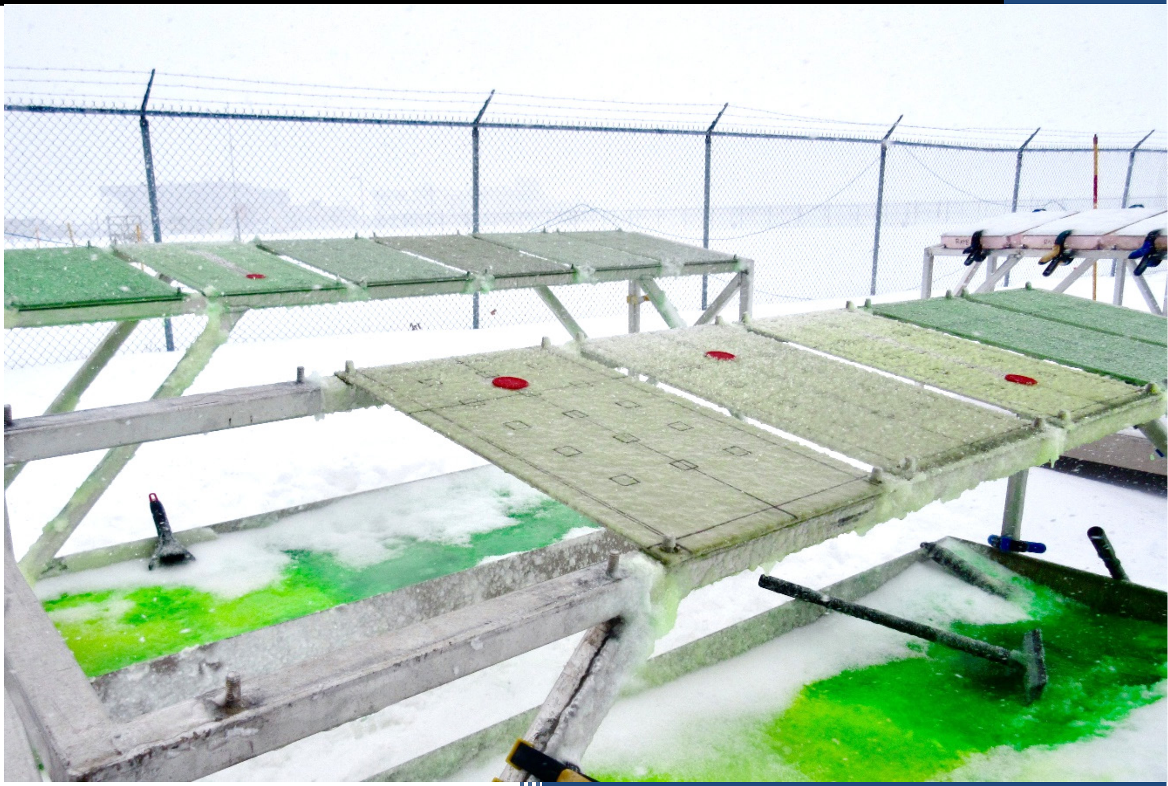
TP 15338E

AIRCRAFT GROUND DE/ANTI-ICING FLUID HOLDOVER TIME DEVELOPMENT PROGRAM FOR THE 2015-16 WINTER



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and the
Federal Aviation Administration
William J. Hughes Technical Center

Final Version 1.0
January 2017

TP 15338E

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by

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and

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Final Version 1.0

January 2017

The contents of this report reflect the views of APS Aviation Inc. and not necessarily the official view or opinions of the Transportation Development Centre of Transport Canada.

The Transportation Development Centre does not endorse products or manufacturers. Trade or manufacturers' names appear in this report only because they are essential to its objectives.

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PREFACE

Under contract to the Transportation Development Centre of Transport Canada with support from the Federal Aviation Administration, APS Aviation Inc. has undertaken a research program to advance aircraft ground de/anti-icing technology. The primary objectives of the APS Aviation Inc. test program are the following:

- To develop holdover time data for all newly-qualified de/anti-icing fluids and update and maintain the website for the holdover time guidelines;
- To evaluate fluid holdover times for snow at very cold temperatures close to -25°C;
- To conduct heavy snow research to determine the highest usable precipitation rate (HUPR) for which operations are permitted;
- To evaluate the effects of deploying flaps and slats, prior to takeoff, on fluid protection times;
- To conduct exploratory testing to evaluate fluid effectiveness and characterize contamination on high angle vertical surfaces;
- To conduct general and exploratory de/anti-icing research;
- To obtain full-scale operational documentation of anti-icing fluid flow-off, fluid freezing-in-flight, and residual fluid thickness;
- To conduct wind tunnel testing to support the development of the guidance material for operating in conditions mixed with ice pellets;
- To update the regression coefficient report with the newly-qualified de/anti-icing fluids; and
- To update the source documents used by Transport Canada and the Federal Aviation Administration for the maintenance and publication of the holdover time guidance material.

The research activities of the program conducted on behalf of Transport Canada during the winter of 2015-16 are documented in five reports. The titles of the reports are as follows:

- TP 15338E Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2015-16 Winter;
- TP 15339E Regression Coefficients and Equations Used to Develop the Winter 2016-17 Aircraft Ground Deicing Holdover Time Tables;
- TP 15340E Aircraft Ground Icing General Research Activities During the 2015-16 Winter;
- TP 15341E Wind Tunnel Trials to Support Further Development of Ice Pellet Allowance Times: Winter 2015-16; and
- TP 15342E Testing of Endurance Times on Extended Flaps and Slats.

This report, TP 15338E, has the following objective:

- To develop holdover time data for new de/anti-icing fluids and to document changes made to the holdover time guidelines.

This objective was met by conducting endurance time tests with fluids in simulated freezing precipitation at the National Research Council Canada Climatic Engineering Facility in Ottawa and in natural snow at the APS Aviation Inc. test site at Montreal-Trudeau Airport in Montreal.

PROGRAM ACKNOWLEDGEMENTS

This multi-year research program has been funded by Transport Canada with support from the Federal Aviation Administration, William J. Hughes Technical Center, Atlantic City, NJ. This program could not have been accomplished without the participation of many organizations. APS Aviation Inc. would therefore like to thank the Transportation Development Centre of Transport Canada, the Federal Aviation Administration, National Research Council Canada, and supporting members of the SAE International G-12 Aircraft Ground Deicing Committee.

APS Aviation Inc. would also like to acknowledge the dedication of the research team, whose performance was crucial to the acquisition of hard data. This includes the following people: Yelyzaveta Asnytska, Brandon Auclair, Steven Baker, Stephanie Bendickson, Benjamin Bernier, Chloë Bernier, Trevor Butler, John D'Avirro, Jesse Dybka, Ben Falvo, Benjamin Guthrie, Michael Hawdur, Gabriel Maatouk, Philip Murphy, Matthew Pilling, Dany Posteraro, Marco Ruggi, Gordon Smith, David Youssef, and Nondas Zoitakis.

Special thanks are extended to Antoine Lacroix, Howard Posluns, Yvan Chabot, Warren Underwood and Charles J. Enders, who on behalf of the Transportation Development Centre and the Federal Aviation Administration, have participated, contributed and provided guidance in the preparation of these documents.

PROJECT ACKNOWLEDGEMENTS

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Several research reports for testing of de/anti-icing technologies were produced for previous winters on behalf of Transport Canada. These are available from the Transportation Development Centre. Several reports were produced as part of this winter's research program. Their subject matter is outlined in the preface. This project was co-sponsored by the Federal Aviation Administration.

16. Abstract

The primary objective of the 2015-16 holdover time test program was to evaluate the performance of new deicing and anti-icing fluids over the entire range of conditions encompassed by the holdover time (HOT) guidelines. The objective was met by conducting endurance time tests. The procedure for these tests consisted of pouring fluids onto clean aluminum test surfaces inclined at 10º. The onset of failure was recorded as a function of time in natural frost, natural snow, artificial snow, simulated freezing fog, simulated freezing drizzle, simulated light freezing rain, and simulated rain on a cold-soaked wing. A total of 896 tests were conducted with seven fluids.

Changes to the HOT guidelines for the winter of 2016-17 include:

- Fluid-specific HOT guidelines were added for four new fluids: Beijing Yadilite Aviation YD-102 Type II (Type II), Clariant Max Flight AVIA (Type IV), Clariant Safewing EG IV NORTH (Type IV) and Shaanxi Cleanway Aviation Cleansurface IV (Type IV).
- AllClear AeroClear MAX (Type III) and Deicing Solutions ECO-SHIELD® (Type IV) holdover times were updated as a result of supplemental testing with new samples.
- LNT Solutions P250 (Type II), Cryotech Polar Guard® (Type IV) and Dow Chemical UCAR™ FlightGuard AD-480 (Type IV) were removed from the guidelines as per the protocol for removal of obsolete data.
- The holdover times for snow in the "below -14°C to LOUT" row were reduced for all Type II and Type IV fluids. Some of the reductions were later retracted for specific conditions in supplemental guidance materials.
- Changes were made to the Type II and Type IV generic HOT guidelines as a result of the new and removed fluids. The Type IV generic HOT table was expanded to include holdover times for three snowfall intensities: very light, light and moderate.
- Several changes have been made to the allowance time tables. These include: reordering of the rows, the addition of new precipitation type rows, minor changes to some existing allowance times, and minor changes to the existing Type IV temperature bands.
- Transport Canada published special HOT tables for use when flaps/slats are deployed prior to de/anti-icing. The new tables contain holdover times that are 90 percent of the standard table values.

It is recommended that any new Type I, Type II, Type III or Type IV fluids be evaluated over the entire range of conditions in the HOT guidelines, that further frost testing be conducted with existing fluids and that research to mitigate the reductions to the Type II/IV very cold snow holdover times be considered.

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Plusieurs rapports de recherche sur des essais de technologies de dégivrage et d'antigivrage ont été produits au cours des hivers précédents pour le compte de Transports Canada. Ils sont disponibles au Centre de développement des transports. De nombreux rapports ont été rédigés dans le cadre du programme de recherche de cet hiver. Leur objet apparaît à l'avant-propos. Ce projet était coparrainé par la Federal Aviation Administration.

16. Résumé

Le principal objectif du programme d'essai sur les durées d'efficacité de l'hiver 2015-2016 était d'évaluer la performance de nouveaux liquides de dégivrage et d'antigivrage pour toute la gamme des conditions météorologiques couvertes par les lignes directrices relatives aux durées d'efficacité. Pour atteindre cet objectif, des essais d'endurance ont été menés. La procédure suivie pour ces essais consistait à verser les liquides sur des surfaces d'aluminium propres, inclinées à 10°. On notait ensuite l'amorce de la perte d'efficacité en fonction du temps, sous le givre naturel, la neige naturelle et artificielle, et dans des conditions artificielles simulant du brouillard verglaçant, de la bruine verglaçante, de la pluie verglaçante faible et de la pluie sur une aile imprégnée de froid. Un total de 896 essais ont été menés, avec sept liquides.

Parmi les changements apportés aux lignes directrices relatives aux durées d'efficacité pour l'hiver 2016-2017, on note ce qui suit.

- Des lignes directrices relatives aux durées d'efficacité spécifiques à quatre nouveaux liquides, soit Beijing Yadilite Aviation YD-102 Type II (type II), Clariant Max Flight AVIA (type IV), Clariant Safewing EG IV NORTH (type IV) et Shaanxi Cleanway Aviation Cleansurface IV (type IV), ont été ajoutées.
- Les durées d'efficacité des liquides AllClear AeroClear MAX (type III) et Deicing Solutions ECO-SHIELDMD (type IV) ont été mises à jour à la suite d'essais supplémentaires effectués à l'aide de nouveaux échantillons.
- Les liquides LNT Solutions P250 (type II), Cryotech Polar GuardMD (type IV) et Dow Chemical UCARMC FlightGuard AD-480 (type IV) ont été retirés des lignes directrices, conformément au protocole régissant le retrait des données obsolètes.
- Les durées d'efficacité dans des conditions de neige de la rangée « au-dessous de -14 °C à LOUT » ont été réduites pour tous les liquides de type II et de type IV. Certaines de ces réductions ont par la suite été, dans le cas de conditions précises, retirées de documents d'orientation supplémentaires.
- À la suite du retrait de certains liquides et de l'ajout de nouveaux, des changements ont été apportés aux lignes directrices relatives aux durées d'efficacité génériques des liquides de type II et de type IV. Le tableau générique des durées d'efficacité des liquides de type IV a été étoffé pour inclure les durées d'efficacité dans de conditions de chutes de neige de trois intensités, soit très faibles, faibles et modérées.
- Plusieurs changements ont été apportés aux tableaux des marges de tolérance. Parmi ceux-ci, notons la réorganisation des rangées, l'ajout de rangées pour de nouveaux types de précipitations, des changements mineurs apportés à certaines des marges de tolérance existantes et d'autres changements mineurs relatifs aux plages de température existantes pour les liquides de type IV.
- Transports Canada a publié des tableaux spéciaux des durées d'efficacité conçus pour être utilisés lorsque les volets et becs de bord d'attaque sont déployés avant les opérations de dégivrage ou d'antigivrage. Ces nouveaux tableaux contiennent des durées d'efficacité dont les valeurs représentent 90 pour cent de celles du tableau standard des durées d'efficacité.

Il est recommandé que tout nouveau liquide de type I, de type II, de type III ou de type IV soit évalué pour toute la gamme des conditions couvertes par les lignes directrices relatives aux durées d'efficacité, que des essais supplémentaires dans des conditions de givre soient menés avec les liquides existants et que des recherches visant à atténuer les réductions appliquées aux durées d'efficacité des liquides de type II ou de type IV dans des conditions de neige très froide soient envisagées.

17. Mots clés Antigivrage, dégivrage, liquide de dégivrage, durées d'efficacité, précipitation, temps d'endurance, type I, type II, type III, type IV, aéronef, sol, essai, hiver	18. Diffusion Le Centre de développement des transports dispose d'un nombre limité d'exemplaires.

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EXECUTIVE SUMMARY

Under contract to the Transportation Development Centre of Transport Canada, with support from the Federal Aviation Administration (FAA), and several fluid manufacturers, APS Aviation Inc. (APS) has undertaken a testing and research program to further advance aircraft ground de/anti-icing technology. The program has a number of objectives, and work completed to address these objectives is documented in a series of related reports. The primary objective, the development of holdover time (HOT) guidelines for new de/anti-icing fluids, is addressed in this report. The objective was met by conducting holdover time tests with several de/anti-icing fluids. This report also documents changes made to the HOT guidelines for the winter of 2016-17.

Test Procedures

Test conditions, test parameters, and test bed specifications were determined based on the requirements of Aerospace Recommended Practice (ARP) 5485 and ARP5495, which were developed by the SAE International (SAE) G-12 Holdover Time Committee for Type II/III/IV and Type I fluids, respectively. The tests consisted of pouring freezing point depressant fluids onto clean, inclined (10°), standard flat aluminum plates. The plates were mounted on test stands and systematically exposed to a variety of natural or simulated icing conditions. For each plate, the elapsed time required to reach a predefined end condition was recorded.

The variables measured during testing included: failure time, type of precipitation, rate of precipitation, visibility, wind speed, wind direction, ambient temperature, test surface temperature, fluid brand, fluid type, and fluid concentration.

Data Collection and Testing

During the 2015-16 test season, data was collected during natural snow and natural frost events at the APS test site at Montreal-Trudeau Airport in Montreal and several mobile test sites and in simulated precipitation conditions (freezing drizzle, light freezing rain, freezing fog, rain on cold-soaked surface) at the National Research Council Canada (NRC) Climatic Engineering Facility in Ottawa.

APS conducted 896 tests in the winter of 2015-16. The results of testing were incorporated into the winter 2016-17 HOT guidelines.

Changes to the HOT Guidelines

The changes below were made to the HOT guidelines for winter 2016-17.

1. Fluid-specific HOT guidelines were added for four new fluids: Beijing Yadilite Aviation YD-102 Type II (Type II), Clariant Max Flight AVIA (Type IV), Clariant Safewing EG IV NORTH (Type IV) and Shaanxi Cleanway Aviation Cleansurface IV (Type IV).

2. AllClear AeroClear MAX (Type III) and Deicing Solutions ECO-SHIELD® (Type IV) holdover times were updated as a result of supplemental testing with new samples.

3. LNT Solutions P250 (Type II), Cryotech Polar Guard® (Type IV) and Dow Chemical UCAR™ FlightGuard AD-480 (Type IV) were removed from the HOT guidelines.

4. The holdover times for snow in the "below -14°C to LOUT" row were reduced for all Type II and Type IV fluids. Some of the reductions were later retracted in supplemental guidance materials.

5. Changes were made to the Type II and Type IV generic HOT guidelines as a result of the new and removed fluids. The Type IV generic HOT table was expanded to include holdover times for three snowfall intensities: very light, light and moderate.

6. Several changes were made to the Type III and Type IV allowance time tables. These include reordering of the existing precipitation type rows, the addition of new precipitation type rows, minor changes to some existing allowance times, and minor changes to the existing Type IV temperature bands.

7. Transport Canada published special HOT tables for use when flaps/slats are deployed prior to de/anti-icing. These tables contain holdover times that are 90 percent of the standard HOT table values.

8. Changes have been made to the Type I and Type II/IV fluid application tables to improve harmonization with the FAA and SAE fluid application tables.

9. Guidance for the application of Type III fluid was previously provided in the same table as the guidance provided for the application of Type II/IV fluid. This guidance was moved to two new Type III fluid application tables.

Recommendations

It is recommended that any new Type I, Type II, Type III or Type IV fluids be evaluated over the entire range of conditions encompassed by the HOT tables.

SOMMAIRE

En vertu d'un contrat avec le Centre de développement des transports de Transports Canada, avec l'appui de la Federal Aviation Administration (FAA) et de plusieurs fabricants de liquides, APS Aviation Inc. (APS) a entrepris des essais et un programme de recherches visant à approfondir la technologie de dégivrage et d'antigivrage d'aéronefs au sol. Le programme poursuivait plusieurs objectifs et les travaux effectués pour atteindre ces objectifs sont documentés dans une suite de rapports connexes. Le principal objectif, le développement de lignes directrices sur les durées d'efficacité (HOT) de nouveaux liquides de dégivrage et d'antigivrage, fait l'objet du présent rapport. Pour atteindre cet objectif, des essais sur les durées d'efficacité ont été menés avec plusieurs liquides de dégivrage et d'antigivrage. Le présent rapport documente également l'ensemble des changements apportés aux lignes directrices sur les durées d'efficacité pour l'hiver 2016-2017.

Procédures d'essai

Les conditions d'essai, les paramètres d'essai et les spécifications relatives au banc d'essai ont été déterminés en vertu des exigences des pratiques recommandées en aérospatiale ARP5485 et ARP5495, élaborées par le comité G-12 de la SAE International (SAE) sur les durées d'efficacité pour les liquides de types II/III/IV et de type I, respectivement. Ces tests consistaient à verser des liquides abaisseurs du point de congélation sur des plaques en aluminium et en matériaux composites standards, plates, propres et inclinées (à 10°). Les plaques étaient montées sur un support d'essai et systématiquement exposées à une gamme de conditions de givrage, naturelles ou simulées. Pour chaque plaque, on notait le temps écoulé avant l'atteinte d'un état final prédéfini.

Parmi les variables mesurées dans le cadre de ces essais, on notait : temps de défaillance, type de précipitation, taux de précipitation, visibilité, vitesse du vent, direction du vent, température ambiante, température de la surface d'essai, marque de commerce du liquide, type de liquide et concentration du liquide.

Collecte de données et essais

Les données recueillies au cours de la saison d'essai 2015-2016 concernaient des tests sous neige naturelle et givre naturel menés à l'installation d'essai d'APS, à l'aéroport Montréal-Trudeau, à Montréal, ainsi que sur plusieurs sites d'essai mobiles dans des conditions de précipitations simulées (bruine verglaçante, pluie verglaçante faible, brouillard verglaçant et pluie sur des surfaces imprégnées de froid) à l'installation de génie climatique du Conseil national de recherches du Canada (CNRC), à Ottawa.

Au cours de l'hiver 2015-2016, un total de 896 essais ont été menés par APS. Les résultats des essais effectués ont été inclus dans les lignes directrices relatives aux durées d'efficacité pour l'hiver 2016-2017.

Changements aux lignes directrices sur les durées d'efficacité

Les changements ci-dessous ont été apportés aux lignes directrices relatives aux durées d'efficacité pour l'hiver 2016-2017.

1. Des lignes directrices relatives aux durées d'efficacité spécifiques à quatre nouveaux liquides, soit Beijing Yadilite Aviation YD-102 Type II (type II), Clariant Max Flight AVIA (type IV), Clariant Safewing EG IV NORTH (type IV) et Shaanxi Cleanway Aviation Cleansurface IV (type IV), ont été ajoutées.
2. Les durées d'efficacité des liquides AllClear AeroClear MAX (type III) et Deicing Solutions ECO-SHIELD^{MD} (type IV) ont été mises à jour à la suite d'essais supplémentaires effectués à l'aide de nouveaux échantillons.
3. Les liquides LNT Solutions P250 (type II), Cryotech Polar Guard^{MD} (type IV) et Dow Chemical UCAR^{MC} FlightGuard AD-480 (type IV) ont été retirés des lignes directrices relatives aux durées d'efficacité.
4. Les durées d'efficacité dans des conditions de neige de la rangée « au-dessous de -14 °C à LOUT » ont été réduites pour tous les liquides de type II et de type IV. Certaines de ces réductions ont par la suite été retirées de documents d'orientation supplémentaires.
5. À la suite du retrait de certains liquides et de l'ajout de nouveaux, des changements ont été apportés aux lignes directrices relatives aux durées d'efficacité génériques des liquides de type II et de type IV. Le tableau générique des durées d'efficacité des liquides de type IV a été étoffé pour inclure les durées d'efficacité dans de conditions de chutes de neige de trois intensités, soit très faibles, faibles et modérées.
6. Plusieurs changements ont été apportés aux tableaux des marges de tolérance des liquides de type III et de type IV. Parmi ceux-ci, notons la réorganisation des rangées existantes relatives aux types de précipitations, l'ajout de rangées pour de nouveaux types de précipitations, des changements mineurs apportés à certaines des marges de tolérance existantes et d'autres changements mineurs relatifs aux plages de température existantes pour les liquides de type IV.
7. Transports Canada a publié des tableaux spéciaux des durées d'efficacité conçus pour être utilisés lorsque les volets et becs de bord d'attaque sont déployés avant les opérations de dégivrage ou d'antigivrage. Ces tableaux

contiennent des durées d'efficacité dont les valeurs représentent 90 pour cent de celles du tableau standard des durées d'efficacité.

8. Des changements ont été apportés aux tableaux d'application des liquides de type I, de type II et de type IV afin de mieux les harmoniser aux tableaux d'application des liquides de la FAA et de la SAE.
9. Les lignes directrices pour l'application des liquides de type III étaient précédemment fournies dans le même tableau que celles relatives à l'application des liquides de type II et de type IV. Ces lignes directrices apparaissent désormais dans deux nouveaux tableaux pour l'application des liquides de type III.

Recommandations

Il est recommandé que tout nouveau liquide de type I, de type II, de type III ou de type IV soit évalué pour toute la gamme des conditions couvertes par les lignes directrices relatives aux durées d'efficacité.

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GLOSSARY

APS	APS Aviation Inc.
ARP	Aerospace Recommended Practice
CEF	Climatic Engineering Facility
FAA	Federal Aviation Administration
HOT	Holdover Time
IREQ	Institut de Recherche d'Hydro-Québec
LOUT	Lowest Operational Use Temperature
LOWV	Lowest On-Wing Viscosity
NRC	National Research Council Canada
SAE	SAE International
TDC	Transportation Development Centre
WSET	Water Spray Endurance Test

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1. INTRODUCTION

Under winter precipitation conditions, aircraft are cleaned with a freezing point depressant fluid and protected against further accumulation by an additional application of such a fluid, possibly thickened to extend the protection time. Aircraft ground deicing had, until recently, never been researched and there is still an incomplete understanding of the hazard and of what can be done to reduce the risks posed by the operation of aircraft in winter precipitation conditions. This "winter operations contaminated aircraft – ground" program of research is aimed at overcoming this lack of knowledge.

Since the early 1990s, the Transportation Development Centre (TDC) of Transport Canada has managed and conducted de/anti-icing related tests at various sites in Canada; it has also coordinated worldwide testing and evaluation of evolving technologies related to de/anti-icing operations with the co-operation of the United States Federal Aviation Administration (FAA), the National Research Council Canada (NRC), several major airlines, and deicing fluid manufacturers. The TDC is continuing its research, development, testing and evaluation program.

Under contract to the TDC, with financial support from the FAA, APS Aviation Inc. (APS) has undertaken research activities to further advance aircraft ground de/anti-icing technology.

1.1 Background

APS has completed considerable testing related to de/anti-icing fluids on behalf of Transport Canada over the past two decades. Specifically, research has been conducted to determine fluid holdover times, to substantiate holdover time (HOT) tables, and to further the knowledge and development of deicing technology. A summary of the holdover time related research activities completed by APS is provided in Table 1.1.

1.2 Objectives

The primary objectives of the 2015-16 holdover time test program were to conduct flat plate tests under conditions of natural and simulated precipitation to determine de/anti-icing fluid endurance times for new fluids, to develop HOT guidelines based on samples of newly and previously qualified deicing and anti-icing fluids, and to document changes made to the HOT guidelines for the winter of 2016-17.

The detailed objectives of the 2015-16 test program are provided in the work statement excerpt in Appendix A.

Table 1.1: Summary of APS Holdover Time Testing Activities

Year	TDC Publication #	Conditions Tested	Fluids Tested	Test Locations
1990-91	TP 11206E	• Natural Precipitation (mostly snow)	• Type II (100%)	Mostly Montreal Worldwide
1991-92	TP 11454E	• Natural Precipitation (mostly snow)	• Type III (first gen)	Mostly Montreal St. John's
1992-93	TP 11836E	• Natural Snow • Simulated Freezing Drizzle (prelim) • Simulated Freezing Fog (outdoor) • Artificial Snow (prelim)	• Type I • Type II (100%) • Type III (first gen)	Montreal Ottawa (NRC) Rigaud
1993-94	TP 12915E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (outdoor)	• Primarily: Type II (dilutions) • Also: Type II (neat), Type I	Montreal Ottawa (NRC)
1994-95	TP 12654E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface (prelim)	• Type I • Type II • Type IV (prelim)	Montreal Ottawa (NRC)
1995-96	TP 12896E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface	• Type I • Type II • Type IV	Montreal Ottawa (NRC)
1996-97	TP 13131E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface	• Type I • Type II (100%) • Type III (first gen) • Type IV	Montreal Ottawa (NRC)
1997-98	TP 13318E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface	• Type IV	Montreal Ottawa (NRC)
1998-99	TP 13477E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Artificial Snow	• Type I • Type II • Type IV (LV)	Montreal Ottawa (NRC)
1999-2000	TP 13659E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Artificial Snow • Preliminary Frost	• Type I • Type II • Type IV	Montreal Ottawa (NRC) Varennes (IREQ)

Table 1.1: Summary of APS Holdover Time Testing Activities (cont'd)

Year	TDC Publication #	Conditions Tested	Fluids Tested	Test Locations
2000-01	TP 13826E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Artificial Snow • Preliminary Frost	• Type I • Type II • Type IV	Montreal Ottawa (NRC) Varennes (IREQ)
2001-02	TP 13991E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Artificial Snow • Preliminary Frost	• Type I • Type II • Type IV	Montreal Ottawa (NRC) Val-d'Or North Bay Thompson
2002-03	TP 14144E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Artificial Snow • Preliminary Frost	• Type I • Type II • Type IV	Montreal Ottawa (NRC) Varennes (IREQ) St-Alexis
2003-04	TP 14374E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Natural Frost • Artificial Snow	• Type II • Type III	Montreal Ottawa (NRC) Val-d'Or Ste-Adele
2004-05	TP 14443E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Natural Frost	• Type II • Type III • Type IV	Montreal Ottawa (NRC)
2005-06	TP 14712E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Natural Frost • Ice Pellets / Mixed Conditions	• Type I • Type II • Type IV	Montreal Ottawa (NRC)
2006-07	TP 14776E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Natural Frost • Artificial Snow • Ice Pellets / Mixed Conditions	• Type I • Type II • Type IV	Montreal Ottawa (NRC)

Table 1.1: Summary of APS Holdover Time Testing Activities (cont'd)

Year	TDC Publication #	Conditions Tested	Fluids Tested	Test Locations
2007-08	TP 14869E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Natural Frost • Artificial Snow • Ice Pellets / Mixed Conditions • Snow Pellets	• Type II • Type III • Type IV	Montreal Ottawa (NRC)
2008-09	TP 14933E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Natural Frost • Ice Pellets / Mixed Conditions	• Type II • Type III • Type IV	Montreal Ottawa (NRC)
2009-10	TP 15050E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Ice Pellets / Mixed Conditions • Snow Pellets	• Type I • Type II • Type IV	Montreal Val-d'Or Dolbeau-Mistassini Thetford Mines St-Sauveur Ottawa (NRC)
2010-11	TP 15156E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Artificial Snow • Ice Pellets / Mixed Conditions	• Type I • Type II • Type IV	Montreal Ottawa (NRC)
2011-12	TP 15156E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Artificial Snow	• Type I • Type II • Type III	Montreal Gaspésie Rimouski St-Jovite Edmundston Ottawa (NRC)
2012-13	TP 15228E	• Natural Snow • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Artificial Snow	• Type I • Type II • Type III	Montreal Ottawa (NRC)
2013-14	TP 15271E	• Natural Snow/Frost • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Artificial Snow	• Type I • Type II • Type III • Type IV	Montreal Val-d'Or Timmins Kuujjuaq Ottawa (NRC)

Table 1.1: Summary of APS Holdover Time Testing Activities (cont'd)

Year	TDC Publication #	Conditions Tested	Fluids Tested	Test Locations
2014-15	TP 15321E	• Natural Snow/Frost • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Artificial Snow	• Type I • Type II • Type III • Type IV	Montreal Mirabel Morin Heights Beaconsfield Grand Prairie Ottawa (NRC)
2015-16	TP 15338E	• Natural Snow/Frost • Simulated Freezing Drizzle • Simulated Light Freezing Rain • Simulated Freezing Fog (indoor) • Rain on a Cold-Soaked Surface • Artificial Snow	• Type II • Type III • Type IV	Montreal Beaconsfield Blainville (PMG) St-Adèle Schefferville Iqaluit Ottawa (NRC)

1.3 Content of this Report

APS has written a report on the holdover time test program for each year it has been carried out. In 2003-04, the report was condensed to increase readability and to present the reader with, for the most part, only new and current information over the previous year's report.

Notably, the reader is now directed to Transport Canada report, TP 14144E, *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2002-03 Winter* (1), for the detailed test methodology and individual fluid test information is provided in appendices to the report rather than within the report itself.

In the winter of 2009-10, a decision was made to include detailed test information only for fluids that are expected to be qualified and commercialized. Test information for other fluids is not included.

1.4 Report Format

The subsequent sections of this report contain the following:

a) Section 2 summarizes 2015-16 testing;

b) Section 3 documents changes to the Type I HOT guidelines;

c) Section 4 documents changes to the Type II HOT guidelines;

d) Section 5 documents changes to the Type III HOT guidelines;

e) Section 6 documents changes to the Type IV HOT guidelines;

f) Section 7 documents changes to other HOT guidelines content;

g) Section 8 documents supplemental natural snow testing conducted at very low temperatures;

h) Section 9 documents supplemental frost testing;

i) Section 10 presents conclusions derived from the test program; and

j) Section 11 lists recommendations for future testing.

1.5 Publication of HOT Guidelines

HOT guidelines are published annually by both Transport Canada and the FAA.

1.5.1 Transport Canada

The Transport Canada HOT guidelines are published on the following website:

- http://www.tc.gc.ca/eng/civilaviation/standards/commerce-holdovertime-menu-1877.htm

The Transport Canada HOT guidelines are intended to be used in conjunction with TP 14052E, *Guidelines for Aircraft Ground Icing Operations (Second Edition)* (2), which includes reference material related to ground icing operations. TP 14052E (2) is also available on the Transport Canada website.

1.5.2 FAA

The FAA HOT guidelines are published on the following website:

- http://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/deicing/

The FAA HOT guidelines are intended to be used in conjunction with the N 8900 series notice, *Revised FAA-Approved Deicing Program Updates, Winter 20xx-20xx* (3), which is published annually and provides additional guidance and reference material applicable to the current winter. The latest N 8900 series is also available on the FAA website.

2. TESTING IN 2015-16

An overview of the testing completed in the winter of 2015-16 is provided in this chapter.

2.1 Procedures

Test procedures for holdover time testing of Type II, III and IV fluids were developed in accordance with SAE International (SAE) Aerospace Recommended Practice (ARP) 5485, *Endurance Time Tests for Aircraft Deicing/Anti-Icing Fluids: SAE Type II, III, and IV* (4). Test procedures for holdover time testing of Type I fluids were developed in accordance with ARP5945, *Endurance Time Tests for Aircraft Deicing/Anti-Icing Fluids: SAE Type I* (5).

Because this report serves as the publishing mechanism for the APS endurance time test program, all current endurance time test procedures are included in the report, even if they are not updated or used in a given year (for example, the Type I procedure is included even if no Type I fluids are tested). This is to ensure the most current procedure is available for reference.

The procedures valid for the 2015-16 winter are included in Appendix B. They include:

1. Procedure for Conducting Endurance Time Tests for SAE Deicing/Anti-icing Fluids – SAE Type II, III and IV;
2. Determination of Endurance Times of Type I Fluids Under Natural Snow Precipitation at Dorval;
3. Procedure: Endurance Time Testing in Frost with Type I, II, III and IV Fluids;
4. Procedure: Endurance Time Test Requirements for Simulated Snow Flat Plate Testing – Type II, III and IV Fluids;
5. Procedure: Development of Type I Protocol for Indoor Snow (ARP5495); and
6. Overall Program of Tests at NRC, March/April 2016.

The first two procedures provide the detailed test methodology for natural snow testing. The third procedure provides the detailed test methodology for indoor simulated light freezing rain, freezing fog, freezing drizzle and rain on cold-soaked surface testing. The fourth and fifth procedures provide the detailed test methodology for frost and artificial snow testing, respectively.

The sixth procedure was developed to coordinate holdover time testing and other aircraft ground icing research projects at the annual APS indoor simulated precipitation test session. Holdover time testing and other program element testing were conducted at the same session to maximize use of the facility and resources.

The endurance time test methodology is described in detail in the Transport Canada report, TP 14144E, *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2002-03 Winter* (1).

The primary details of the test procedures used each winter, including details specific to the given winter (i.e. test sites), are summarized annually in a test methodology report. A copy of this report is included as Appendix C. The report is also included as an annex to each fluid manufacturer report (see Subsection 2.6).

2.2 Software

Over the winters of 2012-13 and 2013-14, two software projects were completed to improve the holdover time testing process.

1. A new interface was created for the freezing precipitation (indoor) rate management program. The new interface streamlines the process for measuring and managing precipitation rates in freezing precipitation.

2. An application was created to replace the paper-based end condition data form. It improves efficiency and accuracy in recording endurance times and adds new features to better manage the testing process.

Further details on these upgrades are provided in the Transport Canada report, TP 15269E, *Aircraft Ground Icing General Research Activities During the 2013-14 Winter* (6).

2.3 Test Sites

Simulated precipitation testing (freezing drizzle, light freezing rain, freezing fog and rain on cold-soaked surfaces) was conducted at the NRC Climatic Engineering Facility (CEF) in Ottawa.

Natural snow testing was conducted primarily at the APS test site at the Pierre Elliott Trudeau Airport in Montreal. Several tests were also conducted at remote locations using a mobile test site. The remote locations included Beaconsfield (Quebec), Schefferville (Quebec), St-Adèle (Quebec) and Iqaluit (Nunavut).

Artificial snow testing was required in the winter of 2015-16. It was conducted at the APS test site at the Montreal airport and at the PMG Technologies Inc. cold chamber in Blainville (Quebec).

2.4 Fluids Tested

Seven fluids underwent endurance time testing in the winter of 2015-16. As described in Subsection 1.3, only the endurance time results of fluids that are expected to be commercialized are published in this report; the results of any other fluids that undergo testing are provided only to the fluid manufacturer(s).

Two Type II fluids were tested:

- Beijing Yadilite Aviation YD-102 Type II: This new Type II fluid underwent endurance time testing in winter 2015-16 and is expected to be commercialized in the future. The detailed test results are provided in Appendix D.

- Type II Experimental Fluid: A Type II experimental fluid was submitted for testing. Testing was cancelled midway through the testing season at the request of the fluid manufacturer. This fluid will not be commercialized and therefore the detailed test results are not provided in this report.

One Type III fluid was tested:

- AllClear AeroClear MAX: A new formulation of this Type III fluid underwent endurance time testing in winter 2015-16 (100/0 only, no dilutions) and is expected to be commercialized in the future. The fluid was tested for use applied at ambient temperature. As a result of this testing, the previously published holdover times for this fluid were updated. The detailed test results are provided in Appendix E.

Four Type IV fluids were tested:

- Clariant Max Flight AVIA: This new Type IV fluid underwent endurance time testing in winter 2015-16 and the 100/0 fluid (only) is expected to be commercialized in the future. The detailed test results are provided in Appendix F.

- Clariant Safewing EG IV NORTH: This new Type IV fluid underwent endurance time testing in winter 2015-16 and the 100/0 fluid (only) is expected to be commercialized in the future. The detailed test results are provided in Appendix G.

- Shaanxi Cleanway Aviation Cleansurface IV: This new Type IV fluid underwent endurance time testing in winter 2015-16 and is expected to be commercialized in the future. The detailed test results are provided in Appendix H.

- Deicing Solutions ECO-SHIELD: A new formulation of this Type IV fluid underwent endurance time testing in winter 2015-16 (100/0 only, no dilutions) and is expected to be commercialized in the future. As a result of this testing, the previously published holdover times for this fluid were updated. The detailed test results are provided in Appendix I.

