

[50] 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).

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

Issued February 14, 2017, by SAE G-12 ADF.

Sponsor Alun Williams.

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 AMS1428K, which is defined as the base specification.

Keywords
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 – glycol (conventional and non-conventional) based fluid, Title at p 1, s 1.1.1
Type II/III/IV – glycol (conventional) based, s 1.1.1
Type II/III/IV – glycol (non-conventional) based, s 1.1.1
Type II/III/IV – purchase documents, ss 2, 9.2
Type II/III/IV – specification – AMS1428/1, Title at p 1

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

Issued February 9, 2017, by SAE G-12 ADF.

Sponsor: Alun Williams.

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 AMS1428, which is called the base specification.

Keywords
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 – glycol (conventional and non-conventional) based, Title at p 1, s 1.1.1
Type II/III/IV – glycol (conventional) based, s 1.1.1
Type II/III/IV – glycol (non-conventional) based, s 1.1.1
Type II/III/IV – purchase documents, ss 2, 9.2
Type II/III/IV – specification – AMS1428/2, Title at p 1

AS9968A Laboratory Viscosity Measurement of Thickened Aircraft Deicing/Anti-Icing Fluids with a Viscometer

Issued July 23, 2021, by SAE G-12 ADF.

Sponsor: Kevin Connor; for the next version, the sponsor is undetermined at this time.

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.

Prior to AS9968A, fluid manufacturers published alternate methods to AS9968 for fluids. AS9968A now allows for a measurement of viscosity with different spindles, temperatures other than 20°C and rotational speeds other than 0.3 rpm which were prescribed in the first issue of AS9968.

This revised standard calls for an accurate reporting of all the conditions of viscosity measurement: sample volume, spindle number, sample temperature, rotational speed, measurement duration, and the type of viscometer used. By specifying all the measurement parameters, fluid manufacturers can now refer to AS9968A for the viscosity method.

The expanded scope of this revision allows for AMS1428 viscosity conformance testing as well as for quality assurance purposes. To compare viscosities, exactly the same measurement elements must have been used to obtain those viscosities.

It is also possible to use a viscometer other than the Brookfield LV as long as equivalency is established.

A section (Appendix A) provides information on the effect of test parameters on accuracy and precision of the viscosity measurements.

Keywords
ASTM D2196 – analogous to AS9968, s 3
ASTM E3116 – analogous to AS9968, s 3
Type II/III/IV – viscosity measurement, Title at p 1
viscometer, Anton Paar, s 7
viscometer, Brookfield LV, Rationale at p 1, ss 1, 4.2, 4.5, 4.6, 7
viscometer. *See also* Type II/III/IV – viscosity measurement
viscosities – comparison of, s 1
viscosity measurement – accuracy, s 1, Appendix 1
viscosity measurement – air bubble removal by centrifugation ss 4.1, 6.1
viscosity measurement – calibration and checks, ss 5.1–5.2, 5.4
viscosity measurement – effect of sample chamber geometry, s 1
viscosity measurement – measurement duration, s 4.7
viscosity measurement – precision, s 1, Appendix 1
viscosity measurement – rotational speed, s 4.4
viscosity measurement – sample at 0°C precautions, s 6.2
viscosity measurement – sample homogeneous, s 6.1
viscosity measurement – sample loading, s 6.2
viscosity measurement – sample no lumps, s 6.1
viscosity measurement – sample no pipetting, s 6.2
viscosity measurement – sample no stratification, s 6.1
viscosity measurement – sample no syringing, s 6.2
viscosity measurement – sample shearing, s 6.2
viscosity measurement – sample substantially free of air bubbles, ss 6.1–6.2
viscosity measurement – sample volume, ss 4.6, Appendix A at par 2
viscosity measurement – spindle insertion, s 6.2
viscosity measurement – spindle selection, s 4.5, Appendix A at par 3
viscosity measurement – spindles, ss 4.5, 6.2, 7
viscosity measurement – temperature check, s 5.3
viscosity measurement – temperature control, s 4.3, Appendix A at par 1
viscosity measurement – viscosity standard, ss 4.8, 5.4
viscosity measurement report – AS9968, use of, s 7
viscosity measurement report – measurement duration, s 7
viscosity measurement report – presentation of results, s 7
viscosity measurement report – rotational speed, s 7
viscosity measurement report – sample temperature, s 7
viscosity measurement report – sample volume, s 7
viscosity measurement report – spindle number, s 7

AIR5704 Field Viscosity Test for Thickened Aircraft Anti-Icing Fluids

Reaffirmed September 6, 2016, 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 refraction, pH, appearance or other tests as may be recommended by the fluid manufacturer.

This field viscosity test is not suitable for all Type II/III/IV.

Keywords

Documents Issued by the SAE G-12 Holdover Time Committee

ARP6207 Qualification Required for SAE Type I Aircraft Deicing/Anti-Icing Fluids

Issued October 10, 2017, by SAE G-12 HOT.

Sponsor: Marco Ruggi.

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 Type I holdover times, and iii) to be listed on the FAA and Transport Canada list of fluids.

Meeting all the technical requirements of AMS1424 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 fluid list and 3) have a performance such that it can be used with the 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 Type I holdover time guidelines, e) explains the process for inclusion and exclusion of fluids on the FAA/Transport Canada fluid lists, 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 ARP5718 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 – effect on Type II/III/IV protection time, s 3.2
alkali organic salt based Type I – exclusion from the fluid list (FAA/TC), s 3.2
alkali organic salt based Type I – HOT – invalid, s 3.2

ARP5945A Endurance Time Tests for SAE Type I Aircraft Deicing/Anti-Icing Fluids

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

Sponsors: Stephanie Bendickson; Ben Bernier for the next version.

ARP5945 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, ARP5945 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)

[51] 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 ARP5945.

Its sister document for AMS1428 Type II/III/IV fluids is ARP5485 whose title is *Endurance Time Test Procedures for SAE Type II/III/IV Aircraft Deicing/Anti-Icing Fluids*.

Keywords

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

Revised December 7, 2017, by SAE G-12 HOT.

Sponsors: Stephanie Bendickson; Ben Bernier for the next version.

In its version B, this 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 ARP5718 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 fluid list.

Meeting all 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 the fluid list 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 fluid lists, f) describes the role of the SAE G-12 ADF and HOT

Committees and g) explain 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 – precipitation – ice pellets and small hail, s 5.1.1f
allowance time – sample selection – Type II/III/IV, s 3.4.3
allowance time – wind tunnel testing, ss 3.4.1, 3.4.2, 3.4.3
allowance time. *See also* wind tunnel testing
AMIL gel residue tables[52], s 3.2.3
AMIL residue tables. *See* AMIL gel residue tables
AMS1428 – purpose – minimum requirements for Type II/III/IV fluids, s 3.2.1
AMS1428/1 – purpose – identity of freezing point depressant, s 3.2.1
AMS1428/2 – purpose – 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, 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/TC list of fluids. *See* definition – fluid list (FAA/TC)
definition – fluid list (FAA/TC), s 2.3
definition – highest useable precipitation rate. *See* definition – HUPR
definition – HOT guideline, fluid-specific, s 2.3
definition – HOT guideline, generic, ss 2.3, 5.8
definition – HOT guideline, s 2.3
definition – HOT table. *See* definition – HOT guideline
definition – HOT, s 2.3
definition – HUPR, 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
definition – precipitation rate, lowest useable. *See* definition – LUPR

[52] AMIL, "Anti-icing Fluids Gel Residue Testing Results", 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.

[53] 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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[54] 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).
[55] Field spray trial (p 1) and field spray test (s 4.1) appear to be used interchangeably in ARP5718B.

ARP5485B Endurance Time Test Procedures for SAE Type II/III/IV Aircraft Deicing/Anti-Icing Fluids

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

Sponsors: Stephanie Bendickson; Ben Bernier for the next issue.

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[57] or 3) indoors with artificial snow made as the test is being performed[58]. 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

[56] *See* footnote 3.
[57] The collected snow process and subsequent distribution method were developed at AMIL.
[58] The instantaneous shaving core snowmaker method was developed at NCAR and extensively used by APS Aviation.

temperature/snow precipitation rate combinations may not be tested during a given winter; indoor tests are performed under controlled conditions.

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*.

Keywords
contamination [frozen] – appearance – frost on treated surface, s 4.7.2
contamination [frozen] – appearance – ice crystals, disseminated, s 4.7.2
contamination [frozen] – appearance – ice front, s 4.7.2
contamination [frozen] – appearance – ice pieces imbedded in fluid, s 4.7.2
contamination [frozen] – appearance – ice pieces partially imbedded in fluid, s 4.7.2
contamination [frozen] – appearance – ice sheet, s 4.7.2
contamination [frozen] – appearance – slush front, s 4.7.2
contamination [frozen] – appearance – slush in clusters, s 4.7.2
contamination [frozen] – appearance – snow bridges, s 4.7.2
crystallization, delayed, s 4.7.3
definition – endurance time, Foreword at p 1
endurance time – definition, Foreword at p 1
endurance time tests – Type II/III/IV – crystallization, delayed, s 4.7.3
endurance time tests – Type II/III/IV – data examination by SAE G-12 HOT, Foreword at p 1, ss 1.1, 1.2
endurance time tests – Type II/III/IV – data validation by SAE G-12 HOT, Foreword at p 1, ss 1.1, 1.2
endurance time tests – Type II/III/IV – facility – independence from fluid manufacturer, s 1.5.1
endurance time tests – Type II/III/IV – facility, s 1.5
endurance time tests – Type II/III/IV – failure mode – visual, Foreword at p 1
endurance time tests – Type II/III/IV – failure mode, snow – dilution, s 10.4.6
endurance time tests – Type II/III/IV – failure mode, snow – snow-bridging, s 10.4.6
endurance time tests – Type II/III/IV – failure, frozen contamination – 30% area, s 4.7.2
endurance time tests – Type II/III/IV – failure, frozen contamination – appearance, s 4.7.2
endurance time tests – Type II/III/IV – failure, snow – 30% area or non-absorption over 5 crosshairs, s 10.4.6
endurance time tests – Type II/III/IV – fluid manufacturer documentation – freezing point data, s 3.2.5c
endurance time tests – Type II/III/IV – fluid manufacturer documentation – color, s 3.2.5a
endurance time tests – Type II/III/IV – fluid manufacturer documentation – refraction data, s 3.2.5a
endurance time tests – Type II/III/IV – fluid manufacturer documentation – safety data sheet, s 3.2.5c
endurance time tests – Type II/III/IV – fluid manufacturer documentation – viscosity, 3.2.5b
endurance time tests – Type II/III/IV – fluid manufacturer documentation – viscosity method, 3.2.5b
endurance time tests – Type II/III/IV – fluid manufacturer documentation – freezing point depressant, s 3.2.5c
endurance time tests – Type II/III/IV – fluid manufacturer documentation – test name, s 3.2.5a
endurance time tests – Type II/III/IV – fluid manufacturer documentation – dilutions to be tested, s 3.2.5c
endurance time tests – Type II/III/IV – freezing drizzle, s 7
endurance time tests – Type II/III/IV – freezing fog, s 6
endurance time tests – Type II/III/IV – frost, laboratory, s 5
endurance time tests – Type II/III/IV – frost, natural, s 12
endurance time tests – Type II/III/IV – ice crystal seeding, s 4.7.3
endurance time tests – Type II/III/IV – icing intensity measurements, s 4.6.2
endurance time tests – Type II/III/IV – icing intensity measurements by regression analysis, s 4.6.2.2
endurance time tests – Type II/III/IV – icing intensity measurements with reference ice-catch plates, s 4.6.2.1
endurance time tests – Type II/III/IV – light freezing rain, s 8
endurance time tests – Type II/III/IV – manufacturer's mandatory documentation, s 3.1.5
endurance time tests – Type II/III/IV – purpose, Foreword at p 1, s 1.1

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

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

Sponsors: Stephanie Bendickson; Ben Bernier for the next issue.

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 groundcrews or flightcrews 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.

Keywords

[59] Frozen contaminants and frozen contamination are generally used as synonyms.

Documents Issued by the SAE G-12 Methods Committee

AS6285D Aircraft Ground Deicing/Anti-Icing Processes

Revised May 18, 2021, by SAE G-12 M.
Effective August 01, 2021.

Sponsor: Fernando Echeverri.

This document sets the procedures to perform deicing and anti-icing of aircraft subject to any form of freezing or frozen precipitation.

It distinguishes the responsibilities of the pilot-in-command, the aircraft operator, the service provider, the airport authority, the regulator and air traffic control.

It covers methods to deice and anti-ice aircraft using AMS1424- and AMS1428-qualified fluid and processes not using fluids. It provides procedures to deal with frost prevention with cold-soaked aircraft and spot deicing.

It informs on the checks to be performed to ascertain if deicing is required or to verify for the presence of frozen contamination after deicing. It describes the how communications should be done.

It explains the requirement for quality program, quality assurance and quality control. It states that staff must be trained and qualified.

The major change in this revision D is the removal of fluid application tables by referring to the application tables published by the FAA and Transport Canada in their respective annual *Holdover Time Guidelines*. Other changes include new definitions, additional language for fluid appearance, clarification of postdeicing/anti-icing communications, the additional of the requirement that gravel deflectors be free of frozen contamination and many editorial modifications on the capitalization and hyphenation of words.

Keywords
°Brix – definition, s 2.2.2.2 *sub verbo* “Brix”
aircraft configuration (deicing), ss 5.2b, 5.2c, 5.6, 5.8, 5.9, 8.7.5
aircraft deicing configuration. *See* aircraft configuration (deicing)

[60] AS6285E is not explicit about the need to communicate with the flightcrew if deicing/anti-icing is performed in its absence. *See* s 14.b. of FAA Notice N 8900.594 for more information.

[61] *See* footnote 65.
[62] One can think of appearance as a superset of color, e.g., clear green liquid.
[63] Pre-season and start-of-the-season appear to be used interchangeably.

[64] When the surface is at or below the frost point, frost is formed by deposition (also known as desublimation or sublimation), that is from the water vapor in the atmosphere directly to solid phase on the surface, without going through a liquid phase. Sublimation: “Direct evaporation from ice. In meteorology, the term is also applied to the reverse process, in which water vapour changes directly to the solid phase.” Deposition: “The formation of ice on a surface directly from water vapour, without passing through a liquid phase. See sublimation”. Source: oxfordreference.com.

[65] Although not listed in section 4.3.6c of AS6285D, the following should appear on a sample label: name of the airline or service provider sending the sample and hazard category of the fluid, a mandatory requirement for shipping chemicals.

[66] Although not covered in AS6285D, a complete sampling procedure should cover safety precautions, personal protective equipment, special hazards at airport, environmental considerations, etc. See Q&A 110 for more details.

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

ARP6257 issued October 25, 2016, by SAE G-12 M.

Sponsor: David Thornton.

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

Keywords

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 – postdeicing/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

AS5537A Weather Support to Deicing Decision Making (WSDMM) Winter Weather Nowcasting System

Revised February 10, 2021, by SAE G-12 M.

Sponsor: Scott Landolt.

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
LWES, ss 1.2, 3.3
METAR – hourly snow intensity based on visibility, s 1.2
METAR – no provision of liquid equivalent snowfall rate, s 1.2
METAR – snowfall intensity underestimation – heavily rimed snow, s 1.2
METAR – snowfall intensity underestimation – high-visibility high-snowfall rate conditions, s 1.2
METAR – snowfall intensity underestimation – snow containing single crystals of compact shape, s 1.2
METAR – snowfall underestimation – wet snow, s 1.2
nowcasting, Title at p 1, ss 1.1, 1.2
precipitation gauge – GEONOR, s 4.1
precipitation gauge – hot plate, 4.3
precipitation gauge – OTT Pluvio, s 4.2
snow gauge. *See* precipitation gauge
snowfall intensity – underestimation in heavily rimed snow, METAR, s 1.2
snowfall intensity – underestimation in snow containing single crystals of compact shape, METAR, s 1.2
snowfall intensity – underestimation in wet snow, METAR, s 1.2
snowfall rate – liquid water equivalent, Foreword at p 2, s 1.2
visibility
weather support to deicing decision making, Title at p 1
windshield, ss 4.1, 4.2

Documents Issued by the SAE G-12 Deicing Facilities Committee

ARP5660A Deicing Facility Operational Procedures

ARP5660A revised January 6, 2011, by SAE G-12 DF.

Sponsor: Bryan Crabtree.

ARP5660 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. AIR5660 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

ARP4902C Design of Aircraft Deicing Facilities

Revised February15, 2018, by SAE G-12 DF.

Sponsor: Oliver Arzt.

ARP4902C 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

[67] Section 2 of ARP4902C defines staging area, yet the deicing pad definition refers to staging bay.

AS5635 Message Boards (Deicing Facilities)

AS5635 issued February 16, 2005, by SAE G-12 DF.

Sponsor: Gabriel Lépine.

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

deicing 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

ARP1971D Aircraft Deicing Vehicle - Self-Propelled

Revised February 13, 2019, by SAE G-12 E.

ARP1971D covers requirements for a self-propelled, boom type aerial device, equipped with an aircraft deicing/anti-icing fluid spraying system, with open basket or enclosed cabin.

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
cabin. *See* deicing unit – basket/cabin; deicing unit – cabin
deicing truck. *See* deicing unit
deicing unit – acceptance, s 4
deicing unit – aerial device, ss 3.1, 3.2.3, 3.4, 4.3.3
deicing unit – aircraft washing, s 3.9.17
deicing unit – axle mass, s 3.2.12
deicing unit – basket/cabin – load capacity, ss 3.2.3, 3.2.12
deicing unit – basket/cabin – person capacity – number of persons, ss 3.2.3, 3.2.12
deicing unit – basket/cabin – weight capacity, s 3.2.3
deicing unit – basket/cabin, ss 3.1, 3.2.3, 3.2 note, 3.2.12, 3.3.2, 3.4.1, 3.4.2, 3.4.4, 3.4.6.1, 3.4.6.3, 3.4.7.8-3.4.18, 3.5.2, 3.5.10, 3.5.12, 3.8.1, 3.8.6, 3.9.1, 3.9.3, 3.9.11, 3.9.16, 3.9.17, 3.9.21, 3.9.29, 4.3.2, 4.3.4, 4.3.7
deicing unit – blower, s 3.2.9
deicing unit – boom elevation system, s 3.2.11
deicing unit – boom, ss 3.1, 3.2, 3.2.4, 3.2.8, 3.2.11, 3.4-3.4.18, 3.5.12, 3.7.1, 3.7.6, 3.8.1, 3.8.9, 3.9.9, 3.9.21, 3.9.29, 3.9.29.5, 4.3.2, 4.3.5, 4.3.7,
deicing unit – cabin. *See also* deicing unit – basket/cabin; deicing unit – cabin
deicing unit – cabin, s 3.9.29
deicing unit – chassis, ss 3.1, 3.2.2, 3.2.9, *3.3-3.3.13*, 3.9.7, 3.9.27,
deicing unit – combustion heaters, s 3.2.7
deicing unit – controls and instrumentation, s 3.6
deicing unit – engine speed, s 3.2.9
deicing unit – fast heating system, s 3.2.7
deicing unit – fill ports – sizes, s 3.9.19
deicing unit – fill ports, s 3.9.19
deicing unit – fluid contamination[68], s 3.5.6
deicing unit – fluid degradation test, s 3.9.1
deicing unit – fluid delivery pressure, s 3.2.4

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[68] ARP1971D 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.

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

Issued January 22, 2015, by SAE G-12 E.

Sponsor: David Thornton.

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

ARP5058A Enclosed Operator's Cabin for Aircraft Ground Deicing Equipment

Revised June 12, 2004, by SAE G-12 E.

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

Keywords

Documents Issued by the SAE G-12 Training and Quality Control Committee

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

Revised June 11, 2020, by SAE G-12 T and effective August 1, 2020.

Sponsor: Alun Williams.

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

Its purpose is to serve as a global aircraft deicing training manual (Rationale at par 4).

A standard teaching plan with theoretical and practical elements is proposed in sections 6.2 and 6.4.

Appendix A provides background to the theoretical elements of the standard teaching plan

Appendix B 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.