Additional relevant fluid receipt data for the commercialized fluids is provided in Table 2.1 (fluid receipt data) and Table 2.2 (fluid characteristic data).

Table 2.1: Fluid Receipt Data (Commercialized Fluids)

Fluid Manufacturer	Fluid Name	Fluid Type	Fluid Formulation	Date Received	Batch #	Dilutions Received (%)
Beijing Yadilite Aviation	YD-102 Type II	II	Propylene Glycol	06-Jan-16	20151220	100, 75, 50
AllClear	AeroClear MAX	III	Ethylene Glycol	21-Sep-15	CB1-PB8000A-2	100
Clariant	Max Flight AVIA	IV	Ethylene Glycol	22-Dec-15	TV 548	100, 75, 50
Clariant	Safewing EG IV NORTH	IV	Ethylene Glycol	22-Dec-15	TV 549	100, 75, 50
Shaanxi Cleanway Aviation	Cleansurface IV	IV	Propylene Glycol	23-Nov-15	15031901	100, 75, 50
Deicing Solutions	ECO-SHIELD®	IV	Propylene Glycol	04-Feb-16	160108D-CC	100

Table 2.2: Fluid Characteristic Data (Commercialized Fluids)

Fluid	Fluid Dil.	Brix (Measured)	WSET (mins)	Freeze Point (Stated, °C)	Aerodynamic LOUT (Stated, °C)	Viscosity (Measured, mPa.s)	
						Mfr. Method	AS9968 Method
Beijing Yadilite Aviation YD-102 Type II	100/0	35.25°	56	-38.0	-29.0	4,500[1]	4,500[1]
	75/25	27.75°	n/a	-24.0	-19.5	12,850[1]	12,850[1]
	50/50	19.0°	n/a	-13.0	-9.5	820[1]	300[2]
AllClear AeroClear MAX	100/0	33.75°	n/a	-44.0	-16.0/-35.5[3]	7,300[4]	n/a
Clariant Max Flight AVIA	100/0	31.75°	>120	-39.9	-28.5	1,000[2]	1,000[2]
	75/25	24.75°	n/a	-23.5	-19.5	n/a[5]	n/a[5]
	50/50	17.25°	n/a	-12.6	-9.5	n/a[5]	n/a[5]
Clariant Safewing EG IV NORTH	100/0	31.5°	117	-39.5	-30	830[2]	830[2]
	75/25	24.5°	n/a	-23.6	-20	n/a[5]	n/a[5]
	50/50	17.0°	n/a	-11.8	-9.5	n/a[5]	n/a[5]
Shaanxi Cleansurface IV	100/0	38.5°	>120	-40.0	-28.5	15,200[6]	15,200[6]
	75/25	31.25°	n/a	-25.2	-20.0	28,500[6]	28,500[6]
	50/50	21.75°	n/a	-11.0	-9.5	17,500[6]	17,500[6]
Deicing Solutions ECO-SHIELD	100/0	35.75°	110	-34.0°C	-25.5°C	11,050[7]	11,050[7]

1 Spindle LV1, 600 mL low form (Griffin) beaker, 575 mL of fluid, 20°C, 0.3 rpm, for 10.0 minutes
2 Spindle LV0, UL adapter, 16 mL of fluid, 20°C, 0.3 rpm, for 10.0 minutes
3 Low speed/high speed ramp
4 Spindle SC4-31, small sample adapter, 9 mL, 0°C, 0.3 rpm, for 30.0 mins
5 Viscosity measurements were not confirmed. Obtained results were not repeatable.
6 Spindle LV2, 600 mL low form beaker, 425 mL of fluid, 20°C, 0.3 rpm, for 10.0 minutes
7 Spindle LV1 (with guard leg), 600 mL low form (Griffin) beaker, 575 mL of fluid, 20°C, 0.3 rpm, for 10.0 minutes

2.5 Description of Tests

In total, 896 endurance time tests were conducted during the winter of 2015-16. A summary of the total number of tests conducted is shown by precipitation condition in Table 2.3. Details for each test are included in the detailed reports provided to the manufacturers (see Subsection 2.5).

Table 2.3: Summary of Tests Conducted

Precipitation Condition	Tests Conducted
Natural Snow	491
Artificial Snow	3
Freezing Fog	128
Freezing Drizzle	104
Light Freezing Rain	102
Rain on Cold-Soaked Surface	40
Natural Frost	28
Total	**896**

2.6 Reporting

A comprehensive report was created for each fluid tested to document its performance in detail. These reports were provided to the fluid manufacturers. As per Subsection 1.3, copies of the reports for fluids which are expected to be qualified/commercialized have been included as appendices to this report. The relevant reports can be found in Appendices D, E, F, G, H and I. In addition, the Winter 2015-16 test methodology report is also provided as annex to each report. This report can be found in Appendix C.

2.7 Supplemental Testing – Very Cold Snow Research

Supplemental endurance time testing was conducted with Type II and Type IV fluids in snow at very cold temperatures in the winter of 2015-16. This research is documented in this report in Section 8.

2.8 Supplemental Testing – Frost Holdover Time Substantiation

Supplemental endurance time testing was conducted in active frost conditions in the winter of 2015-16. This research is documented in this report in Section 9.

3. CHANGES TO THE TYPE I HOT GUIDELINES

Changes made to the Type I HOT guidelines for the winter of 2016-17 are documented in this chapter. The Transport Canada and FAA 2016-17 Type I HOT guidelines are included in Appendix J.

3.1 New Fluids/Data

A significant body of previous research and testing has indicated that all Type I fluids formulated with glycol perform in a similar manner from an endurance time perspective. As a result, regulators no longer require Type I deicing fluids formulated with propylene glycol, ethylene glycol or diethylene glycol to undergo endurance time testing. However, they do require testing of fluids formulated with other glycol bases or with non-glycol bases. This is to ensure the endurance time performance of these fluids is similar to that of the Type I fluids used to generate the current Type I holdover times.

Endurance times of Type I fluids are still tested in some years, either (a) at the request of the fluid manufacturer or (b) because the fluid is not propylene glycol, ethylene glycol or diethylene glycol based.

No Type I fluids were tested in the winter of 2015-16.

3.2 Changes to HOT Guidelines Format

No changes were made to the format of the Type I HOT guidelines for winter 2016-17.

3.3 Type I Generic Holdover Time Values

No changes were made to the Type I generic holdover times for the winter of 2016-17.

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4. CHANGES TO THE TYPE II HOT GUIDELINES

Changes made to the Type II HOT guidelines for the winter of 2016-17 are documented in this chapter. The Transport Canada and FAA 2016-17 Type II HOT guidelines are included in Appendix J.

4.1 New Fluids/Data

4.1.1 New Fluids

One new Type II fluid was added to the HOT guidelines for the winter of 2016-17: **Beijing Yadilite YD-102 Type II**. This fluid underwent endurance time testing in the winter of 2015-16. Details of this testing are included in the associated report included as Appendix D. The introduction of this fluid led to several reductions in the generic Type II holdover times (see Subsection 4.4.2).

At the request of the manufacturer, supplemental tests were conducted with YD-102 Type II to evaluate the impact of a dye on its endurance time performance. The conclusion of these tests was that the holdover times derived for the fluid are valid for both undyed (colourless) and dyed (coloured) versions of the fluid. Details of this testing are included in Appendix D.

4.1.2 Supplemental Data

Supplemental data was collected with a variety of Type II and Type IV fluids in very cold natural snow conditions in the winter of 2015-16. This data indicated the existing generic snow holdover times in the coldest temperature band were not appropriate. As a result, the holdover times in these cells were reduced for the winter of 2016-17. This research is described in further detail in Section 8.

4.2 Removed Fluids/Data

LNT Solutions P250 was removed from the HOT guidelines for the winter of 2016-17 at the request of the regulators. The removal of this fluid did not impact the generic Type II holdover times (see Subsection 4.4.2).

4.3 Changes to HOT Guidelines Format

No changes were made to the format of the Type II HOT Guidelines for winter 2016-17.

4.4 Type II Generic Holdover Time Values

Generic Type II holdover times are published annually. These holdover times represent the worst case performance of all Type II fluids and can be used with any Type II fluid. The protocol used to determine the Type II generic holdover time values each winter is described in Subsection 4.4.1. Subsection 4.4.2 describes the impact of new and removed data on the generic holdover times. Subsection 4.4.3 presents the changes to the generic holdover times for winter 2016-17 and details the fluids that are responsible for each generic holdover time value.

4.4.1 Protocol for the Determination of Type II Generic Holdover Times

The generic HOT guidelines for Type II fluid were developed prior to 1996-97 based on the results of endurance time tests with "grandfathered" fluids. Since 1999-2000, fluid-specific holdover times have been developed for each new Type II fluid tested, and the generic Type II holdover times have been generated each year by taking the shortest holdover times of:

1. All Type II fluids listed in the Transport Canada and FAA HOT guidelines documents;
2. The "grandfathered" fluid data (included to account for the performance of grandfathered fluids which do not have fluid-specific holdover time data available, i.e. Kilfrost ABC-3); and
3. All fluids on the Transport Canada and FAA list of Type IV fluids (included because all Type IV fluids also qualify as Type II fluids).

It should be noted that the HOT guidelines includes fluids whose qualifications have recently expired (i.e. within four years). Fluids are only removed from the generic analysis when they are removed from HOT guidelines.

4.4.2 Use of Generic Holdover Times in Very Cold Snow

Following the winter of 2003-04, a decision was made that fluid-specific holdover times would not be provided for Type II fluids in snow at temperatures below -14°C. This was due to the limited data that exits for most fluids at these temperatures.

Instead, all Type II fluids are given pre-established "generic" holdover times in very cold snow. These holdover times are determined based on historical data and analysis. As described in Section 8, modifications were made to these values for the winter of 2016-17 (specific details provided in Subsection 8.11.1).

4.4.3 Impact of New and Removed Fluids/Data

The addition of the new Type II fluid led to twelve reductions to the Type II generic holdover times. All of the reductions were 5 minutes or less.

4.4.4 Type II Generic Holdover Time Values and the Fluids Responsible

The Type II generic holdover times and the fluids that are responsible for them are shown in Table 4.1 and Table 4.2 for winters 2015-16 and 2016-17, respectively. Changes made to the holdover times for winter 2016-17 are show in Table 4.2 in red (decreases) and green (increases). The winter 2015-16 table is included for reference.

Due to space limitations, the following abbreviations are used in the tables:

- ABAX Ecowing 26 (A-E26);
- Aviation Shaanxi Cleanwing II (AS-CII);
- Beijing Yadilite YD-102 Type II (B-YD);
- Clariant Safewing MP II FLIGHT (C-Flight);
- Clariant Safewing MP II FLIGHT PLUS (C-Flight+);
- Kilfrost ABC-Ice Clear II (K-A-IC);
- Kilfrost ABC-K Plus (K-ABC-K+);
- Newave Aerochemical FCY-2 (N-FCY-2); and
- Newave Aerochemical FCY-2 Bio+ (N-FCY-2B).

In both tables it should be noted that:

- "Grandfather" is indicated where "grandfathered" fluids are responsible for times in the cells;
- "Type IV" is indicated where Type IV fluids are responsible for times in the cells; and
- A "U" indicates the fluid is responsible for the upper value in the cell, an "L" indicates the fluid is responsible for the lower value in the cell, and a "B" indicates the fluid is responsible for both the upper and lower cell values.

Table 4.1: Type II Generic Holdover Time Values and Responsible Fluids – Winter 2015-16

Outside Air Temperature (Degrees Celsius)	Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)				
		Freezing Fog or Ice Crystals	**Snow, Snow Grains or Snow Pellets**	**Freezing Drizzle**	**Light Freezing Rain**	**Rain on Cold Soaked Wing**
-3 and above	100/0	**0:35 – 1:30**	**0:20 – 0:45**	**0:30 – 1:00**	**0:15 – 0:30**	**0:07 – 0:40**
		Grandfather **(B)**	Grandfather **(B)**	Grandfather **(B)**	Grandfather **(B)**	K-A-IC **(L)** Grandfather **(U)**
	75/25	**0:25 – 1:00**	**0:15 – 0:30**	**0:20 – 0:45**	**0:10 – 0:25**	**0:05 – 0:25**
		Grandfather **(B)**	Grandfather **(B)**	Grandfather **(B)** N-FCY-2 **(U)** K-A-IC **(U)**	Grandfather **(B)** N-FCY-2 **(U)** N-FCY-2B **(U)**	Grandfather **(B)** N-FCY-2 **(B)** K-A-IC **(L)**
	50/50	**0:15 – 0:30**	**0:05 – 0:15**	**0:10 – 0:20**	**0:05 – 0:10**	CAUTION: No holdover time guidelines exist
		K-A-IC **(B)** N-FCY-2B **(B)** Grandfather **(L)**	Grandfather **(B)** K-ABC-K+ **(U)** K-A-IC **(U)** N-FCY-2B **(U)** Type IV **(U)**	Grandfather **(B)** K-A-IC **(B)** N-FCY-2 **(B)** N-FCY-2B **(B)**	Grandfather **(B)** A-E26 **(U)** K-A-IC **(U)** N-FCY-2 **(U)** N-FCY-2B **(U)**	
below -3 to -14	100/0	**0:20 – 1:05**	**0:15 – 0:30**	**0:20 – 0:45**	**0:10 – 0:20**	
		Type IV **(L)** K-ABC-K+ **(U)**	N-FCY-2 **(B)** N-FCY-2B **(B)** Grandfather **(L)**	N-FCY-2 **(B)**	Grandfather **(L)** N-FCY-2 **(U)**	
	75/25	**0:25 – 0:50**	**0:08 – 0:20**	**0:15 – 0:30**	**0:08 – 0:15**	
		Type IV **(B)** Grandfather **(L)** K-ABC-K+ **(L)** C-Flight **(L)**	N-FCY-2B **(B)** N-FCY-2 **(U)**	N-FCY-2 **(B)** Type IV **(L)**	N-FCY-2 **(B)**	
below -14 to LOUT	100/0	**0:15 – 0:35**	**0:15 – 0:30**			
		Type IV **(L)** N-FCY-2 **(U)**	Historic Generic **(B)** Grandfather **(B)**			

L = DRIVES LOWER LIMIT U = DRIVES UPPER LIMIT B = DRIVES BOTH

Table 4.2: Type II Generic Holdover Time Values and Responsible Fluids – Winter 2016-17

Outside Air Temperature (Degrees Celsius)	Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)				
		Freezing Fog or Ice Crystals	**Snow, Snow Grains or Snow Pellets**	**Freezing Drizzle**	**Light Freezing Rain**	**Rain on Cold Soaked Wing**
-3 and above	100/0	**0:35 – 1:30**	**0:20 – 0:45**	**0:30 – 1:00**	**0:15 – 0:30**	**0:07 – 0:40**
		Grandfather **(B)**	Grandfather **(B)**	Grandfather **(B)**	Grandfather **(B)**	K-A-IC **(L)** Grandfather **(U)**
	75/25	**0:25 – 0:55**	**0:15 – 0:25**	**0:15 – 0:40**	**0:10 – 0:20**	**0:04 – 0:25**
		B-YD **(B)** Grandfather **(L)**	B-YD **(B)** Grandfather **(L)**	B-YD **(B)**	B-YD **(B)** Grandfather **(L)**	B-YD **(B)** Grandfather **(U)** N-FCY-2 **(U)**
	50/50	**0:15 – 0:25**	**0:05 – 0:10**	**0:08 – 0:15**	**0:05 – 0:09**	CAUTION: No holdover time guidelines exist
		B-YD **(B)** K-A-IC **(L)** N-FCY-2B **(L)** Grandfather **(L)**	B-YD **(B)** Grandfather **(L)**	B-YD **(B)**	Grandfather **(L)** B-YD **(U)**	
below -3 to -14	100/0	**0:20 – 1:05**	**0:15 – 0:30**	**0:20 – 0:45**	**0:10 – 0:20**	
		Type IV **(L)** K-ABC-K+ **(U)**	B-YD **(B)** N-FCY-2 **(B)** N-FCY-2B **(B)** Grandfather **(L)**	N-FCY-2 **(B)**	Grandfather **(L)** N-FCY-2 **(U)**	
	75/25	**0:25 – 0:50**	**0:08 – 0:20**	**0:15 – 0:25**	**0:08 – 0:15**	
		B-YD **(U)** Grandfather **(L)** K-ABC-K+ **(L)** C-Flight **(L)**	B-YD **(B)** N-FCY-2B **(B)** N-FCY-2 **(U)**	B-YD **(B)** N-FCY-2 **(L)** Type IV **(L)**	N-FCY-2 **(B)** B-YD **(U)**	
below -14 to LOUT	100/0	**0:20 – 0:35**	**0:08 – 0:10**			
		Type IV **(L)** B-YD **(L)** AS-CII **(L)** K-A-IC **(L)** N-FCY-2B **(L)** C-Flight+ **(L)** Grandfather **(L)** N-FCY-2 **(U)**	Generic **(B)**			
L = DRIVES LOWER LIMIT U = DRIVES UPPER LIMIT B = DRIVES BOTH						

4.5 Further Changes to Holdover Times Published for Type II/IV Fluids in Very Cold Snow

Following the publication of the winter 2016-17 original issue holdover time guidance materials in August 2016, Transport Canada and the FAA subsequently reviewed the reductions made to holdover times published for Type II and Type IV fluids in snow at temperatures below -14°C. This was done at the request of the industry.

The result of this review was that the regulators issued optional changes (increases) to the holdover times in snow for:

- Type IV ethylene glycol based fluids, below -14°C; and
- Type II/IV propylene glycol based fluids, below -14 to -18°C.

In these conditions, the holdover times reverted to the holdover times that were published for all Type II and Type IV fluids in snow below -14°C for winter 2015-16.

Transport Canada published the updated holdover times and regression information through an Advisory Circular. Advisory Circular 007-040, *Supplemental Holdover Timetables and Regression Information for SAE Type II and IV Fluids*, was published on October 18, 2016. FAA published the updated holdover times in an addendum to the HOT Guidelines, which was published on September 30, 2016.

Copies of the Transport Canada Advisory Circular and FAA HOT Guidelines addendum are included in Appendix K.

5. CHANGES TO THE TYPE III HOT GUIDELINES

Changes made to the Type III HOT guidelines for the winter of 2016-17 are documented in this chapter. The Transport Canada and FAA 2016-17 Type III HOT guidelines are included in Appendix J.

5.1 New Fluids/Data

A new formulation of the Type III fluid **AllClear AeroClear MAX** underwent endurance time testing in the winter of 2015-16. The fluid was tested for use applied at ambient temperature and only 100/0 fluid was tested (no dilutions were tested). Due to the fluid's unusually low lowest operational use temperature (LOUT), special testing was conducted in artificial snow to determine holdover times for the fluid in snow at very cold temperatures. Details of this testing are included in the associated report included as Appendix E.

The protocol for integrating new data for an existing fluid is provided in ARP5718, *Qualification Process for SAE AMS1428 Type II, III, and IV Fluids* (7) §5.5.4. As the formulation had the same viscosity as the previously tested formulation, the lowest test data from the two formulations was used to determine each fluid-specific holdover time in the two associated fluid-specific HOT tables, which were updated accordingly for the winter of 2016-17.

5.2 Removed Fluids/Data

The protocol for removing obsolete holdover time data is given in ARP5718 (7). No Type III data was removed from the HOT guidelines for the winter of 2016-17.

5.3 Changes to HOT Guidelines Format

No changes were made to the Type III HOT guidelines format for the winter of 2016-17.

5.4 Type III Generic Holdover Time Values

As the two Type III fluids currently in the HOT guidelines are intended for use with different application temperatures (and no data exists for the fluids for the other application temperature), it is not possible at this time to provide generic holdover times for Type III fluids. Therefore, a generic Type III HOT table is not included in the 2016-17 HOT guidelines. This could change in future if the available fluids and/or data changes.

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6. CHANGES TO THE TYPE IV HOT GUIDELINES

Changes made to the Type IV HOT guidelines for the winter of 2016-17 are documented in this chapter. The Transport Canada and FAA 2016-17 Type IV HOT guidelines are included in Appendix J.

6.1 New Fluids/Data

6.1.1 New Fluids

Three new Type IV fluids were added to the HOT guidelines for the winter of 2016-17: **Clariant Max Flight AVIA**, **Clariant Safewing EG IV NORTH** and **Shaanxi Cleanway Aviation Cleansurface IV.** These new fluids underwent endurance time testing in the winter of 2015-16. Details of this testing are included in the associated reports included as Appendices F, G and H, respectively. It should be noted that, at the request of the manufacturer, holdover times were only provided for 100/0 fluid for the Clariant fluids (not for 75/25 or 50/50). The introduction of these fluids led to several reductions in the generic Type IV holdover times (see Subsection 6.4.2).

6.1.2 New Formulations of Existing Fluids

A new formulation of the Type IV fluid **Deicing Solutions ECO-SHIELD** underwent endurance time testing in the winter of 2015-16 (100/0 only, no dilutions). Details of this testing are included in the associated report included as Appendix I. The protocol for integrating new data for existing fluids is provided in ARP5718 (7) §5.5.4. As the formulation had a higher viscosity than the previously tested formulation, the data collected in 2015-16 replaced the data collected previously and the holdover times and lowest on-wing viscosity (LOWV) for this fluid were updated accordingly. The new ECO-SHIELD data resulted in several changes to the generic Type IV holdover times (see Subsection 6.4.2).

6.1.3 Supplemental Data

Supplemental data was collected with a variety of Type II and Type IV fluids in very cold natural snow conditions in the winter of 2015-16. This data indicated the existing generic snow holdover times in the coldest temperature band were not appropriate. As a result, the holdover times in these cells were reduced for the winter of 2016-17. This research is described in further detail in Section 8.

6.2 Removed Fluids/Data

The protocol for removing obsolete holdover time data is given in ARP5718 (7). As per the protocol, **Cryotech Polar Guard** and **Dow Chemical UCAR™ FlightGuard AD-480** were removed from the HOT guidelines for the winter of 2016-17, as was obsolete data for **Deicing Solutions ECO-SHIELD** (see Subsection 6.1). The removal of these fluids significantly impacted the generic Type IV holdover times (see Subsection 6.4.2).

6.3 Changes to HOT Guidelines Format

Columns were added to the Type IV generic HOT guidelines for moderate, light and very light snow (previously there was a single snow column populated with moderate snow data). This was possible for the first time in winter 2016-17 as all Type IV fluid-specific HOT guidelines included cells for moderate, light and very light snow.

6.4 Type IV Generic Holdover Time Values

Generic Type IV holdover times are published annually. These holdover times represent the worst case performance of all Type IV fluids and can be used with any Type IV fluid. The protocol used to determine the generic holdover time values each winter is described in Subsection 6.4.1. Subsection 6.4.2 describes the impact of new and removed data on the generic holdover times. Subsection 6.4.3 presents the changes to the generic holdover times for winter 2016-17 and details the fluids that are responsible for the values.

6.4.1 Protocol for the Determination of Type IV Generic Holdover Times

The values in the Type IV generic HOT table are generated each year by taking the shortest holdover times of all Type IV fluids listed in the Transport Canada and FAA HOT guidelines. It should be noted that the HOT guidelines includes fluids whose qualifications have recently expired (i.e. within four years). Fluids are only removed from the generic analysis when they are removed from HOT guidelines.

6.4.2 Use of Generic Holdover Times in Very Cold Snow

Following the winter of 2003-04, a decision was made that fluid-specific holdover times would not be provided for Type IV fluids in snow at temperatures below -14°C. This was due to the limited data that exits for most fluids at these temperatures.

Instead, all Type IV fluids are given pre-established "generic" holdover times in very cold snow. These holdover times are determined based on historical data and analysis. As described in Section 8, modifications were made to these values for the winter of 2016-17 (specific details provided in Subsection 8.11.1).

6.4.3 Impact of New and Removed Fluids/Data

The impact of the new and removed fluids/data on the Type IV generic holdover times was as follows:

- The addition of Max Flight resulted in one 2-minute decrease;
- The addition of Safewing EG IV NORTH resulted in one 2-minute decrease;
- The addition of Shaanxi Cleanway Aviation Cleansurface IV resulted in one 5-minute decrease;
- The new ECO-SHIELD data resulted in three 10 to 15 minute decreases and one 15-minute increase;
- The removal of Cryotech Polar Guard resulted in six 5 to 10-minute increases; and
- The removal of Dow Chemical UCAR™ FlightGuard AD-480 resulted in ten increases of 5 to 20 minutes.

6.4.4 Type IV Generic Holdover Time Values and the Fluids Responsible

The Type IV generic holdover times and the fluids that are responsible for them are shown in Table 6.1 and Table 6.2, for winters 2015-16 and 2016-17, respectively. Changes made to the holdover times for winter 2016-17 are show in Table 6.2 in red (decreases) and green (increases). The winter 2015-16 table is included for reference.

Due to space limitations, the following abbreviations are used in the tables:

- ABAX Ecowing AD-49 / Dow UCAR FlightGuard AD-49 (A/D-49);
- Clariant Max Flight 04 (C-MF-04);
- Clariant Max Flight SNEG (C-MF-S);
- Clariant Safewing MP IV LAUNCH PLUS (C-L+);
- Clariant Safewing EG IV NORTH (C-NORTH);
- Cryotech Polar Guard (CR-PG);

- Cryotech Polar Guard Advance (CR-PGA);
- Deicing Solutions ECO-SHIELD (DS-ES);
- Dow UCAR FlightGuard AD-480 (D-480);
- Kilfrost ABC-S PLUS (K-ABCS+);
- LNT Solutions E450 (L-E450);
- Newave Aerochemical FCY 9311 (N-9311); and
- Shaanxi Cleanway Aviation Cleansurface IV (SC-CIV).

In both tables, the following abbreviations are used:

- A "U" indicates the fluid is responsible for the upper value in the cell;
- An "L" indicates the fluid is responsible for the lower value in the cell; and
- A "B" indicates the fluid is responsible for both the upper and lower values in the cell.

In Table 6.2, holdover times are provided for given precipitation rates in snow. These correspond to the snow holdover times as follows:

- Very light snow (Transport Canada): 4 g/dm²/h;
- Very light snow (FAA): lower limit = 3 g/dm²/h; upper limit = 4 g/dm²/h;
- Light snow: lower limit = 4 g/dm²/h; upper limit = 10 g/dm²/h; and
- Moderate snow: lower limit = 10 g/dm²/h; upper limit = 25 g/dm²/h.

Finally, it should be noted that Transport Canada caps snow holdover times at two hours while FAA caps them at three hours. The values in the tables are capped at three hours.

Table 6.1: Type IV Generic Holdover Time Values and Responsible Fluids – Winter 2015-16

Outside Air Temperature (Degrees Celsius)	**Type IV Fluid Concentration Neat Fluid/Water** (Volume %/Volume %)	**Approximate Holdover Times Under Various Weather Conditions (hours:minutes)**				
		Freezing Fog or Ice Crystals	**Snow, Snow Grains or Snow Pellets**	**Freezing Drizzle**	**Light Freezing Rain**	**Rain on Cold Soaked Wing**
-3 and above	100/0	**1:30 – 2:25**	**0:35 – 1:10**	**0:50 – 1:30**	**0:35 – 0:50**	**0:10 – 1:25**
		DS-ES **(B)**	N-9311 **(B)**	D-480 **(B)**	D-480 **(L)** DS-ES **(U)**	A/D-49 **(L)** CR-PG **(U)** N-9311 **(U)**
	75/25	**1:25 – 2:40**	**0:30 – 1:05**	**0:50 – 1:15**	**0:30 – 0:45**	**0:09 – 1:15**
		K-ABCS+ **(B)** CR-PG **(U)**	D-480 **(B)**	D-480 **(B)**	D-480 **(B)** K-ABCS+ **(L)**	CR-PGA **(L)** CR-PG **(U)** D-480 **(U)**
	50/50	**0:25 – 0:40**	**0:09 – 0:15**	**0:15 – 0:25**	**0:09 – 0:15**	CAUTION: No holdover time guidelines exist
		CR-PG **(B)** A/D-49 **(L)**	D-480 **(L)** CR-PG **(U)**	CR-PG **(B)** D-480 **(B)** A/D-49 **(L)** K-ABCS+ **(L)**	D-480 **(B)** CR-PGA **(L)** A/D-49 **(U)** CR-PG **(U)**	
below -3 to -14	100/0	**0:20 – 1:20**	**0:25 – 0:50**	**0:25 – 1:10**	**0:15 – 0:25**	
		D-480 **(B)** A/D-49 **(L)**	N-9311 **(B)**	CR-PG **(B)** A/D-49 **(L)** C-L+ **(L)** C-MF-04 **(L)** D-480 **(L)** K-ABCS+ **(L)**	CR-PG **(L)** D-480 **(L)** A/D-49 **(U)**	
	75/25	**0:25 – 0:50**	**0:20 – 0:40**	**0:15 – 1:05**	**0:15 – 0:25**	
		D-480 **(B)**	CR-PG **(B)** D-480 **(L)**	A/D-49 **(B)** C-L+ **(U)** C-MF-S **(U)** CR-PG **(U)** CR-PGA **(U)** D-480 **(U)**	A/D-49 **(B)** K-ABCS+ **(B)** D-480 **(L)**	
below -14 to LOUT	100/0	**0:15 – 0:40**	**0:15 – 0:30**			
		D-480 **(B)** A/D-49 **(U)** CR-PG **(U)**	Historic Generic **(B)**			

L = DRIVES LOWER LIMIT U = DRIVES UPPER LIMIT B = DRIVES BOTH

Table 6.2: Type IV Generic Holdover Time Values and Responsible Fluids – Winter 2016-17

Outside Air Temperature (Degrees Celsius)	Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets				Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing
			25 g/dm²/h	10 g/dm²/h	4 g/dm²/h	3 g/dm²/h			
-3 and above	100/0	1:15 – 2:40	0:35	1:10	2:20	2:45	0:40 – 1:30	0:35 – 0:40	0:08 – 1:25
		DS-ES **(B)**	N-9311	N-9311	N-9311	L-E450	DS-ES **(B)**	DS-ES **(B)**	C-NORTH **(L)** N-9311 **(U)**
	75/25	1:25 – 2:40	0:45	1:15	2:05	2:15	0:50 – 1:20	0:30 – 0:45	0:09 – 1:15
		K-ABCS+ **(B)**	CR-PGA K-ABCS+ SC-CIV	K-ABCS+	A/D-49 K-ABCS+	A/D-49	SC-CIV **(L)** K-ABCS+ **(U)**	K-ABCS+ **(L)** SC-CIV **(U)**	SC-CIV **(B)** CR-PGA **(L)**
	50/50	0:25 – 0:50	0:15	0:25	0:40	0:45	0:15 – 0:30	0:09 – 0:15	CAUTION: No holdover time guidelines exist
		A/D-49 **(B)**	A/D-49 CR-PGA K-ABCS+ SC-CIV	A/D-49	A/D-49	A/D-49	A/D-49 **(B)** K-ABCS+ **(L)**	CR-PGA **(L)** A/D-49 **(U)**	
below -3 to -14	100/0	0:20 – 1:35	0:25	0:45	1:20	1:40	0:25 – 1:20	0:20 – 0:25	
		A/D-49 **(B)**	N-9311 SC-CIV	SC-CIV	SC-CIV	SC-CIV	A/D-49 **(L)** C-L+ **(L)** C-MF-04 **(L)** K-ABCS+ **(L)** N-9311 **(U)**	A/D-49 **(B)** C-MF-04 **(L)** K-ABCS+ **(L)** N-9311 **(L)** SC-CIV **(L)**	
	75/25	0:30 – 1:10	0:20	0:45	1:40	2:00	0:15 – 1:05	0:15 – 0:25	
		A/D-49 **(B)** C-MF-S **(L)**	SC-CIV	SC-CIV	C-MF-S SC-CIV	C-MF-S K-ABCS+	A/D-49 **(B)** C-L+ **(U)** C-MF-S **(U)** CR-PGA **(U)**	A/D-49 **(B)** K-ABCS+ **(B)**	
below -14 to LOUT	100/0	0:20 – 0:40	0:08	0:10	0:20	0:25			
		C-MF-S **(L)** C-MF-04 **(L)** A/D-49 **(U)**	Generic	Generic	Generic	Generic			

L = DRIVES LOWER LIMIT U = DRIVES UPPER LIMIT B = DRIVES BOTH

6.5 Further Changes to Holdover Times Published for Type II/IV Fluids in Very Cold Snow

Following the publication of the winter 2016-17 original issue holdover time guidance materials in August 2016, Transport Canada and the FAA subsequently reviewed the reductions made to holdover times published for Type II and Type IV fluids in snow at temperatures below -14°C. This was done at the request of the industry.

The result of this review was that the regulators issued optional changes (increases) to the holdover times in snow for:

- Type IV ethylene glycol based fluids, below -14°C; and
- Type II/IV propylene glycol based fluids, below -14 to -18°C.

In these conditions, the holdover times reverted to the holdover times that were published for all Type II and Type IV fluids in snow below -14°C for winter 2015-16.

Transport Canada published the updated holdover times and regression information through an Advisory Circular. Advisory Circular 007-040, *Supplemental Holdover Timetables and Regression Information for SAE Type II and IV Fluids*, was published on October 18, 2016. FAA published the updated holdover times in an addendum to the HOT Guidelines, which was published on September 30, 2016.

Copies of the Transport Canada Advisory Circular and FAA HOT Guidelines addendum are included in Appendix K.

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7. OTHER CHANGES TO HOT GUIDELINES CONTENT

In addition to the changes made to the Type I, II, III and IV HOT Guidelines, a number of other changes were made to the HOT Guidelines for winter 2016-17. These changes are documented in this chapter.

7.1 Active Frost HOT Guidelines

Endurance time testing in frost was conducted with all fluids submitted for endurance time testing in the winter of 2015-16. The test durations were compared to the related generic holdover times: all completed ("failed") tests surpassed the generic holdover times, as did all tests that were not completed (due to active frost ending before fluid failure could occur). This analysis indicates that the generic frost holdover times can be considered substantiated for all fluids added to the HOT guidelines for winter 2016-17.

No content or formatting changes were made to the active frost HOT guidelines for winter 2016-17. However, a new note was added to provide guidance on the appropriate outside air temperature to select in changing conditions.

7.2 Allowance Time Tables

Several changes were made to the allowance time table values based on the collection of additional data in the winter of 2015-16. This data is documented in the Transport Canada report, TP 15341E, *Wind Tunnel Trials to Support Further Development of Ice Pellet Allowance Times: Winter 2015-16* (8). These changes include:

- The addition of allowance times to the Type IV fluid table for "Light Ice Pellets Mixed with Light Snow" and "Light Ice Pellets Mixed with Moderate Snow" in the "Below -10 to -16°C" temperature band; and
- The addition of new rows/allowance times to the Type IV table for two new precipitation conditions: "Moderate Ice Pellets (or Small Hail) Mixed with Moderate Freezing Drizzle" and "Moderate Ice Pellets (or Small Hail) Mixed with Moderate Rain."

In addition, the following changes were made:

- The rows in both the Type III and Type IV allowance time tables, each containing a specific precipitation condition, were reordered for ease of use;

- A note has been added to both the Type III and Type IV allowance time tables indicating they are for use with aircraft with rotation speeds of 100 knots or greater only;
- A review of existing data resulted in a change to the Type III allowance time for “Light Ice Pellets Mixed with Moderate Snow” in the “Below -5 to -10°C” cell (from 10 to 5 minutes); and
- The coldest temperature band in the Type IV table was divided into two temperature bands: “Below -10 to -16°C” and “Below -16 to -22°C.”

7.3 Fluid Application Tables

Guidance for the application of Type III fluid was previously provided in the same table as the guidance provided for the application of Type II/IV fluid. For the winter of 2016-17, this guidance is provided in two separate Type III fluid application tables: one table provides guidance for the application of heated Type III fluid and a second table provides guidance for the application of unheated Type III fluid.

In addition, changes were made to the Type I and Type II/IV fluid application tables to improve harmonization between Transport Canada and the FAA and with the SAE fluid application tables.

7.4 Transport Canada Adjusted Holdover Time and Allowance Time Tables for Use When Flaps/Slats Deployed Prior to Anti-icing

Research into holdover times on deployed flaps/slats has been ongoing for several years. There is a substantive amount of evidence that demonstrates extended flaps and slats accelerate anti-icing fluid degradation off aircraft wings, which is a potential safety risk.

To mitigate this risk, Transport Canada published adjusted holdover time and allowance time tables in the winter 2016-17 HOT guidelines. These tables are to be used when flaps/slats have been deployed prior to anti-icing. The tables include values which have been decreased by 10 percent (holdover times are 90 percent of standard holdover times). This is an interim measure which will be in place until data collection and analysis have been completed.

It should be noted that the FAA has included similar 90 percent adjusted tables in their HOT guidelines since the winter of 2014-15.

8. SUPPLEMENTAL RESEARCH: ENDURANCE TIME TESTING IN SNOW AT VERY COLD TEMPERATURES

In the winter of 2015-16, supplemental endurance time testing was conducted with Type II and Type IV fluids in natural snow at very cold temperatures. The testing is documented in this section.

8.1 Background – Historical Data and Holdover Times

Until the winter of 2003-04, most Type II and Type IV fluids were given fluid-specific holdover times in snow in the coldest temperature band in the Type II/IV HOT tables (below -14ºC to LOUT). The fluid-specific holdover times were based on extrapolations of natural snow data collected at warmer temperatures. This methodology was used because holdover time testing is conducted in Montreal, where natural snow rarely occurs below -14ºC, and therefore natural snow data below -14°C was typically not available.

At the May 2003 SAE G-12 Holdover Time Committee meeting, it was recommended that this methodology be changed as it was felt it may not be providing appropriate holdover times. The alternative put forward was to collect data with artificial snow machines at -25°C and use this data to determine holdover times for snow for the below -14 to -25ºC temperature band (later changed to below -14ºC to LOUT).

The artificial snow data was subsequently collected during the winter of 2003-04 by APS and Anti-Icing Materials International Laboratory (AMIL). As a result of this testing, the SAE G-12 Holdover Time Committee introduced generic holdover times for the coldest snow temperature band for all Type II and IV fluids, with the exception of one ethylene glycol based fluid which retained fluid-specific holdover times. The generic holdover times were 15 to 30 minutes.

When cells were added for light snow and very light snow to the Type II/IV HOT tables in 2013-14, additional snow machine testing was conducted with select Type II/IV fluids to determine appropriate generic holdover time values for the new coldest temperature band (below -14ºC to LOUT) cells. Holdover times were determined for light snow (30 to 40 minutes) and very light snow (40 to 50 minutes).

In both cases, the analysis approach used to determine holdover times from the artificial snow data assumed the snow machine provides conservative endurance times relative to natural snow testing. This assumption was based on correlational work completed previously, primarily at temperatures of -14°C and warmer. The specific approaches used to determine the Type II/IV generic holdover times were:

- Moderate snow: average of artificial snow endurance times; and
- Light/very light snow: average less 1 sigma of artificial snow endurance times.

8.2 Background – Winter 2014-15 Testing

A small project was undertaken in the winter of 2014-15 to conduct tests in natural snow at very cold temperatures with all fluid types. The objective of the project was to validate the existing generic snow holdover times at very cold temperatures.

There were two factors which stimulated the project:

1. The generic snow holdover times in the coldest temperature band had never been validated using natural snow data and no in-depth research had been completed to correlate artificial and natural snow data at very cold temperatures; and

2. Since the generic snow holdover times in the coldest temperature band were determined for Type II/IV fluids in 2004-05 and 2013-14, no data had been collected (in either natural or artificial snow) to validate those holdover times for new Type II/IV fluids that came to market after the original artificial snow testing was completed.

Limited testing was carried out with select fluids representing all fluid types. It was expected that the data collected would validate the generic holdover times for all fluid types; however, this was not the case. The testing did not identify an issue with the current generic holdover times for Type I and Type III fluids, but it did indicate that the Type II/IV generic holdover times in these conditions may not be sufficiently conservative.

Further testing with additional fluids was recommended to confirm the issue with the generic holdover times for Type II/IV fluids in snow at very cold temperatures and to determine new holdover times if necessary. That testing was carried out in the winter of 2015-16 and is documented in the remaining sections of this chapter.

The 2014-15 testing is documented in the Transport Canada report, TP 15321E, *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2014-15 Winter* (9).

8.3 Objective

Two theories were put forward to explain why the some of the endurance time data collected in natural snow in winter 2014-15 was below the published generic holdover times.

1. **Theory 1**: The original artificial snow data was not accurately interpreted. At the time the data was collected, it was assumed that at a given temperature and precipitation rate, the endurance time measured with a snow machine was

shorter than the endurance time measured in natural snow, especially at cold temperatures and high rates. If this assumption was incorrect, the interpretation of the artificial snow data would be incorrect, leading to an inappropriate analysis methodology and artificially long generic holdover times.

2. **Theory 2**: The original snow data did not include data for the weakest performing fluids in snow at very cold temperatures. Tests were carried out with a limited number of fluids both times very cold snow testing was done. If the weakest performing fluids available at the time were not tested and/or if the fluids that later came to market have weaker performance than those originally tested, the generic holdover times would not be appropriate.

The primary objective of the very cold snow research in the winter of 2015-16 was to collect data to evaluate both of these theories and to determine new Type II/IV generic holdover times if needed. The objective was achieved by carrying out tests in artificial and natural snow at very cold temperatures with most Type II and Type IV fluids currently on the market. Specifically:

1. Natural snow data was collected at very cold temperatures to develop a large set of very cold snow data to analyse; and

2. Artificial snow data was collected to supplement the natural snow data to:

   a) Better understand the relationship between natural and artificial data;

   b) Link the original historic artificial snow data to the 2015-16 data; and

   c) Fill in gaps where natural snow data could not be collected (i.e. at higher precipitation rates).

8.4 Test Methodology

Tests were carried out according to the methodology described in the following subsections, which detail test locations, test procedures and fluids.

8.4.1 Test Locations

Artificial snow testing was conducted at the PMG Technologies Inc. climatic chamber test facility located in Blainville, Quebec.

As the very cold temperatures needed for this project rarely occur in Montreal, APS planned to travel to the far north regions of Canada ("far north") to collect the necessary natural snow data.

APS analysed weather trends in various locations in the far north to find locations which offered very cold temperatures and sufficient snowfall to allow for a few days of testing at a time. Weather forecasts for these locations were monitored over the winter.

Two trips were made to the far north to collect natural snow data. The test locations were Schefferville, Quebec and Iqaluit, Nunavut. Photo collages of these locations are provided in Photo 8.1 and Photo 8.2.

8.4.2 Test Procedures

Tests were carried out according to standard endurance time testing procedures for natural snow and artificial snow, as detailed in Subsection 2.1. Additional test procedures were written to coordinate the specific details of the artificial and natural snow testing for this project. Copies of these procedures are provided in Appendix L (natural snow) and Appendix M (artificial snow).

Figure 8.1 depicts the collapsible test stand that was manufactured specifically for very cold snow testing. It was designed for testing in the far north, which requires personnel to travel by air on short notice to the test sites with all required equipment and fluids. The collapsible test stand can easily be transported as checked luggage.

Standby test "kits" were prepared with all necessary fluids and supplies for testing so that travel to the far north could be undertaken with relatively little notice. A photo of the equipment required to be transported packed in airline approved luggage is shown in Photo 8.3. Photos 8.4 to 8.8 show further details of the far north test setup.

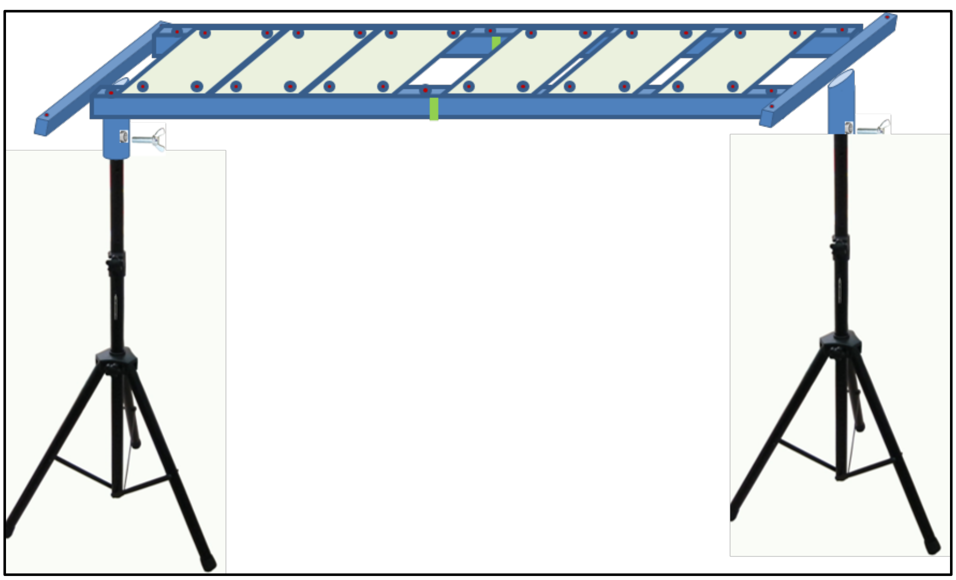


Figure 8.1: Rendering of Collapsible Test Stand

8.4.3 Fluids Tested

A request for LOWV samples was sent to manufacturers of all Type II and Type IV fluids. LOWV samples were required as they are assumed to provide the worst case performance of each fluid, and are used to conduct all standard holdover time testing.

The majority of manufacturers provided LOWV samples of their fluids. In cases where manufacturers did not provide LOWV samples, a further effort was made to obtain samples:

a) APS inventory was searched and LOWV samples were found;
b) APS inventory was searched and production viscosity fluids were found;
c) Fluid manufacturers agreed to provide production viscosity samples; or
d) In some cases no samples could be obtained.

Samples of the Type II and Type IV fluids submitted for holdover time testing in the winter of 2015-16 were also included in the very cold snow testing.

The significant effort undertaken to procure fluid samples for testing resulted in a very good number of currently commercialized fluids being tested. The majority of Type II/IV fluids expected to be in the 2016-17 HOT guidelines were tested. Only two fluids were not tested: Clariant Safewing MP II FLIGHT PLUS and Dow/ABAX AD-49. Table 8.1 summarizes the number of fluids tested relative to the number of fluids expected to be in the 2016-17 HOT guidelines. Table 8.2 provides details of the fluids tested.

It should be noted that the viscosity of all fluids was checked and samples with viscosities below the published LOWV were not used.

Table 8.1: Number of Fluids Tested in Winter 2015-16

Fluid Type	Fluids Expected in 2016-17 Guidelines	LOWV Fluids Tested	Production Viscosity Fluids Tested	No Fluids Tested
Type II	11*	7	3	1
Type IV	14**	11	2	1
Total (#)	25	18	5	2
Total (%)	100%	72%	20%	8%

* Excludes Cryotech Polar Guard II (this is a Type IV fluid marketed under a Type II brand name and is included in the Type IV list); includes LNT Solutions P250 which was expected to be included in the 2016-17 HOT guidelines but was not.

** Counts the Dow and ABAX versions of AD-49 as a single fluid as the data is the same for these fluids.

Table 8.2: Details of Fluids Tested in Winter 2015-16

Fluid Name	Fluid Type	Viscosity Type	Source
ABAX Ecowing 26	II	LOWV	FM Supplied
Aviation Shaanxi Cleanwing II	II	LOWV	FM Supplied
Beijing Yadilite YD-102 Type II	II	LOWV	HOT LOWV
Clariant Max Flight 04	IV	LOWV	APS Inventory
Clariant Max Flight AVIA	IV	LOWV	HOT LOWV
Clariant Max Flight SNEG	IV	LOWV	APS Inventory
Clariant Safewing EG IV NORTH	IV	LOWV	HOT LOWV
Clariant Safewing MP II FLIGHT	II	Production	APS Inventory
Clariant Safewing MP IV LAUNCH	IV	Production	APS Inventory
Clariant Safewing MP IV LAUNCH PLUS	IV	LOWV	APS Inventory
Cryotech Polar Guard II/Advance*	II/IV	LOWV	FM Supplied
Deicing Solutions ECO-SHIELD	IV	LOWV	HOT LOWV
Dow EG106	IV	LOWV	FM Supplied
Kilfrost ABC-3	II	Production	FM Supplied
Kilfrost ABC-Ice Clear II	II	LOWV	HOT LOWV
Kilfrost ABC-K Plus	II	Production	FM Supplied
Kilfrost ABC-S Plus	IV	Production	APS Inventory
LNT Solutions E450	IV	LOWV	FM Supplied
LNT Solutions P250	II	LOWV	FM Supplied
Newave Aerochemical FCY 9311	IV	LOWV	FM Supplied
Newave Aerochemical FCY-2	II	LOWV	FM Supplied
Newave Aerochemical FCY-2 Bio+	II	LOWV	HOT LOWV
Shaanxi Cleanway Cleansurface IV	IV	LOWV	HOT LOWV

*This is the same fluid/data which is marketed under two different brand names.

8.5 Testing Challenges

Testing in remote locations poses unique challenges. Some of these include:

1. Unreliable weather forecasts;
2. Limited on-location monitoring of storms (internet availability in remote areas limited);
3. Significant luggage (can't send equipment ahead when traveling on short notice);
4. Limited/costly transportation to northern locations; and
5. Unknown test site locations: need to create test sites "on the fly."

Testing at very cold temperatures poses unique challenges. Some of these include:

1. Physically intense cold testing – frozen fingers/eyes (see Photo 8.8); and
2. Equipment limitations/freeze ups.

For this specific project, there were additional unique challenges:

1. The occurrence of snow at high precipitation rates is infrequent in natural conditions; and
2. The cost of conducting of artificial snow testing, especially at very cold temperatures, is high. This limited the amount of data that could be collected.

8.6 Data Collected – Natural Snow

8.6.1 Winter 2015-16 Only

A total of 99 tests were conducted in natural snow in the winter of 2015-16. A log of these tests is provided in Table 8.3. Fluid names are not provided in the log, as the data was collected with the intention of analyzing it in aggregate.

Table 8.4 provides a summary of testing events at which natural snow data was collected in the winter of 2015-16, including associated locations, temperatures and average precipitation rates.

Table 8.5 provides a summary of tests conducted by fluid type and viscosity type.

Table 8.3: Log of Tests – Natural Snow

#	Fluid Type	Viscosity Type	Endurance Time (mins)	Precipitation Rate (g/dm²/h)	Temperature (°C)
C1	4-Feb-16	LOWV	34.6	2.5	-22.7
C2	4-Feb-16	LOWV	40.2	2.2	-22.7
C3	4-Feb-16	LOWV	98.7	1.2	-22.6
C4	4-Feb-16	Production	39.2	2.2	-22.7
C5	4-Feb-16	Production	30.5	2.5	-22.7
C6	4-Feb-16	Production	45.0	1.9	-22.7
C7	4-Feb-16	LOWV	40.4	2.0	-22.7
C8	4-Feb-16	LOWV	39.8	2.0	-22.7
C10	4-Feb-16	LOWV	37.8	2.0	-22.7
C11	4-Feb-16	LOWV	30.7	1.1	-22.4
C13	4-Feb-16	LOWV	78.7	1.4	-22.3
C15	4-Feb-16	LOWV	77.5	1.4	-22.3
C17	4-Feb-16	LOWV	27.5	1.2	-22.4
C25	4-Feb-16	LOWV	44.9	2.4	-22.0
C26	4-Feb-16	LOWV	41.5	2.3	-22.0
C27	4-Feb-16	LOWV	46.0	2.5	-22.0
C28	4-Feb-16	Production	32.8	2.2	-22.0
C29	4-Feb-16	Production	36.5	2.3	-22.0
C30	4-Feb-16	Production	39.9	2.3	-22.0
C31	4-Feb-16	LOWV	31.3	2.2	-22.0
C32	4-Feb-16	LOWV	36.0	2.2	-22.0
C34	4-Feb-16	LOWV	30.0	2.2	-22.0
C35	4-Feb-16	LOWV	24.5	4.3	-21.9
C36	4-Feb-16	LOWV	26.8	4.3	-21.9
C37	4-Feb-16	LOWV	32.9	4.3	-21.9
C39	4-Feb-16	LOWV	39.0	4.5	-21.8
C40	4-Feb-16	Production	28.5	4.2	-21.8
C41	4-Feb-16	LOWV	24.8	4.2	-21.8
C42	4-Feb-16	LOWV	34.4	4.4	-21.8
C43	4-Feb-16	LOWV	26.8	4.1	-21.8
C47	4-Feb-16	LOWV	41.8	1.8	-21.6
C50	26-Feb-16	LOWV	106.8	1.5	-24.3
C51	26-Feb-16	LOWV	265.0	1.3	-24.0
C52	26-Feb-16	LOWV	269.0	1.3	-24.0

Table 8.3: Log of Tests – Natural Snow (cont'd)

#	Fluid Type	Viscosity Type	Endurance Time (mins)	Precipitation Rate (g/dm²/h)	Temperature (°C)
C53	26-Feb-16	LOWV	280.5	1.3	-24.0
C54	26-Feb-16	Production	84.5	1.6	-24.3
C55	26-Feb-16	LOWV	101.3	1.4	-24.3
C56	26-Feb-16	LOWV	80.5	1.6	-24.3
C57	26-Feb-16	LOWV	84.8	1.6	-24.3
C58	26-Feb-16	LOWV	88.4	1.6	-24.3
C59	26-Feb-16	LOWV	49.4	2.1	-23.8
C60	26-Feb-16	LOWV	50.3	2.1	-23.8
C61	26-Feb-16	Production	29.7	2.6	-23.9
C62	26-Feb-16	Production	78.5	1.8	-23.6
C63	26-Feb-16	LOWV	34.9	2.4	-23.9
C64	26-Feb-16	LOWV	48.0	2.0	-23.8
C66	26-Feb-16	LOWV	93.4	0.7	-23.6
C68	26-Feb-16	LOWV	88.8	0.7	-23.8
C69	26-Feb-16	Production	86.3	0.7	-23.8
C70	26-Feb-16	LOWV	105.8	0.7	-23.7
C71	26-Feb-16	LOWV	102.8	0.8	-23.8
C72	26-Feb-16	LOWV	144.0	0.7	-23.7
C73	26-Feb-16	Production	125.0	0.7	-23.7
C74	27-Feb-16	LOWV	99.1	5.9	-22.9
C76	27-Feb-16	LOWV	90.0	6.1	-22.9
C77	27-Feb-16	LOWV	99.9	5.9	-23.0
C78	27-Feb-16	LOWV	46.6	5.7	-22.7
C79	27-Feb-16	LOWV	32.8	5.1	-22.6
C80	27-Feb-16	LOWV	36.5	5.0	-22.6
C81	27-Feb-16	LOWV	36.0	4.9	-22.6
C82	27-Feb-16	LOWV	34.3	4.9	-22.6
C83	27-Feb-16	LOWV	118.0	5.3	-23.0
C84	27-Feb-16	LOWV	43.2	5.6	-23.2
C85	27-Feb-16	Production	42.7	5.7	-23.2
C86	27-Feb-16	LOWV	43.2	5.8	-23.2
C87	27-Feb-16	LOWV	55.8	5.2	-23.3
C88	27-Feb-16	LOWV	40.7	5.7	-23.2
C89	27-Feb-16	Production	19.5	6.7	-23.4

Table 8.3: Log of Tests – Natural Snow (cont'd)

#	Fluid Type	Viscosity Type	Endurance Time (mins)	Precipitation Rate (g/dm²/h)	Temperature (°C)
C90	27-Feb-16	Production	28.5	7.3	-23.4
C92	27-Feb-16	Production	33.5	7.7	-23.4
C93	27-Feb-16	LOWV	23.4	6.4	-23.4
C94	27-Feb-16	LOWV	47.0	9.6	-23.4
C95	27-Feb-16	LOWV	25.5	6.3	-23.4
C96	27-Feb-16	LOWV	24.8	6.1	-23.4
C97	27-Feb-16	Production	20.3	5.3	-23.4
C98	27-Feb-16	LOWV	28.5	6.2	-23.4
C100	27-Feb-16	LOWV	138.0	5.1	-22.7
C101	27-Feb-16	LOWV	128.0	4.8	-22.7
C102	27-Feb-16	LOWV	132.5	4.9	-22.7
C103	27-Feb-16	LOWV	118.0	4.7	-22.8
C105	27-Feb-16	Production	43.8	6.9	-23.0
C106	27-Feb-16	LOWV	30.6	8.0	-23.0
C107	27-Feb-16	LOWV	25.5	8.6	-23.0
C108	27-Feb-16	LOWV	29.9	8.0	-23.0
C109	27-Feb-16	LOWV	63.8	6.0	-22.9
C110	27-Feb-16	LOWV	44.7	3.9	-22.4
C111	27-Feb-16	Production	46.8	4.5	-22.4
C112	27-Feb-16	Production	39.3	3.5	-22.4
C113	27-Feb-16	LOWV	43.0	3.9	-22.4
C114	27-Feb-16	Production	34.5	3.3	-22.4
C115	27-Feb-16	LOWV	43.0	4.2	-22.4
C116	27-Feb-16	Production	32.7	7.7	-22.0
C118	27-Feb-16	LOWV	31.5	7.8	-22.0
C119	27-Feb-16	LOWV	24.0	8.2	-22.1
C120	27-Feb-16	LOWV	30.5	7.8	-22.0
C121	27-Feb-16	LOWV	30.0	7.9	-22.0
C122	27-Feb-16	LOWV	31.7	7.8	-22.0
C123	27-Feb-16	LOWV	36.3	7.9	-22.0
C124	27-Feb-16	LOWV	44.0	7.8	-22.0

Table 8.4: Summary of Testing Events – Winter 2015-16

Event #	Location	Temperatures	Precipitation Rates	Date	Data Points
1	Schefferville, QC	-22 to -23°C	1 to 5 g/dm²/h	04-Feb-16	31
2	Iqaluit, NU	-24°C	1 to 3 g/dm²/h	26-Feb-16	22
3	Iqaluit, NU	-22 to -23°C	3 to 10 g/dm²/h	27-Feb-16	46
All	**Various**	**-22 to -24°C**	**1 to 10 g/dm²/h**	**Various**	**99**

Table 8.5: Summary of Tests Conducted by Fluid Type and Viscosity Type

Fluid/Viscosity Type	Tests
Type II LOWV	35
Type II Production	15
Type IV LOWV	42
Type IV Production	7
All	**99**

8.6.2 Winter 2014-15 and 2015-16 Combined Data Set

Some of the data collected in very cold snow during the winter of 2014-15 (see Subsection 8.2) was included in the analysis completed for this project. The combined 2014-15 and 2015-16 data set is described in this subsection.

Three fluids tested in 2014-15 were eliminated from the analysis as their viscosities had not been checked and therefore the data was not considered sufficiently robust for the final analysis.

Table 8.6 provides a summary of testing events at which natural snow data was collected in the winters of 2014-15 and 2015-16, including associated locations, temperatures and average precipitation rates.

A total of 126 tests from the two winters of testing were included in the analysis. Table 8.7 provides a summary of tests conducted by fluid type and viscosity type.

Table 8.6: Summary of Testing Events – Winters 2014-15 and 2015-16

Event #	Location	Temperatures	Precipitation Rates	Date	Data Points
1	Grande Prairie, AB	-19°C	7 g/dm²/h	27-Nov-14	4
2	Montreal, QC	-19 to -22°C	6 to 9 g/dm²/h	02-Feb-15	11
3	Montreal, QC	-16 to -18°C	8 to 10 g/dm²/h	08-Feb-15	9
4	Montreal, QC	-16°C	1 g/dm²/h	14-Feb-15	2
5	Montreal, QC	-16°C	7 g/dm²/h	19-Feb-15	1
6	Schefferville, QC	-22 to -23°C	1 to 5 g/dm²/h	04-Feb-16	31
7	Iqaluit, NU	-24°C	1 to 3 g/dm²/h	26-Feb-16	22
8	Iqaluit, NU	-22 to -23°C	3 to 10 g/dm²/h	27-Feb-16	46
All	**Various**	**-16 to -24°C**	**1 to 10 g/dm²/h**	**Various**	**126**

Table 8.7: Summary of Tests Conducted by Fluid Type and Viscosity Type – Combined 2014-15 and 2015-16 Data Set

Fluid/Viscosity Type	Tests
Type II LOWV	43
Type II Production	17
Type IV LOWV	58
Type IV Production	8
All	**126**

8.6.3 Fluid Failure Photos

Several photos of fluid failure were taken over the course of the testing. Photos 8.9 to 8.12 are four of these photos and cover various testing conditions (different precipitation rates, fluids, etc.). They visually demonstrate that the current holdover times are not appropriate.

- Photo 8.9: The picture (example 1) was taken when the fluid was failed (35 minutes into the test). The expected failure time is 57 minutes. The picture clearly shows that the fluid is failed, much earlier than the expected failure time.

- Photo 8.10: The picture (example 2) was taken when the fluid was failed (30 minutes into the test). Recall that fluid failure on a plate is determined when one-third of the plate surface is failed. The expected failure time is 55 minutes. The picture clearly shows that the fluid is failed, much earlier than the expected failure time.

- Photo 8.11: The picture (example 3) was taken when the fluid was expected to fail (36 minutes into the test). The actual failure time was 23 minutes. The picture clearly shows that the fluid failure progression was much beyond the regular failure.

- Photo 8.12: The picture (example 4) was taken 43 minutes into the test, just after the fluid was expected to fail (37 minutes). The actual failure time was 25 minutes. The picture clearly shows that the fluid failure progression was much beyond the regular failure.

8.7 Data Collected – Artificial Snow

A total of 66 tests were conducted in artificial snow. A log of these tests is provided in Table 8.8. Fluid names have not been provided in the log, as the data was collected with the intention of analyzing it in aggregate.

The majority of tests conducted were conducted at -25°C and at the precipitation rate boundaries for snow currently encompassed in the HOT guidelines: 3, 4, 10, and 25 g/dm²/h. In addition, tests were conducted at a rate of 50 g/dm²/h, which may become a precipitation rate boundary in future.

Additional data was collected at temperatures and precipitation rates equivalent to natural snow data points that had already been collected. This data was collected to evaluate the endurance time performance of the snow machine relative to outdoor natural data.

Table 8.8: Log of Tests – Artificial Snow

#	Fluid Type	Viscosity Type	Endurance Time (mins)	Precipitation Rate (g/dm²/h)	Temperature (°C)
1	II	LOWV	27.5	6	-23
2	II	LOWV	30.8	6	-23
3	II	LOWV	30.3	6	-23
4	IV	LOWV	41.6	5	-23
5	IV	LOWV	31.0	5	-23
12	II	LOWV	19.6	10	-25
13	II	LOWV	5.0	50	-25
14	II	LOWV	51.8	3	-25
15	II	LOWV	36.0	4	-25
16	II	LOWV	17.0	10	-25
17	II	LOWV	9.5	25	-25
18	II	LOWV	5.8	50	-25
19	II	LOWV	14.1	10	-25
20	II	LOWV	3.5	50	-25
21	II	LOWV	17.9	10	-25
22	II	LOWV	61.5	3	-25
23	II	LOWV	45.6	4	-25
24	II	LOWV	17.9	10	-25
25	II	LOWV	9.5	25	-25
26	II	LOWV	4.3	50	-25
27	II	LOWV	19.5	10	-25
28	II	LOWV	6.0	50	-25
29	II	Production	15.6	10	-25
30	II	LOWV	12.3	10	-25
31	IV	LOWV	51.7	10	-25
32	IV	LOWV	8.1	50	-25
35	IV	LOWV	69.8	3	-25
36	IV	LOWV	41.0	4	-25
37	IV	LOWV	16.5	10	-25
38	IV	LOWV	10.6	25	-25
39	IV	LOWV	7.1	50	-25
40	IV	LOWV	18.5	10	-25
41	IV	LOWV	6.1	50	-25
42	IV	LOWV	30.0	10	-25
43	IV	LOWV	32.5	10	-25

Table 8.8: Log of Tests – Artificial Snow (cont'd)

#	Fluid Type	Viscosity Type	Endurance Time (mins)	Precipitation Rate (g/dm²/h)	Temperature (°C)
44	IV	LOWV	6.2	50	-25
45	IV	LOWV	13.0	10	-25
46	IV	LOWV	5.5	50	-25
47	IV	LOWV	36.4	3	-25
48	IV	LOWV	29.5	4	-25
49	IV	LOWV	19.8	10	-25
50	IV	LOWV	10.5	25	-25
51	IV	LOWV	4.6	50	-25
52	IV	Production	30.5	10	-25
53	IV	LOWV	21.6	10	-25
54	IV	LOWV	31.1	10	-25
55	IV	LOWV	6.8	50	-25
56	IV	LOWV	32.0	10	-25
57	IV	LOWV	6.4	50	-25
58	IV	LOWV	26.5	10	-25
59	IV	LOWV	6.8	50	-25
71	II	LOWV	30.5	4	-25
79	IV	LOWV	50.6	4	-25
88	II	Production	48.2	3	-25
89	II	Production	37.0	4	-25
90	II	Production	10.2	25	-25
101	II	LOWV	11.4	25	-25
113	IV	LOWV	47.5	4	-25
123	IV	LOWV	11.0	25	-25
126	IV	LOWV	32.1	4	-25
135	IV	Production	58.2	3	-25
136	IV	Production	37.1	4	-25
137	IV	Production	12.2	25	-25
142	IV	LOWV	11.5	25	-25
151	IV	LOWV	14.0	25	-25
155	IV	LOWV	14.3	25	-25

8.8 Analysis

The data described in Subsections 8.6 and 8.7 is plotted in Figure 8.2. This includes natural snow data collected in the winters of 2014-15 and 2015-16 and artificial snow data collected in the winter of 2015-16.

The data is plotted on a chart of rate of precipitation vs. endurance time. Different colours and shapes are used to distinguish the data by fluid type, viscosity type, and snow type.

The Type II/IV generic holdover times are plotted on the charts as black circles. The black lines drawn between the generic holdover time data points represent the generic holdover times at all rates. Data points that are above the black generic holdover times line indicate data that is above/longer than the associated generic holdover times. Data points below the black line indicate data is below/did not meet the associated generic holdover times. This data is of concern.

The artificial snow data collected in the winter of 2015-16 is compared to the historic artificial snow data collected in 2003-04 and 2012-13 in Figure 8.3.

The artificial snow data points that were collected to replicate specific tests conducted in natural snow are plotted together with the equivalent natural snow data points in Figure 8.4.

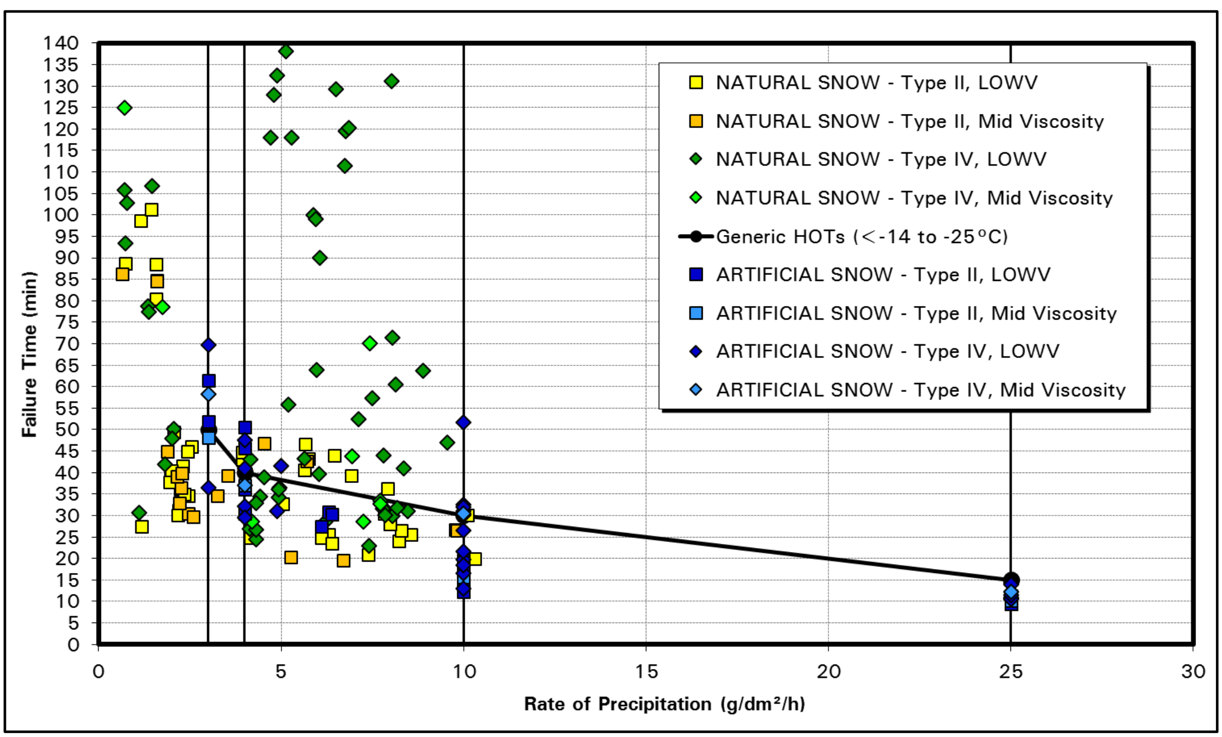


Figure 8.2: Results by Snow Type, Fluid Type and Viscosity Type

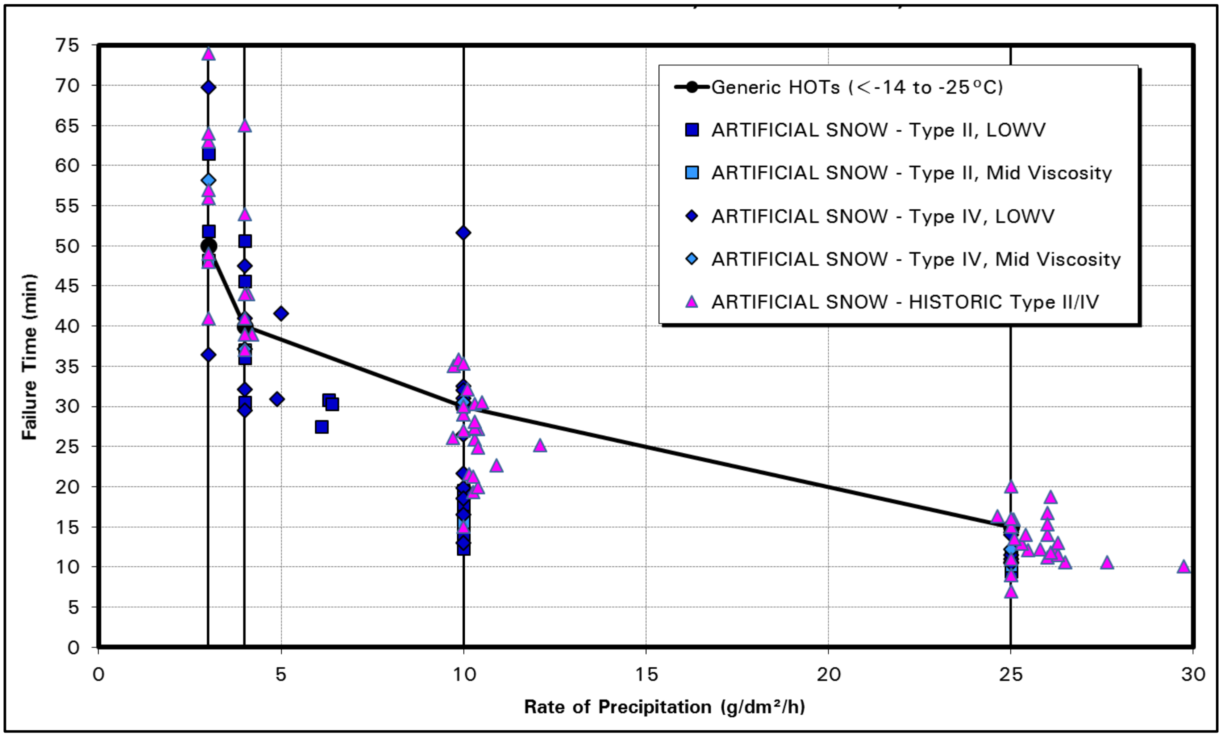


Figure 8.3: Comparison of 2015-16 and Historic Artificial Snow Data

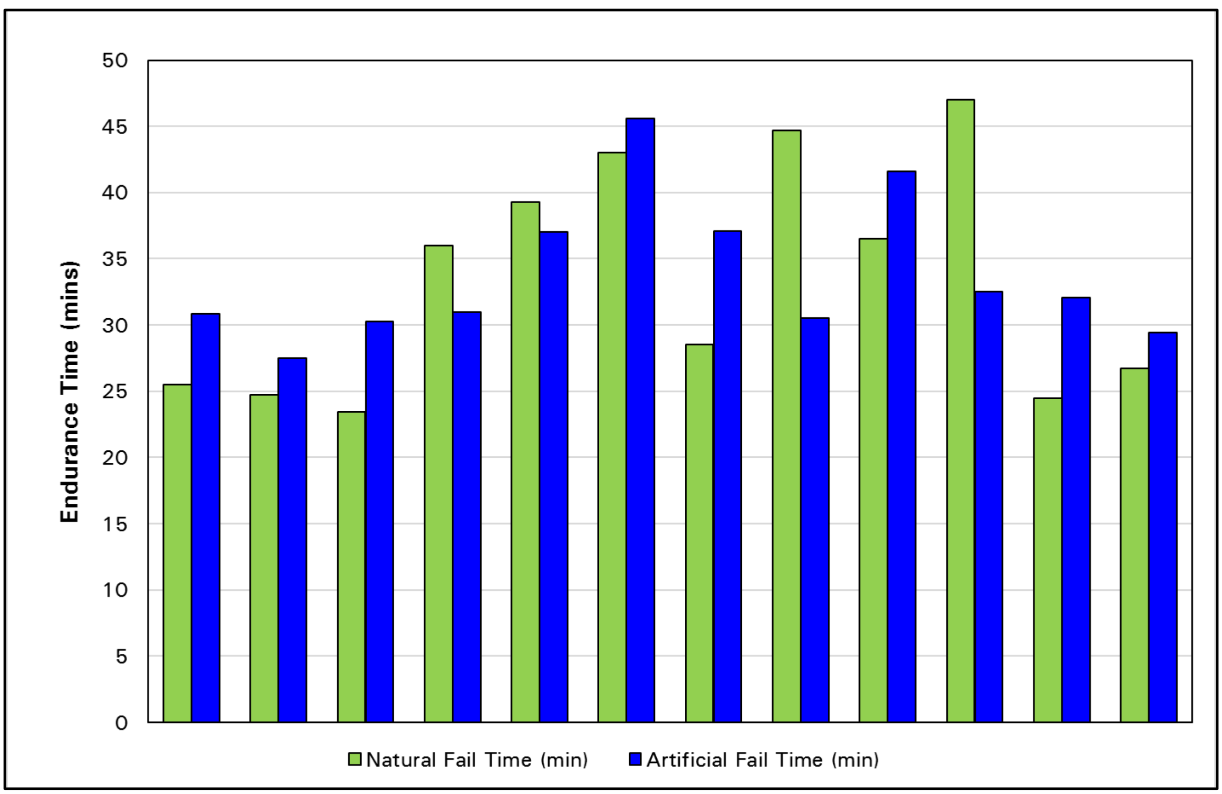


Figure 8.4: Results of Natural vs. Artificial Replication Data Points

8.9 Observations

As can be seen in Figure 8.2:

- The data collected in 2015-16 confirm the preliminary findings of the data collected in 2014-15, i.e. many fluids do not achieve the current generic holdover times at very cold temperatures (illustrated by the data points below the black curve in the figure);
- Both Type II and Type IV fluids and both LOWV and production viscosity fluids are represented in the data below the generic line; and
- The majority of natural snow data was collected in precipitation rates below 10 $g/dm^2/h$.