Appendix C provides recommended training times for the theoretical elements of the training plan.

Keywords
accountable executive – definition, s 2.3.1 *sub verbis* “winter program manager”
accountable person – definition, s 2.3.1 *sub verbis* “winter program manager”
aircraft category. *See* category, aircraft
aircraft configuration (deicing) – elevator, s B.1.1.7
aircraft configuration (deicing), ss 6.4, A.14.1.1, A.14.1.5,
aircraft diagram, Fig B1
aircraft dimensions – Airbus A220-100, s B.1.2.1.9
aircraft dimensions – Airbus A220-200, s B.1.2.1.10
aircraft dimensions – Airbus A318/319/320/321, s B.1.2.1.6
aircraft dimensions – Airbus A330, s B.1.2.1.2
aircraft dimensions – Airbus A340, s B.1.2.1.1
aircraft dimensions – Airbus A350-1000, s B.1.2.1.11
aircraft dimensions – Airbus A380, s B.1.2.1.3
aircraft dimensions – Airbus AE120310, s B.2.2.1.5
aircraft dimensions – Antonov AN-12, s B.1.2.4.1
aircraft dimensions – Antonov AN-124, s B.1.2.4.4
aircraft dimensions – Antonov AN-70, s B.1.2.4.2
aircraft dimensions – Antonov AN-74/AN-74T, s B.1.2.4.3
aircraft dimensions – ATR42/ATR72, s B.1.2.3.8,
aircraft dimensions – Avro RJ, s B.1.2.3.3
aircraft dimensions – BAe 146/Avro RJ, s B.1.2.3.3
aircraft dimensions – BAe ATP, s B.1.2.3.1
aircraft dimensions – BAe Jetstream 31/41, s B.1.2.3.2
aircraft dimensions – Beech 1900 D, s B.1.2.5.2
aircraft dimensions – Beech Beechjet 400A, s B.1.2.5.3
aircraft dimensions – Beech King Air 350, s B.1.2.5.1
aircraft dimensions – Beech King Air B200, s B.1.2.5.5

[69] Numerical sequence of this sections appears incorrect; B.2.2.2.10 follows B.1.2.2.9.

[70] AS6285 defines this check performed by the flightcrew or the groundcrew, prior to departure to determine the need to as a “preflight check”. in s A.8.2.4 and C.1 it defines it as “contamination check”. AS6286 calls it a “preflight contamination check” in ss 2.3.1, 8.4.1 and as “contamination check” in ss 4.5, 4.7, 5.2, 6.2, 6.4, A.8.2.4, C.1 As AS6285 is the primary standard [AS6286 is the standard that explains how to teach AS6285], I indexed the AS6286 “preflight contamination check” as “preflight check”.

[71] AS6285 says “fluid delivery”, from a groundcrew perspective it should be fluid acceptance.

[72] Section 4.3 appears to be missing a training qualification level for dispatch personnel, yet section 3.3.1 par 2 calls for training of dispatch personnel.

AS6332A Aircraft Ground Deicing/Anti-Icing Quality Management

Issued July 29, 2021, by SAE G-12 T.

Sponsor: Jerry Lewis.

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 continual improvement.

Keywords

Documents Issued by Regulators

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 (latest version).

EASA and ICAO also publish guidance material.

Documents Issued by the Federal Aviation Administration

FAA, *Holdover Time Guidelines Winter 2021-2022,* Original Issue

Effective August 4, 2021, issued by the FAA.[73]

Contact person for technical content: Warren Underwood (warren.underwood@faa.gov)
Contact person for FAA Flight Standard policies: Charles Enders (charles.j.enders@ faa.gov)

This document provides generic and fluid-specific holdover time guidelines and allowance times for Type II fluids, EG-based and PG-based Type IV fluids. It includes a list of fluids tested for anti-icing performance (WSET and HHET) and aerodynamic acceptance. The FAA *Holdover Time Guidelines* are designed to be used with FAA Notice N 8900.594 *Revised FAA-Approved Deicing Program Updates, Winter 2021-2022*.

Significant changes to the FAA Holdover Time Guidelines 2021-2022

In this FAA HOT 2021-2022 issue, four Type I are listed, one Type II is delisted, one Type II listed, one Type IV delisted, eight Type IV listed. Minor decreases are made to the Type II generic

[73] https://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/deicing/.

HOT table as a result of the new Type II fluid. Several decreases are made to the Type IV generic HOT table as a result of the new Type IV fluids (p 6).

Further testing in very cold snow enabled several fluids to acquire fluid-specific holdover times for snow below -14°C (p 6).

Freezing mist was added to the "Freezing Fog and Ice Crystals" precipitation condition column which now reads "Freezing Fog, Freezing Mist or Ice Crystals" (p 6).

Notes have been modified (note 5 for Type I and Type III; note 4 for Type II/IV) to allow for use of the light freezing rain holdover times for very light snow mixed with drizzle or light snow mixed with drizzle (p 6).

A separate allowance table was created for EG-based Type IV fluids (p 6, Table 48). Applicable METAR codes and precipitation intensity designators were added to the allowance tables (p 7).

Reference is given to the guidance material and the database for degree-specific holdover times (DSHOT) (p 5).

Note to the reader

As the FAA and Transport Canada *Holdover Time Guidelines* originate from the same data set and are similar, I use the same keyword list for both documents. If the entry pertains only to the FAA document, there is the mention "(FAA)", similarly "(TC)" for Transport Canada.

If it is a new feature of the 2021-2022 winter, it is indexed as "2021-2022 (FAA & TC)". If the new feature only pertains to the FAA, it reads "2021-2022 (FAA)" and for Transport Canada "2021-2022 (TC)".

Keywords

2021-2022 (FAA & TC) – allowance time – METAR code -FZDZPL – ice pellets, light – mixed with light freezing drizzle, Tables 47–49

2021-2022 (FAA & TC) – allowance time – METAR code FZDZPL – ice pellets, light – mixed with moderate freezing drizzle, Tables 47–49

2021-2022 (FAA & TC) – allowance time – METAR code -FZRAPL – ice pellets, light – mixed with light freezing rain, Tables 47–49

2021-2022 (FAA & TC) – allowance time – METAR code GR with remark less than ¼ – in U.S. – small hail, Tables 47–49, note 4

[74] Other obscurations listed in FMH-1 (s 8.3.2): mist, volcanic ash, widespread dust, sand and spray. Yet, freezing mist is a precipitation that is not reported by METAR. According to the FAA HOT Guidelines, it can occur when mist is present at or below 0°C (e.g., see note 4 of Type IV HOT tables).
[75] *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.
[76] Although the FAA and Transport Canada harmonize most of the information contained in their respective Holdover Time Guidelines, the Snowfall Intensity as a Function of Prevailing Visibility tables are different. See Q&A no. 1

FAA, Notice N 8900.594, "Revised FAA–Approved Deicing Program Updates, Winter 2021–2022"

Effective date: August 26, 2021; cancellation date: August 26, 2022. Issued by the FAA.[77] Replaces FAA Notice N 8900.519 which had an effective date of August 11, 2020.

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.[78]

Significant changes to N 8900.594 in 2021-2022

A note was added to section 7.b.(8) explaining that Type IV fluids that have not undergone the full range testing required to obtain fluid-specific HOT in very cold snow (< -14°) are assigned generic values which are different for Type IV EG-based and Type IV PG-based fluids (pp 2, 6). [There is only one generic Type IV fluid HOT chart. This means that the EG-based and PG-based data is separated to be able to develop EG-based and PG-based generic data for very cold snow.]

A new section 8.a.(2)(c) was added to provide guidance to flightcrews when weather conditions vary after the completion of the anti-icing procedure worsen or improve (pp 2, 10).

Section 8.c. was renumbered to 8.c.(1) and the new section 8.c.(2) was added to provide guidance for the use of HOTs in freezing mist (pp 2, 11).

FAA guidance for use of degree specific holdover times (DSHOT) appears in section 13.

Keywords
14 CFR § 121.629, ss 5, 8.d.(2), 8.g.(2), 9.c., 9.e.(4)(b), 12.c., 14.i.
active frost. *See* frost – active

[77] https://www.faa.gov/documentLibrary/media/Notice/N_8900.594.pdf.
[78] Regulators have different names for the programs that airlines and service providers must have in place to deal with ground icing. FAA calls it "FAA-Approved Deicing Program" in document N 8900.xxx and "Ground Deicing/Anti-Icing Program" in AC 120-60B, Transport Canada uses the terms "Approved Ground Icing Program" and "ground icing operations program", ICAO calls it "ground de-icing/anti-icing programme", and SAE refers to ground deicing program in AS6285. To facilitate indexing, these programs are indexed as ground deicing program, e.g., ground deicing program (FAA), ground deicing program (TC), etc.

[79] Refractometer measurement error can be introduced, for instance, by the imperfect temperature compensation of analog temperature-compensated refractometers.

[80] 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 subsequent N 8900 documents.

[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) *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) *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) *conditions without holdover time but where, with special dispatch procedures, takeoff can occur*, e.g., heavy snow and 4) *conditions without holdover time*, e.g. moderate freezing rain, heavy freezing rain, hail, heavy ice pellets.

[82] "If additional information provided with the METAR makes clear that the weather condition is snow pellets and not small hail then snow holdover times can be used".

83

[84] See footnote 74.

[85] 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 its accepted specification range.

[86] 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 or iron oxides are generally thought to be acceptable. The criterion of acceptability is sometimes formulated as “substantially free from suspended matter”.

[87] For example, contamination with other fluids, silicone oil, rust, RDP, jet fuel, diesel fuel, rain water, melted snow, etc.

[88] 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.

[89] *Neat fluid* or *undiluted 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 8900.525 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 undiluted fluid and 25 parts water.”

[90] 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 black iron particles (not rust) are generally thought to be acceptable. The criterion of acceptability is sometimes formulated as “substantially free from suspended matter”.

FAA, Degree-Specific Holdover Time Data, Winter 2021-2022, Original Issue

Issued August 4, 2021, by the FAA.[92]

This is the 2021-2022 database for degree-specific holdover times. It is in the form of an Excel spreadsheet comprising several tabs. This is the first time a degree specific holdover time database is issued by the FAA.

[91] *See* footnote 89
[92] https://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/deicing/.

Guidance and conditions of use with this 2021-2022 degree specific database are found in the FAA Notice N 8900.594, "Revised FAA–Approved Deicing Program Updates, Winter 2021–2022", issued August 26, 2021.

A similar document is issued by the Transport Canada.

Keywords
DSHOT database, all sections

FAA, *Holdover Time Regression Guidelines Information, Winter 2021-2022,* Original Issue

Issued August 4, 2021, by the FAA.[93]

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[94], pp 6-7
HOT – 76% adjusted – regression calculations, p 6
HOT – regression information – changes in 2021-2022, p 5
HOT – regression limitations – caution outside precipitation rate limits, pp 7–8
HOT – regression limitations – no allowance times, p 8
HOT – regression limitations – no interpolation for Type II/III/IV non-standard dilutions, p 7
HOT – regression limitations – no regression coefficients for frost, p 8
HOT – regression limitations – use at > 0°C, p 7
HOT – regression limitations – use of LUPR, p 7
HOT – regression limitations – use of snow precipitation rate ≤ 50 g/dm^2/h, p 8
HOT – regression limitations – use with CTDS/HOTDS conforming to Advisory Circular (FAA), p 6
HOT – regression limitations, pp 7–8
HOT – Type I – regression calculations, p 6
HOT – Type I – regression coefficients, Tables 1-1, 1-2
HOT – Type II fluid-specific – regression calculations, pp 6–7
HOT – Type II fluid-specific – regression coefficients, Tables 2-2 to 2-12

[93] https://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/deicing/.
[94] The Transport Canada HOT Regression Information document does not mention check time determination systems.

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

Issued December 12, 2004, by the FAA.[95]

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

Keywords

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[95] US, Federal Aviation Administration, FAA Advisory Circular AC 120-60B "Ground Deicing and Anti-icing Program" (20 December 2004), http://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/23199
.

[96] The appears to be four kinds of icing checks: 1) *preflight check* (aka contamination check) performed by the flightcrew or groundcrew 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.

[97] AC 120-60 uses the term “frozen contamination”, here we index it as “contamination [frozen]”.

FAA, Advisory Circular AC 120-112, "Use of Liquid Water Equivalent System to Determine Holdover Times or Check Times of Anti-icing Fluids"

Issued July 14, 2015, by the FAA.[99]

Although the FAA does not certify or approve specific liquid water equivalent system (LWES), some U.S. aircraft operators (§ 121.629(c) category) may be required by U.S. 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 LEW rate and endurance time regression equations, calculates holdover time (HOT) or check time (CT).

[98] AC 120-60 appears to use different terms for the check that is an integral part of the deicing/anti-icing process: "post deicing check" s 3.g., "post deicing/anti-icing check" s 6.e.(3), 6.f.(3)D, "post application check" s 6.f.(3)D. SAE documents usually call it "post deicing/anti-icing check" such as, AS6285D s 7.3 and AS6286 A.13.5, although for short it is sometimes called "post deicing check".

[99] https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1027819.

Keywords

LWES – quality assurance – guidance (FAA), s 2-3
LWES – siting – guidance (FAA), s 2-7
LWES – *superset of* check time determination system, s 1-1
LWES – *superset of* HOTDS, s 1-1
LWES – system description – guidance (FAA), s 2-4
LWES – testing specification (FAA), s 2-6
LWES – training manual – guidance (FAA), s 2-8
LWES – training manual – guidance (FAA), ss 2-6, 2-8
LWES – ultrasonic wind sensor performance standards (FAA), s 3-6
LWES – user manual – guidance (FAA), s 2-6
LWES – verification of CT – guidance (FAA), s 2-5
LWES – verification of HOT – guidance (FAA), s 2-5
LWES – wind speed sensor performance standard (FAA), s 3-5
regression analysis, endurance time – definition, Appendix 2
regression equation, use of endurance time – for LWES, s 1-1
supercooled large droplets *superset of* freezing drizzle, s 3-11
supercooled large droplets *superset of* freezing rain, s 3-11

FAA, Advisory Circular AC 150/5300-14D, "Design of Aircraft Deicing Facilities"

Revised March 17, 2020, by the FAA.[100]

This document provides guidance and recommendations of the designing of deicing facilities. It covers the sizing, siting, environmental considerations and operational requirements to maximize deicing capacity while maintaining safety and efficiency. There is emphasis on centralized deicing facilities and the issues associated with such facilities. Design considerations for infrared deicing facilities are discussed.[101]

Keywords
14 CFR § 139, s 3 at p i[102]
aircraft deicing facility. *See* deicing facility
aircraft parking area length, s 3.1.1.1
aircraft parking area width, s 3.1.1.2
aircraft parking area, deicing pad – definition, s 1.2.3
Airport Certification Manual (U.S.), s 3 at p i
Airport Improvement Program (U.S.), s 3 at p i
airport, certificated (FAA), s 3 at p i
CDF – air traffic control tower line-of-sight, s 2.2.3
CDF – aircraft access routes, s 4
CDF – airport layout plan (FAA), s 1.5

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[100] https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1037335.

[101] Infrared deicing facilities were built at JKF airport in NY, Buffalo NY, Newark NJ, Rhinelander NY, and Oslo, Norway. Buffalo, Newark, and Oslo facilities were dismantled. JFK and Rhinelander are not operational. The builder of infrared facilities is no longer offering them for sale [FAA private communications. June 2016].

[102] AC 150/5300-14D has an introductory section (aka cover letter) at pp i to vi that uses the same section numbering as the main document. When the referring to a section in the introductory part, the pages are indicated.

[103] AC 150/5300-14D defines all off-gate deicing facilities as centralized deicing facilities, see s 1.1.

[104] Historical: in AC 150/5300-14C, the expression "remote deicing facility" was dropped from the definition of CDF (s 4a at p i). In the *Guide*, we abbreviate centralized deicing facility as CDF.

FAA, Policy Statement: Type Certification Policy for Approval of Use of Type II, III, and IV Deicing/Anti-Icing Fluids on Airplanes Certificated Under 14 CFR Parts 23 and 25, Policy No: PS-ACE-23-05, PS-ANM-25-10

Issued May 3, 2015, by the FAA.

This FAA policy describes the testing and approval process for aircraft manufacturer to enable the use of SAE Type II, III and IV on aircraft certificates under 14 CFR parts 23 and 25.

This document seeks to determine if using Type II, III or IV fluids will result in significant or unusual flight or ground handling characteristics. This is determined by flight tests or by showing similarity to previously tested models.

The policy addresses takeoff performance, lift loss determination, takeoff angle-of-attack margin tests, controllability, vibration and buffeting, postflight inspections, effect on aircraft systems, and maintenance instructions, including cleaning, lubrication and how to deal with fluid residues and rehydrated residues.

A less detailed similar document was published by Transport Canada entitled *Guidelines for Aeroplane Testing Following Deicing/Anti-Icing Fluid Application*, Working Note No. 38, Initial Issue.

Keywords
aerodynamic effect of fluids – aircraft certification, FAA, s Title at p 1
aerodynamic effect of fluids – not addressed by AS5900 – control surface effectiveness, p 4 par 2
aerodynamic effect of fluids – not addressed by AS5900 – control forces, p 4 par 2
aerodynamic effect of fluids – on aircraft responsiveness to pitch control input, s 2
aerodynamic effect of fluids – on low takeoff speed aircraft, p 4 par 5
aerodynamic effect of fluids – on unpowered longitudinal flight control, p 4 par 4-5
aerodynamic effect of fluids – operational limitations – delayed response to pilot pitch control input, p 5 par 1
aerodynamic effect of fluids – operational limitations – higher than normal control column back pressure, p 4 par 4
aerodynamic effect of fluids – operational limitations – increased rotation speed, p 4 par 3
aerodynamic effect of fluids – operational limitations – pilot force to initiate rotation, p 4 par 3
aerodynamic effect of fluids – operational limitations – takeoff flap setting limitations, p 4 par 3
aerodynamic effect of fluids – rejected takeoff, p 4 par 4
aircraft certification – Type II/III/IV – AFM – aircraft specific limitations, s 8.a
aircraft certification – Type II/III/IV – AFM – list of approved Types of fluid, s 8.a
aircraft certification – Type II/III/IV – AFM – list of prohibited fluids, s 8.a
aircraft certification – Type II/III/IV – AFM – LOUT limitations, s 8.a
aircraft certification – Type II/III/IV – AFM – takeoff speed increase, s 8.a
aircraft certification – Type II/III/IV – AFM, p 13
aircraft certification – Type II/III/IV – buffeting, s 3
aircraft certification – Type II/III/IV – controllability, s 2
aircraft certification – Type II/III/IV – effect of heated surfaces, s 6.b
aircraft certification – Type II/III/IV – effect of ice protection systems, s 6.b
aircraft certification – Type II/III/IV – effect on air data probes, s 6.b
aircraft certification – Type II/III/IV – effect on APU, s 6.a
aircraft certification – Type II/III/IV – effect on environmental control system, s 6.a
aircraft certification – Type II/III/IV – effect on fluid baking, s 6.b
aircraft certification – Type II/III/IV – effect on vent blocking, s 6.a
aircraft certification – Type II/III/IV – flight tests, p 6 par 3, p 13
aircraft certification – Type II/III/IV – fluid application, s 5.b
aircraft certification – Type II/III/IV – fluids to be tested, s 5.a
aircraft certification – Type II/III/IV – handling qualities, s 7.a
aircraft certification – Type II/III/IV – ICA, p 13
aircraft certification – Type II/III/IV – lift loss determination, s 1.a
aircraft certification – Type II/III/IV – maintenance instructions – drain hole inspections, s 9.a
aircraft certification – Type II/III/IV – maintenance instructions – control balance bay inspections, s 9.a
aircraft certification – Type II/III/IV – maintenance instructions – aerodynamically quiet area inspections, s 9.a
aircraft certification – Type II/III/IV – maintenance instructions – internal control system component inspection, s 9.a
aircraft certification – Type II/III/IV – maintenance instructions – residue removal, ss 9.b, 9.c
aircraft certification – Type II/III/IV – maintenance instructions – lubrication, s 9.b

Documents Issued by Transport Canada

Transport Canada, *Holdover Time Guidelines Winter 2021-2022,* Original Issue.