As can be seen in Figure 8.3:

- The data collected in artificial snow in 2015-16 with almost all currently qualified fluids shows performance similar to the historical data collected in artificial snow. The historical data was collected with limited fluids in the winters of 2003-04 and 2012-13, as described in Subsection 8.1.

As can be seen in Figure 8.4:

- The replication tests illustrate that while there is variance between endurance times obtained in natural and artificial snow under similar average temperatures and precipitation rates, on average the artificial snow endurance times are similar to the natural snow endurance times, not predominantly longer or shorter (average artificial/natural difference = 106 percent; standard deviation = 22 percent).

8.10 Conclusions

The data collected in the winter of 2015-16 provides very strong evidence that the existing Type II/IV generic holdover times for very cold snow are not appropriate. The data also indicates that endurance time data measured in artificial snow at very cold temperatures should not be assumed to be conservative; it should be taken at "face value."

It should be noted that data for two key fluids was not collected and that no LOWV data was collected for a number of fluids. It is therefore possible that the data collected does not represent the most conservative holdover time performance of all Type II/IV fluids in very cold snow.

8.11 Recommendations

Recommendations arising from the very cold snow research conducted in the winters of 2014-15 and 2015-16 are provided in the subsections below.

8.11.1 Reductions to Existing Generic Holdover Times

It is recommended that new generic holdover times for Type II/IV fluids for snow at very cold temperatures be implemented. The current protocol used to determine all other Type II/IV generic holdover times should be used to determine the new holdover times for very cold snow: the shortest endurance time for all existing fluids/data, rounded to the nearest 5 minutes, should become the generic holdover time.

If this protocol is used, the holdover times are as follows:

- Very Light Snow: 20 to 25 minutes (FAA), 20 minutes (Transport Canada);
- Light Snow: 10 to 20 minutes; and
- Moderate Snow: 8 to 10 minutes.

The times are shown plotted with the data in Figure 8.5. They represent an approximate reduction of 50 percent relative to the current Type II/IV fluid very cold snow holdover times.

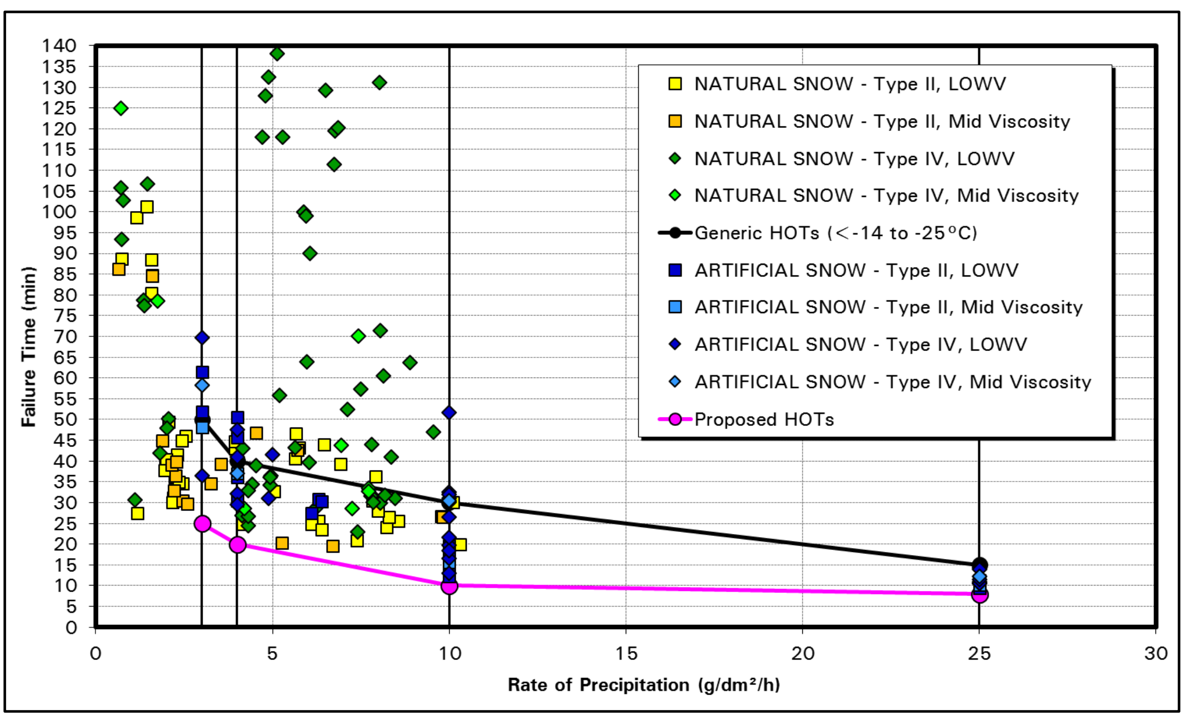


Figure 8.5: Recommended New Generic Holdover Times

8.11.2 Very Cold Snow Testing for New Type II/IV Fluids

A second recommendation is that the performance of all new Type II and Type IV fluids submitted for holdover time testing be evaluated in very cold snow. Details of what testing is required/appropriate will need to be determined; the data may be collected in natural and/or artificial conditions.

8.12 Possible Future Mitigations

The recommendation to reduce holdover times for Type II/IV fluids in very cold snow was accepted by regulators who introduced the changes in the winter 2016-17 HOT guidelines, which were published in August 2016.

Feedback from industry is that the reductions could have significant impact on some operations, especially those at airports that experience significant cold temperatures. As a temporary form of relief, some of the reductions were temporarily removed, as described in Subsections 4.5 and 6.5.

Possible future mitigations are being considered to provide permanent and/or further relief to operators. Two possible mitigations are listed below.

1. **Providing fluid-specific holdover times for Type II/IV fluids in very cold snow.** This requires that additional data be collected and a new analysis methodology be developed to determine holdover times from the collected data. This would provide relief for some fluids, most notably for ethylene glycol based fluids which were observed to have significantly longer holdover times in very cold snow than most propylene glycol based fluids.

2. **Introducing a new temperature band for below -14°C to a warmer temperature than LOUT.** This would also require the collection of additional data. As holdover times generally shorten as temperature decreases, splitting the coldest temperature band in two would provide longer holdover times for temperatures encompassed by the new temperature band.

Photo 8.1: Schefferville Photo Collage

Photo 8.2: Iqaluit Photo Collage

Photo 8.3: Far North Testing – Required Equipment in Luggage

Photo 8.4: Far North Testing – Test Stand Setup

Photo 8.5: Far North Testing – Assembled Test Stand

Photo 8.6: Far North Testing – Rate Station

Photo 8.7: Far North Testing – Test Site

Photo 8.8: Cold Weather Testing Physical Challenges

Photo 8.9: Fluid Failure Photo – Example 1

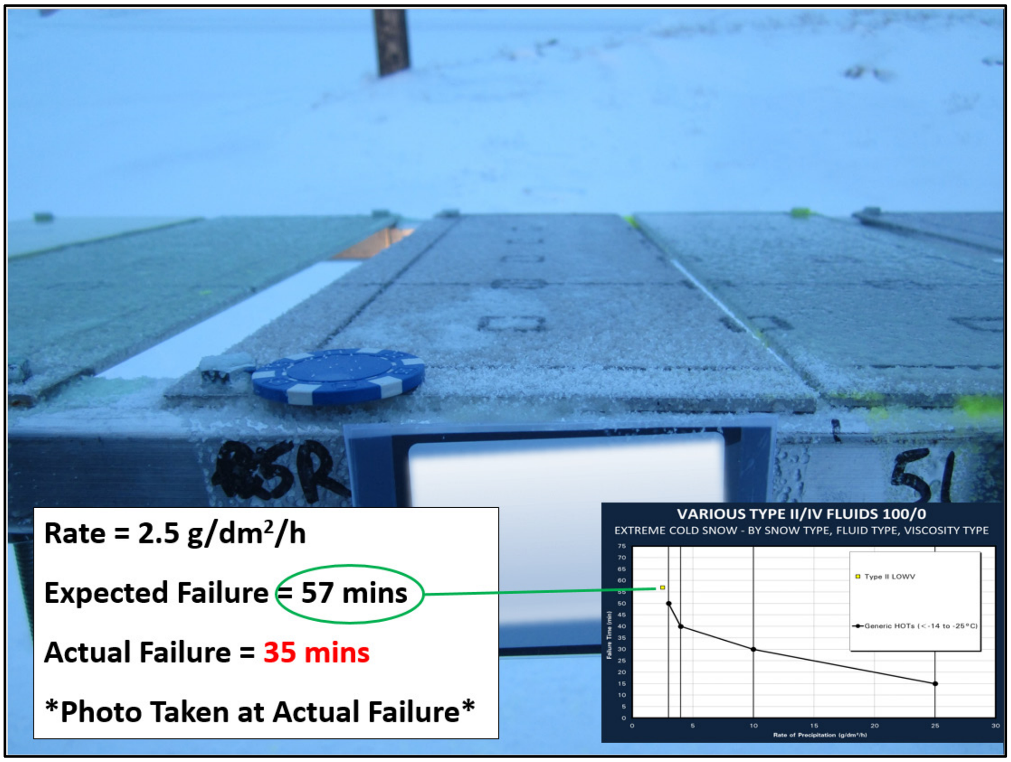


Photo 8.10: Fluid Failure Photo – Example 2

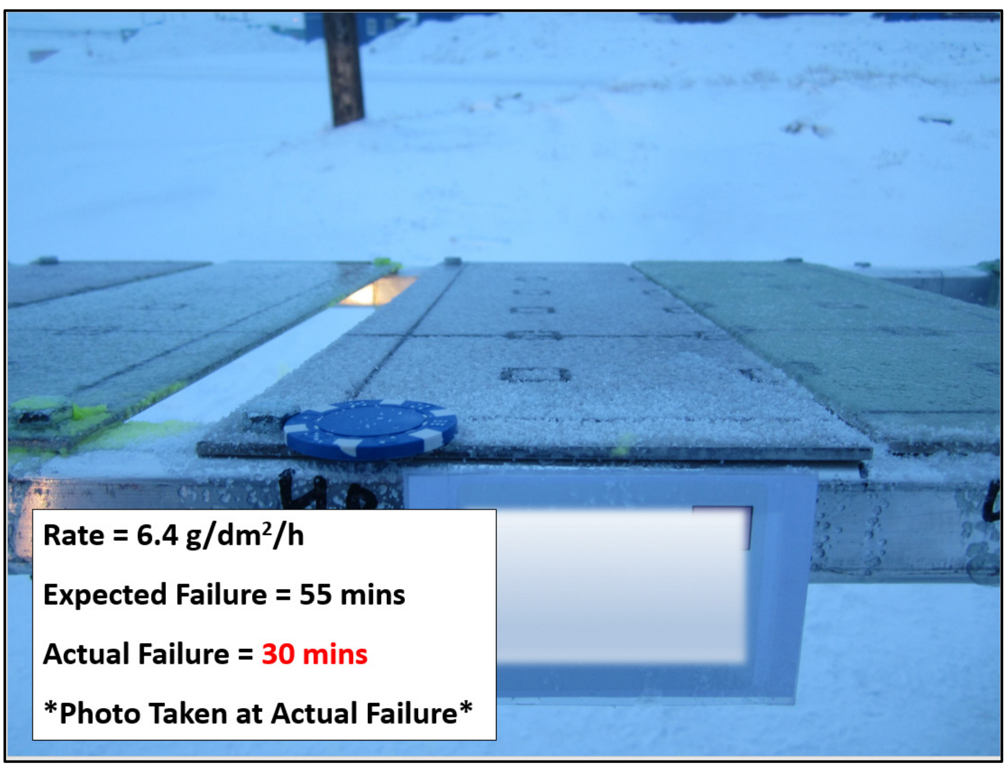


Photo 8.11: Fluid Failure Photo – Example 3

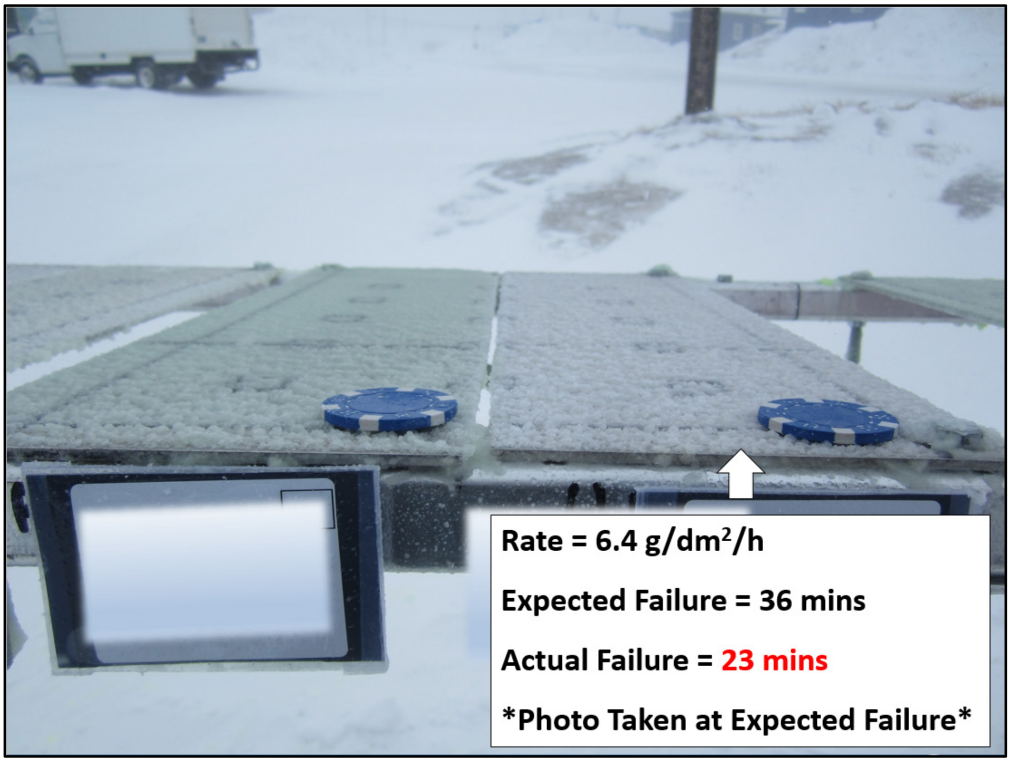
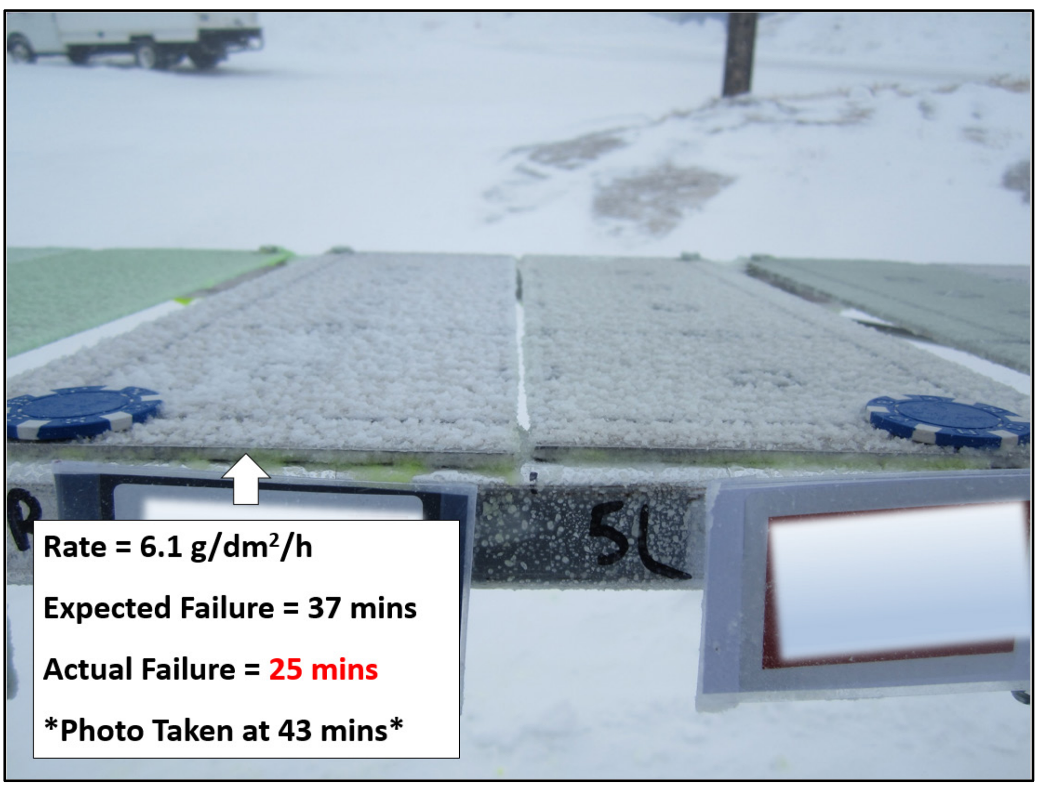


Photo 8.12: Fluid Failure Photo – Example 4



9. SUPPLEMENTAL RESEARCH: DATA COLLECTION FOR REVIEW OF FROST HOLDOVER TIMES

In the winter of 2015-16, supplemental endurance time testing was conducted in active frost conditions in order to obtain additional data for review and substantiation of the active frost holdover times. The testing is documented in this section.

9.1 Background

The active frost HOT table was initially developed based on results from the high humidity endurance time tests conducted as part of the fluid certification process. During the SAE G-12 Holdover Time Subcommittee meeting in Toulouse, France, in May 2000, APS was asked to conduct a comprehensive series of tests for all the frost conditions in the SAE HOT Guidelines using several fluids.

APS conducted endurance time testing in simulated frost conditions at the Institut de Recherche d'Hydro-Quebec (IREQ) during the 2000-01 testing season. The tests were conducted in accordance with the proposed ARP5485 (4) procedure for measuring fluid endurance times in simulated frost conditions. However, it was found during this testing that the environmental conditions specified in ARP5485 (4) did not produce the desired frost rates and that further research was necessary.

During the 2001-02 testing season, additional research was carried out at IREQ to attempt to determine test conditions that would produce the desired frost intensities at the various test temperatures in a laboratory setting. Ultimately, the desired parameters proved to be non-reproducible and it was determined that outdoor field work in natural conditions would be necessary.

Following some preliminary outdoor testing conducted in the winter of 2002-03 using Type I fluids, it was recommended that Type II, III, and IV fluids also have their active frost holdover time values substantiated through outdoor testing in natural frost conditions. This recommendation was accepted by the SAE G-12 holdover time working group in September 2003 and a natural frost outdoor testing project began in the winter of 2003-04. Over the next six winter testing seasons, natural frost tests were conducted. This work is documented in the Transport Canada report, TP 14938E, *Substantiation of Aircraft Ground Deicing Holdover Times in Frost Conditions* (10). A new, more conservative frost HOT table was developed based on the data collected and was published in the 2009-10 HOT Guidelines.

The fluids used to develop the active frost holdover times implemented in 2009-10 were fluids that were commercially available at the time the testing was completed; however, many of these fluids have since become obsolete. Additionally, many fluids that came to market following this initial testing were never tested in active frost conditions.

Questions were raised as to whether substantiation of the active frost HOT table would be possible using only data from currently commercially available fluids. Additionally, consideration was given to the possibility that changes to the active frost holdover times could be supported (either due to poor performing fluids from the initial substantiation project becoming obsolete or as a result of untested current fluids having holdover times that don't meet the current generic times).

A project was carried out in the winter of 2014-15 to investigate these questions. The work is documented in the Transport Canada report, TP 15323E, *Aircraft Ground Icing Research General Activities During the 2014-15 Winter* (11). The analysis performed within that report identified that the current active frost data set required more data with current commercially available fluids in several cells of the active frost HOT table in order to substantiate the existing generic holdover times.

As a result of this work, supplemental frost testing was recommended to be performed in the winter of 2015-16 with the goal of obtaining data with commercially available fluids with a particular emphasis on those holdover time cells identified as requiring additional data.

9.2 Objective

The objectives of this project were to:

a) Conduct active frost testing with current commercially available fluids in order to obtain data in areas that were previously identified as requiring more testing for complete generic holdover time substantiation;

b) Evaluate the current active frost data set (including tests conducted in 2015-16 as part of objective a) to determine whether substantiation of the generic frost holdover times is possible in all cells of the HOT table and with all current fluids; and

c) To review the current generic frost holdover times and determine whether changes (either extensions or reductions) are required.

9.3 Test Methodology

In the winter of 2015-16, frost testing was conducted with the goal of collecting more data with current commercially available fluids. This was made possible as a large selection of LOWV fluid samples were submitted in Winter 2015-16 for use in a number of different projects.

The testing was conducted using the standard active frost test procedure, *Test Plan: Endurance Time Testing in Frost with Type I, II, III and IV Fluids – Further Substantiation of Frost Holdover Times*, which can be found in Appendix N. As one of the objectives of this project was to review and investigate potential changes to the generic active frost holdover times, additional emphasis was placed upon running the individual frost tests as long as possible (either to failure, or for durations that are well in excess of the existing generic holdover times).

9.4 Data Collected in 2015-16

Table 9.1 shows the frost testing data that was collected in 2015-16. This includes the frost tests conducted as part of the standard fluid holdover time testing as well as the supplemental tests conducted with the purpose of improving the current active frost data set.

For the most up to date information concerning the frost data collected in past years, please refer to Transport Canada report, TP 15323E, *Aircraft Ground Icing Research General Activities During the 2014-15 Winter* (11).

Table 9.1: Frost Data Collected in Winter 2015-16

Test No.	Date	Fluid Dil.	Fluid Type	Fluid Name	Test Surface	Endurance Time (min)	Failed or DNF	Average Rate (g/dm²/h)	Temp Range	Average OAT (°C)	Average RH (%)	Wind Speed (km/h)
FROST TESTS - HOLDOVER TIME TESTING												
HOT1	Jan-04-16	100%	4	Clariant Max Flight AVIA	Al. Plate	582	DNF	0.08	Below -14 to -21	-19.1	80	7
HOT2	Jan-04-16	100%	4	Clariant Safewing EG IV North	Al. Plate	581	DNF	0.08	Below -14 to -21	-19.1	80	7
HOT4	Jan-04-16	100%	4	Shaanxi Cleansurface IV	Al. Plate	579	DNF	0.08	Below -14 to -21	-19.1	80	7
HOT9	Jan-07-16	100%	4	Clariant Max Flight AVIA	Al. Plate	631	DNF	0.18	Below -3 to -10	-5.2	89	9
HOT10	Jan-07-16	100%	4	Clariant Safewing EG IV North	Al. Plate	629	DNF	0.18	Below -3 to -10	-5.2	89	9
HOT11	Jan-07-16	100%	4	Shaanxi Cleansurface IV	Al. Plate	628	DNF	0.18	Below -3 to -10	-5.2	89	9
HOT12	Jan-07-16	75%	2	Yadilite YD-102	Al. Plate	473	Failed	0.17	Below -3 to -10	-5.3	89	9
HOT13	Jan-07-16	100%	2	Yadilite YD-102	Al. Plate	599	DNF	0.18	Below -3 to -10	-5.4	90	9
HOT14	Jan-07-16	75%	4	Clariant Max Flight AVIA	Al. Plate	586	DNF	0.18	Below -3 to -10	-5.4	90	9
HOT15	Jan-07-16	75%	4	Clariant Safewing EG IV North	Al. Plate	585	DNF	0.18	Below -3 to -10	-5.4	90	9
HOT16	Jan-07-16	75%	4	Shaanxi Cleansurface IV	Al. Plate	582	DNF	0.18	Below -3 to -10	-5.4	90	9
HOT17	Feb-18-16	75%	2	Yadilite YD-102	Al. Plate	178	Failed	0.16	Below -10 to -14	-11.9	83	7
HOT18	Feb-18-16	75%	4	Clariant Safewing EG IV North	Al. Plate	412	Failed	0.15	Below -10 to -14	-12.4	84	6
HOT19	Feb-18-16	75%	4	Clariant Max Flight AVIA	Al. Plate	417	Failed	0.15	Below -10 to -14	-12.4	84	6
HOT20	Feb-18-16	100%	4	Clariant Max Flight AVIA	Al. Plate	423	DNF	0.15	Below -10 to -14	-12.5	85	6
HOT21	Feb-18-16	100%	4	Clariant Safewing EG IV North	Al. Plate	424	DNF	0.15	Below -10 to -14	-12.5	85	6
HOT22	Feb-18-16	100%	4	Shaanxi Cleansurface IV	Al. Plate	425	DNF	0.15	Below -10 to -14	-12.5	85	6
HOT23	Feb-18-16	100%	2	Yadilite YD-102	Al. Plate	425	DNF	0.15	Below -10 to -14	-12.5	85	6
HOT24	Feb-18-16	100%	4	Deicing Solutions ECO-SHIELD	Al. Plate	427	DNF	0.15	Below -10 to -14	-12.5	85	6
HOT25	Feb-18-16	75%	4	Shaanxi Cleansurface IV	Al. Plate	435	DNF	0.15	Below -10 to -14	-12.5	85	6
HOT26	Apr-17-16	50%	4	Clariant Max Flight AVIA	Al. Plate	390	DNF	0.02	-1 and Above	4.8	66	5
HOT27	Apr-17-16	50%	4	Shaanxi Cleansurface IV	Al. Plate	389	DNF	0.02	-1 and Above	4.8	66	5
HOT28	Apr-17-16	50%	4	Clariant Safewing EG IV North	Al. Plate	389	DNF	0.02	-1 and Above	4.8	66	5
HOT29	Apr-17-16	50%	2	Yadilite YD-102	Al. Plate	388	DNF	0.02	-1 and Above	4.8	66	5

Table 9.1: Frost Data Collected in Winter 2015-16 (cont'd)

Test No.	Date	Fluid Dil.	Fluid Type	Fluid Name	Test Surface	Endurance Time (min)	Failed or DNF	Average Rate (g/dm²/h)	Temp Range	Average OAT (°C)	Average RH (%)	Wind Speed (km/h)
HOT30	Apr-17-16	100%	3	AllClear AeroClear MAX (CB18000A2)	Al. Plate	388	DNF	0.02	-1 and Above	4.8	66	5
FROST TESTS – FROST HOT SUBSTANTIATION												
FRS1	Jan-04-16	100%	2	Kilfrost ABC-Ice Clear II	Al. Plate	413	Failed	0.08	Below -14 to -21	-19.0	79	6
FRS2	Jan-04-16	100%	4	Clariant MaxFlight 04	Al. Plate	579	DNF	0.08	Below -14 to -21	-19.1	80	7
FRS3	Jan-04-16	100%	4	Clariant Safewing MP IV Launch Plus	Al. Plate	503	Failed	0.08	Below -14 to -21	-19.1	79	6
FRS4	Jan-04-16	100%	4	Cryotech Polar Guard Advance	Al. Plate	502	Failed	0.08	Below -14 to -21	-19.1	79	6
FRS5	Jan-07-16	100%	4	Clariant MaxFlight 04	Al. Plate	635	DNF	0.18	Below -3 to -10	-5.2	89	9
FRS6	Jan-07-16	100%	4	Cryotech Polar Guard Advance	Al. Plate	634	DNF	0.18	Below -3 to -10	-5.2	89	9
FRS7	Jan-07-16	100%	4	Newave FCY 9311	Al. Plate	632	DNF	0.18	Below -3 to -10	-5.2	89	9
FRS8	Jan-07-16	100%	4	Clariant Max Flight SNEG	Al. Plate	608	DNF	0.18	Below -3 to -10	-5.2	89	9
FRS9	Jan-07-16	75%	4	Cryotech Polar Guard Advance	Al. Plate	587	DNF	0.18	Below -3 to -10	-5.4	90	9
FRS10	Feb-18-16	75%	2	Shaanxi Cleanwing II	Al. Plate	282	Failed	0.16	Below -10 to -14	-12.1	84	7
FRS11	Feb-18-16	75%	4	Cryotech Polar Guard Advance	Al. Plate	384	Failed	0.16	Below -10 to -14	-12.3	84	7
FRS12	Feb-18-16	100%	2	LNT Solutions P250	Al. Plate	422	DNF	0.15	Below -10 to -14	-12.5	85	6
FRS13	Feb-19-16	100%	4	Newave FCY 9311	Al. Plate	418	DNF	0.15	Below -10 to -14	-12.5	85	6
FRS14	Feb-19-16	100%	4	Clariant Max Flight SNEG	Al. Plate	417	DNF	0.15	Below -10 to -14	-12.5	85	6
FRS15	Feb-19-16	100%	4	Cryotech Polar Guard Advance	Al. Plate	416	DNF	0.15	Below -10 to -14	-12.5	85	6
FRS16	Feb-19-16	100%	2	Shaanxi Cleanwing II	Al. Plate	415	DNF	0.15	Below -10 to -14	-12.5	85	6

9.5 Analysis Methodology

This section describes the methodology behind the analyses performed. The methodology for each objective is described separately.

9.5.1 Evaluation of Number of Data Points in Each HOT Table Cell

The first part of the work consisted of reviewing all of the current natural frost data collected to determine how many valid points exist for each of the cells found within the active frost HOT table. A valid point is defined as any test that meets one of the following criteria:

1) Test was run until failure and the endurance time exceeded the applicable generic holdover time given in the active frost HOT table; or
2) Test was terminated prior to failure, however the duration of the test exceeded the applicable generic holdover time given in the active frost HOT table.

All tests were additionally flagged as either "current" or "obsolete", depending on the status of the fluid used for the testing. The data set consisting of all valid current tests was then evaluated in order to determine if there are enough current data points to substantiate the existing frost HOT table or if specific cells have data deficiencies. Particular attention was given to ensure that there is sufficient data across all temperature bands, fluid types and concentrations.

9.5.2 Review of Current Data and Existing Active Frost Generic Holdover Times

The second part of the work was to examine the currently valid data points to determine if there are particular cells where the generic holdover times are too conservative and could potentially be increased. This analysis was primarily concerned with tests allowed to run to failure. These are a better indicator of fluid performance as opposed to tests that did not fail as they give more accurate detail on how long a given fluid will last in active frost conditions, however, only a relatively small proportion of the current data points actually reached failure. Due to the relative lack of failed data points, consideration was also given to valid tests where failure was not reached but where the test duration exceeded the associated generic holdover time.

It should be noted that all frost testing conducted as of the winter of 2015-16 has put additional emphasis on the importance of running tests to failure, or as a minimum, for a duration that is well in excess of the established generic holdover time.

9.6 Analysis

This section describes the analysis performed for objectives b) and c).

9.6.1 Evaluation of Number of Data Points in Each HOT Table Cell

Table 9.2 shows the breakdown of the data points in the current active frost HOT table.

When this analysis was initially performed in Transport Canada report, TP 15323E, *Aircraft Ground Icing Research General Activities During the 2014-15 Winter* (11), it was identified that the current data set overall had fewer data points than the historic data set used for initial active frost holdover time substantiation. This was expected as a number of Type II/IV used in the initial substantiation project have since become obsolete.

While it is not critical to have an equivalent number of valid data points in the current set relative to the historic set (as historical obsolete fluids were acceptable fluids at the time of the initial substantiation), it is important to have a good distribution of valid data points across the various temperature bands and concentrations. A good minimum target would be two valid tests per HOT table cell. Several cells are lacking in current data and testing for the 2016-17 winter should aim to cover these gaps.

Table 9.2: Active Frost Data Points – Current Fluids

OAT (°C)	Fluid Concentration	Current Data Points			
		Type I	Type II	Type III	Type IV
-1 and Above	100/0	8	0	5	0
	75/25		1	0	1
	50/50		4	2	4
Below -1 to -3	100/0	6	1	0	0
	75/25		2	0	5
	50/50		4	0	7
Below -3 to -10	100/0	14	8	1	14
	75/25		8	1	10
Below -10 to -14	100/0	18	9	1	8
	75/25		11	0	5
Below -14 to -21	100/0	23	8	3	15
Below -21 to -25	100/0	2	1	0	1
Totals		71	57	13	70

Table 9.3 shows a breakdown of the cells which should be targeted for additional data acquisition during the 2016-17 testing season. No Type I testing is planned for this testing season. It should be noted that although there is limited Type III 75/25 and 50/50 data in multiple temperature bands, this is not considered a priority testing target as only one Type III fluid is currently available in 75/25 and 50/50 dilutions (Clariant Safewing MP III 2031 ECO) and this fluid expired in 2015 (expired fluids are removed from the HOT guidelines after four years).

Table 9.3: Active Frost Data Acquisition Targets for 2016-17 Testing Season

OAT (°C)	Fluid Concentration	Highest Priority Data Targets - 2016-17		
		Type II	Type III	Type IV
-1 and Above	100/0			
	75/25			
	50/50			
Below -1 to -3	100/0			
	75/25			
	50/50			
Below -3 to -10	100/0			
	75/25			
Below -10 to -14	100/0			
	75/25			
Below -14 to -21	100/0			
Below -21 to -25	100/0			
Shaded cells are the highest priority data targets. Other cells to be tested where fluid permits.				

9.6.2 Review of Current Data and Existing Active Frost Generic Holdover Times

The second objective of the analysis was to take a more in-depth look at the endurance times of the tests performed in order to determine if any changes to the generic active frost holdover times could be supported. The goal was to identify cells of the active frost HOT table for which multiple valid tests that were run to failure exist (e.g. Type II Fluids – Below -1°C to -3°C – Neat). From there, the endurance time of each of these applicable tests can be compared to the existing generic active frost holdover time. If for a given cell there are multiple failed tests where all of the measured endurance times far exceed (or are lower than) the existing generic holdover time, then it is possible that a change to the existing generic times could be supported.

Table 9.4 lists the endurance times of all current Type II active frost tests run to failure as well as "Did Not Fail" (DNF) tests for all fluid dilutions and temperature bands. Also given are the corresponding generic holdover times for comparison purposes.

The majority of the usable Type II data for this analysis is in the "Below -3°C to -10°C," "Below -10°C to -14°C" and "Below -14°C to -21°C" temperature bands. As such, it is these temperature bands that currently have the most convincing evidence for potential generic holdover time expansion. While there is likely not enough failed data in the current set to fully support extensions at this time, it should be noted that this is an ongoing project and the results seen thus far are encouraging.

Testing in the coming winter season should emphasize obtaining additional failed data in the warmer temperature bands with all dilutions of Type II fluids.

There is generally much more failed active frost test data available for Type II fluids in comparison with Type IV fluids (likely due to the reduced protection time generally offered by Type II fluids).

Table 9.4: Type II Active Frost Holdover Time Comparison

Temp Band	Fluid Dilution	Endurance Times of Failed Points (minutes)	Did Not Fail (minutes)	Generic HOT (minutes)	Evidence for Increase?
-1°C and Above	100/0	None	None	480	No
	75/25	None	348	300	No
	50/50	None	338, 338, 183, 180	180	Yes
Below -1°C to -3°C	100/0	None	522	480	No
	75/25	None	521, 366	300	No
	50/50	191, 125, 114, 113	None	90	No
Below -3°C to -10°C	100/0	628	749, 724, 620, 618, 618, 601, 599	480	Yes
	75/25	557, 473, 401	619, 617, 615, 600, 384	300	Yes
Below -10°C to -14°C	100/0	716, 551	644, 530, 491, 464, 462, 425, 422, 415	360	Yes
	75/25	592, 439, 395, 282, 268, 254, 178, 152	491, 463, 461, 254	60	Yes
Below -14°C to -21°C	Neat	637, 622, 481, 479, 413	678, 469, 361	360	Yes
Below -21°C to -25°C	Neat	None	217	120	No

Table 9.5 lists the endurance times of all current Type III active frost tests run to failure as well as DNF tests for all fluid dilutions and temperature bands. Also given are the corresponding generic holdover times for comparison purposes.

The existing data set for Type III fluids is limited; however, all of the failures observed did greatly exceed their corresponding generic holdover time. If more data could be gathered in the future, it is possible that there would be a case for extending the Type III generic holdover times across the board. Extensions should not be considered for Type III diluted fluids at this time, as the only Type III fluid with holdover times published for dilutions, Clariant Safewing MP III 2031 ECO, is currently expired and will be removed from the guidelines within several years [as per the removal protocol listed in ARP5718 (7)].

It would be beneficial to collect additional data in all temperature bands with the only non-expired Type III fluid in the guidelines, AllClear AeroClear MAX, to support future generic holdover time extensions.

Table 9.5: Type III Active Frost Holdover Time Comparison

Temp Band	Fluid Dilution	Endurance Times of Failed Points (minutes)	Did Not Fail (minutes)	Generic HOT (minutes)	Evidence for Increase?
-1°C and Above	100/0	None	388, 335, 152, 151, 145	120	Yes
	75/25	114	335	60	Yes
	50/50	None	None	30	No
Below -1°C to -3°C	100/0	None	None	120	No
	75/25	None	None	60	No
	50/50	None	None	30	No
Below -3°C to -10°C	100/0	556	None	120	Yes
	75/25	442	None	60	Yes
Below -10°C to -14°C	100/0	None	459	120	Yes
	75/25	None	None	60	No
Below -14°C to -21°C	Neat	599	324, 306	120	Yes
Below -21°C to -25°C	Neat	None	None	120	No

Table 9.6 lists the endurance times of all current Type IV active frost tests run to failure as well as DNF tests for all fluid dilutions and temperature bands. Also given are the corresponding generic holdover times for comparison purposes.

As was the case for Type II fluids, the majority of the usable Type IV data for this analysis is in the "Below -3°C to -10°C," "Below -10°C to -14°C" and "Below -14°C to -21°C" temperature bands. This is due to the increased emphasis on running frost tests to completion or for durations far exceeding the generic holdover time that was first implemented prior to the 2015-16 winter testing season (the majority of the frost data gathered during this year was in the aforementioned temperature bands).

These temperature bands currently have the most evidence for potential generic holdover time expansion, however more data is needed before extensions can be fully supported.

Testing in the coming winter season should emphasize obtaining additional failed data in the warmer temperature bands with all dilutions of Type IV fluids.