Issued August 4, 2021, by Transport Canada.[105]

Contact person: Yvan Chabot.

This document, updated every year, provides the holdover time guidelines as published by Transport Canada. The Transport Canada *Holdover Time Guidelines Winter 2021-2022* are meant to be used in conjunction with the latest issue of the *Guidelines for Aircraft Ground Icing Operations*, TP 14052E (sixth issue, August 2021) where additional guidance on aircraft ground deicing can be found.

<u>Significant changes to the Transport Canada Holdover Time Guidelines 2021-2022</u>

In this TC HOT 2021-2022 issue, four Type I are listed, one Type II is delisted, one Type II listed, one Type IV delisted, eight Type IV listed. Minor decreases are made to the Type II generic HOT table as a result of the new Type II fluid. Several decreases are made to the Type IV generic HOT table as a result of the new Type IV fluids (p 6).

Further testing in very cold snow enabled several fluids to acquire fluid-specific holdover times for snow below -14°C (p 6).

Freezing mist was added to the “Freezing Fog and Ice Crystals” precipitation condition column which now reads “Freezing Fog, Freezing Mist or Ice Crystals” (p 6).

Notes have been modified (note 5 for Type I and Type IIII; note 4 for Type II/IV) to allow for use of the light freezing rain holdover times for very light snow mixed with drizzle or light snow mixed with drizzle (p 6).

[105] https://tc.canada.ca/en/aviation/general-operating-flight-rules/holdover-time-hot-guidelines-icing-anti-icing-aircraft.

A separate allowance table was created for EG-based Type IV fluids (p 6, Table 48). Applicable METAR codes and precipitation intensity designators were added to the allowance tables (p 7).

Note to the reader

As the FAA and Transport Canada *Holdover Time Guidelines* originate from the same data set and are similar, I use the same keyword list for both documents. If the entry pertains only to the FAA document, there is the mention “(FAA)”, similarly “(TC)” for Transport Canada.

If it is a new feature of the 2021-2022 winter, it is indexed as “2021-2022 (FAA & TC)”. If the new feature only pertains to the FAA, it reads “2021-2022 (FAA)” and for Transport Canada “2021-2022 (TC)”.

Keywords

2021-2022 (FAA & TC) – allowance time – METAR code -FZDZPL – ice pellets, light – mixed with light freezing drizzle, Tables 47–49
2021-2022 (FAA & TC) – allowance time – METAR code FZDZPL – ice pellets, light – mixed with moderate freezing drizzle, Tables 47–49
2021-2022 (FAA & TC) – allowance time – METAR code -FZRAPL – ice pellets, light – mixed with light freezing rain, Tables 47–49
2021-2022 (FAA & TC) – allowance time – METAR code GR with remark less than ¼ – in U.S. – small hail, Tables 47–49, note 4
2021-2022 (FAA & TC) – allowance time – METAR code GS – in Canada – small hail, Tables 47–49, note 4
2021-2022 (FAA & TC) – allowance time – METAR code GS – outside the U.S. – small hail, Tables 47–49, note 4
2021-2022 (FAA & TC) – allowance time – METAR code GSFZDZ – in Canada – small hail – mixed with moderate freezing drizzle, Tables 48–49
2021-2022 (FAA & TC) – allowance time – METAR code GSFZDZ – outside the U.S. – small hail – mixed with moderate freezing drizzle, Tables 48–(49
2021-2022 (FAA & TC) – allowance time – METAR code GSRA – in Canada – small hail – mixed with moderate rain, Tables 48–49
2021-2022 (FAA & TC) – allowance time – METAR code GSRA – outside the U.S. – small hail – mixed with moderate rain, Tables 48–49
2021-2022 (FAA & TC) – allowance time – METAR code -PL – ice pellets, light, Tables 47–49
2021-2022 (FAA & TC) – allowance time – METAR code PL – ice pellets, moderate, Tables 47–49
2021-2022 (FAA & TC) – allowance time – METAR code -PLFZDZ – ice pellets, light – mixed with light freezing drizzle, Tables 47–49
2021-2022 (FAA & TC) – allowance time – METAR code PLFZDZ – ice pellets, moderate – mixed with moderate freezing drizzle, Tables 48–49
2021-2022 (FAA & TC) – allowance time – METAR code -PLFZRA – ice pellets, light – mixed with light freezing rain, Tables 47–49
2021-2022 (FAA & TC) – allowance time – METAR code -PLRA – ice pellets, light – mixed with light rain, Tables 47–49
2021-2022 (FAA & TC) – allowance time – METAR code PLRA – ice pellets, moderate – mixed with moderate rain, Tables 48–49
2021-2022 (FAA & TC) – allowance time – METAR code -PLSN – ice pellets, light – mixed with light snow, Tables 47–49

Transport Canada, Advisory Circular AC700-061, "Degree-Specific Holdover Times", Issue 01

Effective July 16, 2021.[108]

Contact person: Yvan Chabot

This advisory circular provides acceptable means of compliance with regulations and standards with respect to degree specific holdover time (DSHOT) for Canadian operators.

Keywords

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[106] *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.
[107] Although the FAA and Transport Canada harmonize most of the information contained in their respective *Holdover Time Guidelines*, the Snowfall Intensity as a Function of Prevailing Visibility tables are different. See Q&A no. 1
[108] https://tc.canada.ca/sites/default/files/2021-07/AC_700-061_-_ISSUE_01.PDF.

Transport Canada, Degree-Specific Holdover Times Winter 2021-2022, Original Issue

Issued August 4, 2021.

Contact person: Yvan Chabot.

This is the 2021-2022 database for degree-specific holdover times. It is in the form of an Excel spreadsheet comprising several tabs. This is the first time a degree specific holdover time database is issued by Transport Canada.

Guidance and conditions of use with this 2021-2022 degree specific database are found in Transport Canada Advisory Circular AC700-061 issued July 16, 2021.

Keywords
DSHOT database, all sections

Transport Canada, *Guidelines for Aircraft Ground Icing Operations*, TP 14052E, Issue 6

Revised August 2021 by Transport Canada.[109]

Contact person: Yvan Chabot.

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.

Keywords
aerodynamic acceptance test – definition, s 18
aerodynamic acceptance test – high speed ramp – guidance (TC)), ss 8.1.6.1 e), 8.1.6.1 f)
aerodynamic acceptance test – low speed ramp – guidance (TC), ss 8.1.6.1 e), 8.1.6.1 h)
aerodynamic acceptance test – middle speed ramp – guidance (TC), ss 8.1.6.1 e), 8.1.6.1 g)
aerodynamic acceptance test – objective, s 8.1.6.1 e)
aerodynamic effect of asymmetric contamination, s 12.6.8
aerodynamic effect of contamination – guidance (TC), s 12.6.8
aerodynamic effect of contamination. *See also* contamination [frozen] – effect on
aerodynamic effect of leading edge roughness, s 12.6.8
aerodynamic effect of roughness, s 12.6.8
air heaters. *See* contamination [frozen] – removal with air heaters
air operator (TC) – definition, s 18
air operator certificate (TC) – definition, s 18
AIR6284, s 19.5.2 i)
aircraft configuration (deicing) – flaps and slats, s 12.3
aircraft configuration (deicing), s 12.3
aircraft deicing configuration. *See* aircraft configuration (deicing)
aircraft deicing facility. *See* deicing facility
aircraft manufacturer documentation – fluid pressure, maximum, s 8.1.7
aircraft manufacturer documentation – fluid Type for aircraft models, ss 8.1.6.1 e), note following 8.1.6.1 h)
alkali organic salt based Type I – guidance (TC), s 10.8.1
allowance time – end of, s 11.1.16

[109] https://tc.canada.ca/en/aviation/publications/guidelines-aircraft-ground-icing-operations-tp-14052.

[110] Refractometer measurement error can be introduced, for instance, by the imperfect temperature compensation of analog temperature-compensated refractometers. See Q&A 48.

[111] Another risk factor would be the difficult weather in which often deicing is performed, coupled with poor visibility.

[112] *Transport Canada Holdover Time Guidelines Winter 2015-2016* spelled out clearly that there were no Type III generic HOT guidelines. There is no Type III generic HOT guideline in the 2019-2020 version, but it is not specified as such.

[113] 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?

[114] Section 10.5 f) calls cabin windows a no-spray zone whereas section 8.7.1.2 c) call for indirect spraying.

Transport Canada, *Holdover Time (HOT) Guidelines Regression Information Winter 2021-2022*

Issued August 4, 202,1 by Transport Canada.

Contact person: Yvan Chabot.

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.

Keywords

Transport Canada, Civil Aviation Safety Alert CASA 2019-09, "Use of SAE Type I Fluids as an Anti-icing Fluid", Issue 1

Issued November 15, 2019, by Transport Canada.[115]

Contact person: Yvan Chabot.

This document clarifies the use of Type I fluid as a deicing fluid and as an anti-icing fluid.

The communications with flightcrew must be such that the flightcrew will clearly understand if there is no holdover time or if there a holdover time.

When deicing only is performed with Type I to remove frozen contamination, there is no minimum quantity applied and there is no holdover time. Holdover start time must not be provided to the pilot-in-command.

[115] https://www.tc.gc.ca/en/services/aviation/reference-centre/safety-alerts/use-sae-type-I-fluid-anti-icing-fluid.html.

When there is precipitation or active frost (a form of precipitation) or precipitation is forecasted and deicing/anti-icing is performed with Type I for the purpose of using the holdover time guidelines, the Type I must be heated to at least 60°C and a minimum of at least 1 L/m^2 must be applied after the contamination is removed. Holdover start time must be provided to the pilot-in-command.

When flightcrew is not given a start time, it must assume that there is no holdover time. When in doubt, ask.

Keywords
communication with flightcrew – HOT, start of, p 2
fluid application – Type I – anti-icing, pp 1-3
fluid application – Type I – deicing v anti-icing, pp 1–3
fluid application – Type I – deicing, pp 1-3
holdover start time. *See* HOT – start of
HOT – guidance (TC), pp 1-3
HOT – start of, p 2
HOT – Type I – guidance (TC), pp 1-3
HOT, no – Type I – no HOT start time, p 2
HOT, no – Type I unheated, p 2
pilot-in-command – responsibility to communicate deicing/anti-icing treatment required, p 2

Transport Canada, Advisory Circular AC 700-030, "Electronic Holdover Time (eHOT) Applications"

Issued November 18, 2014, by Transport Canada.[116]

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.

Keywords
definition – EFB, s 3.0 (1)
EFB – definition, s 3.0 (1)
eHOT app – acceptance process (TC), s 5.0
eHOT app – authorization (TC), s 6.0
eHOT app – definition, s 3.0 (1)
eHOT app – demonstration of equivalence or superiority to HOT paper version, s 6.0 (2)
eHOT app – guidance (TC), ss 1.1, 4.0,

[116] https://www.tc.gc.ca/en/services/aviation/documents/AC_700-030.pdf.

Transport Canada, Standard 622.11, "Ground Icing Operations", Canadian Aviation Regulations

Effective December 9, 2020.[117]

Section 602.11 of the Canadian Aviation Regulations require air operators to have a ground deicing program. This Standard 622.11 outlines the ground deicing program minimum requirements.

Keywords

[117] https://tc.canada.ca/en/corporate-services/acts-regulations/list-regulations/canadian-aviation-regulations-sor-96-433/standards/standard-62211-ground-icing-operations-canadian-aviation-regulations-cars.

Transport Canada, Standard 622.11 Appendix A, "Minimum Assurance Requirement and Performance Specifications for Holdover Time Determination Systems (HOTDS)", Canadian Aviation Regulations

Effective December 9, 2020.[118]

This document sets the minimum assurance requirements and performance specifications for holdover time termination systems (HOTDS) for air operators to use HOT generated by HOTDS.

Keywords
definition – HOTDS test data, s 4.3 b)
HOTDR – content – fluid brand, s 5.1.22
HOTDR – content – fluid type, s 5.1.22
HOTDR – content – HOT, s 5.1.22
HOTDR – content – other, s 5.1.22
HOTDR – content – precipitation intensity, s 5.1.22
HOTDR – content – precipitation trend, s 5.1.22
HOTDR – content – precipitation type, s 5.1.22
HOTDR – retention – 24 months, s 5.1.23
HOTDS – 0°C input for temperature > 0°C, s 5.1.20
HOTDS – accuracy requirements, ss 4.1–4.2
HOTDS – built-in fault detection – data corruption, s 4.3 f)
HOTDS – built-in fault detection – hardware failure, s 4.3 f)
HOTDS – built-in fault detection – loss of input, s 4.3 f)
HOTDS – built-in fault detection – loss of input, s 4.3 f)
HOTDS – built-in fault detection – software failure, s 4.3 f)
HOTDS – built-in fault detection, s 4.3 f)
HOTDS – capping – freezing drizzle 2 h, 5.1.19
HOTDS – capping – freezing fog 4 h, 5.1.19
HOTDS – capping – light freezing rain 2 h, s 5.1.19
HOTDS – capping – rain on cold soaked wing 2 h, s 5.1.19
HOTDS – capping – snow 2 h, 5.1.19
HOTDS – freezing drizzle LUPR, s 5.1.15
HOTDS – freezing rain LUPR, s 5.1.15
HOTDS – hardware assurance standards, s 4.3 g)
HOTDS – HOT determination – precipitation ≥ 2.0 g/dm^2/h, s 5.1.11
HOTDS – HOT guideline cautions, s 5.1.20
HOTDS – HOT guideline conditions, s 5.1.20
HOTDS – HOT guideline notes, s 5.1.20
HOTDS – HOT, no – freezing drizzle > 25 g/dm^2/h, s 5.1.16
HOTDS – HOT, no – freezing fog > 25 g/dm^2/h, s 5.1.16
HOTDS – HOT, no – freezing rain > 25 g/dm^2/h, s 5.1.16
HOTDS – HOT, no – rain on cold soaked wing > 75 g/dm^2/h, s 5.1.16
HOTDS – HOT, no – snow > 50 g/dm^2/h, s 5.1.17
HOTDS – precipitation accuracy – detect fog or freezing fog, s 5.1.4
HOTDS – precipitation accuracy – detect rate of 2.0 g/dm^2/h at least 90% of the time, s 5.1.4

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[118] https://tc.canada.ca/en/corporate-services/acts-regulations/list-regulations/canadian-aviation-regulations-sor-96-433/standards/standard-62211-ground-icing-operations/standard-62211-appendix-minimum-assurance-requirements-performance-specifications-holdover-time-determination.

Barry B. Myers, Aircraft Anti-icing Fluid Endurance, Holdover, and Failure Times Under Winter Precipitations Conditions, Transport Canada, TP 13832

Issued November 2001 by Transport Canada.

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.

Keywords

Transport Canada, Working Note No. 38, "Guidelines for Aeroplane Testing Following Deicing/Anti-Icing Fluid Application" Initial Issue

Issued November 5, 2010, by Transport Canada.

In this document, Transport Canada considers that the aerodynamic acceptance test described in SAE AS5900 establishes a standard to ensure acceptable aerodynamic characteristics of aircraft deicing/anti-icing fluids during the takeoff ground roll and initial climb.

The aerodynamic acceptance test measures the boundary layer thickness over a flat plate covered with fluid during a simulated takeoff run. The premise is that the boundary layer thickness over the flat plate correlated to the boundary layer over a curved aerodynamic surface.

Transport Canada considers that aircraft configurations, airfoil sections and fluid continue to evolve and recommends limited flight tests on individual aircraft types. These flight tests, can be used 1) to establish system operation characteristics, 2) identify operational procedures and 3) maintenance procedures for deicing/anti-icing.

This document provides guidance for these aircraft tests.

The purpose of this document appears similar to the of FAA Policy Statement, Policy No: PS-ACE-23-05, PS-ANM-25-10, "Type Certification Policy for Approval of Use of Type II, III, and IV Deicing/Anti-Icing Fluids on Airplanes Certificated Under 14 CFR Parts 23 and 25".

Keywords

[119] This Transport Canada document refers to SAE Type I/II/II/IV. However, testing is recommended on Type III/IV fluids. Since the equivalent FAA document focuses more on the effects of Type II/III/IV, to simplify indexing, we index this document referring to Type II/III/IV.

Transport Canada, *Commercial and Business Aviation Inspection and Audit (Checklists) Manual*, 1st ed, TP 13750E

Issued October 2000 by Transport Canada.[120]

TP 13750E is a ground icing operations program checklist issues by Transport Canada.

Only the ground icing operations section is indexed.

Keywords

[120] https://www.tc.gc.ca/eng/civilaviation/publications/tp13750-menu-2404.htm.

Documents Issued by EASA

EASA Safety Information Bulletin No.: 2015-27, "Potential Adverse Effect of Alkali Organic Salt-based Aircraft De-Icing Fluids on Anti-Icing Holdover Protection and Potential Aircraft Corrosion"

Issued December 16, 2015, by EASA.

Advisory information explaining the potentially deleterious effects of alkali 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/III/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 – guidance (EASA), pp 1–2
non-glycol based Type I – guidance (EASA), pp 1–2
Type I – non-glycol based – effect on Type II/III/IV, pp 1–2
Type I – non-glycol based – galvanic corrosion of metal parts, pp 1–2
Type I – non-glycol based – need for inspections, pp 1–2
Type I – non-glycol based – need for maintenance, pp 1–2

EASA Safety Information Bulletin No.: 2017-11, "Global De-icing Standards"

Issued November 14, 2017, by EASA.

As the AEA documents are no longer published, EASA Safety Information Bulleting (SIB) 2017-11 recommends to European air operators the use the latest version of the global standards (SAE AS6285, AS6286, AS6332, and AS6257), the FAA Holdover Time Guidelines and the FAA 8900.xxx documents to establish their ground deicing procedures.

Keywords
AEA recommendations – publication discontinuation, p 2
EASA recommendation to use – FAA Holdover time Guidelines, pp 2–3
EASA recommendation to use – FAA Notice N 8900.xxx FAA-Approved Deicing program Updates, Winter 20xx-20yy, pp 2–3
EASA recommendation to use – global aircraft deicing standards, p 3
FAA Holdover Time Guidelines – recognition – EASA, pp 2–3
FAA Notice N 8900.xxx – recognition – EASA, pp 2–3

EASA GM1 CAT.OP.MPA.250, "Ice and other contaminants – ground procedures: terminology"

Revised April 23, 2021, by EASA.[121]

Guidance Material (GM) issued by EASA consists of three sections labeled GM1, GM2 and GM3. This latest version is ED Decision 2021/005/R (23 April 2021) and is the Update of the Acceptable Means of Compliance and Guidance Material to Regulation (EU) No 965/2012.

Keywords

[121] https://www.easa.europa.eu/sites/default/files/dfu/amc_gm_to_part-cat_-_issue_2_amendment_18.pdf.

definition – LOUT, s (n) at pp 16–17
definition – LWES, s (m) at p 16
definition – pretakeoff contamination check (EASA), s (q) at p 17
definition – ROGIDS, s (k) at p 16[122]
deicing – definition, s (h) at p 16
deicing fluid – definition, s (i) at p 16
deicing/anti-icing – definition, s (j) at p 16
GIDS – definition, s (k) at p 16
GIDS. *See* also ROGIDS
ground ice detection system. *See* also ROGIDS
ground ice detection system. *See* GIDS
HOT – definition, s (l) at p 16
LOUT – definition, s (n) at pp 16–17
LWES – definition, s (m) at p 16
postdeicing check. *See* postdeicing/anti-icing check
postdeicing/anti-icing check – definition, s (o) at p 17
postdeicing/anti-icing check – qualified staff, s (o) at p 17
post-treatment check[123]. *See* postdeicing/anti-icing check
pretakeoff check (EASA), s (p) at p 17
pretakeoff contamination check (EASA) – definition, s (q) at p 17
ROGIDS – definition, s (k) at p 16[124]

EASA GM2 CAT.OP.MPA.250, "Ice and other contaminants – ground procedures: de-icing/anti-icing – procedures"

Revised April 23, 2021, by EASA. [125]

Guidance Material (GM) issued by EASA consists of three sections labeled GM1, GM2 and GM3. This latest version is ED Decision 2021/005/R (23 April 2021) and is the Update of the Acceptable Means of Compliance and Guidance Material to Regulation (EU) No 965/2012.

Keywords
aircraft manufacturer documentation – contamination [frozen], limits on thickness of, s (a) (1) at p 17
aircraft manufacturer documentation – contamination [frozen], limits on areas of, s (a) (1) at p 17
aircraft manufacturer documentation – fluid application restrictions, s (b) (5) at p 18
aircraft manufacturer documentation – Type II/III/IV residue – prevention, s (b) (5) at p 18
aircraft manufacturer documentation – type-specific aircraft deicing/anti-icing recommendations, s (a) at p 17
anti-icing code, s (d) (2) at p 20
check, contamination. *See* contamination check
check, post-treatment *See* postdeicing/anti-icing check
check, tactile. *See* tactile check
clear ice – detection of, ss (a) at p 17, (b) (6) at p 19

[122] 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.
[123] EASA considers post-treatment check, postdeicing check and postdeicing/anti-icing check to be synonymous, s (o) at p 17.
[124] *See* footnote 122.
[125] https://www.easa.europa.eu/sites/default/files/dfu/amc_gm_to_part-cat_-_issue_2_amendment_18.pdf.

[126] 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. Section 5.8 of AS6285D states that pilot-in-command is equivalent to commander.

EASA GM3 CAT.OP.MPA.250, "Ice and other contaminants – ground procedures: de-icing/anti-icing background information"

Revised April 23, 2021, by EASA. [127]

Guidance Material (GM) issued by EASA consists of three sections labeled GM1, GM2 and GM3. This latest version is ED Decision 2021/005/R (23 April 2021) and is the Update of the Acceptable Means of Compliance and Guidance Material to Regulation (EU) No 965/2012.

In this document, as it did in EASA Safety Information Bulleting (SIB) 2017-11, EASA recognizes AS6285, AS6286, AS6332 and ARP6287 which constitute the global aircraft deicing standards.

Keywords

[127] https://www.easa.europa.eu/sites/default/files/dfu/amc_gm_to_part-cat_-_issue_2_amendment_18.pdf.

Documents Issued by ICAO

ICAO, Doc 9640-AN/940, "Manual of Aircraft Ground De-icing/Anti-icing Operations", 3 ed (advance unedited)

Revised in 2018 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 maintaining information updated and provides web links and bibliography to do such.

Keywords

[128] 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.

[129] This quantitative recommendation does not appear in AS6285 nor in AS6286. Current (January 2021) ICAO personnel were not aware of its origin.

ICAO, Doc 4444, “Procedures of Air Navigation Services: Air Traffic Management”, 16th Edition

Revised October 11, 2016 by ICAO.

This document has a short section[130] that describes the standard phraseology to be used by flightcrew and groundcrew in deicing/anti-icing operations. Only the section (12.7.2) dealing with deicing/anti-icing operations is indexed in the *Guide.*

Keywords
anti-icing code, s. 12.7.2.2
communication with flightcrew – aircraft configuration (deicing), s 12.7.2.1
communication with flightcrew – all clear signal, s 12.7.2.2
communication with flightcrew – anti-icing code, s 12.7.2.2
communication with flightcrew – before starting deicing/anti-icing, s 12.7.2.1
communication with flightcrew – deicing unit proximity sensor activation s 12.7.2.3
communication with flightcrew – emergency, s 12.7.2.3
communication with flightcrew – interrupted operations, s 12.7.2.3
communication with flightcrew – postdeicing/anti-icing check completion, s 12.7.2.2
communication with flightcrew – proximity sensor activation s 12.7.2.3
communication with flightcrew – HOT, start of, s 12.7.2.2
communication with flightcrew – fluid Type, s 12.7.2.2
emergency – communications, s 12.7.2.3
PANS-ATM – deicing/anti-icing phraseology, s 12.7.2
phraseology, deicing/anti-icing, s 12.7.2

[130] (Montreal: ICAO, 10 November 2016) at pp 12-43 to 12-44, http://flightservicebureau.org/wp-content/uploads/2017/03/ICAO-Doc4444-Pans-Atm-16thEdition-2016-OPSGROUP.pdf.

Documents Issued by Others

Transportation Safety Board of Canada, Air Transportation Safety Investigation Report A17C0146

Issued October 28, 2021, by the Transportation Safety Board of Canada.

The is the investigation report into the West Wind Aviation L.P. ATR-42 accident in Fond-du-Lac, Saskatchewan on December 13, 2017.

The aircraft accumulated ice on descent into Fond-du-Lac and more contamination while on the ground.

> Company departures from remote airports, such as Fond-du-Lac, with some amount of surface contamination on the aircraft's critical surfaces had become common practice, in part due to the inadequacy of de-icing equipment or services at these locations. The past success of these adaptations resulted in this unsafe practice becoming normalized and this normalization influenced the flight crew's decision to depart.
>
> Although the flight crew were aware of icing on the aircraft's critical surfaces, they decided that the occurrence departure could be accomplished safely. Their decision to continue with the original plan to depart was influenced by continuation bias, as they perceived the initial and sustained cues that supported their plan as more compelling than the later cues that suggested another course of action.
>
> ... immediately after liftoff, the aircraft began to roll to the left without any pilot input. This roll was as a result of asymmetric lift distribution due to uneven ice contamination on the aircraft.
>
> This loss of control in the roll axis, which corresponds with the known risks associated with taking off with ice contamination, ultimately led to the aircraft colliding with terrain 17 seconds after takeoff (pp 8–9).

The Transportation Safety Board of Canada considers the unavailability or inadequacy of equipment to inspect, deice or anti-icing aircraft at remote airports to pose a high risk to transportation safety (p 11).

Only the sections dealing with ground icing are indexed as several sections of the report are beyond the scope of the *Guide*. Ground icing and frost formation (pp 35–40) are succinctly well explained.

It is remarkable that this investigation report makes full use of modern psychology to explain the effects of various cognitive biases, such as confirmation bias and plan continuation bias, and their effects on situational awareness and decision making (ss 1.18.2–1.18.3)[131].

[Opinion: people involved in ground deicing should read the entire report, it is well worth the time.]

Keywords
adaptation – definition, s 2.2.4.1.3
adaptation – normalization, s 2.2.4.2
aircraft icing conditions – definition s 1.7.3.1
airport remote. *See* remote airport
bias, cognitive, s 1.18.2.2
bias, confirmation – definition, s 1.18.2.2
bias, continuation – definition, s 1.18.2.2
bias, continuation, p 8, ss 1.18.2.2, 2.1.2, 2.2.4.3. 3.1
check, spoiler – definition, s 1.1.5
clean aircraft concept – definition, s 2.2.3
clear ice – difficulty to detect, s 2.1.3.2
clear ice – formation from supercooled mist droplets, ss 2.1.3.1–2.1.3.2
cognitive bias.
condensation – definition, s 1.7.3.4.2
contamination [frozen] – from engine exhaust, s 2.1.3.5
decision making – definition, s 1.18.2
definition – adaptation, s 2.2.4.1.3
definition – aircraft icing conditions s 1.7.3.1
definition – bias, confirmation, s 1.18.2.2
definition – bias, continuation, s 1.18.2.2
definition – clean aircraft concept, s 2.2.3
definition – condensation, s 1.7.3.4.2
definition – decision making, s 1.18.2
definition – dewpoint, s 1.7.3.4.2
definition – engine hotel mode, s 1.1.4
definition – fog, s 1.7.3.4.2
definition – frost point, s 1.7.3.4.2
definition – icing conditions, aircraft s 1.7.3.1
definition – icing conditions, atmospheric s 1.7.3.1
definition – latent heat, s 1.7.3.4.2
definition – mist, s 1.7.3.4.2
definition – nucleation, s 1.7.3.4.2
definition – safety risk management, s 1.17.2.6.4
definition – saturation, s 1.7.3.4.2
definition – situational awareness, s 1.18.2
definition – spoiler check, s 1.1.5
definition – supercooled water, s 1.7.3.4.2

[131] The TSB of Canada refers to Sidney Dekker, *Drift Into Failure: From Hunting Broken Components to Understanding Complex Systems* (Boca Raton: Ashgate, 2011) [a demanding book, but it explains a lot of our complex world].

[132] The ice to water vapor saturation curve is also known as the sublimation curve.

Standardized International Aircraft Ground Deicing Program (SIAGDP), Revision July 2020

Issued July 7, 2020, by United States 14CRF Part 121 air carriers.

The Standardized International Aircraft Ground Deicing Program (SIAGDP) is an FAA recognized program allowing FAA 14CFR Part 121 carriers to share a compliant standardized program in international locations [outside the United States]. This allows the participating airlines to pool deicing audits results. At the core of this program are the de/anti-icing vendor audits (DEVA). Results of DEVA audits, performed by each participant airline are hosted by Airlines for America (A4A). The information submitted to A4A comprises 1) list of designated auditors, 2) schedule of planned audits, 3) DEVA results, and 4) corrective actions including acceptance or rejection of the audited location.

The participating FAA 14CFR Part 121 airlines as of July 01, 2020, are Alaska Airlines, American Airlines, Delta Air Lines, Federal Express, Express Jet, Horizon Air, Sky West, United Air Lines, and UPS.

Keywords

[133] Pre-season and start-of-the-season appear to be used interchangeably.

[134] Although not listed in the SIAGDP, the hazard category of the fluid, a mandatory requirement for shipping chemicals, should appear on the sample label or the shipping manifest.

[135] AS6285 says “fluid delivery”, from a groundcrew perspective, it should be fluid acceptance.

Joel Hille, "Deicing and Anti-icing Fluid Residues", (2007) Q1 Boeing Aero Magazine article 3.

Issued 2007 by Boeing.[136]

Provides information about the hazards, formation and inspection of Type II/III/IV fluid residues on aircraft.

Keywords

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[136] Joel Hille, (2007) Q1 Boeing Aero Magazine, article 3, https://www.boeing.com/commercial/aeromagazine/articles/qtr_1_07/article_03_1.html.

Haruiko Oda et al, “Safe Winter Operations”, (2010) Q4 Boeing Aero Magazine article 2

Issued October 2010 by Boeing.[137]

[137] Haruiko (Harley) Oda, Philip Adrian, Michael Arriaga, Lynn Davies, Joel Hille, Terry Sheehan, E.T. (Tom) Suter, (2010) Q04 Boeing Aero Magazine 13, http://www.boeing.com/commercial/aeromagazine/articles/2010_q4/2/.

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

Keywords

PART TWO: THE RUNWAY DEICING DOCUMENTS

A chart of the runway deicing documents can be found in Figure 2 at p 338.

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

AMS1431E Solid Runway Deicing/Anti-Icing Product

Revised October 24, 2018, by SAE G-12 RDP.

Sponsor: Melissa Copeland.

AMS1431 sets the technical requirements for runway deicing and anti-icing products in solid form. 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
definition – RDP, solid – lot, s 4.3
RDP, solid – acceptance tests – chloride content, s 4.2.1
RDP, solid – acceptance tests – flash point, s 4.2.1
RDP, solid – acceptance tests – total water content, 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 – appearance, s 3.1.5
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 – brining, s 1.3.1.1
RDP, solid – cadmium as contaminant, s 3.1.2
RDP, solid – cadmium corrosion, s 3.2.9.3.1
RDP, solid – carbon brake oxidation, s 3.2.11
RDP, solid – changes in ingredients, s 4.4.2
RDP, solid – changes in manufacturing, s 4.4.2
RDP, solid – chloride content, ss 3.2.3, 4.2.1
RDP, solid – chromium as contaminant, s 3.1.2
RDP, solid – commingling, s 1.3.1
RDP, solid – compatibility with other RDP, s 1.3.1
RDP, solid – composition, s 3.1
RDP, solid – containers, ss 5.1.2, 5.1.4, 8.4
RDP, solid – delivery, s 5

[138] Usually liquefaction is a process whereby, in a phase transition, a gas or a solid becomes a liquid. In this case, it seems dissolution would be a better term as the RDP is dissolved in water to form a solution. The dissolution process of a salt is also known as brining.

RDP, solid – safety data sheet, s 4.5.1
RDP, solid – sampling plan, s 4.3
RDP, solid – sampling, s 4.3
RDP, solid – sandwich corrosion, s 3.2.9.1
RDP, solid – statistical sampling, s 4.3.1
RDP, solid – storage stability, s 3.2.4
RDP, solid – stress corrosion resistance, s 3.2.9.5.1
RDP, solid – subcontractor manufacturing, s 4.4.3
RDP, solid – sulfur as contaminant, s 3.1.2
RDP, solid – TOD, s 3.1.1.2
RDP, solid – total immersion corrosion, s 3.2.9.2
RDP, solid – total water content, ss 3.1.3, 4.2.1
RDP, solid – trace contaminants, s 3.1.2
RDP, solid – transportation, s 5.1.4
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

AMS1435D Liquid Runway Deicing Product

Revised November 2, 2018, by SAE G-12 RDP.

Sponsor: Carla Potts.

AMS1435 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, sometimes called runway deicing fluids, must never be used as aircraft deicing fluid.

Keywords
aircraft maneuvering area deicing product. *See* RDP
airfield deicing fluid. *See* RDP
apron deicing product. *See* RDP
definition – RDP, liquid – lot, s 4.3
fluid runway and taxiway deicing/anti-icing compound. *See* RDP. liquid
liquid runway and taxiway deicing/anti-icing compound. *See* RDP, liquid
RDF. *See* RDP, liquid
RDP, fluid. *See* RDP, liquid

AIR6130A Cadmium Plate Cyclic Corrosion Test

Revised May 18, 2017, by SAE G-12 RDP.

Sponsor: Joel Hille; Michael Arriaga for the next version.

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 AMS1431E and AMS1435D 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 corrosion test – AMS1431 sample, s 3c
cadmium plate corrosion test – AMS1435 sample, s 3b
cadmium plate corrosion test – cleaning of test specimens, s 5b
cadmium plate corrosion test – criterion for undesirable corrosion effects, s 6
cadmium plate corrosion test – gravimetric results, ss 5i., 5l.
cadmium plate corrosion test – procedure, s 5
cadmium plate corrosion test – runway deicing compound sample, s 3
cadmium plate corrosion test – sample preparation, s 4
cadmium plate corrosion test – steel substrate, s 3
cadmium plate corrosion test – test coupons, s 3
cadmium plate corrosion test – test results, s 6
cadmium plate corrosion test – test specimen, s 3
cadmium plated aircraft parts – RDP caused corrosion, s 1
cadmium plated aircraft parts corrosion test. *See* cadmium plate corrosion test
corrosion of cadmium plated aircraft parts – undesirable corrosion criterion, s 6
corrosion of cadmium plated aircraft parts, s 1
RDP – cadmium plate 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

AS6170 Ice Melting Test Method for Runways and Taxiways Deicing/Anti-Icing Chemicals

Issued October 28, 2021, by SAE G-12 RDP; replaces AIR6170A.

Sponsor: Marc-Mario Tremblay.

AS6170 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.

Keywords

AS6172 Ice Undercutting Test Method for Runways and Taxiways Deicing/Anti-Icing Chemicals

Issued October 28, 2021, by SAE G-12 RDP; replaces AIR6172A.

Sponsor: Marc-Mario Tremblay.

AS6172 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 3.4.4
RDP ice undercutting test dye – fluorescein, s 3.4.4
RDP ice undercutting test equipment, s 3.3
RDP ice undercutting test ice cavity preparation, s 3.3.5
RDP ice undercutting test ice preparation, s 3.3.4
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 – potassium acetate solution, ss 3.3.1, 3.4.3, 3.4.3.1, 3.4.3.2
RDP ice undercutting test reference control solution – potassium acetate ACS grade, ss 3.3.1, .4.3, Table 1
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
RDP ice undercutting test temperature, ss 3.5, 3.6
RDP ice undercutting test, Title at p 1
RDP, liquid – ice undercutting test. *See* RDP ice undercutting test
RDP, solid – ice undercutting test. *See* RDP ice undercutting test
SHRP H-332, s 2.3

AS6211 Ice Penetration Test Method for Runways and Taxiways Deicing/Anti-Icing Chemicals

Issued November 16, 2021, by SAE G-12 RDP; replaces AIR6211A.

Sponsor: Marc-Mario Tremblay.

AS6211 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 ACS grade, ss 3.3.1, 3.4.3, 3.4.3.1, 3.4.3.2, Table 1
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

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

AIR5490A Carbon Brake Contamination and Oxidation

Revised April 12, 2016, 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.[139]

[139] 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.

Keywords

[140] 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.

[141] 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).

AIR5567A Test Method for Catalytic Brake Oxidation

Issued August 17, 2015, 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

[142] 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.

Documents Issued by SAE AE-8A Elec Wiring and Fiber Optic Interconnect Systems Installation

AIR7988 Impact of Alkali Metal-Based Runway De-icing Fluids on Aircraft Electrical Systems

Issued December 21, 2021, by SAE AE-8A.

This document was issued to raise awareness of the degrading effects of alkali organic salts runway deicing products on electrical wiring interconnection systems (EWIS) of aircraft.

It provides historical perspective of the introduction of alkali organic salt based (potassium formate, potassium acetate, sodium formate and sodium acetate) runway deicing products due to environmental regulations displacing urea and glycol based runway deicing products.

Issues related to connector corrosion, connector shorting, arcing in wire bundles, electrical connectors, switches and relays are described. The areas affected are landing gear systems, and electrical systems in wing flaps and leading edges.

Results of conductivity testing and wet arc track testing are presented.

Mitigation strategies are proposed to reduce effect of alkali metal based runway deicing product on aircraft electrical systems.

Keywords
alkali organic salts – effect on aircraft electrical systems, Title on p 1, ss 3, 4
alkali organic salts – electrical connector arcing, s 4
alkali organic salts – electrical connector corrosion, s 4
alkali organic salts – electrical connector shorting, s 4
alkali organic salts – electrical switch arcing, s 4
alkali organic salts – electrical wire bundle arcing, s 4
potassium acetate – *See* alkali organic salts
potassium formate – *See* alkali organic salts
RDP – aluminum corrosion, s 5
RDP – cadmium corrosion – mitigation, s 5
RDP – conductivity testing, s 5
RDP – effect on aircraft electrical systems, Title on p 1, ss 3, 4
RDP – effect on electrical systems – mitigation, s 6
RDP – electrical connector arcing, s 4
RDP – electrical connector corrosion, s 4
RDP – electrical connector shorting, s 4
RDP – electrical switch arcing, s 4

Documents Issued by SAE G-15 Airport Snow and Ice Control

AMS1448B Sand, Airport Snow and Ice Control

Stabilized September 5, 2014, by SAE G-15.

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

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 December 31, 2008, by the FAA.[143]

This bulletin informs aircraft owners and operators of the deleterious effect of alkali organic salt based runway deicing products on aircraft with carbon brakes. The alkali moiety of the organic salts is 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 – inspection frequency, pp 2–3
carbon brake – inspection of rotor, pp 2–3
carbon brake – inspection of stator, pp 2–3
carbon brake contamination – detection – visual – carbon chips, p 2
carbon brake contamination – detection – visual – crushed carbon, p 2
carbon brake contamination – detection – visual – damaged carbon, p 2
carbon brake contamination – detection – visual – debris, p 2
carbon brake contamination – detection – visual – flaked carbon, p 2
carbon brake contamination – detection – visual – frayed carbon, p 2
carbon brake contamination – detection – visual – missing carbon, p 2
carbon brake contamination – detection – visual – soft carbon, p 2
carbon brake contamination – detection – visual p 2
carbon brake contamination – effect – brake failure during aborted takeoff, p 2
carbon brake contamination – effect – brake failure, p 3
carbon brake contamination – effect – dragged brake, p 2
carbon brake contamination – effect – overheated brakes, p 2
carbon brake contamination – effect – vibrations, p 2
carbon brake contamination – process, pp 1-2
carbon brake contamination – source – catalyst – alkali metal based RDP, p 1
carbon brake contamination – source – catalyst – potassium acetate, p 1
carbon brake contamination – source – catalyst – potassium formate, p 1
carbon brake contamination – source – catalyst – RDP, p 1
RDP – catalytic oxidation of carbon brakes, p 1
RDP – oxidation of carbon brakes, p 1

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143 https://rgl.faa.gov/Regulatory_and_Guidance_Library/rgSAIB.nsf/0/E6256BF39E321CD18625753000552A06?OpenDocument&Highlight=%20nm-08-27r1.