Table 9.6: Type IV Active Frost Holdover Time Comparison

Temp Band	Fluid Dilution	Endurance Times of Failed Points (minutes)	Did Not Fail (minutes)	Generic HOT (minutes)	Evidence for Increase?
-1°C and Above	100/0	None	None	720	No
	75/25	None	361	300	No
	50/50	None	390, 389, 389, 363	180	Yes
Below -1°C to -3°C	100/0	None	None	720	No
	75/25	None	523, 384, 378, 376, 365	300	Yes
	50/50	227, 204	457, 455, 454, 377, 375	180	No
Below -3°C to -10°C	100/0	None	813, 748, 725, 662, 648, 643, 636, 635, 634, 632, 631, 629, 608, 603	600	Yes
	75/25	None	625, 602, 588, 587, 586, 585, 582, 564, 562, 561	300	Yes
Below -10°C to -14°C	100/0	None	460, 427, 425, 424, 423, 418, 417, 416, 416	360	Yes
	75/25	417, 412, 388, 384	435, 286	60	Yes
Below -14°C to -21°C	Neat	618, 598, 503, 502, 430	772, 680, 679, 633, 582, 581, 579, 579, 469, 379	360	Yes
Below -21°C to -25°C	Neat	None	247	240	No

9.7 Observations

As this project is still on-going and will be continued throughout the 2016-17 testing season, no final conclusions have been made. This section will document observations based on the current status of the project as of the end of the 2015-16 testing year.

The current valid data set used for frost holdover time substantiation is lacking in several areas relative to the historical data set used for initial substantiation. If considering two valid current data points as a target, several cells of the active frost HOT table are under-represented in the current data set (refer to Table 9.3 for a breakdown of cells where additional data acquisition should be considered). Currently, the warmer temperature bands are relatively under-represented in the data set, as much of the supplemental testing conducted in the 2015-16 testing season was performed in the colder temperature bands.

Although there are some cells lacking data in the current data set, it is not an immediate cause for concern. All of the current frost tests that reached failure demonstrate endurance times that exceed their respective generic holdover time (in many cases greatly exceed).

There is evidence that several cells of the existing active frost HOT table may have generic holdover times that are overly conservative, however additional data is still required before changes to these generic times could be supported. Specifically, data should be obtained with all fluids of a given Type before any changes could be introduced as it would not be possible to identify the worst-performing fluids if there are fluids that remain untested.

9.8 Recommendations

It is recommended that active frost testing for the Winter 2016-17 testing season be targeted towards augmenting the current data set in the cells outlined in Table 9.3. As much of the active frost testing in Winter 2015-16 was conducted in the colder temperature bands, there is a particular need for data from warmer frost events. It should be noted however that there is still value in obtaining failed test data in all temperature bands to support future extensions to the generic active frost holdover times.

10. CONCLUSIONS

The conclusions derived from the testing conducted in the winter of 2015-16 are provided below.

10.1 Annual Testing

Endurance time testing was carried out with seven de/anti-icing fluids in the winter of 2015-16. The results of this testing resulted in several changes being made to the HOT guidelines. The changes, described below, were included in the winter 2016-17 HOT guidelines.

Type I Fluids

- No changes were made to the Type I fluid HOT guidelines.

Type II Fluids

- A fluid-specific HOT table was added for the new fluid Beijing Yadilite Aviation YD-102 Type II.
- LNT Solutions P250 was removed.
- Minor changes (both increases and decreases) were made to the Type II generic fluid holdover times as a result of the new and removed Type II fluids.
- The holdover times for snow in the “below -14°C to LOUT” row were reduced for all Type II fluids.

Type III Fluids

- Supplemental testing with AllClear AeroClear MAX (Type III) resulted in changes to most of its holdover times.

Type IV Fluids

- Fluid-specific HOT tables were added for the new fluids Clariant Max Flight AVIA, Clariant Safewing EG IV NORTH and Shaanxi Cleanway Aviation Cleansurface IV.
- Supplemental testing with Deicing Solutions ECO-SHIELD® (Type IV) resulted in changes to most of its holdover times.
- Cryotech Polar Guard® and Dow Chemical UCARTM FlightGuard AD-480 were removed from the guidelines as per the protocol for removal of obsolete data.

- Significant changes (both increases and decreases) were made to the Type IV generic holdover times as a result of the new and removed Type IV fluids. In addition, the Type IV generic HOT table was expanded to include holdover times for three snowfall intensities: very light, light and moderate.
- The holdover times for snow in the "below -14°C to LOUT" row were reduced for all Type IV fluids.

Allowance Time Tables

- Several changes were made to the Type III and Type IV allowance tables. These include reordering of the existing precipitation type rows, the addition of new precipitation type rows, minor changes to some existing allowance times, and minor changes to the existing Type IV temperature bands.

Active Frost Table

- A note was added to the active frost HOT table to provide guidance on the appropriate outside air temperature to select in changing conditions.

Other Changes

- Changes were made to the Type I and Type II/IV fluid application tables to improve harmonization between the Transport Canada, FAA and SAE fluid application tables.
- Guidance for the application of Type III fluid was previously provided in the same table as the guidance provided for the application of Type II/IV fluid. This guidance was moved to two new Type III fluid application tables.
- Transport Canada published special HOT tables for use when flaps/slats are deployed prior to de/anti-icing. These tables contain holdover times that are 90 percent of the standard HOT table values.

10.2 Further Changes to Holdover Times Published for Type II/IV Fluids in Very Cold Snow

The FAA and Transport Canada published optional holdover time guidance for Type II and Type IV fluids in very cold snow in September and October 2016, respectively. This guidance provided increases to holdover times in very cold snow for ethylene glycol based Type IV fluids below -14°C and for propylene glycol based Type II and Type IV fluids below -14 to -18°C.

10.3 Supplemental Research: Very Cold Snow

The supplemental testing conducted in snow at very cold temperatures indicated that the current generic holdover times are not appropriate for Type II and Type IV fluids. The testing also indicated that endurance times measured in artificial snow at very cold temperatures should not be assumed to be conservative. Changes were recommended and accepted by regulators to reduce the generic Type II and Type IV holdover times in very cold snow.

10.4 Supplemental Research: Review of Current and Obsolete Frost Endurance Time Data

The current active frost data set including only data from currently available commercial fluids is lacking in several areas relative to the historical data set used for the initial active frost holdover time substantiation. Supplemental active frost testing is ongoing with the goal of obtaining more data in areas where the current active frost data set is lacking. This analysis will be repeated at the conclusion of the 2016-17 testing season.

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11. RECOMMENDATIONS

It is recommended that:

1. All new Type I, II, III or IV fluids be evaluated over the entire range of conditions of the HOT tables;

2. Further research be considered to mitigate the reductions made to the Type II and Type IV very cold snow holdover times; and

3. Further active frost testing be conducted with current commercially available fluids to augment the existing frost endurance time data set.

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REFERENCES

1. Bendickson, S., Campbell, R., Chaput, M., D'Avirro, J., Dawson, P., Mayodon, M., *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2002-03 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, December 2003, TP 14144E, XX (to be published).

2. *Guidelines for Aircraft Ground Icing Operations (Second Edition)*, Transport Canada, April 2005, TP 14052E.

3. *Revised FAA-Approved Deicing Program Updates, Winter 20xx-20xx,* Federal Aviation Administration, N 8900.xxx.

4. Society of Automotive Engineers Aerospace Recommended Practice 5485, *Endurance Time Tests for Aircraft Deicing/Anti-Icing Fluids: SAE Type II, III, and IV*, July 2004.

5. SAE International Aerospace Recommended Practice 5945, *Endurance Time Tests for Aircraft Deicing/Anti-Icing Fluids: SAE Type I*, July 2007.

6. Youssef, D., *Aircraft Ground Icing General Research Activities During the 2013-14 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, November 2014, TP 15269E, XX (to be published).

7. SAE International Aerospace Recommended Practice 5718, *Qualification Process for SAE AMS1428 Type II, III, and IV Fluids*, March 2008.

8. Bernier, B., Ruggi, M., *Wind Tunnel Trials to Support Further Development of Ice Pellet Allowance Times: Winter 2015-16*, APS Aviation Inc., Transportation Development Centre, Montreal, December 2016, TP 15341E, XX (to be published).

9. Bendickson, S., *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2014-15 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, December 2016, TP 15321E, XX (to be published).

10. Ruggi, M., *Substantiation of Aircraft Ground Deicing Holdover Times in Frost Conditions,* APS Aviation Inc., Transportation Development Centre, Montreal, October 2009, TP 14938E, 120.

11. Asnytska, Y., Bendickson, S., Bernier, B., Bernier, C., D'Avirro, J., Ruggi, M., Youssef, D., *Aircraft Ground Icing Research General Activities During the 2014-15 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, February 2016, TP 15323E, 244.

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APPENDIX A

TRANSPORTATION DEVELOPMENT CENTRE
WORK STATEMENT EXCERPT –
AIRCRAFT & ANTI-ICING FLUID
WINTER TESTING 2015-16

TRANSPORTATION DEVELOPMENT CENTRE
WORK STATEMENT EXCERPT –
AIRCRAFT & ANTI-ICING FLUID
WINTER TESTING 2015-16

3.3 Holdover Time Testing for New Fluids

This program element is funded by the fluid manufacturers. The extent of effort for this program element will be determined by the number of new fluids submitted for testing.

(For the 2015-16 testing season, more HOT fluids were received than initially anticipated.)

a) Conduct flat plate tests with samples of Type I, Type II, Type III and Type IV fluids supplied by fluid manufacturers. Testing will be conducted using the methodology provided in Aerospace Recommended Practice (ARP) 5485 and/or 5945 under conditions of:

   i. Natural snow and two frost events at the P.E.T. test site under a wide range of temperature, precipitation rate, precipitation type, and wind conditions (in some cases, travel to other locations may be necessary to collect a more complete set of data); and

   ii. Simulated freezing precipitation at the NRC CEF (in freezing drizzle, light freezing rain, freezing fog, and rain on a cold-soaked surface).

b) Record individual fluid endurance times; and

c) Analyze the data collected, report the findings, and prepare presentation material for the SAE G-12 meetings.

3.4 Endurance Time Testing in Snow Conditions at Very Cold Temperatures to Validate Holdover Times at -25°C

a) Determine which fluids should be tested, and request LOWV samples of these fluids from the manufacturers;

b) Conduct flat plate tests with samples of Type II, Type III, Type IV and limited Type I fluids using the methodology provided in ARP5485 and/or ARP5945 under conditions of natural snow at temperatures close to -25°C (travel will be required);

c) Conduct snowmaker tests at -25°C. Approximately 15 days (30 tests) of testing will be required for Type I, II, IV fluids and an additional 5 days (8 tests) will be required for Type III fluid. While 20 days are required, approximately 10 days are budgeted as all the fluids may not be received. This snowmaker work can only be started in late winter after the natural snow data is analyzed;

d) Analyze the data collected and provide recommendations for changes to the HOT guidelines if required; and

e) Report the findings and prepare presentation material for the SAE G-12 annual meeting.

3.11 Further Substantiation of Frost HOTs

a) Review historical data set used for substantiating frost HOT's and determine possible areas with lacking data due to fluids which have become obsolete;

b) Review and, if required, modify the procedure for outdoor natural frost testing;

c) Conduct natural frost endurance time testing with commercialized fluids (will require LOWV samples from fluid manufacturers, samples will be obtained as part of separate task);

d) Analyze data and results and review impact on guidance; and

e) Report the findings and prepare presentation material for the SAE G-12 meetings.

3.47 Endurance Time Testing with Coloured and Uncoloured Formulations

a) Conduct a subset of the standard holdover time testing using coloured and uncoloured formulations of the same holdover time fluid;

b) Analyze the data collected; and

c) Report on findings.

APPENDIX B

PROCEDURES FOR HOLDOVER TIME TESTING

- Procedure for Conducting Endurance Time Tests for SAE Deicing/Anti-Icing Fluids – SAE Type II, III and IV
- Procedure: Determination of Endurance Times of Type I Fluids Under Natural Snow Precipitation at Dorval
- Procedure: Endurance Time Testing in Frost with Type I, II, III and IV Fluids
- Procedure: Endurance Time Test Requirements for Simulated Snow Flat Plate Testing – Type II, III and IV Fluids
- Procedure: Development of Type I Protocol for Indoor Snow (ARP5495)
- Overall Program of Tests at NRC, March/April 2016

PROCEDURE FOR CONDUCTING ENDURANCE TIME TESTS FOR SAE DEICING/ANTI-ICING FLUIDS SAE TYPE II, III AND IV

CM 1892.001

PROCEDURE FOR CONDUCTING ENDURANCE TIME TESTS
FOR SAE DEICING/ANTI-ICING FLUIDS
SAE Type II, III and IV

2003-04

for Prepared by: Nicoara Moc

Reviewed by: John D'Avirro

January 20, 2004
Version 1.0

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FOREWORD

Aircraft deicing/anti-icing fluids certified under AMS 1428 (Types II, III and IV fluids) must be tested for endurance time as described in Aerospace Standard (AS 5485). Endurance time can be defined as the time that a fluid can endure controlled and defined temperature and precipitation conditions before failure. These temperature and precipitation conditions were developed taking into consideration meteorological data. The endurance time data are presented to the SAE G-12 Holdover Time Subcommittee for examination and validation. If of acceptable quality, these data are used to update holdover time guidelines for the appropriate fluid type, taking into consideration the effects of natural variability of precipitation both in time and space.

This procedure provides peer reviewed written documentation for laboratory endurance time testing for freezing fog, freezing drizzle, light freezing rain and rain on cold soaked wing. In addition, the current outdoor snow test procedure is included in this document.

1. SCOPE:

1.1 Purpose:

The purpose of this procedure is to provide 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 Holdover Time Subcommittee.

The procedure comprises of a general section, individual endurance time testing procedures for each precipitation condition, a section containing attachments, a section containing forms, followed by a section that includes the calibration instructions for the testing equipment.

For information purposes only, a similar procedure that includes Type I aircraft deicing fluids, certified under the AMS 1424, can be found at ..\..\..\CM1680(exBM3833)\Procedures\AS5485\AS 5485 PROCEDURE (new).doc.

1.2 Examination of Endurance Time Data:

Periodically, the SAE G-12 Holdover Time Subcommittee examines endurance time test data of aircraft deicing/anti-icing fluids SAE Type II, III, and IV and validates, based on the endurance time data, if such fluids can be used in conjunction with SAE Type II, III, or IV holdover time guidelines. As the SAE G-12 Holdover Time Subcommittee examines endurance time data, it will take into consideration the effects of natural variability of precipitation both in time and space to generate or adjust holdover time guidelines.

1.3 Limits:

This procedures provides laboratory simulation of freezing fog, freezing drizzle, light freezing rain and rain on cold soaked wing. It also describes test conditions for outside natural snow tests. Other forms of freezing/frozen precipitation are not addressed in this procedure.

1.4 Testing Agent(s):

1.4.1 Independence of Testing Agent(s):

A testing agent shall be independent of the fluid manufacturer or fluid vendor.

1.4.2 Role of the Testing Agent:

APS Aviation Inc. will coordinate activities related to the sample selection procedures (section 2).

1.4.3 Sending Samples:

In order to receive the fluid samples, APS will write a request letter to the fluid manufacturer. The complete process of receiving fluid is described in detail in ATTACHMENT 7.

Fluid samples for testing sent to APS will be verified to ensure that the sample selection procedures have been adhered to. In turn APS, if the requirements of the applicable sample selection procedure are fulfilled, will send the samples to the test facility/site for endurance time testing.

1.5 Test Facility/Site and Test Personnel/Training:

1.5.1 Independence of the Test Facilities/Sites:

The test facilities/sites shall be independent of the fluid manufacturer or fluid vendor.

1.5.2 Role of the Test Facility/Site:

The test facilities/sites are responsible for providing the facility for performing the endurance time tests (sections 3 to 10).

Typically, APS will conduct tests at:

a) NRC under conditions of ZF, ZD, ZR and CSW;
b) IREQ under condition of frost; and
c) The APS test site and other various locations for natural snow.

1.5.3 Test Personnel and Training:

The personnel involved in testing, for each of the above conditions, can be found in ATTACHMENT 8.

1.6 Units:

This procedure and tests will use SI units or both.

1.7 Safety:

While the materials, methods, applications, and processes described or referenced in this procedure may involve the use of hazardous materials, it is the sole responsibility of the testing agent to ensure familiarity with the safe and proper use of any hazardous materials and processes and to take necessary precautionary measures to ensure the health and safety of all personnel involved. APS will advise all team members of the safe measures outlined in ATTACHMENT 1.

2. APPLICABLE DOCUMENTS:

The issues of the following documents form a part of this procedure to the extent specified herein. When the referenced document has been canceled and no superseding document has been specified, the last published issue of that document shall apply. In the event of conflict between the text of this document and the Aerospace Standard 5485, the standard takes precedence.

This procedure contains data forms. The data forms are grouped into a section, and they can be found at the end of this document.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001:

AIR 9968 Field Viscosity Test of Thickened Aircraft Deicing/Anti-icing Fluids

AMS 1424 Deicing/Anti-icing Fluid, Aircraft, SAE Type I

AMS 1428 Fluid, Aircraft Deicing/Anti-icing Fluid, Non-Newtonian (Pseudoplastic), SAE Types II, III, and IV

AMS 4037 Aluminum Alloy Sheet and Plate, 4.4 Cu - 1.5 Mg - 0.6 Mn (2024-T3 Flat Sheet, T351 Plate) Solution Heat Treated

AMS 4041 Aluminum Alloy, Alclad Sheet Plate, 4.4 Cu 0.60 Mn (Alclad 2024 and 1-½% T3 Flat sheet, 1-½% Alclad 2024 T351 Plate)

ARP4737 Aircraft Deicing/Anti-icing Methods with Fluids

AS 5901 Water Spray and High Humidity Endurance Test Methods for SAE AMS 1424 and SAE AMS 1428 Aircraft Deicing/Anti-icing Fluids

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959:

ASTM D 1193 Reagent Water

2.3 ISO Publications:

Available from International Organization for Standardization, Case postale 56, rue Varembe, CH -1211, Switzerland:

ISO 10012: Quality assurance requirements for measuring equipment

2.4 Transport Canada Publications:

Available from Transportation Development Center, Transport Canada, 800, boul. René-Lévesque Ouest, 6th Floor, Montréal QC H3B 1X9, Canada.

Validation of Methodology for Simulating a Cold Soaked Wing. Transport Canada Document TP 12899E.

Aircraft Ground De/Anti-icing Fluid Holdover Time and Endurance Time Testing Program for the 2001–2002 Winter. Transport Canada Document TP 13991E.

2.5 Other Documents:

Godard, L. (1959), Procédé pour déterminer les dimensions des gouttelettes de brouillard ou de nuages, Bulletin de l'observation du Puy de Dôme, pp.11-13

Godard, S. (1960), Mesure des gouttelettes de nuage avec un film de collargol. Bulletin de l'observation du Puy de Dôme, pp. 41-46.

3. SAMPLE SELECTION PROCEDURE FOR SAE TYPE II, III, AND IV FLUIDS:

3.1 Requirements:

3.1.1 Normal Batch and Viscosity Reduction:

The sample shall be fluid taken from a production batch and its viscosity may be reduced by the manufacturer by some process subsequent to manufacturing.

3.1.2 Water Spray Endurance Time (WSET):

The WSET (measured according to AS 5901 but without shearing) of the sample must be (a) equal to (within experimental error, approximately ± 10%) or less than the WSET of the neat sample (100/0, neat fluid/water) on which certification WSET in 4.2.3.1.1. of AMS 1428 was done and (b) must not be less than 30 minutes for Type II fluids, not less than 20 minutes for Type III fluids, and not less than 80 minutes for Type IV fluids.

3.1.3 Viscosity:

The sample 0.3 rpm 20°C viscosity must be equal to (within experimental error, approximately ± 10%) or less than the 0.3 rpm 20°C viscosity of the neat sample (100/0, neat fluid/water) as measured by AIR 9968 on which the certification water spray endurance time (WSET) in 4.2.3.1.1. of AMS 1428 was done.

3.1.4 Fluid Manufacturer's Documentation:

The fluid manufacturer shall send the AMS 1428 certificates of conformance of the fluid to the testing agent.

3.2 Testing Agent Duties:

3.2.1 Run and Report WSET:

APS will run WSET (without shearing) and report to the manufacturer prior to running any endurance time testing. The results of these tests will be recorded in Form 1.

3.2.2 Run and Report Viscosity:

APS will run the viscosity of the unsheared sample at 0.3 rpm 20°C according to SAE AIR 9968 and report to the manufacturer prior to running any endurance time testing. Instructions for measuring anti-icing fluid viscosity using DV-I+ Brookfield viscometers are given in ATTACHMENT 3. The results of these tests will be recorded in Form 1.

3.2.3 Check Certificates of Conformance:

The testing agent shall ensure that it has on hand the SAE AMS 1428 certificates of conformance for the fluid (to make sure it is fully certified).

3.2.4 Check WSET:

The testing agent shall ensure that the requirements of 3.1.2 are met before proceeding to the next section.

3.2.5 Check Viscosity:

The testing agent shall ensure that the requirements of 3.1.3 are met before proceeding to the next section.

3.3 Authorization to Proceed with Endurance Time Testing:

3.3.1 Manufacturer's Authorization to Proceed:

After reviewing the reports sent by the testing agent, the fluid manufacturer (if desirous of proceeding with endurance tests) shall send to the testing agent authorization to proceed. The authorization receiving date will be recorded in Form 1.

3.3.2 Final Check:

APS will proceed with endurance time testing upon successful completion of 3.2.3, 3.2.4, 3.2.5 and 3.3.1 by sending the sample to the testing facility/site.

3.4 Condition of the Sample to be Tested:

3.4.1 The neat sample shall be tested without shearing.

3.4.2 The 75/25 and 50/50 dilutions of the sample shall be made with hard water and shall be tested without shearing.

3.4.3 Composition of Hard Water:

Dissolve 400 mg ± 5 calcium acetate dihydrate $Ca(C_2H_3O_2)_2.2H_2O$ and 280 mg ± 5 magnesium sulfate heptahydrate $MgSO_4.7H_2O$, both of analytical reagent quality, in 1 liter of ASTM D 1193 Type IV water. If calcium acetate dihydrate is not readily available, use calcium acetate monohydrate or anhydrous calcium acetate of analytical reagent quality and ensure the hard water has 82.6 mg/L Ca^{++} by atomic absorption (or equivalent method).

3.5 Recertification:

If a fluid manufacturer submits a sample which has a 0.3 rpm 20°C viscosity or WSET that does not meet the requirements of 3.2.4 and 3.2.5, the sample may be submitted for endurance time testing provided that prior to testing, the manufacturer submits new certificates of conformance under 4.2.3.1.1 (including all subparagraphs a, b and c) of AMS 1428 demonstrating that the sample meets the requirements of 3.2.4 and 3.2.5.

3.6 Viscosity Measurements:

Viscosity in this section shall be determined using the same Brookfield spindle/sample size combination as used for the AMS 1428 certification (most current).

4. ENDURANCE TIME TEST—GENERAL:

4.1 Purpose:

This section of the procedure establishes the general minimum requirements for test equipment and test procedures used to carry out laboratory endurance time tests of aircraft deicing/anti-icing fluids under freezing fog, freezing drizzle, light freezing rain and rain on cold soaked wing conditions. The primary purpose for such a test method is to determine endurance time for these conditions under controlled laboratory conditions for SAE Type II, III and IV fluids.

This section does not apply to natural snow testing performed outside (Section 10) except where noted otherwise.

4.2 Summary of the Tests:

Fluids to be evaluated are applied to test plates exposed to freezing fog, freezing drizzle, light freezing rain and rain on cold soaked (simulated) wing. Endurance times are evaluated by measuring the minimum exposure time before a specified degree of freezing occurs.

4.3 General Versus Specific Procedures:

This general section (Section 1) covers procedures that are common to laboratory conditions (except where otherwise noted). Sections 4-10 establish the specific procedures for each precipitation condition.

4.4 Test Facility/Site Qualification:

Substantiation that the testing facility and associated staff and resources satisfy the requirements of this endurance time test method including calibration and measurement methods shall be documented. Such documentation shall be kept for 3 years.

This requirement (paragraph 4.4) is applicable to section 10.

Documentation of measurement methods and test site facilities is included in the HOT procedures for natural snow and simulated freezing precipitation. These two documents can be used to substantiate that APS meets the necessary requirements, and they can be found in Appendices B and C of Transport Canada report TP 13991E, *Aircraft Ground De/Anti-Icing Fluid Holdover Time and Endurance Time Testing Program for the 2001-02 Winter*, December 2002.

4.5 General Environmental Chamber Equipment:

4.5.1 Air Temperature Sensor:

The air temperature sensor will be in proximity to the test plate, typically within 1.5 m of the side of the test plate, but outside the spray area (if any). The distance and position of the sensing device shall be recorded on Form 2 for NRC and on Form 6 for IREQ.

4.5.2 Lighting:

The test chamber will be equipped with artificial lighting facilitating ice formation observation but positioned such that it does not interfere with air, fluid and plate temperatures.

The NRC facility is equipped with lights mounted in the ceiling. However, when additional lighting is required, the portable lights will be installed at least 3 m away from the test stand(s). The same procedure will be applied for IREQ.

4.5.3 Data Acquisition System:

The air temperature, plate temperature and humidity sensors shall be linked to an electronic data acquisition system as a means of checking and recording the environmental characteristics of the test chamber and test plates throughout the course of a test run.

The environmental chamber personnel will record the air temperature and relative humidity throughout the test and will provide the results (on floppy disks) to APS Aviation Inc. For easier trace, filenames of the files will be printed on Form 3.

APS Aviation Inc. will record the test surface temperature for each test, save the files on floppy disks after each condition and file the disks along with the forms in the same envelope.

The electronic filenames of these files will be printed on Form 4.

4.5.4 Temperature Control Equipment:

The air temperature (for all conditions) and test plate temperature, if required by the test protocol, shall be maintained at the required level using heat exchangers connected to temperature control equipment comprising solid state temperature sensor such as a platinum resistance probe (100 ohms at 0°C), coupled to a proportional temperature controller having a minimum resolution of 0.5 °C.

The NRC facility maintains the chamber temperature within acceptable limits using their temperature control equipment.

For frost testing, the plate temperature is adjusted and maintained at the required level by means of a controller that regulates the flow of CO_2 in the cryogenic unit.

4.5.5 Air Distribution System:

The air distribution system shall be comprised of a fan or fans to provide air recirculation through the main body of the test chamber and to the heat exchanger. Ducting for the passage of air at both the inlet and the outlet of the heat exchanger shall have entry and exit ports positioned to provide good air recirculation throughout the test chamber. The heat exchanger shall be capable of cooling the air and maintaining it at the specified temperature level. Airflow shall be measured using a suitable anemometer or velocity meter (see also 4.6.4).

The NRC facility complies with the code requirements.

For a complete equipment list, for each condition, see ATTACHMENT 6.

4.5.6 Water Supply for Nozzles:

Water supplied to nozzles shall conform to conform to ASTM D1193 Type IV water or a hardness of less than 300 ppm reported as $CaCO_3$.

The NRC facility complies with the code requirements.

4.6 Calibration and Measurement Methods:

4.6.1 Calibration of Standard Measuring Devices:

All temperature sensors, humidity sensors, electronic balances, anemometers, velocity meters, and timing devices shall be maintained in a known state of calibration in accordance with recognized international standards such as ISO 10012, by calibrating each instrument at least once every six months or whenever a piece of equipment is repaired, replaced, moved, or otherwise suspect. A written record of the calibration for the equipment used is kept in CALIBRATION ATTACHMENT.

4.6.2 Icing Intensity Measurement Methods:

4.6.2.1 Icing Intensity Methods Using Reference Ice-catch Plates (Method A): In most cases the icing intensity on a test plate with fluid cannot be measured directly as the fluid and some of the precipitation will fall off the test plate preventing the weighing of the total precipitation for the duration of the test. Icing intensity is generally established by catching the precipitation with a specified number so-called reference ice-catch plates placed adjacent to the test plate and weighing the amount of precipitation for the duration of the test period. This is the method that APS is using to measure the icing intensity for frost (Section 4).

4.6.2.2 Icing Intensity Methods Using Regression Analysis (Method B): An alternative way of measuring icing intensity is to catch the precipitation a number of times at the very position of the test plate before and after the test and average the results. Furthermore at least two tests with fluid are performed and endurance times determined at each of the targeted rates. The results are analyzed using regression analysis to determine the endurance time at the targeted rates of precipitation. APS Aviation Inc. is currently using this method to measure icing intensity for freezing fog, freezing drizzle, light freezing rain and rain on cold soaked wing (Sections 5, 7, 8 and 10). The full procedure of how to calculate a rate using this method is given in ATTACHMENT 4.

4.6.2.3 Other Icing Intensity Measurement Methods: Icing intensity measurement methods may differ from methods described in 4.6.3.1 or 4.6.3.2 depending on the specific configuration of the equipment (e.g., number of ice-catch plates or their geometry) used to create the various precipitation conditions.

4.6.2.4 Documentation: Each facility/site performing endurance time tests shall develop and document appropriate icing intensity measurement methods for each precipitation condition to ensure that the test conditions are within the specified limits. Reports issued by the facility/site shall describe the icing intensity measurement methods and their results.

The icing intensity measurements for each condition are documented by APS. At the end of the condition they are stored electronically on floppy disks, and a summary of icing intensity measurements (on paper) is also inserted in the envelope for filing. The data is subsequently saved to a designated folder on the local network.

The icing intensity data collected for several recent years at NRC was compiled and analyzed to substantiate that testing under simulated freezing precipitation was conducted at adequate icing intensity rates according to the requirements of this standard. The results from this analysis are stored on the APS's server and can be found at the following location: \\adgaaps\proj\Groups\CM1747\Analysis\Precipitation Rate Variance at NRC\

4.6.3 Icing Intensity Variability Across Test Plates Measurement Methods:

4.6.3.1 Intensity Variability Across a Test Plate Measurement Method (used method A): It is important to establish that icing intensity across each test plate is uniform and within specified limits. The icing intensity variability (uniformity or lack of uniformity) across each test plate can be established by periodically replacing the test plates with a specified number of preweighed ice-catch plates, weighing the precipitation, and calculating the range. The range is simply the highest value minus the lowest value and is a quantitative representation of the variability of precipitation data across each plate. This range must not exceed limits that are specified for each test condition. The measurement of the icing intensity variability across a test plate shall be run at least every six months or whenever a piece of equipment is repaired, replaced, moved or otherwise suspect.

4.6.3.2 Intensity Variability Across all Test Plates Measurement Method (used with method B): is described in 6.2.2.3. The measurement of the icing intensity variability across all test plates shall be run every time experiments are run.

APS will run icing intensity variability measurements across all test plates every time tests are conducted (see ATTACHMENT 11).

4.6.3.3 Other Icing Intensity Variability Across Test Plates Methods: A facility/site may have specific equipment that requires a method for estimating the icing intensity variability across test plates different than in 4.6.3.1 and 4.6.3.2. Such other methods are acceptable if they are shown to be equivalent or more demanding.

4.6.4 Horizontal Air Velocity Measurement:

Horizontal air velocity shall be measured 50 mm above the surface of the test plate using a velocity meter or anemometer.

The measured value will be recorded in Form 5 or Form 7.

4.6.5 Water Droplet Size Measurement:

Several methods are available to determine the water droplet size (median volume diameter). Table 1 lists several acceptable methods as a function of droplet size. A description of the methods used by APS Aviation Inc. follows:

a) Slide Impact Method with Oil: A sample of the water droplets from the precipitation is collected on an oil coated microscope slide. An oil having a viscosity of 5000 mPa.s at 20 °C, spread to an appropriate thickness will be suitable for certain droplet sizes (see Table1 for appropriate thickness). The oil may be either a mineral oil or silicone oil. The droplet size is determined by direct observation under a microscope using an eyepiece with the appropriate graticle, or from enlarged photographs of the slide; and

b) Dye Stain Method: Prepare discs by dusting filter paper discs with a water-activated very finely divided powder form of methylene blue dye. The prepared discs are manually positioned under precipitation for a fixed time in order to acquire a droplet size pattern. A calibration curve is then used to convert from the measured diameter of the droplets on the pattern to the experimental median volume diameter.

Table 1: Examples of Water Droplet Size Measuring Methods

Droplet Size	Slide Impact with Oil (Required Oil Thickness)	Slide Impact with Colloidal Silver	Laser Diffraction	Dye Stain
5 µm		X		
20 µm	X (500 µm)	X	X	
200 µm	X (1000 µm)			X
1000 µm	X (2000 µm)			X

X means recommended.

Water droplet size measurements were conducted in the past and have shown that the simulated precipitation produced at NRC is within the requirements of this standard for freezing drizzle (Table 4), light freezing rain (Table 6) and rain on cold soaked wing (Table 8). The results from these measurements are stored on the APS's local network and can be found at the following location: \\adgaaps\proj\Groups\CM1747\Analysis\Droplet Test

The median volume diameter for freezing fog should be verified during a next testing session at NRC to confirm it complies with the requirements of Table 2.

4.7 General Test Procedures:

4.7.1 Test Plate Cleanliness:

The test plates shall be free of all visible contamination, smears, or stains, except for markings used to estimate ice coverage. Between test runs, any contamination shall be removed by washing with hot water immediately followed by an ethanol rinse. If the same fluid is tested on the same plate for two or more consecutive tests, it is not necessary to clean the plates with ethanol before the second test; a hot water rinse is sufficient. Allow the plates to dry after rinse and ensure they are at the appropriate temperature before use. For freezing fog, freezing drizzle, freezing rain and cold soak wing, a detailed procedure of plate preparation can be found in ATTACHMENT 5.

4.7.2 Appearance of Frozen Contamination:

Failure is called when 30% of the plate is covered with frozen contamination. Appearance of this frozen contamination includes, but is not limited to:

a) Ice front;
b) Ice sheet;
c) Slush, in clusters or as a front;
d) Disseminated fine ice crystals;
e) Frost on surface;
f) Clear ice pieces partially or totally imbedded in fluid; and
g) Snow bridges on top of the fluid.

4.7.3 Delayed Crystallization:

Delayed crystallization may occur during the course of a test run, and is defined as a sudden (within 30 seconds) appearance of frozen contamination covering a large surface area of a test plate. If this sudden coverage exceeds the percentage of the test plate area that is considered to be a failure, the test is invalid and must be repeated. In the case of suspected delayed crystallization, if the test has been invalidated three times, the plate may be seeded at the center top edge of the plate with an ice crystal to initiate crystallization. Seeding consists of putting an ice crystal in contact with the fluid by means of a chilled metal rod (below 0 °C). If upon seeding, the frozen contamination area suddenly exceeds the percentage of the plate area that is considered to be a failure, the test is invalid.

4.7.4 Report:

The report shall include:

a) Name and address of the facility conducting the tests;

b) Statement confirming the test facility is autonomous of the manufacturer or vendor of the fluid;

c) Date(s) tests conducted;

d) Manufacturer or vendor's name and address;

e) Name or reference number and lot number of the fluid tested;

f) Type of fluid (SAE Type II, III or IV) and concentration of the fluid as received and as tested. Examples: received SAE Type IV neat, tested neat; tested diluted 75:25 and 50:50 with hard water;

g) Quantity of fluid applied to test plates, if different from the norm;

h) Summary of test results and the icing intensity results for each test;

i) Icing intensity measurement method including ice-catch raw data;

j) Method of estimation of failure area;

k) Description of appearance of frozen contamination. For natural snow report the form of the snow according to Figure 4;

l) Icing intensity variability across test plates measurement method, its results (range) and date when performed;

m) Distance from test plates and location of air temperature sensor; and

n) For natural snow tests, orientation of the test stand and direction of the wind.

5. ENDURANCE TIME TEST—FROST:

This section to be inserted in future versions of this procedure. When inserting this section, refer to ..\..\..\CM1680(exBM3833)\Procedures\AS5485\AS 5485 PROCEDURE (new).doc for a template.

6. ENDURANCE TIME TEST - FREEZING FOG:

6.1 Freezing Fog Test Equipment and Test Parameters:

6.1.1 Environmental Chamber Equipment and Plates:

In addition to the requirements given in 4.5, environmental chamber and associated equipment requirements for freezing fog endurance time testing are given in Table 2 and in the following paragraphs.

Table 2: Requirements for Freezing Fog Test Equipment

Test Parameters	Requirements
Environmental Chamber	
Minimum volume	7 m³ for each 300 x 500 mm test plate
Air temperature range	0 °C to at least −25 °C
Minimum temperature sampling rate	1 datum per minute
Horizontal air velocity	≤ 0.4 m/s
Relative humidity	> 40 %
Test Plates	
Material	Aluminum alloy AMS 4037 or 4041
Test plate dimensions	500 mm long x 300 mm wide x 3.2 mm thick
Angle	10.0° ± 0.2
Surface finish	Average surface roughness: Ra ≤ 0.5 μm
Temperature at start of test range	Within ± 0.5 °C of air temperature
Number of test plates	2 per fluid tested
Fluid application temperature	Within 3 °C of the air temperature
Ice-catch Plates (Method A)	
Ice-catch plates	100 x 100 x 1.6 mm thick
Number of reference ice-catch plates	8 surrounding each test plate
Number of ice-catch plates for measuring icing intensity variability across test plates	12 per test plate
Spray Equipment	
Water supply temperature	Adjusted to produce supercooled water droplets.
Water droplet median volume diameter	22 μm ± 5

All of the parameters listed in Table 2 are being recorded in Forms 3, 4, 5 and 8.

At the beginning of the condition, and also at the end of the condition, a checklist form will be filled in (Form 14).

6.1.2 Test Plates:

6.1.2.1 Each test plate is removable and placed on a support that is housed within the environmental chamber.

6.1.2.2 Each test plate will be equipped with a temperature sensor located on the underside of or embedded within the plate. This sensor will be capable of measuring to an accuracy of ± 0.5 °C and will be linked to an electronic data acquisition system.