FAA, Advisory Circular AC No 150/5200-30D, "Airport Field Condition Assessments and Winter Operations Safety"

Issued October 29, 2020, by the FAA.[144]

This is a large document addressing various aspects of runway conditions. Only the sections 4.5–4.7 relating to runway deicing products are indexed.

Keywords
AMS1431 – recognition – FAA, ss 4.6.1.2–4.6.1.2.2
AMS1435 – recognition – FAA, s 4.6.1.1.
pavement. *See* runway
RDP – airside application, s 4.6.2
RDP – effect on dissolved oxygen, s 4.6.3.1
RDP – effect on Portland cement, s 4.6.3.2
RDP – liquid v solid, s 4.5.1
runway – friction control – brooms, s 4.5.2
runway – friction control – plowing, s 4.5.2
runway – friction control – RDP, s 4.5.2
runway – friction control – sand, ss 4.5.2, 4.7, 4.7.2
runway – friction control – urea, s 4.6.1.2.2
runway – ice control – prevent bond between ice and pavement, s 4.5.1
runway – ice removal – mechanical removal, s 4.5.1
runway – ice removal – melting of bonded ice, ss 4.5.1–4.5.2
urea – recognition – FAA, ss 4.6.1.2.1–4.6.1.2.2
urea, s 4.6.1.2

Documents Issued by Transport Canada

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

Issued June 26, 2009, by Transport Canada.

This advisory informs aircraft owners and operators of the deleterious effect of alkali organic salt based runway deicing products on aircraft with carbon brakes. The alkali moiety of the organic salts is 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.

[144] https://www.faa.gov/airports/resources/advisory_circulars/index.cfm/go/document.current/documentnumber/150_5200-30.

Keywords
carbon brake – inspection frequency, p 2
carbon brake – inspection of rotor, p 2
carbon brake – inspection of stator, p 2
carbon brake contamination – detection – visual – carbon chips, p 2
carbon brake contamination – detection – visual – crushed carbon, p 2
carbon brake contamination – detection – visual – damaged carbon, p 2
carbon brake contamination – detection – visual – flaked carbon, p 2
carbon brake contamination – detection – visual – missing carbon, p 2
carbon brake contamination – detection – visual – soft carbon, p 2
carbon brake contamination – effect – brake degradation, p 1
carbon brake contamination – effect – brake failure during aborted takeoff, p 1
carbon brake contamination – effect – brake failure, p 1
carbon brake contamination – effect – dragged brake, p 1
carbon brake contamination – effect – overheated brakes, p 1
carbon brake contamination – effect – vibrations, p 1
carbon brake contamination – process, p 1
carbon brake contamination – source – catalyst – alkali metal based RDP, p 1
carbon brake contamination – source – catalyst – potassium acetate, p 1
carbon brake contamination – source – catalyst – potassium formate, p 1
carbon brake contamination – source – catalyst – RDP, p 1
RDP – catalytic oxidation of carbon brakes, p 1
RDP – oxidation of carbon brakes, p 1

Documents Issued by EASA

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

Issued September 01, 2018, by EASA.

Alkali organic salt 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
Aeronautical Information Publication reporting – RDP, p 1
alkali organic salts – aircraft maintenance program, p 1
alkali organic salts – effect on carbon brakes, p 1
alkali organic salts – oxidation of carbon brakes, p 1

carbon brake contamination – process, p 1
RDP – oxidation of carbon brakes, p 1
RDP – reporting recommendation, p 2
RDP – SNOWTAM display, p 1
SNOWTAM – EG, p 2
SNOWTAM – GAC, p 2
SNOWTAM – KAC, p 2
SNOWTAM – KFOR, p 2
SNOWTAM – NAAC, p 2
SNOWTAM – NAFO, p 2
SNOWTAM – PG, p 2
SNOWTAM – SAND, p 2
SNOWTAM – UREA, p 2
SNOWTAM reporting – RDP, p 1

EASA, Safety Information Bulletin SIB No. 2008-19R2, "Catalytic Oxidation of Aircraft Carbon Brakes due to Runway De-icers"

Revised April 23, 2013, by EASA.

This bulletin informs aviation stakeholders of the deleterious effect of alkali organic salt based runway deicing products on aircraft with carbon brakes. The alkali moiety of the organic salts is 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®[145] 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
alkali organic salts – effect on wire bundles, p 2
carbon brake – inspection frequency, p 3
carbon brake – inspection of rotor, p 3
carbon brake – inspection of stator, p 3
carbon brake contamination – detection – visual – carbon chips, p 3
carbon brake contamination – detection – visual – crushed carbon, p 3
carbon brake contamination – detection – visual – damaged carbon, p 3
carbon brake contamination – detection – visual – debris, p 3
carbon brake contamination – detection – visual – flaked carbon, p 3

[145] Trademark of E. I. du Pont de Nemours and Company.

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

Issued in 2017 by EASA.

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

Keywords

Documents Issued by Boeing

Michael Arriaga, "Effects of Alkali Metal Runway Deicers on Carbon Brakes" (2014) Q1:19 Boeing Aero Magazine

Issued in 2014 by Boeing.[146]

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.

Keywords
alkali organic salts – effect on carbon brakes, pp 19–24
carbon brake – advantages – better wear, p 20
carbon brake – advantages – high temperature stability, p 20
carbon brake – advantages – reuse of worn carbon discs, p 20
carbon brake contamination – effect – brake degradation, p 20
carbon brake contamination – effect – brake fire, p 23
carbon brake contamination – effect – brake softening, p 20
carbon brake contamination – effect – debris, p 24
carbon brake contamination – effect – decreased service life, p 20
carbon brake contamination – effect – flight cancellation, p 24
carbon brake contamination – effect – flight delays, p 24
carbon brake contamination – effect – foreign object damage, p 24
carbon brake contamination – effect – mechanical degradation, p 20
carbon brake contamination – effect – structural degradation, p 20
carbon brake contamination – landing, p 20
carbon brake contamination – process, p 19
carbon brake contamination – source – catalyst – alkali metal based RDP, p 19
carbon brake contamination – source – catalyst – alkali metal based RDP, p 19
carbon brake contamination – taking off, p 20
carbon brake contamination – taxiing, p 20
carbon brake oxidation – catalytic v thermal, p 19
carbon brake oxidation – exposure time to alkali, p 20
carbon brake oxidation – exposure to ADF – insignificant contribution, p 19
carbon brake oxidation – exposure to alkali based RDP – significant contribution, p 19
carbon brake oxidation – exposure to glycol based RDP – no catalytic oxidation, p 19
carbon brake oxidation – exposure to urea RDP – no catalytic oxidation, p 19
carbon brake oxidation – history of, pp 19–20
carbon brake oxidation – mitigation – anti-oxidant brake coatings, p 24

[146] (2014) 53 Q01 Boeing Aero Magazine 19, http://www.boeing.com/commercial/aeromagazine/articles/2014_q1/pdf/AERO_2014q1.pdf.

QUESTIONS AND ANSWERS

This section assembles information on aircraft deicing that may be useful to newcomers or experienced practitioners. The questions and answers provide a way to explore some aspects of deicing that may not always be apparent by reading standard documentation. These questions normally arise from a) inquiries sent to SAE about standards, b) discussion at SAE G-12 or c) comments received as a result of the publication of this *Guide*. My aim is to provide crisp, concise, simplified ways of looking at issues, offer hints and tips, and stimulate thinking about deicing/anti-icing concepts. The Q&A section is not meant to provide a complete technical presentation of the subjects.

Holdover Time

1. What are the differences between the FAA and Transport Canada *Holdover Time Guidelines*?

The FAA and Transport Canada *Holdover Time Guidelines* are derived from the same data set. There are some differences[147]:

- **Snowfall intensities**. The snowfall intensities as a function of prevailing visibility tables are significantly different.

- **Very light snow cells**. In 2019-2020, very light snow at TC was based on a precipitation rate of 4 g/dm2/h. In 2020-2011, it is now harmonized with the FAA with a range of 3–4 $g/dm^2/h$.

- **Snow cells**. TC caps snow holdover times at 2 hours; FAA caps snow holdover times at 3 hours. This results in different holdover times in some cases. Holdover time tables impacted: select Type II and Type IV fluid-specific and Type IV generic.

- **Light freezing rain** "-3°C and above" and "below -3 to -6°C" cells. The TC Type I holdover time tables give holdover times for these cells based on testing conducted at -6°C;

[147] Information provided, in 2019, by Stephanie Bendickson of APS Aviation with authorization by Antoine Lacroix of Transport Canada. Updated in 2020 with data provided by Ben Bernier of APS Aviation. Thank you.

the FAA Type I holdover time tables give holdover times for these cells based on testing conducted at -10°C. Holdover time tables impacted: Type I.

- Some **Cautions** of the holdover time tables are different for TC and FAA. Holdover time tables impacted: all.
- Transport Canada divided in 2020-2021 its one-step **fluid application guidelines** into two columns "one-step procedure deicing only" and "one-step procedure anti-icing only". The FAA did not make that change in 2020-2021 and retained the one combined column for one-step procedures (one-step deicing/anti-icing).

The HOT Guidelines must be read with their respective accompanying documents. For the FAA it is the FAA Notice N 8900.594, "Revised FAA–Approved Deicing Program Updates, Winter 2021–2022" and for Transport Canada, *Guidelines for Aircraft Ground Icing Operations,* TP 14052E, issue 6, August 2021. These two documents differ significantly.

2. Is a generic holdover time the same as a generic holdover time table?

No. The generic holdover time is the shortest holdover time for all Type II fluids or for all Type IV fluids within a specified temperature range and for a specific precipitation type. When assembled in the form of a table with cautions and notes, as published by the FAA or Transport Canada, the compilation of the generic holdover times constitutes a *generic holdover time table*.

The series of holdover time tables published by the FAA or Transport Canada, are entitled *Holdover Time Guidelines*.

3. How many generic holdover time guidelines are there?

Excluding the active frost holdover time guideline, there are four holdover time tables that are labeled as generic: 1) a generic Type II holdover time table, 2) an adjusted generic Type II holdover time table, 3) a generic Type IV holdover time table, and 4) an adjusted generic Type IV holdover time table.

4. Is there a generic Type III holdover time guideline?

Not at this time. As there is only one Type III on the market, the only Type III holdover time table is a fluid-specific holdover time table. It would take at least two commercially available Type III fluids to create a generic Type III fluid holdover time guideline.

5. How many Type I fluid holdover time guidelines are there?

Six:
1) the active frost HOT guideline (with Type II/III/IV fluids in the same table)
2) the Type I HOT guideline for aircraft surfaces composed predominantly of aluminum
3) the Type I HOT guideline for aircraft surfaces composed predominantly of composites
4) the adjusted active frost HOT guideline (with Type II/III/IV fluids in the same table)
5) the adjusted Type I HOT guideline for aircraft surfaces composed predominantly of aluminum
6) the adjusted Type I HOT guideline for aircraft surfaces composed predominantly of composites

6. Why are Type I holdover time guidelines not labeled “generic”?

The Type I holdover time guidelines are all-inclusive in the sense that all Type I fluids can be used with Type I holdover time guidelines, irrespective of brand, provided they are listed in the FAA/Transport Canada list of fluids.

Normally, Type I holdover time guidelines are not called “generic” and are not labeled “generic” when published by the FAA and Transport Canada.

In the field of deicing/anti-icing, the term generic implies the construction of holdover time guidelines from fluid-specific holdover times. The are no fluid-specific Type I holdover time guidelines.

Generic holdover time guidelines change each winter due to the listing or delisting of Type II/IV fluids. This process does not occur with Type I fluids.

New Type I fluids are checked for anti-icing performance (WSET and HHET) and aerodynamic acceptance to ensure that they work and if they are listed by the FAA and Transport Canada, they can be used with the Type I holdover time guidelines.

In summary, the Type I holdover time guidelines can be used with all Type I fluids listed by the FAA and Transport Canada but they are not labeled as generic and do not go through the process of producing generic holdover time guidelines from fluid-specific data.

7. What is the meaning of *standard* in "standard holdover time" and "standard allowance time"?

A *standard holdover time* is a simply a holdover time that is not adjusted.

A *standard allowance time* is a simply an allowance time that is not adjusted.

The qualifier "standard" is rarely used in normal parlance. Only when comparing the unadjusted times to adjusted times do we refer to standard holdover times or standard allowance times.

8. What is the meaning of *adjusted* in "adjusted holdover time" and "adjusted allowance time"?

An *adjusted holdover time* is a reduced holdover time to take into consideration that extended flap and slat configurations accelerate fluid drainage from wings, reducing the protection capacity of Type I/II/III/IV fluids.

An *adjusted allowance time* is a reduced allowance time to take into consideration that extended flap and slat configurations accelerate fluid drainage from wings, reducing the protection capacity of Type III/IV fluids. There is no standard allowance time for Type I and Type II fluids, thus no adjusted allowance times for Type I and Type II fluids.

FAA and Transport Canada publish sets of 76% adjusted holdover time tables and 76% adjusted allowance time tables; this means the standard holdover and allowance times have been multiplied by 76% and rounded. In other words, these adjusted times have been reduced by about 24% when compared to standard holdover or standard allowance times.[148]

[148] FAA and Transport Canada started publishing adjusted holdover time and adjusted allowance times for the winter 2014-2015.

9. Are "fluid application tables" the same as a "guidelines for the application of Type I/II/III/IV fluids"?

Yes. The FAA and Transport Canada publish in their respective annual *Holdover Time Guidelines* the following tables:

- Guidelines for the Application of SAE Type I Fluid
- Guidelines for the Application of SAE Type II and IV Fluid
- Guidelines for the Application of Unheated SAE Type III Fluid

The FAA, Transport Canada and users refer collectively to these guidelines as fluid application tables or individually as a fluid application table.

SAE Standards

10. When does any SAE standard (AMS, AS, ARP, AIR) become effective?

It becomes effective on the date of issue unless the standard states an effective date. There is no grace period.

Examples:

AMS1431E and AMS1435D only have issue dates and no separate effective date:

AMS1431E issued and became effective on October 24, 2018;
AMS1435D issued and became effective on November 2, 2018.

AS6285D issued on May 18, 2021, became effective on August 1, 2021.

11. Does a manufacturer need to retest to all the technical requirements when a revised Aerospace Material Specification (AMS) is issued?

My understanding is no; my answer is based on custom and purpose of the SAE G-12 standards in general, of Aerospace Material Specifications in particular and on a precedent setting decision made by the SAE G-12 Fluids Subcommittee (as it was then called) on May 20, 1996.[149] In this particular case, as the Subcommittee had just approved the publication of AMS1424A, the first

[149] SAE Fluids Subcommittee Meeting Minutes, Zurich Airport (10 May 1996) at p 1.

revision ever of AMS1424, it was decided that fluids qualified for AMS1424 would only have to test to the changes in AMS1424A.[150]

In summary, only the tests for which the technical requirements have changed need to be performed. Otherwise, every time a specification is issued, all tests would have to be redone entirely. That would be expensive and inefficient. The purpose of issuing a revised version of a specification is to update whatever has been changed and not to force an entire requalification. For example, sometimes, a caution note will be added and none of the technical requirements change; in those instances, clearly, there is no need to retest the product.

12. Is it necessary to wait for the result of the storage stability test before offering for sale a product according to an AMS specification?

The purchaser can waive this requirement until the results are known. AMS1428 s 4.2.3 allows purchasers to waive storage stability requirement until the results become available. The testing laboratory will generally state on the qualification test report that the long term stability test is under way.

13. Can a purchaser waive a requirement?

There are provisions usually in AMS standards for a purchaser to waive a requirement. For instance, see section 7 of AMS1424R, AMS1428K, AMS1431E and AMS1435D:

> 7. REJECTIONS
> Product not conforming to this specification, or to modifications authorized by purchaser, will be subject to rejection.

The words "modifications authorized by the purchaser" are understood to include waiving of a requirement. If a purchaser waives a requirement, the purchaser should have the required competence, experience and authority, particularly if regulated, to waive the requirement.

[150] SAE AMS1424A Deicing Anti-Icing Aircraft, SAE Type I (October 1996).

Fluid Resides and Residual Fluids

14. Are residual fluid and fluid residue the same?

No. *Residual fluid* refers to Type I, II, III or IV fluid that is left on the surface of the aircraft during flight or after flight.

Fluid residue is usually Type II, III or IV that has dried up in aerodynamically quiet areas of the aircraft. The dried up residue can rehydrate when exposed to rain and humidity to form a gel that may freeze and impede the movement of control surfaces.

Lowest Operational Use Temperature and Highest Operational Use Concentration

15. What is the lowest aerodynamic acceptance temperature of a Type I fluid?

As temperature goes down, the viscosity of a Type I fluid goes up. This makes it more difficult for the Type I fluid to come off the aircraft during the takeoff run. The presence of fluid at takeoff increases lift loss. As the temperature lowers, there can be a point where the higher viscosity causes the fluid to flow off in a manner that creates too much lift loss and it becomes unacceptable to attempt takeoff with the fluid. Wind tunnel tests are performed on Type I fluids to determine the *lowest aerodynamic acceptance temperature* (LAAT). The LAAT corresponds to the lowest temperature at which a fluid does not cause unacceptable lift loss.

There are three aerodynamic acceptance tests: 1) a high speed ramp test, designed for the large jet aircraft (aka high speed aircraft), 2) a middle speed ramp test, designed for the large commuter turbo-prop aircraft (aka middle speed aircraft), and 3) a low speed ramp test, designed for the low speed aircraft.

The high speed LAAT is used to calculate the lowest operational use temperature (LOUT) for high speed aircraft.

The middle speed LAAT is used to calculate the lowest operational use temperature (LOUT) for middle speed aircraft.

The low speed LAAT is used to calculate the lowest operational use temperature (LOUT) for low speed aircraft.

16. What are the highest operational use concentration and the highest operational use refraction of a Type I fluid?

Q&A no. 15 explains that as the temperature goes down, the viscosity of a Type I goes up. As the glycol concentration of a Type I fluid goes up, the viscosity of the Type I fluid also goes up. Viscosity is controlled not only by temperature but also by the glycol concentration. When the aerodynamic acceptance test is run to determine the LAAT, the glycol concentration of the Type I fluid is measured. This glycol concentration becomes the highest glycol concentration at which this Type I can be used; it can be defined as the *highest operational use concentration* (HOUC).

Glycol concentration can be expressed as weight percent glycol in water. More often it is expressed as the volume ratio of Type I fluid concentrate, as sold by the manufacturer, to water; for instance, 75/25 would be 75 parts of Type I concentrate and 25 parts of water. A better way of expressing the highest operational concentration is to express it as refraction.

It is not easy to directly measure the weight percent glycol in water; it is easier to measure it indirectly using a refractometer. The glycol concentration, as measured by refraction, during the aerodynamic test can be defined as the highest operational use refraction (HOUR). The refraction can be expressed in units of refractive index (RI), in degree Brix (°Brix), in degrees Fahrenheit (°F) or degrees Celsius (°C) (see Q&A no. 39).

Refraction is a better way of expressing the highest operational use concentration (HOUC) rather than percent glycol or ratio of concentrate to water because refraction can be measured easily, in the field, with a refractometer.

17. Where can the highest operational use refraction of a Type I fluid be found?

It is the responsibility of the Type I fluid manufacturer to provide the highest operational use refraction (HOUR) for the highest operational use concentration (HOUC) for the high speed, middle speed and low speed aerodynamic acceptance tests. The refraction data will be given in units of refractive index or degree Brix.

The middle speed aerodynamic acceptance test is new and data is still unavailable (as of May 2022).

As an example, the highest operational use concentration for UCAR™ ADF Concentrate is a volume ratio of 75/25 (UCAR™ ADF Concentrate/water) with a highest operational use refraction of 42°Brix. The same volume ratio with the same refraction was used in both the high speed and low speed aerodynamic acceptance tests.

18. Where can the lowest operational use temperature (LOUT) at the highest operational use concentration for a Type I be found?

The lowest operational use temperature (LOUT) at the highest operational use concentration (HOUC) can be found in the FAA and Transport Canada lists of Type I fluids. The FAA and TC lists of fluids can be found in the latest issue of the respective *Holdover Time Guidelines*. The LOUT is given for both the high speed test and for the low speed test.

The FAA and TC lists of fluids state the highest operational use concentration as “Dilution (fluid/water)”; it does not provide the refraction data.

To be clear, at the highest operational use concentration (HOUC), there are two LOUT for a given Type I fluid, one for high speed aircraft and one for low speed aircraft.

The product information bulletin of the fluid manufacturer should provide you with the highest operational use concentration (HOUC) and the *highest operational use refraction* (HOUR) in unit of refractive index or in degree Brix.

The middle speed aerodynamic acceptance test is new and data may start to become available next winter.

19. Who determines if an aircraft is high speed, middle speed or low speed?

It is the responsibility of the aircraft manufacturer to determine if an aircraft is considered high speed, middle speed or low speed.

The aircraft manufacturer may impose special takeoff restrictions (e.g., flap settings, increased V_1 V_r, V_2, increased takeoff field length) when anti-icing fluids are used.

20. Does the LOUT of a neat Type IV change with every batch?

No. The lowest operational use temperature (LOUT) of a neat Type IV is set at the time of qualification. In other words, one does not recalculate the LOUT based on the exact freezing point of each batch of neat Type IV. The LOUT of neat Type IV is published by the FAA and Transport Canada in their annual *Holdover Time Guidelines* in the table entitled “Type IV Fluids Tested for Anti-Icing Performance and Aerodynamic Acceptance”. The same goes for Type II and III fluids.

Operations

21. Running out of Type IV after spraying the left-hand wing, may a different Type IV be applied to the right-hand wing?

No. Fluid application must be symmetrical. See AS6285D section 8.7.4: “Aircraft shall be treated symmetrically, that is, left-hand and right-hand side shall receive the same and complete treatment, even when only one side of the aircraft needs treatment.” There is a caution: “The aircraft is considered UNSAFE if this requirement is not met.”

Freezing Point and Freezing Point Depression

22. What is freezing point?

The temperature at which a liquid starts to become a solid as the temperature is lowered very slowly (at a given pressure).

23. Is freezing point the same as melting point?

Yes. *Freezing point* and *melting point* are defined as the temperature at which the solid phase, the liquid phase and vapor phase are at equilibrium at a given pressure. As a solid melts, it is called the melting point. As a liquid freezes, it is called the freezing point. Both processes occur at the same temperature at a given pressure.

24. Can a substance remain a liquid below its freezing point?

Yes, a liquid can be below its freezing point without going into solid phase.

For crystallization to occur, there needs to be a site where crystallization starts, a site where the formation of the first crystal is facilitated. That site is called a *nucleation site*. When there is no nucleation site, the liquid can remain liquid, for a limited amount of time.

When a liquid is below its freezing point, it is described as *supercooled*.

25. Can water be supercooled?

Yes, water can be supercooled. The purer the water and the smaller the drops of water, the easier it is to have supercool water. For example, clouds, mist and fog below 0°C, are made of tiny, supercooled water droplets.

26. What is pour point?

Some substances will not take a solid form at all or not easily. As the temperature goes down, the viscosity increases and these substances will have temperature at which they will not pour, will fail to flow and set up as a glass. That temperature is called the *pour point*.[151]

27. What is freezing point depression?

The lowering of the freezing point of a substance occurs by adding another substance to it. The substance in greater amount is called the *solvent*; the substance in lesser amount is called the *solute* or the freezing point depressant.

28. What is a solution?

A *solution* is the resultant homogeneous mixture of a solvent and a solute.

29. For deicing/anti-icing fluids, what is the solvent?

For deicing/anti-icing fluids, water is considered the solvent.

In concentrated forms of Type I fluids, one may think of the glycol as the solvent and water the solute.

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[151] Dow Chemical, *A Guide to Glycols*, form no. 117-01682-0804XSI (Midland MI: Dow Chemical, August 2004) at p 9, https://www.dow.com/documents/en-us/app-tech-guide/117/117-01682-01-a-guide-to-glycols.pdf.

30. For deicing/anti-icing fluids, what is the solute?

Glycol, usually ethylene glycol or propylene glycol, is considered the freezing point depressant or solute.

In concentrated forms of Type I fluids, one may think of the water to be the solute and glycol the solvent.

31. What is an aqueous solution?

A solution in which the solvent is water.

A solution is considered an aqueous solution even if the solute is in greater quantity than water. For example, a 90% ethylene glycol/10% water blend is considered an ethylene glycol aqueous solution; an 88% propylene glycol/12% water blend is considered a propylene glycol aqueous solution.

32. Do components, other than glycol, contribute to the freezing point depression of water in deicing/anti-icing fluids?

Yes. Components, other than glycol, such as dyes, surfactants, anti-corrosion agents, do act as freezing point depressants. Since freezing point depression depends on the number of particles of the solute in the solvent, and since the components other than glycol are present in small quantities, the number of particles, from these other components, contributing to the freezing point depression is small (see also Q&A no. 43).

33. What is a colligative property?

A *colligative property* is said of properties of solutions that vary depending on the number of (collection of, concentration of) particles (molecules or ions) present in the solvent rather than the kind of particles.[152]

Freezing point depression is a colligative property of solutions. Other colligative properties are boiling point elevation (a consequence of vapor pressure lowering) and osmotic pressure.[153]

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[152] Colligative from the Latin *colligatus*, collected together or tied together.
[153] Walter J. Moore, *Physical Chemistry*, 3ed (Englewood Cliffs, NJ: Prentice-Hall, 1962) at pp 133–135.

34. What is the freezing point of pure ethylene glycol?

The freezing point of ethylene glycol (1,2-ethanediol) is -13°C.[154]

35. What is the freezing point of pure propylene glycol?

Propylene glycol (1,2-propanediol) has two forms, called *stereoisomers*, that are mirror images of each other. There is the ***d***-form and the ***l***-form. When industrial propylene glycol is manufactured both forms are formed together in equal amount. The equal amount mixture is called the *dl*-form or *racemic mixture*. Industry simply refers to the *dl*-form as propylene glycol.

The *Merck Index*[155] reports the freezing point of propylene glycol (the *dl*-form) as -59°C while the *Handbook of Chemistry and Physics*[156] reports it as -60°C. Dow, a propylene glycol manufacturer, reports that industrial propylene glycol supercools (does not crystallize) and has a pour point below -57°C.[157]

36. Is the freezing point of an aqueous solution related to the freezing point of the freezing point depressant?

No. The freezing point of the solution is related to the number of (concentration of) particles (ions or molecules) in the water. Freezing point depression is a colligative property (see Q&A no. 33).

37. What makes a freezing point depressant more effective than another one?

Since freezing point depression is a colligative property, the product that has more molecules or ions in solution, for a given weight, is the more effective freezing point depressant.

Let's compare, in order of increasing molecular weight (mol wt) ethylene glycol (mol wt 62.07), propylene glycol (mol wt 76.10), glycerine (mol wt 92.09) and sugar (mol wt 342.30).[158]

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[154] Maryadele J. O'Neil, ed, *The Merck Index*, 15th ed (Cambridge, UK: The Royal Society of Chemistry, 2013) monograph no. 3852 at p 702 [*Merck Index*].
[155] *Merck Index*, supra note 154 at monograph no. 7968 at p 1455.
[156] David R. Lide, ed., *CRC Handbook of Chemistry and Physics*, 75th ed (Boca Raton: CRC Press, 1995) no. 9982 at p 3-273.
[157] Dow Chemical, Technical Data Sheet, "Dow PuraGuard™ Propylene Glycol USP/EP", form no. 117-126-01-0321 (Midland MI: Dow Chemical, March 2021), https://www.dow.com/documents/en-us/productdatasheet/117/117-126-01-dow-puraguard-propylene-glycol-usp-ep.pdf.
[158] *Merck Index*, supra note 154 at monograph nos. 3852, 7968, 4520, 9012 respectively.

None of these dissociate in water to produce ions. The molecular weight of a substance is the weight in grams required to have 6.022 x 10^{23} molecules.[159]

Of the products above, the most efficient freezing point depressant is ethylene glycol and the least efficient sugar.

In other words, it takes 62.07 grams of ethylene glycol to have 6.022 x 10^{23} molecules of ethylene glycol and 342.30 grams of sugar to have 6.022 x 10^{23} molecules of sugar to achieve the same freezing point depression.

38. How is freezing point measured?

Freezing point is determined by measuring the temperature of the first crystal formation as the temperature is slowly lowered. This method is time consuming and is not practical to use for day-to-day measurements or measurements in the field.

An indirect method of measurement of freezing point using refraction is used in day-to-day measurements.

Refraction

39. What is refraction?

The bending of light as it passes from one transparent substance into another.

For solutions, the refraction will vary upon the concentration of the solute in the solvent. Using a calibration curve, it is possible to determine the concentration of the solute in the solvent. For example, for aqueous glycol solutions, it is possible to determine the concentration of the glycol in water by measuring refraction with a refractometer and comparing the result to the calibration curve.

[159] Avogadro's number is defined in Bureau international des poids et mesures, *Le système international d'unités – The International System of Units*, 9 ed (Sèvres, France: BIPM, 2019) s 2.2 at p 15, https://www.bipm.org/documents/20126/41483022/SI-Brochure-9.pdf/fcf090b2-04e6-88cc-1149-c3e029ad8232?version=1.18&t=1645193776058&download=true [*SI*].

Refraction can be expressed as index of refraction or as a scale of concentration, e.g., degrees Brix (°Brix), or freezing point (°C or °F).

40. Is refractive index the same as index of refraction?

Yes.

41. What is a refractometer?

An optical apparatus that measures refraction. The results of a refractive measurement can be read as refractive index, degree Brix (°Brix) or freezing point (°C or °F).

42. Why is refraction of deicing/anti-icing fluids measured?

To verify if the concentration of the freezing point depressant, usually ethylene glycol or propylene glycol, is in the right range.

For Type I fluids dilutions, refraction is also measured to get indirectly the freezing point. The freezing point is used to calculate the lowest operational temperature.

For Type II/III/IV fluids, as the lowest operational temperatures are set and published for the neat fluid (100/0), and for the standard dilutions 75/25 and 50/50, refraction is strictly measured to verify if the freezing point depressant concentration is in the right range.

43. What is a calibration?

The process of using known reliable standards, under set conditions, to relate to an experimentally observed value.[160]

For example, a balance can be calibrated with a set of calibration weights, a pH meter calibrated with solutions of known pH, a refractometer calibrated with substances of known refraction, a viscometer calibrated with liquids of known viscosity.

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[160] Suzanne Bell, *Dictionary of Forensic Science* (Oxford: Oxford University Press, 2012) at p 38 *sub verbo* calibration.

44. What is a calibration curve?

A plot of an instrument output (or reading or response) to samples of know concentration or know physical property (e.g., refraction, viscosity, pH).

Calibration curves can be displayed as graphs (e.g., refraction vs glycol concentration), equations or tables.

45. Can the freezing point of a deicing/anti-icing fluid be obtained from a refraction measurement?

Yes, if the calibration curve, i.e., the refraction of the fluid at known concentrations vs freezing point, is available.

Some refractometers have scales from which the freezing point can be read directly for ethylene glycol aqueous solutions or for propylene glycol aqueous solutions. The user of the refractometer must select the appropriate glycol scale (the ethylene glycol scale or the propylene glycol scale). Using the wrong scale, for instance reading the result off the ethylene glycol scale when the fluid is propylene glycol based, will result in a very significant error.

Usually, the calibration curves of these refractometers are prepared with pure ethylene glycol (without additives) in water or pure propylene glycol (without additives) in water, rather than deicing/anti-icing fluids which contain water, glycol and additives. As the deicing/anti-icing fluid additives are missing from the calibration solutions, there will be a small error in the freezing point. The error in freezing point is small, but not insignificant[161], because the additives are usually present in small amounts in deicing/anti-icing fluids.

46. Does temperature affect refraction?

Yes, refraction changes with temperature.

As temperature goes down, refraction increases.

As temperature goes up, refraction decreases.

[161] MISCO, Technical Bulletin¸"*7084VP+ PG Scale vs. Palm Abbe Deicing Scales*" (Solon OH: MISCO, undated).

47. At what temperature is refraction reported?

In the laboratory, refraction is usually measured and reported at 20°C. This means the sample and the refractometer are at 20°C.

48. What is a temperature compensated refractometer?

Some refractometers, meant to be used outside of the laboratory, have a mechanism compensating for the temperature not being 20°C. These refractometers report the refraction as if it had been measured at 20°C.

According to refractometer manufacturers, the traditional analog temperature compensated refractometers can give reasonably accurate readings as long as the instrument is the range of 16°C to 38°C.

As the sample size is small (about one drop), it will equilibrate relatively quickly to the temperature of the refractometer.

Hint: in winter, as outside temperatures are low, it is important to keep these analog refractometers in the range of 16°C to 38°C.

Electronic refractometers also normally have temperature compensation which may be even wider than the analog refractometers. Check with the refractometer manufacturer for the temperature range at which they will provide accurate readings.[162]

Temperature correction curves for refractometers can be obtained from refractometer manufacturers.

49. Can the freezing point of a mixture of ethylene glycol, propylene glycol and water be obtained from a refraction measurement?

No. As the refraction of ethylene glycol and propylene glycol are different, it is impossible to get the correct freezing point by measuring refraction of a water solution that contains both glycols.

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[162] MISCO, Technical Bulletin "Palm Abbe Temperature Compensation – The Heat is On" (Solon, OH: MISCO, undated) states a temperature compensation range of 0°C to 50°C.

50. Why does refraction seems to go up with time?

The most likely cause is evaporation. Water will evaporate faster than glycols. In other words, the vapor pressure of water is higher than that of propylene glycol and ethylene glycol. As the water evaporates, the glycol concentration increases and so does the refraction.

For example, a heated fluid will slowly but surely lose water and its refraction will increase. The same is true of samples is they are left in open jars or with partially closed lids. The rates of evaporation depend on temperature and relative humidity.

Viscosity

51. What is viscosity (qualitative definition)?

Viscosity is the physical property of a fluid that characterizes its resistance to flow. Think of viscosity as resulting from the internal friction of a fluid resisting flow. For example, water is a low viscosity fluid whereas maple syrup has a higher viscosity.

The paragraph above presents a qualitative definition of viscosity.

There is also a quantitative definition (or mathematical definition) of viscosity. To understand it the following three Q&As introduce three notions: shear, shear stress and shear rate.

52. What is stress?

Stress is a force per unit area.

The unit of stress is the newton per square meter (N/m^2) or pascal (P).[163]

One pascal is defined as one newton per square meter. A one thousandth of a pascal is a millipascal (mPa).

When the force per unit area is small, the unit of stress is the millipascal (mPa).

[163] The newton (not capitalized) is the SI unit of force and whose abbreviation is N; the pascal (not capitalized) is the SI unit of pressure or stress and whose abbreviation is Pa. See *SI supra* footnote 159 at Table 4.

53. What is shear stress?

When stress, a force per unit area, acts parallel to the surface, it is called *shear stress*.

The unit of shear stress is the same as for stress, that is the newton per square meter (N/m^2) or pascal (P).

With deicing/anti-icing fluids. since shear stress is usually relatively small, the unit of shear stress is the millipascal (mPa).

Examples of shear stress situations: deicing/anti-icing fluid flowing in a pipe, air flowing above a deicing/anti-icing fluid during an aircraft takeoff run causing the fluid to flow, deicing/anti-icing fluid subjected to an air stream in a wind tunnel, fluid subjected to the rotation of a spindle in a rotational viscometer (e.g., a Brookfield viscometer).

54. What is shear rate?

Shear rate is best understood with the help of an image.

Think of a fluid flowing in a pipe. Think of the fluid as consisting of many layers of fluid. The fluid layer nearest the pipe will move slowest because of frictional force. The next layer of fluid will move a little faster. The layer at the center of the pipe will move at the highest velocity.

Shear rate is the difference in velocity of any two layers of fluid over the distance separating the two layers.

Velocity is in meter per second (m/s) and distance is in meters.

Velocity (m/s) over distance (m). The meters cancel out which leaves 1/s.

1/s is called a reciprocal second (s^{-1}).

The unit of shear rate is the reciprocal second (s^{-1}).

55. What is viscosity (quantitative definition)?

Viscosity is the ratio of shear stress over shear rate.

56. What is the unit of viscosity?

Viscosity is shear stress in pascal over shear rate in reciprocal second (P/s^{-1} = Pa▪s).

The unit of viscosity when viscosities are large is the pascal second (Pa▪s),

The unit of viscosity for deicing/anti-icing fluids is the millipascal second (mPa▪s).

57. What is a centipoise?

The centipoise (cP) is an older style unit for viscosity. In centipoise (cP) the P means poise, not pascal.

One centipoise (cP) is the exactly the same as one millipascal second (mPa▪s).[164]

58. What are synonyms for viscosity?

Apparent viscosity, shear viscosity.[165]

59. What is a Newtonian fluid?

A fluid whose viscosity remains unchanged when a shearing force is applied.

Examples of Newtonian fluids: water, Type I fluids, maple syrup, honey, ethylene glycol, propylene glycol, acetone, ethanol, glycerine. Liquids composed of molecules with a molecular weight of up to about 5000 fit the Newtonian fluid model.[166]

60. What is a non-Newtonian fluid?

A fluid whose viscosity changes when a shear force is applied.

If the viscosity decreases upon application of the shear force, the fluid is called shear thinning or pseudoplastic.

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[164] Don W. Green and Marylee Z. Southard, eds, *Perry's Chemical Engineer's Handbook*, 9th ed (New York: McGraw-Hill, 2019).
[165] H. A. Barnes, J. F. Hutton, and K. Walters, *An Introduction to Rheology* (Amsterdam: Elsevier, 1993) at p 166.
[166] R. Byron Bird, Warren E. Stewart and Edwin N. Lightfoot, *Transport Phenomena*, 2nd ed (New York: John Wiley, 2007) at pp 13, 231.

If the viscosity increases upon application of the shear force, the fluid is called dilatant.

61. What is a shear thinning fluid?

A fluid whose viscosity decreases when a shear force is applied.

62. What is a pseudoplastic fluid?

Pseudoplastic is a synonym for shear thinning. A pseudoplastic fluid is a fluid whose viscosity decreases when a shear force is applied.

AMS1428 requires Type II/III/IV fluids to be non-Newtonian and pseudoplastic (AMS1428K, title and s 1.1.3).

Examples of non-Newtonian shear thinning (pseudoplastic) fluids: Type II/III/IV fluids, paint, ketchup.

63. What are thickened fluids?

The expression, *thickened fluids,* is a generic term for any and all Type II/III/IV fluids, as all these fluids contain thickeners.

Type I fluids do not contain thickeners and are not thickened fluids.

64. What makes Type II/III/IV fluids shear thinning?

Type II/III/IV fluids contain thickeners that increase their viscosities and make them shear thinning.

These thickeners are long chain molecules called polymers. It is the entanglement of these long chain polymers that increase the viscosity.

65. Do Type II/III/IV fluids recover their initial viscosity when the shear force is no longer applied?

Yes, shear thinning is normally a reversible process.

In shear thinning the polymeric thickeners are stretched leading to less entanglement and less viscosity. When the shear force stops, the thickeners regain their original form and the viscosity recovers.

When shear forces are excessive, there may be a permanent viscosity reduction. This process is called *shear degradation*.

66. What conditions are susceptible to degrade Type II/III/IV fluids?

This is not an exhaustive list: contamination, corrosion, dilution, evaporation, heating, excessive shearing, UV radiation and time (shelf life).