6.1.2.3 The test plate support is set-up in such a way that it can accommodate six test plates. The test plate support face shall be inclined from the horizontal as specified in Table 2. The test plates are placed on the support such that the fluid can freely flow off all edges of the plate. A typical test stand is illustrated in ATTACHMENT 9; it may be altered to suit the location and facilities, but the angle for the panels, their arrangement and markings must all conform to ATTACHMENT 9. The test stand should be designed as to minimize the contact between the test surface and the support.

6.1.2.4 For a complete equipment list, see ATTACHMENT 6.

6.1.3 Spray Equipment:

6.1.3.1 It is a fundamental requirement of this test that the spray impinges onto the surface of the test plate as supercooled water droplets that freeze on impact. This is verified by observation of an ice-catch plate.

6.1.3.2 The equipment used to provide the water spray comprises a low flow nozzle supplied with water of quality described in 4.5.6. This equipment is housed in the upper region of the test chamber above the test plate. The exact type and geometry of the spray system used to generate the water spray for the test is left to the discretion of the testing facility, provided the requirements of Table 2 and Table 3 are met.

6.1.4 Example of Spray Equipment:

An example of a suitable spray system is as follows: the nozzle comprises two sections, outer and inner units for the respective passage of water and compressed air. The nozzle reciprocates to provide even and reproducible coverage of the test plate at the specified water spray intensity.

6.2 Freezing Fog Measurement Methods:

6.2.1 Icing Intensity Measurement Methods:

6.2.1.1 For general requirements see 4.6.2.

6.2.1.2 Method A:

APS Aviation Inc. is using method B.

6.2.1.3 Method B:

For a full description of this method see ATTACHMENT 10. To calculate the weighted rate for the tests, APS uses an Excel spreadsheet. A guide of how to use this excel file is shown in ATTACHMENT 11.

6.2.2 Icing Intensity Variability Measurement Methods:

6.2.2.1 For general requirements see 4.6.3.

6.2.2.2 Variability Across a Test Plate Measurement Method (used with method A): APS is using method B.

6.2.2.3 Variability Across All Test Plates Measurement Method (used with method B): With method B the variability is not measured for a single (divided) plate as is with the method A, but it is measured across all the (undivided) plates for a given period of time. The icing intensity variability across all test plates shall be the range of icing intensities for all R1s (R1 for position 1, R1 for position 2, etc, for all positions) defined in ATTACHMENT 10. The range of all R1s shall conform to the value "Icing intensity range across test plates" in Table 3. Furthermore, the range of R2s, R3s and R4s shall also conform to the value "Icing intensity range across test plates" in Table 3. Results from positions not fulfilling this requirement shall not be used.

6.3 Freezing Fog Test Conditions:

Test conditions for freezing fog are in Table 3.

Table 3: Freezing Fog Test Conditions

Test Condition	FOG-A	FOG-B	FOG-C	FOG-D	FOG-E	FOG-F
Type II, III and IV, neat	Yes	Yes	Yes	Yes	Yes	Yes
Types II and IV, 75/25 (neat fluid/hard water)	Yes	Yes	Yes	Yes	No	No
Types II and IV, 50/50 (neat fluid/hard water)	Yes	Yes	No	No	No	No
Air temperature, °C	-3 ± 0.5	-3 ± 0.5	-14 ± 0.5	-14 ± 0.5	-25 ± 1	-25 ± 1
Air temperature standard deviation	± 0.3	± 0.3	± 0.3	± 0.3	± 0.5	± 0.5
† Icing intensity, $g/dm^2/h$	2.0 ± 0.2	5.0 ± 0.2	2.0 ± 0.2	5.0 ± 0.2	2.0 ± 0.2	5.0 ± 0.2
‡ Average icing intensity, $g/dm^2/h$	2.0 ± 0.3	5.0 ± 0.4	2.0 ± 0.3	5.0 ± 0.4	2.0 ± 0.3	5.0 ± 0.4
‡ Icing intensity standard deviation	<0.3	<0.4	<0.3	<0.4	<0.3	<0.4
† Icing intensity range across a test plate, $g/dm^2/h$	≤ 0.4	≤ 0.6	≤ 0.4	≤ 0.6	≤ 0.4	≤ 0.6
‡ Icing intensity range across all test plates, $g/dm^2/h$	≤ 1.2	≤ 1.7	≤ 1.2	≤ 1.7	≤ 1.2	≤ 1.7

*This test will be performed at the LOUT if it is below −25°C.
† Method A
‡ Method B

6.4 Freezing Fog Test Procedure:

6.4.1 Test Plate Cleanliness:

Clean test plates according to 4.7.1.

6.4.2 Temperature Verification:

Ensure the test chamber, fluid and test plates are at the required temperature. The chamber temperature is recorded by NRC for each condition, at a sampling rate of minimum 1 datum per minute, and handed in to APS at the end of the session. The filenames should be recoded on Form 3.

Fluid temperature should be measured just before pouring and must be recorded on Form 5.

Plate temperature is recorded by APS throughout the test, saved on diskettes and included in the envelope along with the forms. The path and filenames should be recorded on Form 4.

6.4.3 Failure Time:

Pour 500 mL of fluid onto each test plate (if more fluid is required, record the quantity of fluid actually used). As soon the fluid has spread over the plates (up to 30 s for Type II, III and IV fluids), expose to precipitation and start the timing device. Observe the plates and, when the failure occurs (defined in 6.4.6), record the time as the endurance time on Form 5.

6.4.4 Icing Intensity:

After all the plates have failed, shield the ice-catch plates from precipitation, and weigh the ice-catch on each ice-catch plate and using a method such as described in 6.2.1, estimate the icing intensity for each test plate. If the icing intensity is not within the specified limits (Table 3) for the test being conducted, the time recorded is not valid.

6.4.5 Delayed Crystallization:

See 4.7.3

6.4.6 Failure Criterion:

Failure is called when 30 % of the plate is covered with frozen contamination. Frozen contamination is described in 4.7.2. Pen marks on the plate can be used to estimate the area of failure. For instance, a line drawn across the plate at 150 mm from the top edge will delineate an area corresponding to 30 % of the plate.

6.4.7 Reproducibility/Precision:

6.4.7.1 Reproducibility/Precision for Method A: APS is using method B.

6.4.7.2 Reproducibility/Precision for Method B: With this method, data is not rejected but incorporated using regression analysis. See 6.2.1.3.

6.4.8 Report:

See 4.7.4.

6.4.9 Personnel:

See ATTACHMENT 8.

7. ENDURANCE TIME TEST—SIMULATED SNOW TESTS PERFORMED IN A LABORATORY:

This section to be inserted in future versions of this procedure. When inserting this section, refer to ..\..\..\CM1680(exBM3833)\Procedures\AS5485\AS 5485 PROCEDURE (new).doc for a template.

8. ENDURANCE TIME TEST—FREEZING DRIZZLE:

8.1 Freezing Drizzle Test Equipment and Test Parameters:

8.1.1 Environmental Chamber Equipment and Plates:

In addition to the requirements given in 4.5, environmental chamber and associated equipment requirements for freezing drizzle endurance time testing are given in Table 4 and in the following paragraphs.

Table 4: Requirements for Freezing Drizzle Test Equipment

Test Parameters	Requirements
Environmental Chamber	
Air temperature range	0 °C to -10 °C
Minimum temperature sampling rate	1 datum per minute
Horizontal air velocity	≤ 1.0 m/s
Relative humidity	> 40 %
Test Plates	
Material	Aluminum alloy AMS 4037 or 4041
Test plate dimensions	500 mm long x 300 mm wide x 3.2 mm thick
Angle	10° ± 0.2
Surface finish	Average surface roughness: Ra ≤ 0.5 μm
Temperature at start of test	Within ± 0.5 °C of air temperature
Number of test plates	2 per fluid tested
Fluid application temperature	Within 3 °C of the air temperature
Ice-catch Pans (Method A)	
Ice-catch pan dimensions	100 mm x 100 mm x 0.8 mm thick with all around rim 15 mm high
Number of reference ice-catch pans	8 surrounding each test plate
Number of ice-catch pans for measuring icing intensity variability across test plates	12 per test plate
Spray Equipment	
Distance between nozzle and test plate	7 m ± 0.5
Water supply temperature	≤ 2 °C just before the nozzle
Water droplet median volume diameter	300 μm ± 100

All of the parameters listed in Table 4 are being recorded in Forms 3, 4, 5 and 8.

At the beginning of the condition, and also at the end of the condition, a checklist form will be filled in (Form 14).

8.1.2 Test Plates:

8.1.2.1 Each test plate is removable and placed on a support that is housed within the environmental chamber.

8.1.2.2 Each test plate will be equipped with a temperature sensor located on the underside of, or embedded within the plate. This sensor will be capable of measuring to an accuracy of ± 0.5 °C and will be linked to an electronic data acquisition system.

8.1.2.3 The test plate support is set-up in such a way that it can accommodate six test plates. The test plate support face shall be inclined from the horizontal (see Table 4 for the angle). The test plates are placed on the support such that the fluid can freely flow off all edges of the plate. A typical test stand is illustrated in ATTACHMENT 9; it may be altered to suit the location and facilities, but the angle for the panels, their arrangement and markings must all conform to ATTACHMENT 9. The test stand should be designed as to minimize the contact between the test surface and the support.

8.1.2.4 For a complete equipment list, see ATTACHMENT 6.

8.1.3 Ice-catch Pans:

The ice-catch pans measure 27.7 cm by 54 cm and are described in 6.2.1.3.

8.1.4 Spray Equipment:

8.1.4.1 It is a fundamental requirement of this test that the spray impinges onto the surface of the test plate as supercooled water droplets which freeze on impact. This is verified by observation of an ice-catch plate.

8.1.4.2 The equipment used to provide the water spray comprises a low flow nozzle supplied with water of quality and condition described in Table 5. This equipment is housed in the upper region of the test chamber above the test plate. The exact type and geometry of the spray system used to generate the water spray for the test is left to the discretion of the testing facility/site, provided the requirements of Table 4 and Table 5 are met.

8.1.5 Example of Spray Equipment:

The hydraulic nozzle is comprised of an outer unit and an inner unit. Water is stored in a pressurized tank and provides the flow through a modified hypodermic needle. To create the droplets, compressed air is directed at an angle through several holes in the outer unit towards the water stream.

8.2 Freezing Drizzle Measurement Methods:

8.2.1 Icing Intensity Methods:

The methods are the same as in 6.2.1 except that Table 3 is replaced by Table 5 throughout.

8.2.2 Icing Intensity Variability Across Test Plate Methods:

The methods are the same as in 6.2.2 except that Table 3 is replaced by Table 5 throughout.

8.3 Freezing Drizzle Test Conditions:

Test conditions for freezing drizzle are in Table 5.

Table 5: Freezing Drizzle Test Conditions

Test Condition	ZL-A	ZL-B	ZL-C	ZL-D
Types II III, and IV, neat	Yes	Yes	Yes	Yes
Types II and IV, 75/25 (neat fluid/water)	Yes	Yes	Yes	Yes
Types II and IV, 50/50 (neat fluid/water)	Yes	Yes	No	No
Air temperature, °C	-3 ± 0.5	-3 ± 0.5	-10 ± 0.5	-10 ± 0.5
Air temperature standard deviation, °C	± 0.3	± 0.3	± 0.3	± 0.3
† Icing intensity, g/dm^2/h	5 ± 0.2	13 ± 0.5	5 ± 0.2	13 ± 0.5
‡ Average icing intensity, g/dm^2/h	5 ± 0.4	13 ± 0.5	5 ± 0.4	13 ± 0.5
‡ Icing intensity standard deviation	< 0.4	< 0.7	< 0.4	< 0.7
† Icing intensity range across a test plate, g/dm^2/h	≤ 0.6	≤ 1.4	≤ 0.6	≤ 1.4
‡ Icing intensity range across all test plates, g/dm^2/h	≤ 1.4	≤ 2.2	≤ 1.4	≤ 2.2

† Method A
‡ Method B

8.4 Freezing Drizzle Test Procedure:

8.4.1 Test Plate Cleanliness:

Clean test plates according to 4.7.1

8.4.2 Temperature Verification:

Ensure the test chamber, fluid and test plates are at the required temperature. The chamber temperature is recorded by NRC for each condition, at a sampling rate of minimum 1 datum per minute, and handed in to APS at the end of the session. The filenames should be recoded on Form 3.

Fluid temperature should be measured just before pouring and must be recorded on Form 5.

Plate temperature is recorded by APS throughout the test, saved on diskettes and included in the envelope along with the forms. The path and filenames should be recorded on Form 4.

8.4.3 Failure Time:

See 6.4.3 except that failure is defined in 8.4.6.

8.4.4 Icing Intensity:

After all the plates have failed, turn off the water spray, and weigh the ice-catch on each ice-catch plate and using a method such as described in 8.2.1, estimate the icing intensity for each test plate. If the icing intensity is not within the specified limits for the test being conducted, the time recorded is not valid.

8.4.5 Delayed Crystallization:

See 4.7.3

8.4.6 Failure Criterion:

See 6.4.6.

8.4.7 Reproducibility/Precision:

See 6.4.7.

8.4.8 Report:

See 4.7.4.

8.4.9 Personnel:

See ATTACHMENT 8.

9. ENDURANCE TIME TEST—LIGHT FREEZING RAIN:

9.1 Light Freezing Rain Test Equipment and Test Parameters:

9.1.1 Environmental Chamber Equipment and Plates:

In addition to the requirements given in 4.5, environmental chamber and associated equipment requirements for light freezing rain endurance time testing are given in Table 6 and in the following paragraphs.

Table 6: Requirements for Light Freezing Rain Test Equipment

Test Parameters	Requirements
Environmental Chamber	
Air temperature range	0 °C to -10 °C
Minimum temperature sampling rate	1 datum per minute
Horizontal air velocity	≤ 1.0 m/s
Relative humidity	> 40 %
Test Plates	
Material	Aluminum alloy AMS 4037 or 4041
Test plate dimensions	500 mm long x 300 mm wide x 3.2 mm thick
Angle	10° ± 0.2
Surface finish	Average surface roughness: Ra ≤ 0.5 μm
Temperature at start of test	Within ± 0.5 °C of air temperature
Number of test plates	2 per fluid tested
Fluid application temperature	Within 3 °C of the air temperature
Ice-catch Pans (Method A)	
Ice-catch pan dimensions	100 mm x 100 mm x 0.8 mm thick with all around rim 15 mm high
Number of ice-catch pans	8 surrounding each test plate
Number of ice-catch pans for measuring icing intensity variability across test plates	12 per test plate
Spray Equipment	
Distance between nozzle and test plate	7 m ± 0.5
Water supply temperature	≤ 2 °C just before the nozzle
Water droplet median volume diameter	1000 μm ± 100

All of the parameters listed in Table 6 are being recorded in Forms 3, 4, 5 and 8.

At the beginning of the condition, and also at the end of the condition, a checklist form will be filled in (Form 14).

9.1.2 Test Plates:

9.1.2.1 Each test plate is removable and placed on a support that is housed within the environmental chamber.

9.1.2.2 Each test plate shall be equipped with a temperature sensor located on the underside of or embedded within the plate. This sensor shall be capable of measuring to an accuracy of ± 0.5 °C and shall be linked to an electronic data acquisition system.

9.1.2.3 The test plate support is set-up in such a way that it can accommodate six test plates. The test plate support face shall be inclined from the horizontal (see Table 6 for the angle). The test plates are placed on the support such that the fluid can freely flow off all edges of the plate. A typical test stand is illustrated in ATTACHMENT 9; it may be altered to suit the location and facilities, but the angle for the panels, their arrangement and markings must all conform to ATTACHMENT 9. The test stand should be designed as to minimize the contact between the test surface and the support.

9.1.2.4 For a complete equipment list, see ATTACHMENT 6.

9.1.3 Ice-catch Pans:

The ice-catch pans measure 27.7 cm by 54 cm and are described in 6.2.1.3.

9.1.4 Spray Equipment:

9.1.4.1 It is a fundamental requirement of this test that the spray impinges onto the surface of the test plate as supercooled water droplets which freeze on impact. This is verified by observation of an ice-catch plate.

9.1.4.2 The equipment used to provide the water spray comprises a low flow nozzle supplied with water of quality described in 4.5.6. This equipment is housed in the upper region of the test chamber above the test plate. The exact type and geometry of the spray system used to generate the water spray for the test is left to the discretion of the testing facility/site, provided the requirements of Table 6 and Table 7 are met.

9.1.5 Example of Spray Equipment:

See 8.1.5.

9.2 Light Freezing Rain Measurement Methods:

9.2.1 Icing Intensity Methods:

The methods are the same as in 6.2.1 except that Table 3 is replaced by Table 7 throughout.

9.2.2 Icing Intensity Variability Across Test Plates:

The method is the same as in 6.2.2 except that Table 3 is replaced by Table 7 throughout.

9.3 Light Freezing Rain Test Conditions:

Test conditions for light freezing rain are in Table 7.

Table 7: Light Freezing Rain Test Conditions

Test Condition	LZR-A	LZR-B	LZR-C	LZR-D
Types II III, and IV, neat	Yes	Yes	Yes	Yes
Types II and IV, 75/25 (neat fluid/water)	Yes	Yes	Yes	Yes
Types II and IV, 50/50 (neat fluid/water)	Yes	Yes	No	No
Air temperature, °C	-3 ± 0.5	-3 ± 0.5	-10 ± 0.5	-10 ± 0.5
Air temperature standard deviation, °C	± 0.3	± 0.3	± 0.3	± 0.3
† Icing intensity, $g/dm^2/h$	13 ± 0.5	25 ± 1.0	13 ± 0.5	25 ± 1.0
‡ Average icing intensity, $g/dm^2/h$	13 ± 0.5	25 ± 1.0	13 ± 0.5	25 ± 1.0
‡ Icing intensity standard deviation	< 0.7	< 1.5	< 0.7	<1.5
† Icing intensity range across a test plate, $g/dm^2/h$	≤ 1.4	≤ 3.0	≤ 1.4	≤ 3.0
‡ Icing intensity range across all test plates, $g/dm^2/h$	≤ 2.0	≤ 4.0	≤ 2.0	≤ 4.0

† Method A
‡ Method B

9.4 Light Freezing Rain Test Procedure:

9.4.1 Test Plate Cleanliness:

Clean test plates according to 4.7.1.

9.4.2 Temperature Verification:

Ensure the test chamber, fluid and test plates are at the required temperature.

The chamber temperature is recorded by NRC for each condition, at a sampling rate of minimum 1 datum per minute, and handed in to APS at the end of the session. The filenames should be recoded on Form 3.

Fluid temperature should be measured just before pouring and must be recorded on Form 5.

Plate temperature is recorded by APS throughout the test, saved on diskettes and included in the envelope along with the forms. The path and filenames should be recorded on Form 4.

9.4.3 Failure Time:

See 6.4.3 except that failure is defined in 9.4.6.

9.4.4 Icing Intensity:

After all the plates have failed, turn off the water spray, and weigh the ice-catch on each ice-catch plate and using a method such as described in 8.2.1, estimate the icing intensity for each test plate. If the icing intensity is not within the specified limits for the test being conducted, the time recorded is not valid.

9.4.5 Delayed Crystallization:

See 4.7.3.

9.4.6 Failure Criterion:

See 6.4.6.

9.4.7 Reproducibility/Precision:

See 6.4.7.

9.4.8 Report:

See 4.7.4.

9.4.9 Personnel:

See ATTACHMENT 8.

10. ENDURANCE TIME TEST—RAIN ON COLD SOAKED WING:

10.1 Rain on Cold Soaked Wing Rain Test Equipment and Test Parameters:

10.1.1 Environmental Chamber Equipment and Plates:

In addition to the requirements given in 4.5, environmental chamber and associated equipment requirements for rain on cold soaked wing endurance time testing are given in Table 8 and in the following paragraphs.

Table 8: Requirements for Rain on Cold Soaked Wing Test Equipment

Test Parameters	**Requirements**
Environmental Chamber	
Air temperature range	1 °C
Minimum temperature sampling rate	1 datum per minute
Horizontal air velocity	≤ 1.0 m/s
Relative humidity	> 40 %
Test Plates	
Material	Aluminum alloy AMS 4037 or 4041
Test plate dimensions	500 mm long x 300 mm wide x 3.2 mm thick
Angle	10° ± 0.2
Surface finish	Average surface roughness: Ra ≤ 0.5 μm
Number of test plates	2 per fluid tested
Fluid application temperature	Within 3 °C of the air temperature
Ice-catch Pans (Method A)	
Ice-catch pan dimensions	100 mm x 100 mm x 0.8 mm thick with all around rim 15 mm high
Number of reference ice-catch pans	8 surrounding each test plate
Cold Soak Box	
Material	Aluminum alloy AMS 4037 or 4041
Material Thickness	1.6 mm
Dimensions	430 mm x 300 mm x 75 mm
Coolant in box	65 % propylene glycol, 35 % water
Spray Equipment	
Distance between nozzle and test plate	7 m ± 0.5
Water supply temperature	≤ 2 °C just before the nozzle

All of the parameters listed in Table 8 are being recorded in Forms 3, 4, 7 and 8.

At the beginning of the condition, and also at the end of the condition, a checklist form will be filled in (Form 14).

10.1.2 Test Plates:

Each test area is the upper surface of the cold soak box.

10.1.3 Cold Soak Box:

10.1.3.1 For an example of the cold soak box preparation procedure, see ATTACHMENT 12.

10.1.3.2 The box will be equipped with a temperature sensing device capable of measuring the temperature of the test plate with an accuracy of ± 0.5 °C and situated within the test plate, 150 mm from the top and 150 mm from the side of the plate. This temperature sensor is linked to a data acquisition system to check and record the test plate temperature throughout the course of a test run. The cold soaked box face will be inclined from horizontal (see Table 8 for the angle).

10.1.3.3 The boxes are placed on the support such that the fluid can freely flow off all edges of the plate. A typical test stand is illustrated in ATTACHMENT 9; it may be altered to suit the location and facilities, but the angle for the panels, their arrangement and markings must all conform to ATTACHMENT 9. There shall be no flanges or obstructions close to the edges of the boxes that could interfere with the airflow over the panels.

10.1.3.4 For a complete equipment list, see ATTACHMENT 6.

10.1.4 Spray Equipment:

The equipment used to provide the water spray comprises a low flow nozzle supplied with water of quality described in Table 8. This equipment is housed in the upper region of the test chamber above the test plate. The exact type and geometry of the spray system used to generate the water spray for the test is left to the discretion of the testing facility/site, provided the requirements of Table 8 and Table 9 are met.
10.1.5 Example of Spray Equipment:

See 8.1.5.

10.2 Rain on Cold Soaked Wing Measurement Methods:

10.2.1 Icing Intensity Methods:

The methods are the same as in 6.2.1 except that Table 3 is replaced by Table 9 throughout.

10.2.2 Icing Intensity Variability Across Test Plates:

The method is the same as in 6.2.2 except that Table 3 is replaced by Table 9 throughout.

10.3 Rain on Cold Soaked Wing Test Conditions:

Test conditions for rain on cold soaked wing are in Table 9.

Table 9: Rain on Cold Soaked Wing Test Condition		
Test Condition	**RCSW-A**	**RCSW-B**
Types II III, and IV, neat	Yes	Yes
Types II and IV, 75/25 (neat fluid/water)	Yes	Yes
Types II and IV, 50/50 (neat fluid/water)	No	No
Air temperature, °C	1 ± 0.5	1 ± 0.5
Air temperature standard deviation, °C	± 0.3	± 0.3
Test plate temperature at start, °C	-10 ± 1	-10 ± 1
Pre-start coolant temperature, °C	-12 ± 1	-12 ± 1
Water droplet median volume diameter	300 µm ± 100	1400 µm ± 150
† Icing intensity, $g/dm^2/h$	5.0 ± 0.2	75.0 ± 3.0
‡ Average icing intensity, $g/dm^2/h$	5.0 ± 0.4	75.0 ± 3.0
‡ Icing intensity standard deviation	< 0.4	< 4.5
† Icing intensity range across a test plate, $g/dm^2/h$	≤ 0.6	≤ 9.0
‡ Icing intensity range across all test plates, $g/dm^2/h$	≤ 1.2	≤ 15

† Method A
‡ Method B

10.4 Rain on Cold Soaked Wing Test Procedure:

10.4.1 Test Plate Cleanliness:

Clean test plates according to 4.7.1.

10.4.2 Temperature Verification:

Prior to the start of a test, ensure the test chamber and fluid are at the required temperatures. Ensure the cold soak box and its coolant are at the pre-start temperature.

The chamber temperature is recorded by NRC for each condition, at a sampling rate of minimum 1 datum per minute, and handed in to APS at the end of the session. The filenames should be recoded on Form 3.

Fluid temperature should be measured just before pouring and must be recorded on Form 7.

Plate temperature is recorded by APS throughout the test, saved on diskettes and included in the envelope along with the forms. The path and filenames should be recorded on Form 4.

Place both paper towels and a cover over the test plate and the ice-catch plates to prevent any accumulation of ice.

10.4.3 Failure Time:

Wait for the temperature of the test plate to be at the start temperature. When the start temperature is reached, remove the paper towels and cover. Continue as in 6.4.3 except that failure is defined in 10.4.6.

10.4.4 Icing Intensity:

After all the plates have failed, turn off the water spray, and weigh the ice-catch on each ice-catch plate and using a method such as described in 8.2.1, estimate the icing intensity for each test plate. If the icing intensity is not within the specified limits for the test being conducted, the time recorded not valid.

10.4.5 Delayed Crystallization:

See 4.7.3.

10.4.6 Failure Criterion:

See 6.4.6.

10.4.7 Reproducibility/Precision:

See 6.4.7.

10.4.8 Report:

See 4.7.4.

10.4.9 Personnel:

See ATTACHMENT 8.

11. ENDURANCE TIME TEST—SNOW TESTS PERFORMED OUTSIDE

The general requirements given in section 1 are not applicable for the natural snow tests performed outside, except where otherwise specified.

11.1 Snow Test Equipment and Test Parameters:

11.1.1 Conditions and Equipment:

Test equipment and other requirements for natural snow endurance time testing are given in Table 10 and in the following paragraphs.

Table 10: Requirements for Snow Outside Test Equipment

Test Plates	
Material	Aluminum alloy AMS 4037 or 4041
Test plates dimensions	500 mm long x 300 mm wide x 3.2 mm thick
Angle	10.0° ± 0.2
Surface finish	Average surface roughness: Ra ≤ 1.0 μm
Plate temperature at start of test	Within ± 0.5 °C of air temperature
Number of tests	See 11.4.5
Fluid application temperature	See 11.4.2
Ice-catch Pans	
Ice-catch pan dimensions	Typically, 430 x 300 x 0.8 mm thick with all around rim 40 mm high and 35 mm flanges protruding from the shorter side.

11.1.2 Outside Air Temperature Measurements:

The outside air temperature shall be measured using a thermometer that is shielded from radiation. The outside air temperature will be recorded on Form 10.

11.1.3 Lighting:

The test site shall be equipped with artificial lighting facilitating ice formation observation but positioned such that it does not interfere with air, fluid and plate temperatures.

11.1.4 Wind Speed:

Wind speed shall be measured using a suitable anemometer or velocity meter, every time the precipitation rate (icing intensity) is measured. Wind speed shall be measured at 2 m above the ground in the proximity of the test stands.

The wind speed will be recorded on Form 11.

11.1.5 Calibration of Standard Measuring Devices:

All thermistors, electronic balances, and timing devices shall be maintained in a known state of calibration in accordance with recognized international standards, by calibrating each instrument at least once every year or whenever a piece of equipment is repaired, replaced, moved, or otherwise suspect. A written record of the calibrations shall be kept available.

11.1.6 Test Plates and Test Stand:

Each test plate is removable and placed on a test stand.

Each test plate shall be equipped with a temperature sensor located on the underside of or embedded within the plate. This sensor shall be capable of measuring to an accuracy of ± 0.5 °C and shall be linked to an electronic data acquisition system.

The test plate support face shall be inclined from the horizontal (see Table 10 for the angle). The test plates are placed on the support such that the fluid can freely flow off all edges of the plate. The test stand should be designed as to minimize the contact between the test surface and the support.
For materials of construction and dimensions, see Table 10 and Figure 1.

11.1.7 Markings:

Panels can have pen markings to help estimate the percent coverage. For instance, each panel can be marked as shown in Figure 1 with lines at 2.5 and 15 cm (1 and 6") from the panel top edge, with 15 crosshair points and with vertical lines 2.5 cm (1") from each side; this marks off a working area of 25x40 cm (10x18") on each panel. All marks can be made using a 0.3 cm (1/8") thick black marker or silk screen process, which does not come off with application of the test fluids or any of the cleaning agents. Re-marking of the plates will be required, from time to time, as markings fade because of cleaning actions.

11.1.8 Test Stand:

A typical test stand is illustrated in Figure 1; it may be altered to suit the location and facilities, but the angle for the plates must conform to Table 10.

There shall be no flanges or obstructions close to the edges of the plates that could interfere with the airflow over the plates.

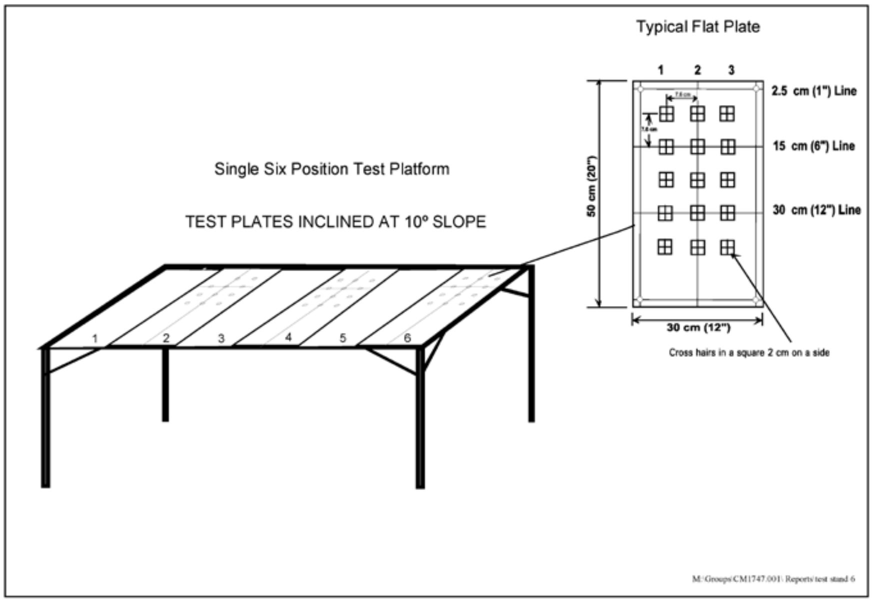


Figure 1: Test Stand and Plate

11.1.8.1 Attachment:

The test plates must be firmly attached to the test stand. For attachment to the test stand, for instance, make at least four holes spaced along the two sides of each panel within 2 cm (0.8") from the panel edge. Fit the stand with protruding bolts matching the pattern of the hole, allowing the panel to be firmly attached. An alternate way is to use magnetic bands fixed to the underside of the test plates and the test stand.

11.1.8.2 Wind Orientation of Test Stand:

The test stand shall be oriented facing into the predominant wind direction or facing the wind at the beginning of the test. A test stand is defined as facing into the wind when the long axes of the test panels are facing into the wind direction. The orientation of the test stand shall be recorded on Form 11. The wind direction shall be recorded at least every 15 minutes. If the wind shifts during the test, do not move the stand.

11.1.9 Plate Pan for Precipitation Rate Measurement:

A plate pan, placed at a 10º inclination on the test stand will be used to collect and weigh snow. The positioning of the plate pan on the test stand shall be such that the longer dimension axis of the pan is parallel with the longer dimension axis of the test plate. The procedure for the collection of precipitation rates using this method is described in 11.2. A schematic of the plate pan is provided in Figure 2.

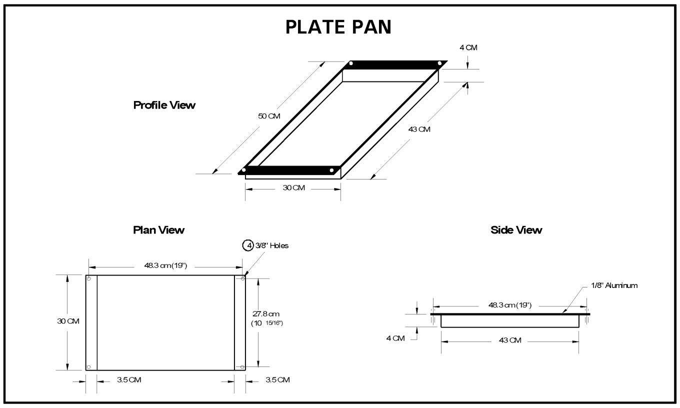


Figure 2: Schematic of Plate Pan

11.2 Snow Measurement Methods:

11.2.1 Snow Intensity Measurement Method:

Ensure that the plate pans are marked when using more than one. Coat the bottom of each plate pan, as well as the inner sides of each pan, with more than 1 mm of neat anti-icing fluid. Weigh the wetted pans to the nearest 0.2 gram. Record the start time (hr/min/sec) of the rate collection before leaving the rate station to place the pans on the test stand, taking into consideration the time delay necessary to proceed outside from the rate station.

The rate pans shall remain on the test stand collecting snow for a period of 10 minutes. While positioned on the test stand, the plate pans should be carefully rotated every 5 minutes to prevent accumulating snow from blowing away. The time of rotation should be reduced to 2 minutes during heavy precipitation or periods of high winds.

Prior to the removal of the plate pans from the test stand for re-weighing, carefully wipe away any accumulated precipitation from the lips of the plate pans (ensure that the precipitation does not fall into the plate pan). Carefully remove the plate pans from the stand and proceed immediately to the rate station to re-weigh the pans. Care must be taken to ensure that snow or ice does not fall into the pans when transporting them into the weighing area. Do not rest the pans on top of one another while transporting. Once inside the protected weigh station area, record the rate collection end time (hr/min/sec). Carefully wipe the bottom, sides and lips of the pans prior to weighing. Weigh the plate pan, record the new weight, and bring the pans back outside. Continue the rate collection procedure until the final plate on the test stand has failed.

11.2.2 Rate Calculation:

The rate for any holdover time test in natural snow is obtained by computing the time-weighted average of the rates collected in the upper and lower pans over the duration of the particular test.

An example of the rate calculation method for tests in natural snow conditions is displayed in Figure 3. The start and end times of the test are 10:15 and 10:45, respectively. Precipitation rates for one pan were collected at three periods during this test, indicated by t_1, t_2, and t_3 (minutes). The calculated rates for each collection period are indicated by R_1, R_2, and R_3 (g/dm^2/h). In order to calculate the average rate for this pan, the following formula is then used:

$$\frac{(R_1 \times t_1 + R_2 \times t_2 + R_3 \times t_3)}{t_1 + t_2 + t_3}$$

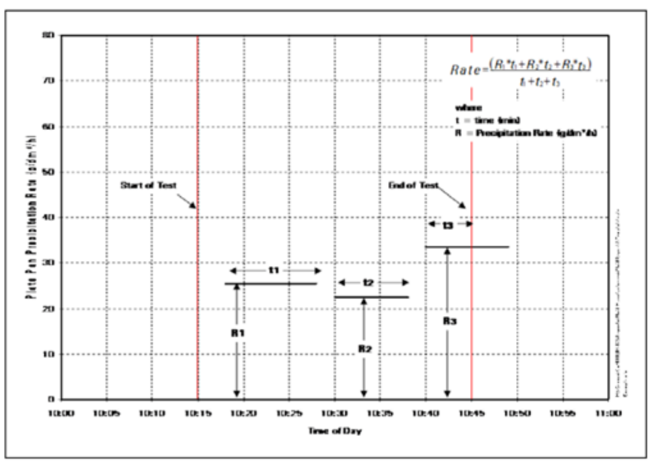


Figure 3: Calculation of Outdoor Precipitation Rate

In the example shown in Figure 3, the rate is calculated as follows:

$$\frac{(25 \times 10 + 22 \times 8 + 34 \times 5)}{10 + 8 + 5}$$

$$= 25.9 \text{ g/dm}^2\text{/h}$$

11.3 Snow Test Temperature:

Since tests are conducted outside, test temperature cannot be controlled. Tests may be conducted at any temperature falling within the requirements of Table 11. It is recommended that data points fall within the distribution described in 11.4.5 but not lower than the lowest operational use temperature of the fluid.

Table 11: Snow test Conditions	
Fluid Type	**Air Temperature (°C)**
Type II Neat, Type IV Neat	Any temperature
Type III Neat	Any temperature
Type II and Type IV, 75/25 (neat fluid/water)	□ -14
Type II and Type IV, 50/50 (neat fluid/water)	□ -3

11.4 Snow Test Procedure:

11.4.1 Test Plate Cleanliness:

The test plates shall be free of any visible contamination.

Before applying test fluid to a plate, squeegee the surface of the test plate to remove any precipitation or moisture. Prior to the start of the test, rinse and clean the test plate with the fluid to be tested. Remove the fluid used to clean the plate with a squeegee and quickly begin the test. To avoid cross-contamination of fluids, one squeegee shall be used per anti-icing product. Alternatively clean according to 4.7.1.

11.4.2 Fluid Application:

Anti-icing fluids should be placed outside, stored according to manufacturer's recommendations, and cold-soaked to ambient air temperature conditions prior to the start of the test session. Anti-icing fluid temperature shall typically be within ±3°C of the ambient air temperature and applied to the test surface at this temperature.

Prior to the application of fluid, the plate temperature should be equilibrated to outside air temperature. The actual plate temperature may be different than outside air temperature due to radiation effects, possibly as much as 2°C.

Pour 1 liter of fluid to each test plate such that the fluid thickness is consistent over the entire plate surface of the plate.

11.4.3 Failure Time:

As soon the fluid has spread over the plates (up to 15 s for Type II, III and IV fluids), start the timing device. Observe the plates and, when the failure occurs (defined in 11.4.4), record the time as the endurance time.

11.4.4 Failure Criterion:

Failure is called when the accumulating snow fails to be absorbed at any five of the crosshair marks on the panels or when 1/3 of the test panel is covered with accumulating precipitation.

Fluid at a crosshair is considered failed when, viewed from a shallow angle, snow (not slush, but white snow) on the fluid is no longer being absorbed by the fluid.
Typically, there are two modes of failure in natural snow tests:

- Dilution failure: The fluid has eroded due to dilution and snow begins to accumulate on the plate surface; and
- Snow-bridging failure: The fluid no longer absorbs the snow and it begins to rest on top of the fluid.

An example of a typical dilution-style failure is shown in Photo 1. In this case, the fluid has been diluted due to ongoing precipitation and the fluid film has eroded substantially. Failures have reached just beyond the 7.6 cm (3") line on the plate (white snow is visible in the failed area). Dilution failures normally occur from top-to-bottom on the test surface, and are common at warm temperatures and low rates of precipitation.

An example of a snow-bridging failure is shown in Photo 2. In this case, the fluid resists dilution and a thick film of fluid remains on the entire plate surface. Plate failure has occurred in this test because snow, resting on top of the fluid, covers more than 1/3 of the plate surface. Snow-bridging failures do not always occur in top-to-bottom fashion, and are common at cold temperatures and high rates of precipitation.

11.4.5 Reproducibility/Precision:

Outdoor snow precipitation is variable in nature. All the data points collected are used for the regression analysis.

The endurance times are obtained by producing a best-fit regression curve using a power law transformation based on all the data collected. A minimum of 20 data points is recommended to generate the regression curves for any neat fluid dilution. A minimum of 15 and 10 data points is recommended to generate the regression curves for any 75/25 fluid dilution and 50/50 fluid dilution, respectively. A minimum test point distribution should contain data collected in all applicable temperature ranges, and data collected in the widest range of snow rate conditions possible.

The equation used to treat the collected data for any fluid is as follows:

$$t = cR^a(2\text{-}T)^b$$

where
- t = time (minutes)
- R = rate of precipitation (g/dm^2/hr)
- a, c = coefficients determined from the regression

The general form of the regression equation was modified for natural snow by substituting (2-T) for the variable T to prevent taking the log of a negative number, as natural snow can occur at temperatures approaching 2 °C.

Best-fit curves are plotted for each fluid in each cell of the snow column using the most restrictive (lowest) temperature for that cell. For example, in cases of natural snow tests conducted at ambient temperatures above 0 °C, the temperature value used in the procedure was 0 °C.

The upper and lower holdover time values were determined from the points at which the best-fit curve intersects the lower and upper precipitation limits (10 and 25 g/dm^2/h), respectively.

11.4.6 Type and Classification of Solid Precipitation:

Classification of solid precipitation: The solid precipitation observed for each test in natural conditions will be classified and recorded. A black velvet-covered board should be used to facilitate the collection and identification of solid precipitation. Expose the black velvet-covered board to the natural precipitation for a period of 10 seconds. Using Figure 4, determine and record the form of the solid precipitation collected on the black velvet-covered board. If several forms of precipitation co-exist, record all of them. For example, if snow grains are mixed with snow, note that both forms of precipitation exist.

Only snow and snow grain data (F1 to F7) will be used to determine snow endurance times. Data obtained containing precipitation classifications other than those identified in F1 to F7 in Figure 4 will not be used to generate snow endurance times.

The type and classification of solid precipitation will be recorded on Form 11.

11.4.7 Report:

See 4.7.4, except for item (l).

12. NOTES:

12.1 Key Words:

Endurance, holdover time, holdover, aircraft, exterior, surfaces, frost, ice, freezing, rain, drizzle, frost, fog, cold, soaked, snow, wing.

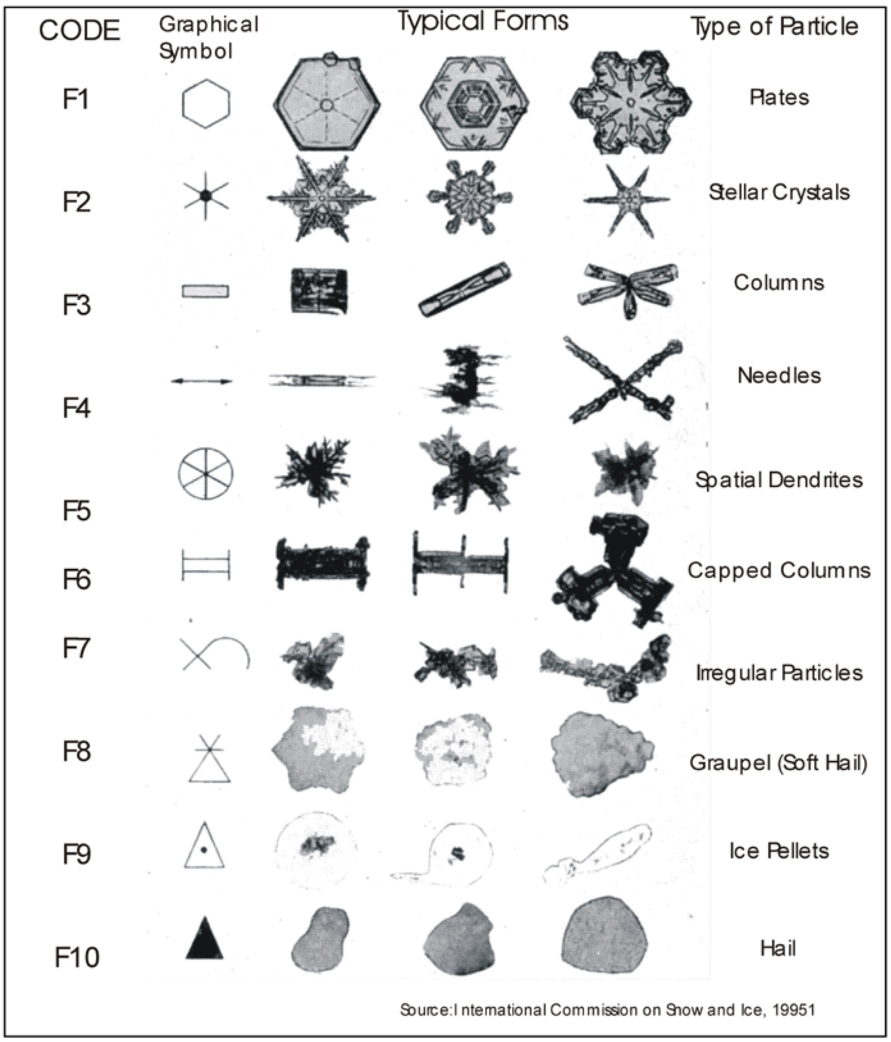


Figure 4: Type of Frozen Precipitation

Photo 1: Dilution Failure

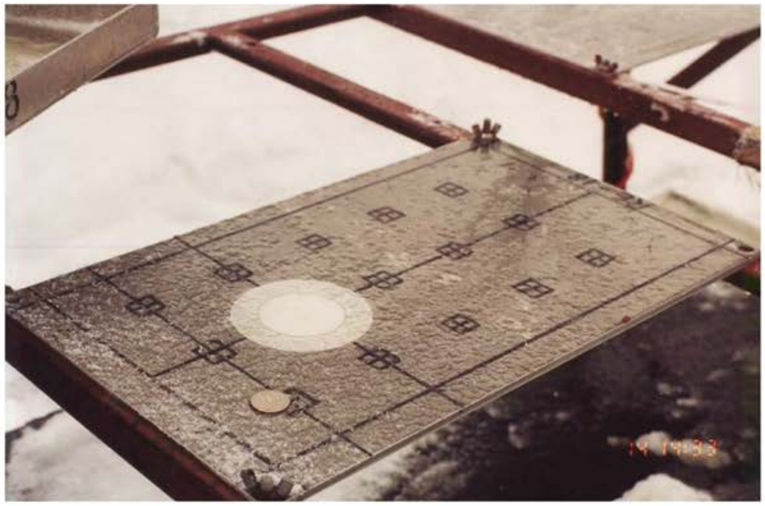


Photo 2: Snow Bridging Failure

DATA FORMS

FORM 1
GENERAL FORM FOR RECEIVING FLUID

RECEIVING LOCATION: **DATE OF RECEIVING:**

GENERAL

Fluid Name: ____________

Manufacturer: ____________ **Fluid Type:** ____ **Batch #:** ____________

APS Code: ____________

Certificates of Conformance acc. to SAE AMS 1424: ☐
(check the box if received)

Fluid Freeze Point Curves (FP vs. Dilution & FP vs. Refraction): ☐
(for Type I Fluids only; check the box if received)

Lowest Operational Use Temperature: ☐
(check the box if received)

WSET Done by the Certification Agency: ☐
(check the box if received)

Date of Production: ____________

Quantity: (L) ________ **Neat** / ________ **75/25** / ________ **50/50**

Quantity: (containers) ________ **Neat** / ________ **75/25** / ________ **50/50**

Manufacturer stated BRIX: ________ **APS Measured BRIX:** ________ **MSDS Sheets Received:** ☐

Manufacturer's Authorization to Proceed with Endurance Time Testing: ☐
(check the box if received)

Authorized by: ____________
(PRINT NAME)

on: ____________
(DATE)

TYPE II, III & IV FLUIDS(1)

Manufacturers stated VISCOSITY mPa*s (cP): ________ **Neat** / ________ **75/25** / ________ **50/50**
(Using Manufacturer's Method)

Manufacturers stated VISCOSITY mPa*s (cP): ________ **Neat** / ________ **75/25** / ________ **50/50**
(Using AIR Method)

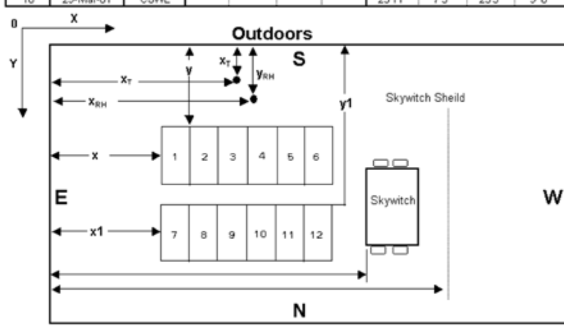
Manufacturer's Method: ____________________________

(1) When fluid is received, extract 2L/1L/1L of 100/75/50 Type II, III or IV; Send 1L of Neat for WSET.

FORM 2
TEST STAND LOCATION FOR EACH CONDITION AT NRC

LOCATION: CEF (Ottawa) DATE: CONDITION: ZR3H ZR3L ZR10H ZR10L ZD3H ZD3L ZD10H ZD10L ZF3H ZF3L ZF10H ZF10L ZF14H ZF14L ZF25H ZF25L CSWH CSWL

Test	Date of Final Position	Condition	Sensor Position				Stand Position				Skywitch Position	Skywitch Sheild Position (*)	Nozzle Position (**)	Rate	Height of nozzle over plate	Comments
			X_T	Y_T	X_{RH}	Y_{RH}	x	y	x1	y1						
1	4-Apr-01	ZR3H					24' 2"	7'	22' 7"	9' 10"				Very Good		Top Stand 19' from snow fence
2	4-Apr-01	ZR3L					24' 2"	7'	22' 7"	9' 10"				Very Good		Top Stand 19' from snow fence
3	4/2/2001	ZR10H					24'	6' 9"	24' 5"	9' 6"				Very Good		Top stand is 20 ft. from snow fence
4	2-Apr-01	ZR10L					24'	6' 9"	24' 5"	9' 6"				Very Good		Top stand is 20 ft. from snow fence
5	27-Mar-01	ZD3H					24' 5"	6'6"	22'	10'4"				Very Good		
6	28-Mar-01	ZD3L					25' 3"	7'3"	25' 3"	9' 6"				Good		
7	2-Apr-01	ZD10H					24'	7'11"	25' 3"	9' 6"				Very Good		
8	2-Apr-01	ZD10L					24'	7' 7"	24' 7"	9' 11"				Good		20 ft. from Snow Fence
9	10-Apr-01	ZFog3H					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
10	10-Apr-01	ZFog3L					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
11	10-Apr-01	ZFog10H					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
12	10-Apr-01	ZFog10L					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
13	9-Apr-01	ZFog14H					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
14	9-Apr-01	ZFog14L					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
15	6-Apr-01	ZFog25H					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
16	6-Apr-01	ZFog25L					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
17	29-Mar-01	CSWH					25'3"		25'3"	9' 6"						
18	29-Mar-01	CSWL					23'11"	7'3"	25'3"	9' 6"						



Notes:

* - "From X" refers to the distance from the East wall.
** - The nozzle should be between positions 5 and 11
RH - Relative Humidity Sensor
T - Temperature Sensor

WEIGH SCALE TECHNICIAN: ____________________

LEADER: ____________________

NEW VALUES (IF DIFFERENT)

Test	Date of Final Position	Condition	Sensor Position				Stand Position				Skywitch Position	Skywitch Sheild Position (*)	Nozzle Position (**)	Rate	Height of nozzle over plate	Comments
			X_T	Y_T	X_{RH}	Y_{RH}	x	y	x1	y1						

FORM 3
GENERAL FORM FOR EACH SESSION AT NRC

LOCATION: CEF (Ottawa)	DATE INTERVAL:

Safety Issues Discussed ☐

Test Plate Material: ☐
(check the box if material used is Aluminum alloy AMS 4037 or 4041)

Test Plate Dimensions: ☐
(check the box if the dimensions are 500mm long x 300mm wide x 3.2mm thick)

Test Box Dimensions: ☐
(only for CSW, check the box if the dimensions are 500mm long x 300mm wide x 75mm thick)

Surface Finish: ☐
(check the box if the average surface roughness is ≤ 0.5 µm)
Refer to Verification Procedure "A-Verif" for methodology

Ice-catch Pan Dimensions: ☐
(check the box if the dimensions are 27,7 cm by 54 cm)

Water Supply to Nozzle: ☐
(check the box if the water supplied to nozzles conforms to ASTM D1193 Type IV water or a hardness of less than 300 ppm reported as $CaCO_3$)

Weigh Scale verification: 2g ☐ 50 g ☐
(see verification procedure)

Calibration of NRC Equipment Completed prior to Testing : ☐
(Anemometer, Thermocouples - refer to Calibration Plan)

Air Temperature (°C):
(to be recorded by the NRC at a sampling rate of minimum 1 datum per minute and handed in to APS at the end of the session on floppy disks)
The air temperature data is saved to the following files (provide filename and extension):

____
____
____
____

Relative humidity (%):
(to be recorded by APS and saved at the end of the session on floppy disks)
The humidity data is saved to the following files (provide filename and extension):

____
____
____

COMMENTS:

____
____
____
____
____

LEADER: ________________

FORM 4
GENERAL FORM F OR EACH CONDITION AT NRC

LOCATION: CEF (Ottawa)	DATE:	CONDITION: ZR3H ZR3L ZR10H ZR10L ZD3H ZD3L ZD10H ZD10L ZF3H ZF3L ZF10H ZF10L ZF14H ZF14L ZF25H ZF25L CSWH CSWL

	PLATE 1	PLATE 6	PLATE 7	PLATE 12
Angle of the Test Stands (°):				

Distance between Nozzle and Test Plates: ☐
(check the box if distance is 7±0.5m for ZD, ZR and CSW)

Distance between Temperature Sensor and Test Plates: ☐
(check the box if distance is within 1.5 m)

Synchronize the timing devices and the computer clock with NRC time: ☐
(check the box if the timing devices are synchronized)

Plate Temperature (°C):
(to be recorded by APS at the end of the each condition, saved on floppy disks and included in the envelope along with the forms)
The plate temperature data is saved to the following files (provide filename and extension):

COMMENTS:

COMPUTER TECHNICIAN: ______________

LEADER: ______________

FORM 5
DE/ANTI-ICING DATA FORM FOR FREEZING PRECIPITATION AT NRC

REMEMBER TO SYNCHRONIZE TIME

LOCATION: CEF (Ottawa)	DATE:	RUN NUMBER:	STAND # :

TIME TO FAILURE FOR INDIVIDUAL CROSSHAIRS (real time)

	Plate 1	Plate 2	Plate 3	Plate 4	Plate 5	Plate 6
Time of Fluid Application:						
Initial Plate Temperature (°C) (NEEDS TO BE WITHIN 0.5°C OF AIR TEMP)						
Initial Fluid Temperature (°C) (NEEDS TO BE WITHIN 3°C OF AIR TEMP)						
FLUID NAME/BATCH						
B1 B2 B3						
C1 C2 C3						
D1 D2 D3						
E1 E2 E3						
F1 F2 F3						
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA						
FAILURE CALL (circle)	V. Dificult Dificult. Easy	V. Dificult Dificult. Easy	V. Dificult Dificult. Easy	V. Dificult Dificult. Easy	V. Dificult Dificult. Easy	V. Dificult Dificult. Easy
HRZ. AIR VELOCITY * (circle)	A B C	A B C	A B C	A B C	A B C	A B C

	Plate 7	Plate 8	Plate 9	Plate 10	Plate 11	Plate 12
Time of Fluid Application:						
Initial Plate Temperature (°C) (NEEDS TO BE WITHIN 0.5°C OF AIR TEMP)						
Initial Fluid Temperature (°C) (NEEDS TO BE WITHIN 3°C OF AIR TEMP)						
FLUID NAME/BATCH						
B1 B2 B3						
C1 C2 C3						
D1 D2 D3						
E1 E2 E3						
F1 F2 F3						
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA						
FAILURE CALL (circle)	V. Dificult Dificult. Easy	V. Dificult Dificult. Easy	V. Dificult Dificult. Easy	V. Dificult Dificult. Easy	V. Dificult Dificult. Easy	V. Dificult Dificult. Easy
HRZ. AIR VELOCITY * (circle)	A B C	A B C	A B C	A B C	A B C	A B C

PRECIP (circle): ZF , ZD , ZR-, MOD

AMBIENT TEMPERATURE: ________ °C

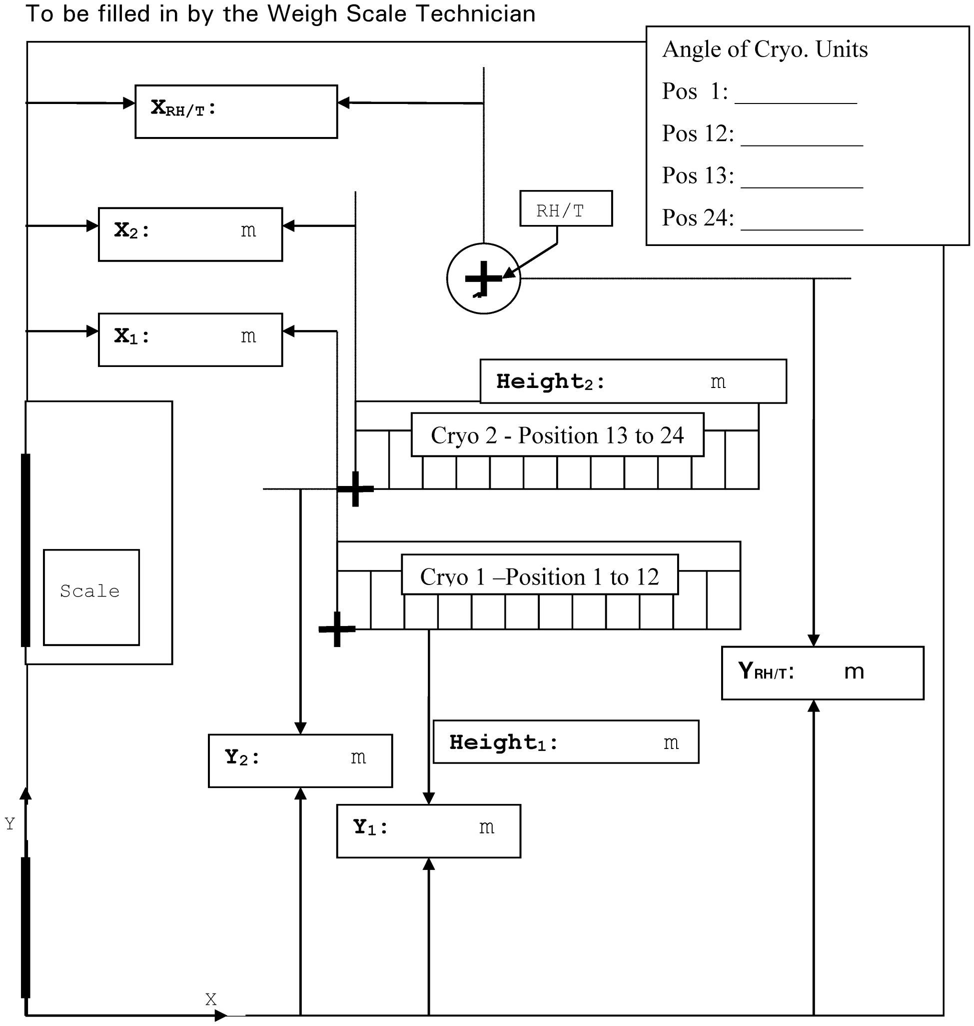
NOTE:
* A: HORIZONTAL AIR VELOCITY ≤ 0.4 m/s
B: 0.4 m/s < HORIZONTAL AIR VELOCITY ≤ 1.0 m/s
C: HORIZONTAL AIR VELOCITY > 1.0 m/s

COMMENTS: ______________________________

LEADER / MANAGER: ______________________

FORM 6
SKETCH OF THE CHAMBER AT IREQ
(Inserted for future reference for frost)

To be filled in by the Weigh Scale Technician



Date: _______________ Time of day: __________ Sketch # _____

Verification of the scale: 50g: ____________ 10g: ____________

2g: ____________

Signature:___________ Date:____________

FORM 7
DE/ANTI-ICING DATA FORM FOR COLD SOAK BOX AT NRC

REMEMBER TO SYNCHRONIZE TIME

LOCATION:	CEF (Ottawa)	DATE:	RUN NUMBER:	STAND # :

TIME TO FAILURE FOR INDIVIDUAL CROSSHAIRS (real time)

Time of Fluid Application	______	______	______	______	______
Initial BOX Temperature (°C) (NEEDS TO BE -10 ± 1)	______	______	______	______	______
Initial Fluid Temperature (°C) (NEEDS TO BE WITHIN 3°C OF AIR TEMP)	______	______	______	______	______
Enter Box Number	Box #	Box #	Box #	Box #	Box #
FLUID NAME/BATCH					
B1 B2 B3					
C1 C2 C3					
D1 D2 D3					
E1 E2 E3					
F1 F2 F3					
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA					
FAILURE CALL (circle)	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy
HRZ. AIR VELOCITY * (circle)	A B	A B	A B	A B	A B

Time of Fluid Application	______	______	______	______	______
Initial BOX Temperature (°C) (NEEDS TO BE -10 ± 1)	______	______	______	______	______
Initial Fluid Temperature (°C) (NEEDS TO BE WITHIN 3°C OF AIR TEMP)	______	______	______	______	______
Enter Box Number	Box #	Box #	Box #	Box #	Box #
FLUID NAME/BATCH					
B1 B2 B3					
C1 C2 C3					
D1 D2 D3					
E1 E2 E3					
F1 F2 F3					
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA					
FAILURE CALL (circle)	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy
HRZ. AIR VELOCITY * (circle)	A B	A B	A B	A B	A B

AMBIENT TEMPERATURE: ________ **°C**

PRE-START COOLANT TEMPERATURE: ________ **°C**
(Code requirements are -12 ± 1 °C)

COMMENTS: ____

NOTE:
* A: HORIZONTAL AIR VELOCITY ≤ 1.0 m/s
B: HORIZONTAL AIR VELOCITY > 1.0 m/s

LEADER / MANAGER: ________________

FORM 8
CHAMBER SETTINGS FOR EACH CONDI TION AT NRC

LOCATION: CEF (Ottawa)	DATE:	CONDITION: ZR3H ZR3L ZR10H ZR10L ZD3H ZD3L ZD10H ZD10L ZF3H ZF3L ZF10H ZF10L ZF14H ZF14L ZF25H ZF25L CSWH CSWL

CONDITION	Needles Used	Flow Rate of Water *	Line Air Pressure (psi)	Line Air Temperature (Celsius)	Line Water Pressure (psi)	Line Water Temperature (Celsius)	Relative Humidity (%)	X Axis Area	Speed	Y Axis Area	Speed	Brace Height (inches)	LT'S on 1	2	3	4	5	6	MT'S on 1	2	3	4	5	6	Last Date
ZR 3 L	**2x20**	**1 GPM**	**60**	**12.5**	**78**	**2**	**75**	**full**	**low**	**full**	**high**		**y**	**y**					**y**	**y**	**y**				**4-Apr-01**
ZR 10 L	2x20	1 GPM	60	12.5	82	2.5	75	full	low	full	high			y					y	y	y				3-Apr-01
ZR 3 H	**2x20**	**1 GPM**	**60**	**12.5**	**61**	**2**	**75**	**partial**	**low**	**full**	**high**								**y**	**y**	**y**				**4-Apr-01**
ZR 10 H	2x20	1 GPM	60	12.5	78	2.5	73	partial	low	full	high			y					y	y	y				3-Apr-01
ZD 3 L	2x24	1 GPM	60	13	65	2.5	75	partial	low	full	high								y	y	y				28-Mar-01
ZD 10 L	2x24	1 GPM	60	12	43	2	76	full	low	full	high			y					y	y	y				30-Mar-00
ZD 3 H	2x23	1 GPM	60	13	62	2.5	90	partial	low	full	high								y	y	y				27-Mar-01
ZD 10 H	2x23	1 GPM	60	12	55	2.5	72	partial	low	full	high		y	y					y	y	y				30-Mar-00
FOG 3 L	1 X 20/50/120	80	80	80	-	73.3	96	full	low	full	low	144							y	y	y				5-Apr-01
FOG 14 L	1 x 20/50/120	55	40	72	-	72.8	80	full	low	full	low	144							Y	Y	Y				11-Apr-01
FOG 25 L	1 x 20/50/120	50	40	72	-	72.8	80	full	low	full	low	144	y	y	y										6-Apr-01
FOG 3 H	1X 20/50/120	75	40	72	-	73.2	95	full	low	full	low	144							y	y	y				10-Apr-01
FOG 14 H	1 x 20/50/120	75	40	73	-	72.8	76	full	low	full	low		y						y	y	y				9-Apr-01
FOG 25 H	1 x 20/50/120	75	40	73	-	73.2	73	full	low	full	low	144	y	y	y										6-Apr-01
CSW 1 H	2x17	1 GPM	60	13.5	75	2	85	part	low	full	high										y	y		y	4-Jun-01
CSW 1 L	2 x 24	1 GPM	60	12.5	30	2.5	89	full	low	full	high										y	y			4-Jun-01
ZD 10 5	2 x 24	1 GPM	60	15	35	4.5	-												y	y	y				16-Jul-99
FOG 35 H	1 X 20/50	12	40	74	-	-	-	partial	low	partial	low	104	y	y	y	y									19-Jul-99
FOG 35 L	1 x 20/50	10	40	73	-	-	-	full	low	partial	low	104	y	y	y	y									19-Jul-99
FOG 30 L	1 x 20/50	10	40	73	-	-	-	full	low	partial	low	104	y	y	y	y									19-Jul-99
FOG 32 L	1 x 20/50	13	40	-	-	-	-	partial	low	full	low	104	y	y	y	y									20-Jul-99
FOG 32 H	1 x 20/50	24	40	-	-	-	-	full	low	full	low	144	y	y	y	y									20-Jul-99
FOG 10 H	1 x 20/50	75	40	74	-	72.6	-	full	low	full	low	144							y	y	y				9-Apr-01
FOG 10 L	1 X 20/50	55	40	-	-	-	-	full	low	full	low	144							y	y	y				9-Apr-01
FOG25L	1x20/50/120	15	40	73	-	70.9	-	full	low	full	low	144		y	y	y									31-Mar-00
FOG25h	1x20/50/120	24	40	79	-	72.9	-	full	low	full	low	144	y	y	y										4-Apr-00
ZR3H-2	2X20	1GPM	60	12.5	90	1.5	-	partial	low	full	high								y	y	y				6-Apr-00

* Dial Readings=X ⟶ Flow Rate for Fog (ml/min) = $0.0033*X^2 + 3.3605*X - 17.512$
Brace height 12'6"

NEW VALUES (IF DIFFERENT)

CONDITION	Needles Used	Flow Rate of Water*	Line Air Pressure (psi)	Line Air Temperature (Celsius)	Line Water Pressure (psi)	Line Water Temperature (Celsius)	Relative Humidity (%)	X Axis Area	Speed	Y Axis Area	Speed	Brace Height (inches)	LT'S on 1	2	3	4	5	6	MT'S on 1	2	3	4	5	6	Date

COMPUTER TECHNICIAN:____________________ LEADER: ____________________

FORM 9
RATE MANAGEMENT FORM AT NRC

CONDITION: ______________

DATE: ____________ **WEIGH SCALE TECHNICIAN:** ______________

PAN #	TIME OUT	1st or 2nd Rate

TIME*	Chamber Temperature	STDEV

* One reading every 30 minutes (Check procedure for air temp. STDEV requirements).
This form is for guidance to manage the sequencing of pans measurement and to verify the chamber temperature STDEV.
(At the end of condition file this form in the same envelope with the endurance time data form)

FORM 10
END CONDITION DATA FORM – NATURAL SNOW

REMEMBER TO SYNCHRONIZE TIME WITH MSC - USE LOCAL TIME

LOCATION:	DATE:	RUN NUMBER:	STAND # :

TIME TO FAILURE FOR INDIVIDUAL CROSSHAIRS (real time)

	Plate 1	Plate 2	Plate 3	Plate 4	Plate 5	Plate 6
Time of Fluid Application:						
Initial Plate Temperature (°C) (NEEDS TO BE WITHIN 0.5°C OF AIR TEMP)						
Initial Fluid Temperature (°C) (NEEDS TO BE WITHIN 3°C OF AIR TEMP)						
FLUID NAME/DILUTION						
B1 B2 B3						
C1 C2 C3						
D1 D2 D3						
E1 E2 E3						
F1 F2 F3						
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA						

	Plate 7	Plate 8	Plate 9	Plate 10	Plate 11	Plate 12
Time of Fluid Application:						
Initial Plate Temperature (°C) (NEEDS TO BE WITHIN 0.5°C OF AIR TEMP)						
Initial Fluid Temperature (°C) (NEEDS TO BE WITHIN 3°C OF AIR TEMP)						
FLUID NAME/DILUTION						
B1 B2 B3						
C1 C2 C3						
D1 D2 D3						
E1 E2 E3						
F1 F2 F3						
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA						

AMBIENT TEMPERATURE: ________ °C

COMMENTS: ____________________

NOTE: PLEASE ENSURE CORRECT FUNCTIONING OF PLATE TEMPERATURE LOGGING SYSTEM AT START OF TEST. AT THE END OF TEST SESSION, SAVE THE ELECTRONIC LOGGER FILE ON A FLOPPY DISK AND ALSO E-MAIL IT TO THE OFFICE. LABEL THE DISKETTE AND PLACE IT WITHIN THE DATA FORM ENVELOPE.

FAILURES CALLED BY: ____________________

LEADER / MANAGER: ____________________

FORM 11
METEO/PRECIPITATION RATE DATA FORM – NATURAL SNOW

REMEMBER TO SYNCHRONIZE TIME WITH MSC - USE LOCAL TIME

LOCATION:	DATE:	RUN # :	STAND # :
HAND HELD VIDEO CASSETTE #:			

PLATE PAN WEIGHT MEASUREMENTS *

PAN #	t TIME BEFORE (h:min:s)	BUFFER TIME (s)	t TIME AFTER (h:min:s)	BUFFER TIME (s)	w WEIGHT BEFORE (g)	w WEIGHT AFTER (g)	COMPUTE RATE (Δ w*4.7/ Δt) (g/dm²/h)	WIND SPEED** (km/h)

* Measurements every 10 min. and at failure time of each test panel.
** Wind speed measurements required only if data not available from MSC.

METEO OBSERVATIONS ***

TIME (h:min)	TYPE (Table 1) ZR, ZL,S, SG IP, IC, BS, SP	CLASSIF. (See snow classification diagram.)	If SNOW, WET or DRY

*** Observations at beginning, end, and every 10 min. intervals.
Additional observations when there are significant changes.

AIR TEMPERATURE AT START OF TEST ____________ °C

WIND DIRECTION AT START OF TEST ____________ °

TEST STAND ORIENTATION
(measured along long axes of the test panels) ____________

COMMENTS : ____

	PRINT	SIGN
WRITTEN & PERFORMED BY :		
VIDEO BY :		
TEST SITE LEADER :		

FORM 12
GENERAL FORM FOR EACH TESTING SESSION – NATURAL SNOW

LOCATION: APS TEST SITE	DATE:

	PLATE 1	PLATE 6	PLATE 7	PLATE 12
Angle of the Test Stands (°): (the angle shall be within 10° ± 0.2)				

Synchronize the timing devices and the computer clock with atomic time (www.time.gov): ☐
(check the box if the timing devices are synchronized)

Plate Temperature Files:
(to be recorded by APS at the end of the each test session, saved on floppy disks and included in the envelope along with the forms)
The plate temperature data is saved to the following files (provide filename and extension):

COMMENTS:

LEADER: ________________

FORM 13
GENERAL FORM FOR EACH WINGTER SEASON – NATURAL SNOW

LOCATION: APS TEST TITE	**DATE INTERVAL:**

Safety Issues Discussed ☐

Test Plate Material: ☐
(check the box if material used is Aluminum alloy AMS 4037 or 4041)

Test Plate Dimensions: ☐
(check the box if the dimensions are 500mm long x 300mm wide x 3.2mm thick)

Surface Finish: ☐
(check the box if the average surface roughness is ? 1.0 µm)
Refer to Verification Procedure "A-Verif" for methodology

Ice-catch Pan Dimensions: ☐
(check the box if the dimensions are 30 cm by 43 cm)

COMMENTS:

____
____
____
____
____

LEADER: ____________________

FORM 14
CONDITION CHECKLIST

1. FREEZING PRECIPITATION

Beginning of the condition

TASKS	DONE - INITIALS
Start the computer and spreadsheet	
Start the scale program (Wedge software)	
Start, reset and level the scale	
Check that the scale is correctly verified to 2g and 50g	
Start the camera and video	
Verify the functionality of the walky-talky system	
Synchronize all clocks to atomic clock (computers, stopwatches)	
Prepare a dated envelope	

End of the condition

TASKS	DONE - INITIALS
Print all results (spreadsheet pages)	
Write on the envelope the tests that have been achieved	
Shut down the computer / Shut down the scale	
The coordinator should write a summary each night	
Stop and shut down the intercoms, camera and video	
Clean stand area (if needed)	
Prepare fluids for the next day	
Save all results on hard drive	
Zip all the results with *Winzip,* save them on a marked diskette	
Provide instructions to laboratory technician for the next day conditions	
Put all results sheets, checklists, and the diskette in the envelope. Forward the envelope to the office	

2. NATURAL SNOW

Beginning of the condition

TASKS	DONE - INITIALS
Start, reset and level the scale	
Check that the scale is correctly verified to 2g and 50g	
Start the computer and check the connections to the datalogger	
Check the connection between the thermistor and the test plate, for each position tested	
Empty the datalogger, label with proper names the channels to be used, and reset the datalogger for the new session	
Synchronize all clocks to atomic clock (computers, dataloggers)	
Prepare rate pans	
Prepare a dated envelope	

End of the condition

TASKS	DONE - INITIALS
Write on the envelope the date and project	
Save all results on hard drive	
Zip all the results with *Winzip,* save them on a marked diskette	
Shut down the computer / Shut down the scale	
Clean and empty waste containers (if needed)	
Clean any mess (if needed)	
Put all results sheets, checklists, and the diskette in the envelope. Forward the envelope to the office	

CO-ORDINATOR / MANAGER ___________________ DATE ____/____/_____

ATTACHMENTS

ATTACHMENT 1
SAFETY AWARENESS ISSUES

1. Review Material Safety Data Sheets (MSDS) for fluids being used at test site/chamber.
2. Protective clothing should be worn.
3. Care should be taken when handling fluid containers.
4. Particular care must be taken during tests involving untrained or inexperienced personnel.
5. Proper measures shall be taken for disposal of fluids.
6. Safety procedures specific to the chamber.
7. Take special care for ice on ground in cold chamber and water on floor in control room.