67. What conditions are susceptible to cause permanent shear degradation of Type II/III/IV fluid viscosity?

Conditions susceptible to cause permanent shear degradation of Type II/III/IV include: high shear pumps such as gear pumps or centrifugal pumps, pumping through a partially open valve, sharp bends in piping, nozzles not designed for thickened fluids, high pressure settings through the nozzle, impingement at high pressure on any surface, including aircraft surfaces or sample bottles, and forced air application to the aircraft.

68. What happens during shear degradation?

Typically, thickeners are long chain molecules that can be overstretched to a breaking point during shear. If the chain is broken, it will be permanently broken and there will be a permanent decrease in viscosity.

69. What types of pump should be used with Type I fluids?

Almost any type of pump will work as Type I fluids are not sensitive to shear degradation. Centrifugal pumps are often used with Type I fluids. Type I bulk trucks are unloaded using gear pumps or air pressure or with a pump supplied by the user.

70. What types of pump should be used with Type II/III/IV fluids?

Low shear pumps such as progressive cavity pumps or positive displacement diaphragm pumps are normally used with Type II/III/IV fluids. Type II/IIIIV bulk trucks are normally unloaded with air pressure or a low shear pump supplier by the user. Do not use a gear pump with Type II/III/IV fluids.

Follow the recommendation of the fluid manufacturer to select the right kind of pump.

71. Can I filter the Type IV fluid?

Probably not. Consult with the fluid manufacturer. Filtering Type IV fluid would likely shear degrade the Type IV (for filtration of Type I see Q&As 119–120).

It is generally considered acceptable to use Type IV that has a small quantity of small particles. The way it is sometimes written in specifications is that the fluid should be *substantially free* of particles.

72. Will the viscosity all Type IV fluids permanently degrade to the same extent when subjected to a given high shear force?

No. Thickeners used in Type IV vary considerably in their resistance to permanent shear degradation of viscosity. A condition that may shear permanently a product may leave another product unaffected.

73. Is it possible to obtain from an independent organization a list of fluids fulfilling all the requirements of AMS1424 or AMS 1428?

No. There is no recognized independent organization compiling such a comprehensive list.

AMIL publishes a list of fluids that have been tested for aerodynamic acceptance, water spray endurance time and high humidity endurance time as well as expiry dates for these tests.

The FAA and Transport Canada publish a list of fluids with which holdover time tables can be used.

No one publishes a list of fluids listing results for compatibility of materials (aka materials compatibility).

74. How many samples of different viscosities must a fluid manufacturer produce to get a qualified Type II/III/ IV product?

Three pre-production samples must be prepared: 1) a high viscosity sample, 2) a low viscosity sample, and 3) a normal sample whose viscosity is degraded to what becomes the lowest on-wing viscosity (LOWV).[167]

75. How is the viscosity of the normal sample degraded?

The fluid manufacturer decides how best to reduce the viscosity of the sample that will become the lowest on-wing viscosity sample.[168]

76. Does the lowest on-wing viscosity of a Type II/III/IV fluid change each year?

No. It remains unchanged year-over-year.

The lowest on-wing viscosity sample is used to perform endurance time testing from which the holdover time fluid-specific table is produced. Endurance time testing is done only once for a given fluid. The viscosity, measured when the endurance time testing is performed, becomes the lowest on-wing viscosity for that Type II/III/IV fluid.

77. Does a Type II/III/IV fluid manufacturer have the freedom to pick any viscosity range for its sales specification?

No. The requirements are a) the higher end of the range must be equal to or lower than the high viscosity pre-production sample and b) the lower end of the range must be equal to or higher than the low viscosity pre-production sample. The fluid manufacturer may decide on any range in viscosity for its sales specification as long as it is within the range requirements.

78. What is the method to measure viscosity?

Each product will have a viscosity method recommended by the fluid manufacturer.

[167] The high viscosity sample is specified in AMS1428 s 4.2.3.1, the low viscosity sample in AMS1428 s 4.2.3.2 and the degraded sample in ARP5719 s 3.2.2.

[168] Early on, it had been suggested that all samples would have to be degraded by shearing. Some fluid did not shear degrade; consensus was for manufacturer to decide how to obtain a low viscosity version of their own fluids.

All viscosity methods should be reported using the protocol of AS9968A.

79. Where can I find the method to measure viscosity for any fluid?

Fluid manufacturers publish the methods they recommend for each fluid. If the fluid manufacturer has, say, two different Type IV fluids, the methods could be different.

The FAA and Transport Canada publish all the fluid manufacturer methods for Type II/III/IV fluids in their respective *Holdover Time Guidelines*.

80. Will the viscosity of a Type II/III/IV fluid change with every batch?

Yes, this is normal. As received by the user, the viscosity should be within the sales specification set by the manufacturer.

81. What affects viscosity measurements?

Everything. The viscometer model, viscometer calibration, air bubbles in the sample, shearing of the fluid as it is delivered into the test chamber, level of fluid in the test chamber, spindle number, centering of the spindle in the test chamber, temperature, temperature uniformity, speed of rotation, and time from start of rotation until the measurement is read off the viscometer.

[Opinion: it is not particularly difficult to accurately test fluid viscosity, but one needs the right equipment and to be careful and precise about doing it.]

82. May I use a spindle number other than the one recommended by the fluid manufacturer?

Most likely not. A different spindle means a different shear rate. Since the viscosity of Type II/III/IV fluids change with shear rate, it will be difficult to compare the result of the viscosity of the different spindle with the result with the right spindle, unless there is a correlation curve. Using a correlation curve is not best practice; best to use the right spindle.

83. If the viscosity of a Type II/III/IV fluid is below the low limit of the fluid manufacturer's sales specification, is the holdover time table for this fluid applicable?

Yes. The fluid-specific holdover time table of a Type IV is considered valid as long as the viscosity (on the wing, after going through the nozzle) is equal to or above the lowest on-wing viscosity for that specific fluid (for information on the notion of sales specification see Q&A 94–98) .

84. If the viscosity of a Type II/III/IV fluid is below the lowest on-wing viscosity, is the holdover time table for this fluid applicable?

No. Endurance times, from which holdover times are derived, are measured on a sample at the lowest -on-wing viscosity. If the viscosity is lower than the lowest-on-wing viscosity, the holdover time is not valid for this fluid.

85. If a viscometer is not available, may I use a refractometer as a substitute?

No. Refraction and viscosity are not necessarily related. For example, a shear degraded fluid will have a lower viscosity and an unchanged refraction. A refractometer is not a substitute for a viscometer.

86. Is the viscosity of a 75/25 Type IV fluid always lower than that of the undiluted Type IV fluid?

No. Some thickened fluids go up in viscosity as they are initially diluted; others do not.

As dilution with water progresses, all thickened fluid, even those that initially go up in viscosity, go down in viscosity.

Nomenclature

87. Is a *neat* Type IV fluid the same as an *undiluted* Type IV fluid?

Yes. *Undiluted* Type IV fluid or *neat* Type IV fluid refers to a Type IV fluid as-delivered by the fluid manufacturer, without added water by the user. Undiluted or neat Type IV fluids, as-delivered by the manufacturer, always contain a freezing point depressant and water. Neat Type IV fluid does not mean there is no water–there is water, but it is water added in the manufacturing process.

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.

88. What does 100/0, 75/25 and 50/50 Type IV fluid concentration mean?

The convention for expressing concentration of Type II/III/IV fluid is that the first number is the number of parts by volume of the undiluted (neat) fluid and the second number is the number of parts by volume of water added by the user.

“100/0 Type IV fluid concentration” means undiluted (neat) Type IV fluid (100 parts) and no added water by the user (0 parts). A 75/25 fluid concentration means a mixture by volume of 75 parts undiluted fluid and 25 parts water. A 50/50 fluid concentration means a mixture by volume of 50 parts undiluted fluid and 50 parts water.

In the expressions 100/0, 75/25, 50/50, none of the numbers refer to the weight or volume percent of the freezing point depressant in the fluid.

89. Are Type II/III/IV concentrations other than 100/0, 75/25 and 50/50 allowed?

It depends. Some Type II/III/IV fluids can only be used in the undiluted form (100/0) as these fluids do not have holdover time for dilutions. Other Type II/III/IV fluids, can be diluted 75/25 and 50/50, as holdover times are published for these standard dilutions. The FAA has special rules for non-standard dilutions of Type II/II/IV fluids.[169]

90. What is miscible?

Describing liquids capable of mixing in any ratio without phase separation.

Examples: ethylene glycol and water are miscible; propylene glycol and water are miscible.

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[169] N 8900.594 s 7.b.(6).

91. What is Type I compatibility with Type II/III/IV fluids?

When a Type I fluid is used in the first step of a two-step application, the Type I fluid should not affect unduly the anti-icing performance of the second step (thickened) fluid. This requirement is set in both ASM1424R (s 1.3.6) and AS6285D (s 8.7.2).

92. How can I tell if the Type I from manufacturer A is compatible with Type II/III/IV from manufacturer B?

The FAA recommends "to contact the respective fluid manufacturers".[170]

How the fluid manufacturers may go about doing this verification was described in ARP4737H (s 6.3.3.2). It was recommended to verify that the Type I fluid did not significantly reduce the WSET of the thickened fluid. When AS6285 superseded ARP4737H, this method of verification was deleted.

[An unwritten assumption is that glycol based Type I fluid from a manufacturer will be compatible with glycol based thickened fluid from the same manufacturer. It is implicit in the FAA statement that the compatibility must be checked if there are two different fluid manufacturers. Salt based Type I fluid are considered incompatible with glycol based Type II/III/IV fluids.]

93. What is fluid commingling?

The mixing, or combination, of two different fluids.

AMS1424R (s 1.3.6) and AMS1428K (s 1.3.4) warn of adverse effect when mixing fluids from different manufacturers. AS6285D (s 10.1) states that "different product shall not be mixed without additional qualification. Consult with the fluid manufacturers."

Examples: the mixing of Type I fluid from two different manufacturer; the combination of EG-based Type I fluid with an PG-based Type I fluid.

[170] FAA Notice N 8900.594 at s 14.e.(2).

Specifications and In-Use Limits

94. What is a deicing/anti-icing fluid sales specification?

A sales specification is a set of quality control limits established by a fluid manufacturer for fluid to be sold.

95. What are the elements of a sales specification?

A sales specification is a formal document that normally has the following elements: name of the product, an effective date, test item and conditions, limits, unit, and method of measurement.

96. Are the specification limits of a sales specification the same as those of the certificate of analysis?

Yes. The limits of a certificate of analysis must match those of the sales specification for a given product.

97. What are deicing/anti-icing fluid in-service limits?

The expression "in-service limits" refers to a set of quality control limits for fluid sampled from storage tanks, trucks, and nozzles of users (e.g., airlines or service providers).

98. Are in-use limits the same as in-service limits?

Yes. In-service limits and in-use limits (sometimes also called in-use or in-service specification) refer to the same notion: in-use/in-service requirements may differ from those of the sales specification.[171]

Example 1. If the viscosity sales specification requirement of Type IV fluid A is 13,000– 20,000 mPa▪s and the lowest on wing viscosity is 12,150 mPa▪s, as published by the FAA, the in-use viscosity requirement would be 12,150 – 20,000 mPa▪s. When fluid manufacturers receive fluids from the field, they issue an analysis report and compare it to what they consider appropriate in-service limits. For viscosity, the fluid manufacturer may decide to set an in-service limit slightly higher than the lowest on-wing viscosity to send a signal to the user that the viscosity is close to

[171] AS6285D at ss 4.3.3.2–4.3.3.3 uses the expression in-service limits.

the lowest on-wing viscosity. For Type IV fluid A, for example, the fluid manufacturer may set the viscosity in-service limit to 12,500 – 20,000 mPa▪s (rather than 12,150 – 20,000).

Example 2. If the refraction sales specification requirement of Type IV fluid B is of 1.3905 – 1.3935 (refractive index, RI), the fluid manufacturer (or the user) may consider that a small increase in refraction, as long as all the other specification requirements (viscosity, pH, and appearance) are met, has no impact on fluid performance. The fluid manufacturer (or the user) may allow an in-use refraction requirement of 1.3905 – 1.3940. If a sample was sent to the manufacturer for verification, say after 6 months in the customer tank, and the refraction was measured at 1.3940, the fluid manufacturer may consider the fluid to be within the in-use requirement.

99. What is a certificate of conformance?

A document declaring that a product fulfills the requirements of a standard.

It is a synonym for certificate of conformity.

A certificate of conformance or certificate of conformity normally does not show test results.

100. What is a certificate of analysis?

A document, issued by a manufacturer, attesting that a lot of a product fulfills the manufacturer's sales specification requirements, listing the tests, the test requirements, the test results on that lot, the lot number and a date.

101. Is a certificate of analysis the same as a certificate of conformance?

No. See Q&As 99–100.

Sampling

102. What is a sample?

A small portion of a larger quantity of a product used to evaluate quality.[172]

[172] Carl Schaschke, *Dictionary of Chemical Engineering* (Oxford: Oxford University Press, 2014).

103. What is a representative sample?

A sample intended to be representative of the larger quantity.

It is important that samples be representative, otherwise the analysis result on the sample is not meaningful.

104. What is a retained sample?

A sample kept under ideal storage conditions for an eventual further verification of product quality.

105. What is a nozzle sample?

A sample taken from a nozzle.

Nozzle samples are taken for Type II/III/IV fluids to verify that they have not permanently shear degraded through the action of the pump and nozzle.

Nozzle samples are taken for Type I fluids to verify the concentration.

106. Is it easy to get a Type II/III/IV representative nozzle sample?

No. It is relatively complicated and messy to get a Type II/III/IV representative sample from a nozzle. If a receiving container is simply placed at the nozzle, the fluid will impinge upon the container wall and will shear degrade, making impossible to know if the shear degradation is due to the nozzle or the impingement. Care must be taken to mimic how fluid is sprayed on the aircraft. In other words, the receiving container must be placed at a distance from the nozzle that is similar to the distance between the aircraft and the nozzle. There is the further complication that opening or closing the nozzle flow valve can cause shear degradation. The nozzle must be aimed away from the receiving container as fluid starts to flow or stops to flow; fluid sprayed away from the receiving container makes it messy. Nevertheless, getting representative nozzle samples is a must to ensure safety.

107. How long should I retain samples of deicing/anti-icing fluids?

There are no set rules, unless set by contractual obligations. Upon shipping or receiving deicing/anti-icing fluids, it is usual to retain representative samples for one year.

108. What is a sampling guideline for deicing/anti-icing fluids?

A document, generally prepared by fluid manufacturers, explaining in general terms how to safely proceed to get representative samples.

109. What is a sampling procedure?

A site-specific or equipment-specific procedure to obtain representative samples.

110. Why do I need a site-specific or equipment-specific sampling procedure?

Sampling guidelines are general, you need to specifically spell out how sampling will be done to get representative samples from delivery trucks, storage tanks, drums, totes, deicing unit tanks, nozzles, what equipment is required (e.g., zone sampler, sample size, sample bottles, record book, labels, permanent markers...), what personal protective equipment is needed (e.g., gloves, safety glasses, protective clothing, etc.), procedures to deal with specific hazards such as heated fluids, movement of trucks or aircraft, disposal of excess fluid taken during sampling, site cleanup after sampling, Other site procedures may apply, such as fall and slip protection, lockout tagout procedure, or confined space entry procedure.

111. Do I need special equipment to sample a tank?

It depends. If there is recirculation, a sample may be taken from a sample point in the recirculation loop. When there is no recirculation or infrequent addition of fresh product, tanks tend to layer out. There may be some evaporation at the top and sedimentation at the bottom. Using a zone sampler is an effective way to get representative samples from the middle of the tank.

112. What is a zone sampler?

An apparatus allowing to sample a tank at different depths.

113. Is sampling hazardous?

Sampling may be hazardous if the proper procedures and equipment are not available. For instance, deicing fluid may be hot and cause burns; dipping a bottle at the surface of hot deicing fluid tank is very risky. You may not see the liquid level of the fluid because of the water vapor above the fluid, the hot fluid may enter your glove resulting in a burnt hand.[173]

114. What other procedures may I need to sample safely?

It depends on what is involved in the sampling. You may need slip and fall prevention procedure, lockout tagout procedure (also variously named red master tag procedure, master lock procedure, isolation of energy procedure) to prevent movement of a truck, to prevent powering of a pump, etc. If you need to enter a vessel, you will absolutely need a confined space entry procedure.

If you are sampling from an aircraft wing, make sure, in addition to the aircraft itself not moving, that the moving parts, e.g., spoiler panels, of the wing will not be activated.[174]

Plan and prepare before you execute any sampling.

115. If I receive several drums or totes with the same lot number, do I need to sample each drum or tote?

No. When receiving product, it is considered that a sample from a tote or drum from a given lot number is representative of all the drums or totes of that lot number.[175]

116. If I receive two bulk tank trucks with the same lot number, do I need to sample each tank truck?

Yes. It is very important to verify the content of each tank truck before unloading. Do not rely on the verification of paperwork only, always sample tank trucks before unloading.

117. What is top loading?

The process of loading a bulk container, such as a tank truck, tank container (tanktainer) or rail car with the same product as the previous load, without washing. This procedure saves time and avoids the risk of washing; although it rarely occurs, washing can be a source of contamination.[176]

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[173] Don't do it, it is very painful.
[174] Think of it: a moving spoiler panel could cause a severe hand injury.
[175] AS6285D s 4.3.1.4 b.
[176] AS6285D s 4.3.1.3 b.; deicing units at airport are top loaded–although this expression "top loaded" is not normally used when filling deicing units.

118. What is prior load?

Prior load refers to the content of a bulk container before its current content.

For some product grades (e.g., food grade, pharmaceutical grade) chemical manufacturers specify what products are not acceptable as prior loads; for industrial products, generally, shipping vessels need to be clean (documented by a certificate of wash), dry and odor free.

119. Can I remove insoluble particles from Type I by filtration?

Probably, yes. Consult with the fluid manufacturer.

There is no thickener in Type I, so filtration cannot shear degrade the thickener.

The filtration must be such that it will not remove any of the ingredients in the formulation of the Type I which is why it is best to consult the fluid manufacturer before attempting any filtration.

120. What is a likely source of insoluble particles in Type I fluid?

Carbon steel unlined storage tanks, rail cars, and piping can generate small amounts of elemental iron or iron oxides. If the product is *substantially free* from these particles, the product is considered to be acceptable. Iron and iron oxide particles go to the bottom of vessels which is why is it important to flush the bottom outlets to take a representative sample. If there is a larger quantity of these particles, it may be possible to filter them out.

Short Stories – Lessons Learned

These stories are true. In some cases, the unfortunate consequence was not avoided; in others, good practices prevented potential unfortunate consequences, and personal or corporate embarrassment.

121. Why does the Type I fluid smell like diesel?

The receiver was expecting a load of deicing fluid. He told the truck driver: “Put it in this tank over there.” The driver proceeded to unload 50 liters of diesel fuel in the Type I storage tank, before realizing it was a mistake.

Consequence: the entire storage tank of Type I had to be disposed of and the tank steam cleaned.

Lesson learned: good signage is very important; make sure all ports and tanks are clearly labeled; for deicing/anti-icing deliveries, check the paperwork, take a sample, check the sample before unloading, and show the delivery person exactly where to attach the delivery hose.

A similar issue happened, at another airport, where deicing fluid was contaminated with a runway deicing product.

122. Why is the Type I pH too high?

The receiver took a sample from the outlet valve of tanktainer before unloading. The pH was high. After flushing a few liters, the fluid pH was normal.

Likely cause: a small amount of caustic soda, from the wash, was left in the tanktainer outlet pipe

Consequence: delayed unloading by a few hours; no big deal.

Lesson learned: to get a representative sample, flush the outlet line from a bulk container before taking a sample.

123. Why is the Type I Brix in the deicing unit too low?

The user called and said: “Hey Jacques, why is the Type I Brix in my deicing truck too low?”. At this airport, they used read-to-use fluid and did not dilute it. The storage tank Brix was on-spec. It was late August and the crew had checked the refraction (in degrees Brix) before putting the truck in service.

Finding: training had been done with water over the summer and the water had not been drained from the truck. Ready-to-use Type I fluid had been added to the truck and the resulting mixture had low refraction.

Consequence: minor embarrassment; nothing serious.

Lesson learned: it is a good thing to follow procedure and check refraction before using fluid from a deicing truck. The deicing crew was very glad to have checked refraction before attempting to deice any aircraft.

124. Why does the Type I Brix goes down, from time to time, in the deicing truck?

Finding: In this instance, the design of the trucks was such that the tank covers were flush with the top of the deicing truck, allowing rain water or melting snow to go into the deicing unit tanks, if the covers were not clamped closed. The refraction would go down when it rained or snowed heavily. The remedy was to close the covers tightly; the tanks were still vented by a separate vent (all tanks must always be vented). Ideally, tank cover design should such that the covers are raised above top of the deicing unit.

Lesson learned: make sure rain or melted snow will not enter tanks.

125. Why does the Type IV not form a uniform layer on the wing?

At first, it was thought not enough Type IV is being applied to the wing, which was the case. But the problem persisted when a sufficient amount of Type IV was applied.

Finding: the wax on the aircraft interfered with the proper wetting of the wing.

Lesson learned: aircraft wax or any aircraft surface coating must be checked against SAE AIR6332 to ensure it does not interfere with wetting of the deicing/anti-icing fluids.

126. Why does the Type I not wet properly?

While spraying an aircraft, it was noticed that the Type I fluid was not wetting normally. Wetting the surface to be protected is an important property of Type I fluids.

Finding: in this case, it was thought that a small amount of silicone oil had contaminated the storage tank. The exact origin of silicone oil was never found.

Consequence: disposal of the contaminated Type I.

Lesson learned: do not use silicone oil to lubricate pumps, or anything coming into contact with deicing/anti-icing fluid.

127. Why does the Type I turn pink?

At this remote airport, the orange (normal color) Type I was repeatedly heated with an electric immersion heater in a small container. A timer shut off the heating overnight to prevent overheating. Nevertheless, after a while, the Type I fluid turned pink (abnormal color).

Finding: the immersion heater was copper clad. Switching to a stainless steel clad immersion heater resolved the problem.

Lesson learned: do not use copper clad electric immersion heaters.

128. Why is the Type I colorless in the sight tube?

Dyes in deicing anti-icing fluids will fade when exposed to UV light. This is normal.

Lesson learned: if the color in the storage tank is the right color, do not worry about the fluid going colorless in sight gages.

The same applies to Type II/III/IV fluids.

Color fading will occur fluid in sample bottles, when exposed to UV light. Keep samples in opaque bottles or protect them from UV to ensure they remain in exactly the same conditions as when they were taken.

Runway Deicing Products

129. What is a brine?

Water with a high concentration of salt.[177]

130. What is brining?

The dissolution of a salt in water. For example, the process of dissolving in water a solid runway deicing product (RDP) , such as sodium acetate, is commonly called brining.

[177] Tony Atkins and Marcel Escudier, *Dictionary of Mechanical Engineering*, 2nd ed. (Oxford: Oxford University Press, 2019) at p 62 *sub verbo* ”brine”.

The process of dissolving a salt in water must not be called liquefaction. Liquefaction is the process of conversion of a gas into a liquid using vapor compression, refrigeration, adiabatic expansion, or gas expansion through a porous plug.[178]

[178] Richard Rennie, ed, *Dictionary of Chemistry,* 8th ed (Oxford: Oxford University Press, 2020) at p 345 *sub verbis* "liquefaction of gases" and at pp 316–317 *sub verbis* "Joule-Thomson effect".

PREFERRED WORDS AND EXPRESSIONS

In SAE G-12 documents, we strive to develop correct and useful knowledge of technical content by clear thinking and writing. Writing is more apt at transferring knowledge effectively through standardization of words used and spelling.

There are always some disagreements about definitions, spelling, hyphenation, compounding, capitalization, and style in documents. This is normal: many minds, many ideas. The following is an attempt to organize thoughts about the subject of style used in G-12 documents.

English is the language used in SAE documents. Which English? American English, also known as U.S. English.

This notion is helpful in the selection of words and in spelling, but still insufficient.

Speakers whose mother tongue is U.S. English, with experience in deicing, have an advantage, as they know often intuitively what word to use. Non-native speakers and writers have to rely on their own experience with the language and expert-written advice. When it gets complicated, everyone has to rely on documents codifying the rules.

Style books

There are five documents or style books that can help with U.S. English in SAE documents and in documents in general:

1. SAE International, *Standards Development Style Manual* (January 2021), https://www.sae.org/exdomains/standardsdev/global_resources/January_2021_Standards_Development_Style_Manual.pdf;
2. United States, Government Publishing Office, *Style Manual: An Official Guide to the Form and Style of the Federal Government Publications* (Washington, DC: U.S. Government Publication Office, 2016), https://www.govinfo.gov/content/pkg/GPO-STYLEMANUAL-2016/pdf/GPO-STYLEMANUAL-2016.pdf;
3. Garner, Bryan A., *Garner's Modern English Usage* (Oxford: Oxford University Press, 2016);
4. University of Chicago, *The Chicago Manual of Style*, 17th ed (Chicago: University of Chicago Press, 2017);
5. Council of Science Editors, *Scientific Style and Format*, 8th ed (Chicago: University of Chicago Press, 2014).

I also find the following useful: McGill Law Journal, C*anadian Guide to Uniform Legal Citation*, 9th ed (Toronto: Thomson Reuters, 2018).

The SAE *Standards Development Style Manual* is short, does cover the styles to be used in SAE documents and but not does cover capitalization in very great details. It does refer to the *Chicago Manual of Style* (*Chicago*) for capitalization of titles.

The U.S. Government *Style Manual* is official and well done. Chapters three and four deal with capitalization. Chapter seven covers compounding of words and hyphenation. It is available online for free. For bibliographies, it recommends the *Chicago Manual of Style*.

Garner is an authority on style and has published many books on the subject for instance in law. He is the editor of the well-known *Black's Law Dictionary* and a contributor to the *Chicago Manual of Style.*

The *Chicago Manual of Style* is cited by many style books and is very detailed. The SAE *Style Manual*, the U.S. Government Publication Office *Style Manual* and Garner refers to the *Chicago Manual of Style*. It appears to be the ultimate reference for U.S. English.

For scientific documents the specialized *Scientific Style and Format,* published by the Chicago University Press, like the *Chicago Manual of Style,* provides detailed information on chemistry nomenclature, physics, biology etc.

Capitalization

I suggest reading chapter three of the U.S. Government *Style Manual.* It is short and covers the basics.

For titles and offices, rule 8.19 of the *Chicago Manual of Style* summarizes it:

> Titles and Offices – the general rule**.** Civil, military, and professional titles are capitalized when they immediately precede a personal name and are thus used as part of the name (traditionally replacing the holder's name). In formal prose and other generic text, titles are normally lowercased when following a name or used in place of a name.

Garner: "The most important is the modern trend away from capitalization, resulting in a minimalist rule: unless there is a good reason to capitalize, don't." (p 143).

Garner also has a short section on overcapitalizing (p 144). He is a bit harsh but I thought would share: “Inexperienced writer—and overzealous house stylists—often to capitalize common nouns inappropriately”.

Name of chemical compounds are not capitalized.

Proper names and adjective derived from proper names are capitalized (e.g., Newton, Newtonian). The force (newton) and pressure (pascal) SI units are not capitalized.

Capitalization of acronyms

Chicago par 10.6

> … if words in a spelled-out version of an acronym or initialism are not derived from proper noun or do not themselves constitute a proper noun (as in the official name of an organization), they should generally be lowercased, even when appear alongside the abbreviated form.
> example: transmission-control protocol/internet protocol (TCP/IP)

This rule, I try to follow in the Abbreviations and Acronyms section of the *Guide*.

Hyphenation and compounding of words

Again, the *U.S. Manual of Style* is helpful. A few simple rules (rules 7.1–7.14) and many examples. Noticeably, flightcrew adopts the one-word form (p 136). Prefixes pre and post generally assume one-word forms (p 162).

For those interested in more information, *Chicago* paragraph 7.89 provides many details.

Dictionaries record common usage and are not meant to replace style guides. *Chicago* warns (par 5.250): “The mere presence of a word in the dictionary’s page does not mean that the word is in all respects fit for print as Standard Written English. The dictionary merely describes how speakers of English have used the language.” *Chicago* considers the best dictionaries to be Merriam-Webster, Webster’s New World, American Heritage, Oxford University Press, and Random House.

Merriam Webster online[179] and the *Random House Dictionary of the English Language*, Unabridged ed (New York: Random House, 1970) were useful in the preparation of the list below.

Preferred spellings

This is a list of preferred spellings related to ground deicing. Comments and suggestions, as always, are welcome.

Preferred	Avoid
1,3-propanediol	1,3-Propanediol
aircraft surface coating	aircraft coating
aircraft	aeroplane
aircraft	airplane
airport	aerodrome[180]
allowance time table	allowance timetable
anti-icing code	deicing/anti-icing code
category specification	detail specification
cold-soaked	cold soaked
cold-soaking	cold soaking; cold-soak effect
deicing	de-icing
deicing/anti-icing fluid	de-/anti-icing fluid; deicing anti-icing fluid
deicing crew	deicingcrew
dewpoint	dew point
diethylene glycol	Diethylene Glycol
drum	barrel
effluent	runoff
engines-on	engines on; engines running
ethylene glycol	Ethylene Glycol
flaps and slats	slats and flaps
flightcrew	cockpit crew, flight crew
flightdeck windows	flight deck windows, windscreens
flightdeck	cockpit, flight deck
foundation specification	base specification
freezing point buffer	buffer, freeze point buffer, freezing point temperature buffer
freezing point	freeze point
frost point	frostpoint
groundcrew	ground crew, ground personnel
highest on-wing viscosity	maximum on-wing viscosity
holdover time table	holdover time-table; holdover timetable
hoarfrost	hoar frost
HOWV[181]	MOWV

[179] https://www.merriam-webster.com.
[180] Aerodrome is used in the expression "Terminal Aerodrome Forecast" (TAF).
[181] *See* footnote 3.

ice, snow and frost	snow, ice and frost
in-flight (adjective)	in flight
in-flight ice accretion	impact ice
infrared	infra-red
liter	litre
lockout tagout	lock-out; tag-out; master lock; red tag
message board	signboard
meter	metre
Newton (the scientist)	
newton (the SI unit of force)	
nonconformance	non-conformance
Pascal (the scientist philosopher)	
pascal (the SI unit of pressure)	
pH	PH
pilot-in-command	commander, pilot in command, Pilot-in-Command
postdeicing/anti-icing check	post application check; post deicing check; post-deicing check; post-treatment check
precooling	pre-cooling
predeicing contamination check	pre-deicing contamination check
predeicing process	pre-deicing process; pre-deicing step; pre-step
prenozzle	pre-nozzle
preoperation	pre-operation
preproduction	pre-production
preseason	pre-season
pretakeoff contamination check	pre takeoff contamination check; pre-takeoff contamination check
pretakeoff	pre takeoff, pre-takeoff
program	programme
propylene glycol	Propylene Glycol
redeicing	re-deicing, re-treatment, retreatment
refreezing	re-freezing
rehydrated	re-hydrated
rotorcraft	helicopter
safety data sheet	material safety data sheet
SDS	MSDS
service provider	FBO
tailcone	tail cone
takeoff	take off, take-off
third party (noun)	
third-party (adjective)	
tote	1 m^3 container; IBC
Type I	type I, type 1, Type 1
Type II	type II, type 2, Type 2
Type III	type III, type 3, Type 3
Type IV	type IV, type 4, Type 4
undiluted	neat

walk-around (noun)	
walk around (verb)	
windshield	windscreen

Indexing difficulties

Sometimes the same concept is expressed by different strings of words in different documents and sometimes by different strings of words by the same organization in the same document. For instance, AS6285 uses the expression “ground deicing program”; Transport Canada uses the expressions “ground icing program”, “ground deicing program”, and “ground icing operations program”; the FAA calls it variously “ground deicing/anti-icing program”, “approved ground deicing program”, “air operator’s program”, “air carrier’s deicing program” “approved deicing/anti-icing program”, “approved program”, and “certificate holder’s program”; ICAO calls it “deicing/anti-icing programme”, “ground deicing programme”, and “the programme”.

If the same concept is indexed using similar words, it makes the index easier to use. This *Guide* uses the following expressions:

ground deicing program
ground deicing program (FAA)
ground deicing program (TC)
ground deicing program (ICAO)

Figure 1 Aircraft Deicing Documents

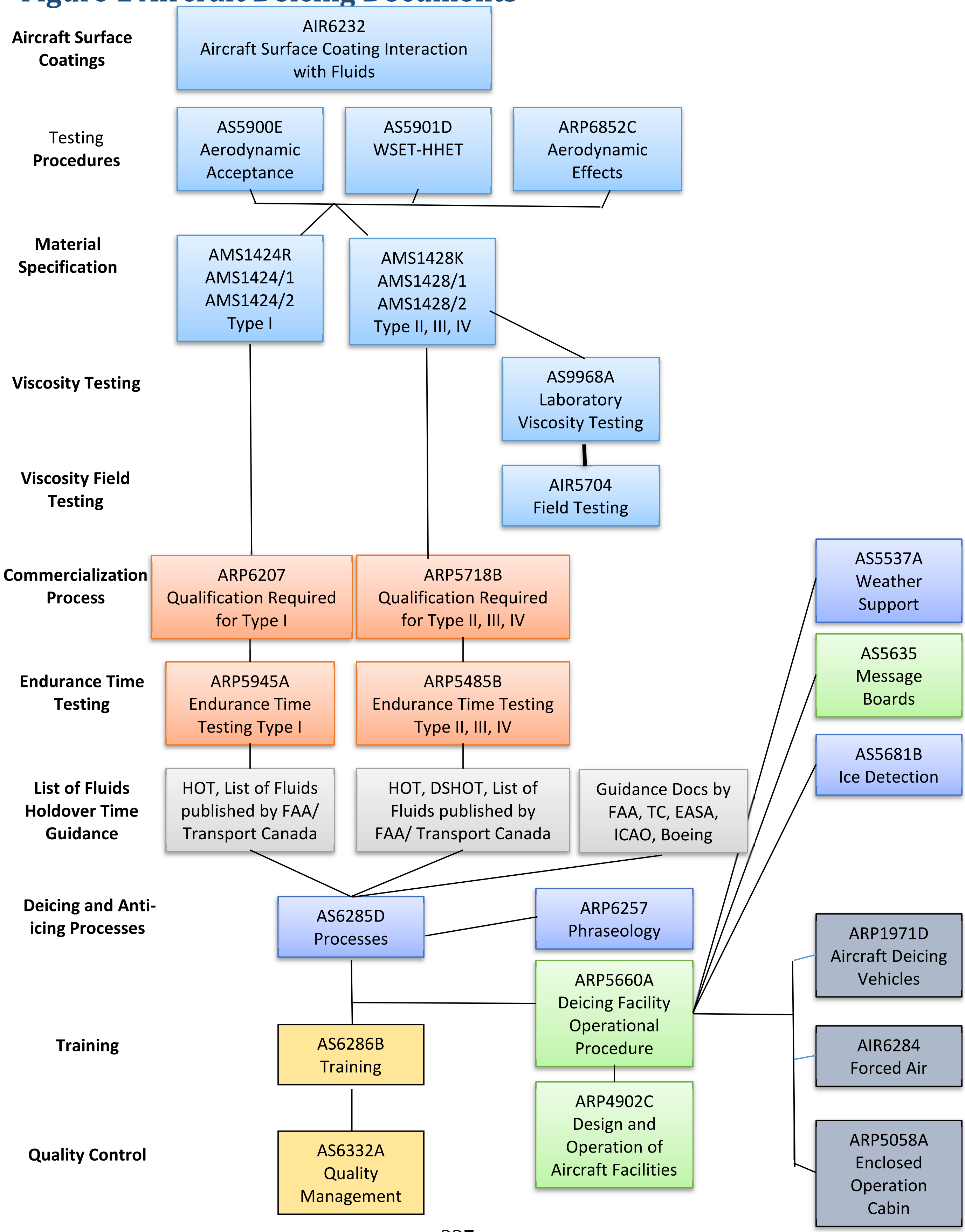
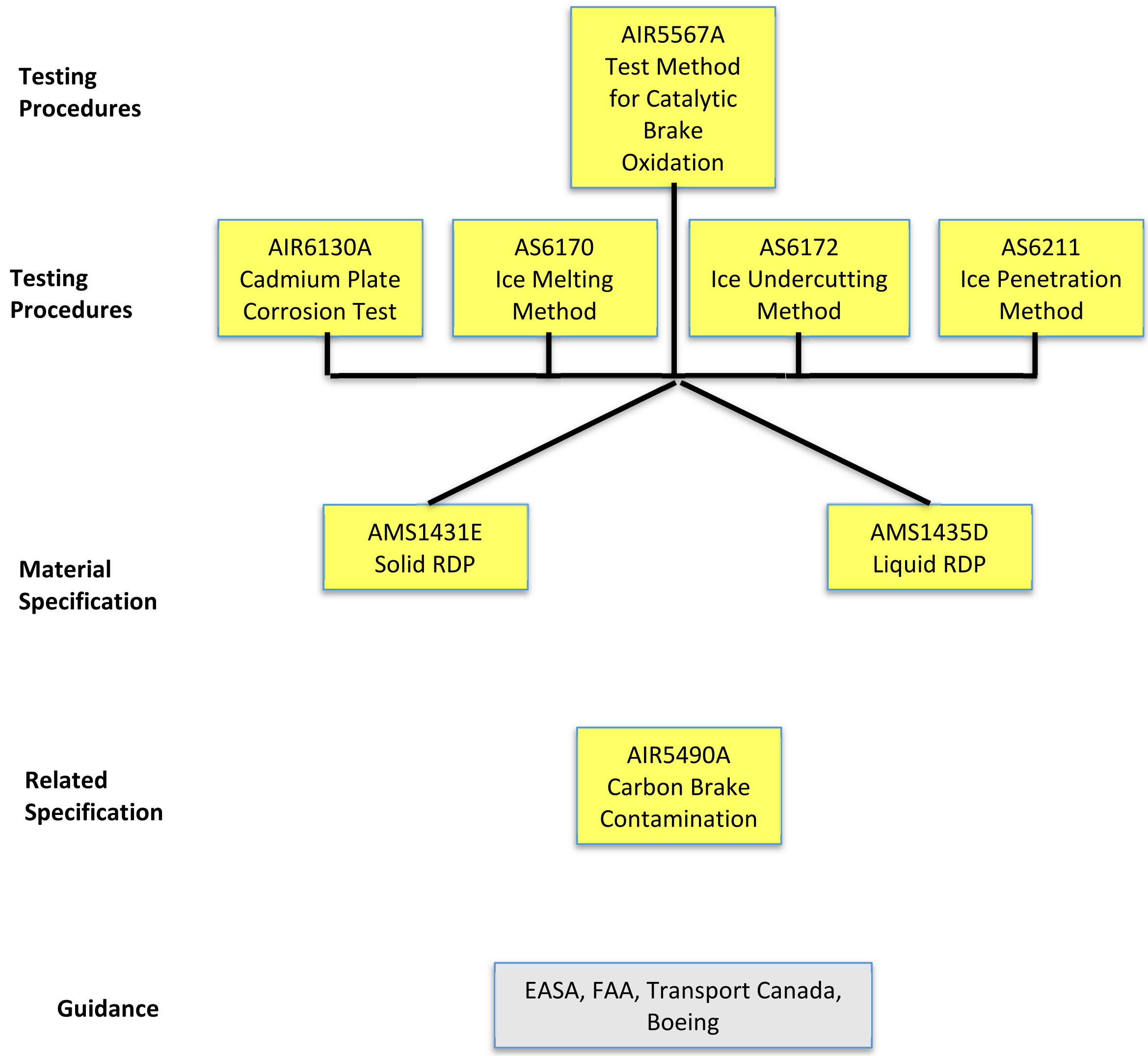


Figure 2 Runway Deicing Documents



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This *Guide to Aircraft Ground Deicing* issue 16 – May 2022 replaces all previous issues of the *Guide to Aircraft Ground Deicing*. Please destroy all previous issues.