ATTACHMENT 2
CEF DETAILED TEST PLAN
Type II, III & IV Fluids

Test #	Precip Type	Test Temp. [°C]	Precip Rate [g/dm²/h]	Dilution [%]	HOT Est.	HOT
1	Cold Soak Box	1	5	100	50	
2	Cold Soak Box	1	5	100	50	
3	Cold Soak Box	1	5	75	40	
4	Cold Soak Box	1	5	75	40	
5	Cold Soak Box	1	75	100	10	
6	Cold Soak Box	1	75	100	10	
7	Cold Soak Box	1	75	75	10	
8	Cold Soak Box	1	75	75	10	
9	Freezing Drizzle	-10	5	100	70	
10	Freezing Drizzle	-10	5	100	70	
11	Freezing Drizzle	-10	5	75	60	
12	Freezing Drizzle	-10	5	75	60	
13	Freezing Drizzle	-10	13	100	30	
14	Freezing Drizzle	-10	13	100	30	
15	Freezing Drizzle	-10	13	75	30	
16	Freezing Drizzle	-10	13	75	30	
17	Freezing Drizzle	-3	5	100	120	
18	Freezing Drizzle	-3	5	100	120	
19	Freezing Drizzle	-3	5	75	120	
20	Freezing Drizzle	-3	5	75	120	
21	Freezing Drizzle	-3	5	50	60	
22	Freezing Drizzle	-3	5	50	60	
23	Freezing Drizzle	-3	13	100	60	
24	Freezing Drizzle	-3	13	100	60	
25	Freezing Drizzle	-3	13	75	80	
26	Freezing Drizzle	-3	13	75	80	
27	Freezing Drizzle	-3	13	50	30	
28	Freezing Drizzle	-3	13	50	30	
29	Light Freezing Rain	-10	13	100	40	
30	Light Freezing Rain	-10	13	100	40	
31	Light Freezing Rain	-10	13	75	30	
32	Light Freezing Rain	-10	13	75	30	
33	Light Freezing Rain	-10	25	100	20	
34	Light Freezing Rain	-10	25	100	20	
35	Light Freezing Rain	-10	25	75	20	
36	Light Freezing Rain	-10	25	75	20	
37	Light Freezing Rain	-3	13	100	60	
38	Light Freezing Rain	-3	13	100	60	
39	Light Freezing Rain	-3	13	75	70	
40	Light Freezing Rain	-3	13	75	70	
41	Light Freezing Rain	-3	13	50	30	
42	Light Freezing Rain	-3	13	50	30	
43	Light Freezing Rain	-3	25	100	40	
44	Light Freezing Rain	-3	25	100	40	
45	Light Freezing Rain	-3	25	75	40	
46	Light Freezing Rain	-3	25	75	40	
47	Light Freezing Rain	-3	25	50	20	
48	Light Freezing Rain	-3	25	50	20	
49	Freezing Fog	-25	2	100	120	
50	Freezing Fog	-25	2	100	120	
51	Freezing Fog	-25	5	100	20	
52	Freezing Fog	-25	5	100	20	
53	Freezing Fog	-14	2	100	180	
54	Freezing Fog	-14	2	100	180	
55	Freezing Fog	-14	2	75	120	
56	Freezing Fog	-14	2	75	120	
57	Freezing Fog	-14	5	100	40	
58	Freezing Fog	-14	5	100	40	
59	Freezing Fog	-14	5	75	30	
60	Freezing Fog	-14	5	75	30	
61	Freezing Fog	-3	2	100	180	
62	Freezing Fog	-3	2	100	180	
63	Freezing Fog	-3	2	75	120	
64	Freezing Fog	-3	2	75	120	
65	Freezing Fog	-3	2	50	50	
66	Freezing Fog	-3	2	50	50	
67	Freezing Fog	-3	5	100	120	
68	Freezing Fog	-3	5	100	120	
69	Freezing Fog	-3	5	75	70	
70	Freezing Fog	-3	5	75	70	
71	Freezing Fog	-3	5	50	20	
72	Freezing Fog	-3	5	50	20	

ATTACHMENT 3
Instructions for Measuring Anti-Icing Fluid Viscosity Using DV-I+ Brookfield Viscometer

Introduction

This document is meant to provide some important instructions for measuring viscosity using a DV-I+ Brookfield Viscometer. Training is obviously needed before any use of the viscometer. For further information, several sources related to the theoretical background on viscosity and the Brookfield Viscometers are cited below.

Step by step instructions

For accurate viscosity measurements, these instructions should be followed:

1. Level the viscometer head by adjusting the three leveling screws on the base of the stand. Adjust so that the bubble level on top of the DV-I+ is centered within the circle. Check level periodically during use.

2. Turn on the viscometer head and allow it to warm up for 10 minutes before any measurement.

3. Turn on the temperature-controlled bath and set it to the desired temperature. With most materials, the relationship between viscosity and temperature is exponential in nature. For some products, an extremely small temperature change can cause an extremely large viscosity change. The temperature factor should be taken seriously.

4. Centrifuging the fluid samples
   Samples would usually contain trapped air bubbles. These bubbles dramatically effect the viscosity measurement. Small bubbles can climb to the surface of the viscometer spindle causing additional drag on the spindle, thus making the fluid appear more viscous than it actually is.
   These instructions should be followed:

   - Even if it is not stated mandatory by all anti-icing fluid manufacturers, centrifuging should be applied on all fluid samples that contain clear and stable trapped bubbles.
   - For Dow products, Dow Company always recommends a centrifugation for 5-10 minutes at 3400 r/min (or 10-20 minutes at 2500 r/min).

- With large sample containers, centrifuging is usually not applied since the amount of the fluid is too large to permit effective and easy centrifugation.

5. Loading the samples

- With viscosity method stating large samples (250 ml or 500 ml), the fluid amount is usually measured using a beaker.
- For the small sample chamber (SC4-13R), the fluid amount required is usually 10 mL and is typically measured with a syringe (with the needle).
- For Dow Ultra+, they found out that the syringe loading method might shear the fluid. Using a graduated cylinder or pipette to measure the amount is not recommended as the thickened fluid will leave excessive amounts of holdup on the walls, thus the amount of fluid delivered to the chamber is not a full 10 mL. Dow recommends the use of a notched card. For the SC4-13R sample chamber with the SC4-31 spindle (usually used for Ultra+ fluids) immerged, the notch in the card should be 1.5 cm deep.
- If the viscosity test is carried out below room temperature (0 °C for Ultra+), condensation will typically form on the top surface of the sample. To avoid that, an absorbent cloth (47 mm outside diameter and 20 mm inside diameter) should be placed on the top surface of the cooling jacket to absorb condensate. This should be left in place during the measurement as well.

6. Autozero the viscometer following these instructions:

a) Remove the spindle (if any attached).
b) Press any key on the viscometer keypad.
c) Wait until the display asks for the spindle to be replaced.
d) Replace the correct spindle (according to the viscosity method).
When placing the correct spindle (according to the viscosity method), make sure that:

  - The Viscometer spindle should be suitably centered in the test sample container. This is of particular importance when using the spindles of largest diameter (LV spindles for instance).
  - All spindles should be properly immersed to the groove found on their shafts. Otherwise, add some fluid to submerge the spindle till its notch.
  - Viscometer ranges will generally change if the spindle is brought near the walls of the container.

7. Turn off the spindle motor.

8. Check that the correct spindle entry code is being used (see Table 1).

9. Set the right spindle rotation speed and time provided in the viscosity method.

10. How much time to wait for the fluid to reach the set temperature?
    Important: Spindles should be attached to the viscometer before starting the time counting:

    a) With large sample adaptor
       Good temperature equilibration with large (250 ml or 500 ml) sample is difficult. Even if the large sample is immersed in a constant temperature bath, the large thermal mass takes a very long time to reach a stable temperature. Brookfield recommends 1 to 2 hours for temperature equilibration of large anti-icing fluid samples. A probe should be used to measure the fluid temperature.

    b) With small sample adaptor
       The small sample adaptor permits rapid temperature equilibration, which can be achieved in about 20 minutes

11. When the fluid is at test temperature, turn the spindle motor on to start the viscosity measurement.

12. Record the viscosity measurement and method in the logbook.

13. Variability in readings.

    Duplicate measurements using a Brookfield viscometer on the same fluid sample will rarely give exactly the same result.

    According to the ASTM method (D 2196-99), the repeatability and the reproducibility are defined as:

    1. Repeatability (in the same laboratory):
       Two results obtained by the same operator at different times should be considered suspect if they differ by more than 7%.
       If X_1 and X_2 are the two results found in the same laboratory (with X_1 higher than X_2), the repeatability (RPT) is calculated as follows (standard deviation relative to the average):

$$\text{RPT (\%)} = [\text{abs}(X_1-X_2)] / [(X_1+X_2)/2]$$

    2. Reproducibility (between different laboratories):

Two results obtained by operators in different laboratories should be considered suspect if they differ by more than 21.6%.
If X_3 and X_4 are the two results found in two different laboratories (with X_3 higher than X_4), the reproducibility (RPD) is calculated as follows:

$$RPD\ (\%) = [abs\ (X_3 - X_4)] / [(X_3 + X_4)/2]$$

If multiple measurements on the same fluid are to be made, or if several fluids are to be compared, the results will be more meaningful if all measurements are made on the same day. Samples might show differences in their chemical structure (like layering, degradation, etc.) over time.

14. How many measurements should be made?

    1. If the result of the first viscosity run has to be compared to the manufacturer value (or other laboratory value) and the reproducibility RPD (21.6%) applies, only one measurement would be sufficient. Otherwise, a second run should be carried out for checking.

       Suggestion: If the difference is higher than 7%, it is advisable to be skeptical about the result and to conduct a second run.

    2. When a viscosity reference value is not provided, two runs should be carried out. The repeatability RPT (7 %) should apply for the inter-laboratories. Otherwise, a third run should be carried out for checking.

Calibration Procedure

For the calibration procedure, see APS calibration book or ask the administrative assistant for the latest version.

Table 1: Spindle and Model Codes

Each spindle has a two digit code which is scrolled to via the keypad on the **DV-I+**. The spindle code directs the **DV-I+** to calculate viscosity for the spindle that is being used. The spindle multiplyer constant (**SMC**) is used to calculate full scale viscosity range for any spindle/speed combination (refer to **Appendix E**). Spindle codes are listed in **Table D-1**.

SPINDLE	CODE	SMC
RV1	01	1
RV2	02	4
RV3	03	10
RV4	04	20
RV5	05	40
RV6	06	100
RV7	07	400
HA1	01	1
HA2	02	4
HA3	03	10
HA4	04	20
HA5	05	40
HA6	06	100
HA7	07	400
HB1	01	1
HB2	02	4
HB3	03	10
HB4	04	20
HB5	05	40
HB6	06	100
HB7	07	400
LV1	61	6.4
LV2	62	32
LV3	63	128
LV4	64	640
LV5	65	1280
SPIRAL	70	105
T-A	91	20
T-B	92	40
T-C	93	100
T-D	94	200
T-E	95	500
T-F	96	1000

SPINDLE	CODE	SMC
ULA	00	0.64
DIN-ULA	85	1.22
TSEL-DIN-81	81	3.7
SSA-DIN-82	82	3.75
SSA-DIN-83	83	12.09
ULA-DIN-85	85	1.22
ULA-DIN-86	86	3.65
ULA-DIN-87	87	12.13
SC4-14	14	125
SC4-15	15	50
SC4-16	16	128
SC4-18	18	3.2
SC4-21	21	5
SC4-25	25	512
SC4-27	27	25
SC4-28	28	50
SC4-29	29	100
SC4-31	31	32
SC4-34	34	64
SC4-37	37	25
CPE40	40	0.327
CPE41	41	1.228
CPE42	42	0.64
CPE51	51	5.178
CPE52	52	9.922
V-71	71	2.62
V-72	72	11.10
V-73	73	53.50

Source: http://www.brookfieldengineering.com

References

1. Brookfield Engineering Laboratories: http://www.brookfieldengineering.com
2. Operational Brookfield manuals:
   http://www.brookfieldengineering.com/support/documentation/index.cfm
   http://www.phys.virginia.edu/classes/311/notes/fluids2/node2.html
   http://scienceworld.wolfram.com/physics/DynamicViscosity.html
   http://hyperphysics.phy-astr.gsu.edu/hbase/pfric.html#vis
3. The British Society of Rheology (BSR):
   http://www.ncl.ac.uk/rheology/bsr/noframes/index.html

ATTACHMENT 4
FORMULAS AND CALCULATION PROCEDURE – NRC

Ice-catch calculation

Rate calculation is performed by placing ice catch pans (27.7 cm x 54 cm) on the test plate support at each test location (maximum of 12 locations). Each pan is marked with a number identifying the collection location on the test plate support. The individual pans are weighed prior to exposure to precipitation and the weights are recorded. Prior to the start of the precipitation catch period, the exact time (hh:mm:ss) is recorded. The pans are then placed on the test plate support for a pre-determined period. The pans are re-weighed following this period and the precipitation rate for each pan is calculated (R1).

$R1 = (W_{a1}-W_{b1})/\text{Area-of-pan}*(T_{a1}-T_{b1})$ where,

W_{a1} = weight after of the 1st measurement
W_{b1} = weight before of the 1st measurement
T_{a1} = time after of the 1st measurement
T_{b1} = time before of the 1st measurement

The pans are then weighed and placed on the test plate support for a second collection period (R2). After the second collection period has expired, the pans are again re-weighed and the rates computed. A test may begin following the second rate collection period.

Following the failure of a test plate, a rate collection pan is weighed and placed at the plate location for a predetermined time interval (R3). It is then re-weighed and placed again (R4) on the stand in order to collect a minimum of two rates before and two rates after each test at this location.

The rate of precipitation for any location on the stand is calculated by averaging the two rates collected prior to the test and the two rates collected following the test. In order for the test to be valid, the average rate must be within the set limits.

Water Spray Intensity Calculation:

Average intensity: $$\frac{R1 + R2 + R3 + R4}{4}$$

The average intensity calculated must be within the specified tolerance in each of the conditions.

ATTACHMENT 5
PREPARATION OF THE PLATES AT NRC

1. Test Plates:

1.1 Each test plate is removable and is placed on a support within the environmental test chamber.

1.2 Each test plate shall be equipped with a temperature sensor located on the underside of or, embedded within the plate. This sensor shall be capable of measuring to an accuracy of +/- 0.5 °C and shall be linked to an automatic data acquisition system.

1.3 The test plates shall be inclined from the horizontal at an angle of 10 degrees + / - 0.2 degrees.

1.4 The test plates are placed on the support in such a way that the fluid can freely flow off all of the edges of the plate.

1.5 The test stand shall not interfere with the test surface and will minimize any contact between the support and the test surface.

2. Test Plate Cleanliness:

2.1 The test plates shall be free of any visible contamination, smears, or stains, except for drawings used to estimate ice coverage. Between runs, any contamination shall be removed with a hot water rinse immediately followed with an ethanol rinse.

2.2 If the same fluid is tested on the same plate for two or more consecutive tests, it is not necessary to clean the plates with ethanol before the second test, a hot water rinse shall be sufficient.

2.3 Allow the plates to dry after rinse and ensure they are at the appropriate temperature before use.

2.4 To avoid any possible contamination with spray or temperature, clean plates are to be stored in a holding area inside the test chamber away from the spray area.

3. Changing Plates on the Test Stand:

3.1 Prior to removing a plate, a clean plate shall be chosen from the hold area inside the test chamber.

3.2 The clean plate shall be protected from becoming contaminated with spray using a clean cover.

3.3 One person shall disconnect the temperature thermistor from the plate to be replaced.

3.4 Another person shall hold the clean plate so as to ensure that no contamination from spray occurs.

3.5 Care must be exercised to ensure that this operation does not affect the spray or test on plates adjacent to the one being replaced.

3.6 The plate to be replaced shall be removed from the test stand and held above the location so as to prevent contaminating the test brackets with frozen spray.

3.7 Prior to placing the clean plate on the stand, the brackets shall be visually inspected to ensure that spray has not contaminated the brackets causing the angle of the plate to change.

3.8 The other person shall place the clean plate with the cover on the brackets underneath the old plate that is being held over the location, the old plate shall then be removed, the temperature thermistor will be connected, lift the cover and hold it over the plate while pouring the fluid, once the pouring is completed, remove the cover.

3.9 Verification shall be made to ensure that no contamination occurred on either the plate being changed or any other plates on the test stand, and that the temperature feeds are properly connected.

ATTACHMENT 6
EQUIPMENT

1. FREEZING PRECIPITATION

TASK	NRC Cold Chamber	
	Resp.	Status
Logistics for Every Test		
Make Hotel reservations	Intermediate Admin	
Rent Mini-Van/Cube truck	Intermediate Admin	
Personnel Advances	All	
Personnel Transportation	Test Leader	
Prior to Testing		
Pre-mix Type I Fluids	Jr. Technologist	
Ensure delivery of fluids to NRC	Test Leader	
Test Equipment		
New Stand (1x6plate stand)	Jr. Technologist	
1x2 plate stand	Jr. Technologist	
Desktop Computer x 1	Jr. Technologist	
Diskettes	Jr. Technologist	
Rags	Jr. Technologist	
Time Cards, Invoices, Expense forms	Test Leader	
Video Tapes	Project Manager	
Batteries AA, 9V	Project Manager	
Laptop Computer	Test Leader	
Still Digital Camera	Test Leader	
Fluid for cold-soak boxes	@NRC	
Weigh Scale x 2 (sartorius) + wiring	Jr. Technologist	
Time lapse video camera	Jr. Technologist	
Boards for cold-soak test	Jr. Technologist	
Clamps x 12	Jr. Technologist	
VCR for time lapse	Jr. Technologist	
Monitor for time lapse	Jr. Technologist	
Reg. Plates (wing nuts) X 10 (with logging capability)	Jr. Technologist	
Red containers with LIDS	Jr. Technologist	
Data Forms for plates	Test Leader	
Precipitation rate Data Forms	Test Leader	
Insulation for weigh scale	Jr. Technologist	
Reports + HOT Tables	Test Leader	
Dilution curves for Type I fluids	Test Leader	
Large Precipitation Pans x 100	Jr. Technologist	
Metal cold-soak box covers	Jr. Technologist	
Large calculator	Jr. Technologist	
Fluids	Jr. Tech/Test Leader	
Clipboards x 5	Jr. Technologist	
Pencils + pens + markers	Jr. Technologist	
Paper Towels	Jr. Technologist	
Rubber squeegees x 4	Jr. Technologist	
Waste containers x 8	Jr. Technologist	
Plastic Refills(red containers) for Fluids and funnels	Jr. Technologist	
Electrical Extension Cords	Jr. Technologist	
Lighting x 2	Jr. Technologist	
Stop watches x 4	Jr. Technologist	
Storage bins for small equipment	Jr. Technologist	
Protective clothing (6)	Jr. Technologist	
Brixometer X 3	Jr. Technologist	
Tie wraps	Jr. Technologist	
Funnels	Jr. Technologist	
Hand-held Temperture Probes (Wahl)	Jr. Technologist	
Thickness Gauges x 5 (both types)	Jr. Technologist	
Scrapers	Jr. Technologist	
Plate covers x 10	Jr. Technologist	
Spray paint	Jr. Technologist	
Tape measure	Jr. Technologist	
Black shelving units x 2	@NRC	
Cold-Soaked Boxes 7.5 cm X 6	Jr. Technologist	
Inclinometer (yellow level)	Jr. Technologist	
Test Procedures X2	Test Leader	
Printer Epson @ site	Jr. Technologist	
Paper for printer (1 packs)	Jr. Technologist	
Washers	Jr. Technologist	
Hard Water for Type I tests x 40 litres	Jr. Technologist	
Hard Water Chemicals	Jr. Technologist	
1 litre pour containers x12	Jr. Technologist	
Large digital clock x 2	Jr. Technologist	

2. NATURAL SNOW

TASK	Natural Snow Tests	
	Resp.	Status
Logistics for Every Test		
Monitor Weather	Test Leader	
Call personnel required to Site	Test Leader	
Prior to Testing		
Syncrhonize clocks	Test Leader	
Ensure Type II and Type IV are at OAT	Test Leader	
Set-up loggers if required	Interm. Technologist	
Stands set into wind and at 10° slope	Test Leader	
Mark crosshairs on all new plates	Interm. Technologist	
Test Equipment		
Test stands (2x6plates)	Interm. Technologist	
Desktop Computer	Jr. Technologist	
Diskettes	Jr. Technologist	
Rags	Interm. Technologist	
Time Cards, Invoices, Expense forms	Jr. Technologist	
Batteries AA, 9V	Project Manager	
Still Photo Camera and still digital camera	Test Leader	
Digital Microscope + forensic scales	Jr. Technologist	
Balance x 2 (sartorius) + wiring	Jr. Technologist	
Digital Video camera	Test Leader	
Video Tapes	Test Leader	
Reg. Plates (with logging capability)	Jr. Technologist	
1 litre pour containers	Jr. Technologist	
Red containers	Jr. Technologist	
Data Forms for plates	Test Leader	
Precipitation rate Data Forms	Test Leader	
Insulation for weigh scale	Jr. Technologist	
Reports + HOT Tables	Test Leader	
Rate distribution pans	Jr. Technologist	
Large calculator	Jr. Technologist	
Fluids	Jr. Tech/Test Leader	
Clipboards x 5	Jr. Technologist	
Pencils + pens	Jr. Technologist	
Paper Towels	Jr. Technologist	
Rubber squeegees x 4	Jr. Technologist	
Waste containers x 20	Jr. Technologist	
Plastic Refills(red containers) for Fluids and funnels	Jr. Technologist	
Electrical Extension Cords	Jr. Technologist	
Lighting x 3	Jr. Technologist	
Stop watches x 4	Jr. Technologist	
Storage bins for small equipment	Jr. Technologist	
Protective clothing (6)	Jr. Technologist	
Brixometer X 3	Jr. Technologist	
Tie wraps	Jr. Technologist	
Funnels	Jr. Technologist	
Hand-held Temperture Probes x 2 (Barnant and Wahl)	Jr. Technologist	
Thickness Gauges x 5 (both types)	Jr. Technologist	
Scrapers	Jr. Technologist	
RH meter	Jr. Technologist	
Spray paint	Jr. Technologist	
Tape measure	Jr. Technologist	
Thermistor Kit + Logger	Jr. Technologist	
Inclinometer (yellow level)	Jr. Technologist	
Large digital clock x 2	Jr. Technologist	
Tarp for fluid collection	Jr. Technologist	

ATTACHMENT 7
FLUID MANAGEMENT PROCEDURE

1. Fluid Request Procedure:

- Write letters to fluid manufactures specifying the following:

Project Specific Information
Objective of the Specific Project/Test
Date for receipt of fluid
Location of Shipment and Contact Persons

Fluid Specific Information
Type of Fluid
Name of Fluid (if available)
Dilutions of Fluid (if required)
Quantity of Fluid Required
Suggested container sizes of shipment (20 liter containers or 200 liter drums)

- Each letter MUST CONTAIN a request that manufactures include with shipment:
  Fluid Batch Number
  Date of Production
  Viscosity Method suggested by Manufacturer
  Manufacturer's stated viscosity
  Manufacturers stated BRIX
  MSDS Sheets

An example of the request letter is presented at the end of this document, in Appendix I.

- Track and ensure the following:
  The Manufacturers receive the letters
  The Manufacturers confirm willingness to ship fluids.
  The Manufacturers confirm that the fluids will be shipped.
  The receipt of the fluids and the fluid specification.

2. Receipt of Fluids

Receipt of fluid will be accompanied by the following documentation:

Fluid Specification – (if not available, request it from the manufacture)

Shipping Slip

For Type I Fluids: Fluid Freeze Point Curve (FP curve)
Lowest Operational Use Temperature (LOUT)

These must be brought back and placed in appropriate binder, and Form 1 must be filled in.

3. Fluid Use and Storage at Site

- Remove fluid from original containers and place in smaller containers.
- Spray paint each container with the code designated for that particular shipment. Label the container (an example of label can be found at the back of this document in Appendix II). This should be done under the supervision of a qualified Test Site Leader.
- The code must contain the following information:
  Batch number
  Date received
  Name of Manufacturer
  Type of fluid
  Name of fluid
  Dilution
- Place fluid containers on outside shelves ensuring that the label is visible. Store original fluid containers in shed and use for waste fluid collection when empty. Waste fluid containers must be spray painted "WASTE".

4. Fluid Samples Storage at Office

- Two samples of the fluid must be brought back to the office. One sample must be sent to AMIL and the other one is kept at the office. Use 1-litre bottle containers. Label all containers.
- Conduct viscosity and brix tests on fluid samples. The obtained values should be recorded in the log, next to the viscometer.
- Place fluid sample containers in boxes that are not subjected to light. Include a copy of the form and store in basement for a period of two years from date of receipt.

A log of all the fluids received, by project number, manufacturer and quantity must be kept. The log needs to be updated every time a new fluid is received.

An example of a log is shown in Appendix III.

Appendix I
EXAMPLE OF REQUEST LETTER

Transports Canada	Transport Canada
Centre de développement des transports	**Transportation Development Centre**
800, bd René-Lévesque O. 6e étage Montréal (Québec) H3B 1X9 Tél. : (514) 283-0000 Télécopieur : (514) 283-7158 Site Web : Www.tc.gc.ca/tdc/index_f.ht m	800 René-Lévesque Blvd. W. 6th Floor Montreal, Quebec H3B 1X9 Tel.: (514) 283-0000 Fax: (514) 283-7158 Web Site: www.tc.gc.ca/tdc/index.htm

Votre référence *Your file*

Notre référence *Our file*

ZCD1455-14

Date:

SUBJECT: Request for fluid samples

Dear Sir:

Transport Canada, in conjunction with the Federal Aviation Administration, is currently planning to undertake testing of de/anti-icing fluids using the services of APS Aviation as in previous years.

The objectives of this year's test program will be the following:

- To conduct endurance time tests with new Type I, Type II, Type III, and Type IV fluid formulations.

Test sample selection procedures for Type II, III and IV fluids, are as outlined in the September 2003 revision of the proposed AS 5485. Note that the sample selection procedure describes viscosity measurements based on the AIR 9968 method. Fluid manufacturers will be responsible for ensuring that all steps in the sample selection procedures are followed.

All dilutions of the de/anti-icing fluids should be made using standard hard water, as outlined in AMS 1424 and 1428.

It is anticipated that Transport Canada will charge the fluid manufacturers $25,000 US for testing Type II or Type IV anti-icing fluids, $16,000 US for testing Type III neat fluids and $12,500 US for testing Type I fluids. Manufacturers who wish to test more than one anti-icing fluid will pay the full price for the first fluid and receive a 20% reduction on the testing of any additional fluids.

In order to maximize testing in natural conditions, please deliver test samples to APS as soon as possible in accordance with Note 1. Please include the following items with the fluid samples:

a) A statement identifying the product name, lot number and date of manufacture;
b) A statement specifying the viscosity of the shipped fluid, the method used to pre-shear the sample fluid and the date of shearing;
c) The MSDS of the fluid;
d) The Brix and freeze point of the fluid; and
e) If possible, the WSET value of the fluid sample.

Fluids should be shipped in manageable (20 litre or less) containers, if possible.

We thank you for your assistance. In order to ensure that proper samples are delivered for testing, please contact Michael Chaput or John D'Avirro at APS Aviation (1-514-878-4388) or Barry Myers at Transport Canada (1-514-283-0054) prior to the preparation of the test samples.

Yours Sincerely,

Barry Myers

Barry Myers
Senior Development Officer

Note 1

The following fluid quantities are requested:

Type I (Concentrate)	60 litres
Type II, III or IV (100% mix)	300 litres
Type II, III or IV (75% mix)	200 litres
Type II, III or IV (50% mix)	140 litres

Samples should be delivered to the following address:

Mr. John D'Avirro/ Mr. Michael Chaput
APS Aviation Inc.
c/o Environment Canada
8000 Herve St-Martin
Dorval, Quebec
Canada – H4Y 1H1
Tel: (514) 878-4388 Fax: (514) 861-6310

Affiliated Custom Broker: *Charles Higgerty Limited*
Ottawa: (613) 748-6600
Montreal: (514) 636-3926

APPENDIX II
EXAMPLE OF LABELS

Winter 2000/2001 HOLDOVER TIME PROJECT SPCA ECOWING 26 TYPE II - NEAT Batch Number: L 1043 APS Aviation Inc.	Winter 2000/2001 HOLDOVER TIME PROJECT SPCA ECOWING 26 TYPE II – 75/25 Batch Number: L 1043 APS Aviation Inc.
Winter 2000/2001 HOLDOVER TIME PROJECT SPCA ECOWING 26 TYPE II - NEAT Batch Number: L 1043 APS Aviation Inc.	Winter 2000/2001 HOLDOVER TIME PROJECT SPCA ECOWING 26 TYPE II – 75/25 Batch Number: L 1043 APS Aviation Inc.
Winter 2000/2001 HOLDOVER TIME PROJECT SPCA ECOWING 26 TYPE II - NEAT Batch Number: L 1043 APS Aviation Inc.	Winter 2000/2001 HOLDOVER TIME PROJECT SPCA ECOWING 26 TYPE II – 75/25 Batch Number: L 1043 APS Aviation Inc.
Winter 2000/2001 HOLDOVER TIME PROJECT SPCA ECOWING 26 TYPE II - NEAT Batch Number: L 1043 APS Aviation Inc.	Winter 2000/2001 HOLDOVER TIME PROJECT SPCA ECOWING 26 TYPE II – 75/25 Batch Number: L 1043 APS Aviation Inc.

APPENDIX III
EXAMPLE OF LOG OF FLUIDS

FLUID REQUEST/RECEIPT

Bottle	Fluid Manufac.	Fluid Type	Date Received	Quantity Ordered (Litres)	Brand Name Received	Quantity Received	Batch #	Brix Stated/Freezing Point(°C)	Brix Measured	Viscosity Stated Using Manufacturer's Method (mPa.s)	Viscosity Measured Using Manufacturers Method	Wset Amil	Comments
CM 1589													
1.0 Holdover Time Testing and Evaluation of De/Anti-Icing Fluids													
	Octagon	T IV Neat	October 10, 2000	-	Maxflight	80	F-21290			6260	6900		
	Octagon	T IV 75/25	October 10, 2000	-	Maxflight	60	F-21290						
	Octagon	T IV 50/50	October 10, 2000	-	Maxflight	40	F-21290						
AE	Kilfrost	T IV Neat	March 27, 2000	125	ABC-S - degraded viscosity	125	P711				2600		
BM 3833													
1.4 Round Robin in Snow													
H	Union Carbide	T IV Neat	December 27, 2000	140	Ultra +	180	10353	40	41	39600	32500		
-	Union Carbide	T IV Neat	-	140	Ultra + (AMIL)	-	-	-	-	-	-		
-	Union Carbide	T IV Neat	-	140	Ultra + (NCAR)	-	-	-	-	-	-		
I	Kilfrost	T IV Neat	January 10, 2001	140	ABC-S		S/93/12/00		36		27300		
J	Kilfrost	T IV 75/25	January 10, 2001	100	ABC-S		S/93/12/00		28		23300		
K	Kilfrost	T IV 50/50	January 10, 2001	80	ABC-S		S/93/12/00		19		2000		
-	Kilfrost	T IV Neat	-	140	ABC-S (AMIL)	-	-	-	-	-	-		
-	Kilfrost	T IV 75/25	-	100	ABC-S (AMIL)	-	-	-	-	-	-		
-	Kilfrost	T IV 50/50	-	80	ABC-S (AMIL)	-	-	-	-	-	-		
-	Kilfrost	T IV Neat	-	40	ABC-S (NCAR)	-	-	-	-	-	-		
-	Kilfrost	T IV 75/25	-	20	ABC-S (NCAR)	-	-	-	-	-	-		
-	Kilfrost	T IV 50/50	-	20	ABC-S (NCAR)	-	-	-	-	-	-		
AA	SPCA	T IV Neat	January 26, 2001	140	AD 480		GT M062		37		20600		
AB	SPCA	T IV 75/25	January 26, 2001	100	AD 480		GT M062		28.75		30500		
AC	SPCA	T IV 50/50	January 26, 2001	80	AD 480		GT M062		20.62		7900		
-	SPCA	T IV Neat	-	140	AD 480 (AMIL)	-	-	-	-	-	-		
-	SPCA	T IV 75/25	-	100	AD 480 (AMIL)	-	-	-	-	-	-		
-	SPCA	T IV 50/50	-	80	AD 480 (AMIL)	-	-	-	-	-	-		
-	SPCA	T IV Neat	-	40	AD 480 (NCAR)	-	-	-	-	-	-		
-	SPCA	T IV 75/25	-	20	AD 480 (NCAR)	-	-	-	-	-	-		
-	SPCA	T IV 50/50	-	20	AD 480 (NCAR)	-	-	-	-	-	-		
6.0 NCAR Snow Maker													
A	Union Carbide	T IV Neat	November 15, 2000	100	Ultra +	120	10353	40	40.75	39600	32,800		
-	Union Carbide	T IV Neat	-	100	Ultra + (NCAR)	-	-	-	-	-	-		
B	Kilfrost	T IV Neat	November 10, 2000	100	ABC-S	75	526/10/00		36		26,900		
C	Kilfrost	T IV 75/25	November 10, 2000	60	ABC-S	50	526/10/00		27025				
D	Kilfrost	T IV 50/50	November 10, 2000	40	ABC-S	25	526/10/00		20				
-	Kilfrost	T IV Neat	-	100	ABC-S (NCAR)	-	-						
-	Kilfrost	T IV 75/25	-	60	ABC-S (NCAR)	-	-						
-	Kilfrost	T IV 50/50	-	40	ABC-S (NCAR)	-	-						
E	SPCA	T IV Neat	December 16, 2000	100	AD 480	90	M4749		37		20,100		
F	SPCA	T IV 75/25	December 16, 2000	60	AD 480	60	M4749		28.75		26,200		
G	SPCA	T IV 50/50	December 16, 2000	40	AD 480	60	M4749		20.25				
3. FLOW OF CONTAMINATED FLUIDS													
R	Ocatgon	T IV Neat		200	Maxflight	300							
4.0 Mesaure of On wing Viscosity													
O	Union Carbide	T IV Neat	January 10, 2001 Aeromag	-	Ultra +	200	-						
P	Clariant	T IV Neat	December 27, 2000	200	Safewing MP IV 2001	200	DEGE 146015	-34°C	35.25	28600			
Q	Clariant	T IV Neat	December 27, 2000	200	Safewing Four	200	DEGE 014112	-34°C	36.75	10000			
BM 3833													
1.0 Holdover Time Testing and Evaluation of De/Anti-Icing Fluids													
S	Octagon	T IV Neat	October 10, 2000	-	Maxflight	80	F-21290		37	**5990**	**5900**		
T	Octagon	T IV 75/25	October 10, 2000	-	Maxflight	60	F-21290		28.75	**34950**	***		
U	Octagon	T IV 50/50	October 10, 2000	-	Maxflight	40	F-21290		21	**41300**	****		
V	Kilfrost	T IV Neat	March 27, 2000	-	ABC-S - degraded viscosity	20	P711		36.25	2600	2450		
Z	Lyondell	T I	October 26, 2000	200	ARCOPLUS ST		ACE 101 311	-	-	-	-		
AG	CAAC	T I	February 18, 2001	200	Nevvave Aerochemical		FCY-1A	-	-	-	-		

ATTACHMENT 8
PERSONNEL AND TRAINING

This attachment enumerates the tasks for each member of the testing personnel and also provides information with regards to the training of personnel.

1. FREEZING PRECIPITATION

The personnel involved in testing typically comprise of coordinator/manager, computer technician, weigh scale technician and fluid technician.

1.1 PERSONNEL – FREEZING PRECIPITATION

1.1.1 Coordinator/Manager

a. Delegate someone to fill in the Condition Checklist (FORM 14), and the General Form for Each Session (FORM 3);
b. Complete and sign the De/Anti-Icing Form For Freezing Precipitation (FORM 5), and the General Form For Each Session (FORM 14)
(FORM 14 to be sent in a separate envelope);
c. Verify and sign:
    i. The General Form For Each Condition (FORM 4);
    ii. The Chamber Setting For Each Condition (FORM 8), and
    iii. Test Stand Location For Each Condition (FORM 2).
d. Ask the operators of the test cell to set the tests conditions;
e. Monitor the rates;
f. Insure that the right fluids are used;
g. Ensure that the fluids used have been verified for Viscosity & Certificates;
h. Insure that the tests are run at the right conditions;
i. Insure that the right test ID is used;
j. Check if the range over the average failure time is less than 10%;
k. Insure the plates and the units are clean; and
l. Insure that failure calls are correct.

1.1.2 Computer Technician

a. Computer Technician notes the following: position/ice catch plate number, plate's initial weight, initial time (time when the plate is placed), final time (time when plate is removed from the unit), final weight;
b. Check that tolerance and range rates are good;

c. Complete the General Form For Each Condition (FORM 4), delegate certain measurements to the Weigh or Fluid Technician (based on availability);
d. Fill in The Chamber Settings For Each Condition (FORM 8);
e. Print all data and results and put them in the envelope;
f. Save all results to hard drive and zip them to save on diskette;
g. Put the diskette in the envelope; and
h. Do the last check up to be sure that all results sheets and diskettes are in the envelope.

1.1.3 Weigh Scale Technician

a. Ensure plates have reached chamber temperature, place the plates on platform, and collect plates for weighing;
b. Communicate with the computer technician the time of placing the plate, the position of the plate, the plate number, the final weight of the plate and the time of placing the new plate;
c. Bring in or take out Rate Pans with the assistance of the Fluid Technician (if available);
d. Clean or dry the rate plates (ATTACHMENT 5);
e. Clean the test plates as indicated in ATTACHMENT 5;
f. Recuperate the fluid of the test plates in a waste container;
g. Clean mess whenever it is necessary;
h. Fill in the Test Stand Location For Each Condition (FORM 2) each time one of the following objects moves: test stand, humidity/temperature sensor. The measured values shall be taken and entered on the FORM 2. Each time new values are used, the form should be numbered, starting at 1 each morning;
i. Complete the Rate Management Form (FORM 9); and
j. Complete the scale verification (see Calibration Procedure), prior to each condition.

1.1.4 Fluid Technician

a. Read the MSDS sheets;
b. Clean the upper surfaces prior to placing the plates;
c. Prepare the trays containing the rate and test plates for the weigh scale technician;
d. Verify that the fluids have been checked (Viscosity, Certificates of Compliance);
e. Pour fluids on the test plates;
f. Communicates with the computer technician to provide beginning and failure time (failure calls);
g. When the weigh scale technician has finished with the plates, take out the plates to the table to clean or dry them; and

h. Help clean plates.

1.2 TRAINING – FREEZING PRECIPITATION

1.2.1 Coordinator/Manager

The Coordinator/Manager will be trained in all the facets of operations contained in this procedure, including, but not limited to:

a. Set-up and tear-down;
b. Understanding how the chamber operates;
c. Understanding of test procedures:
   i. Failure Calls, determination of test end condition, recording information on plate data form, rates, fluids;
   ii. Panel preparation/cleaning, and the pouring of fluids;
   iii. Calculating the rates;
   iv. Modifying the rates.
d. Supervision of the operation of the tests;
   i. Making go/no go decision on whether the test will be run;
   ii. Determining the tests to be run from the Test Plan (ATTACHMENT 2);
   iii. Cross out failed tests on the test plan and record the fluid endurance time;
   iv. Determine whether additional tests are required;
   v. Supervise the personnel the computer, weigh scale, and cleaning technicians.

1.2.2 Computer Technician

The Computer Technician shall be trained to complete all of the tasks in Section 1.1.2 including, but not limited to:

a. Set up and repack the computer and all of the peripherals related to the process of collecting rates (weigh scale, cables, printer, etc);
b. Manage the Excel Spreadsheets (ATTACHMENT 11);
c. Printing rate summaries;
d. Measuring rate distribution (once per condition);
e. Measuring continuous rates (plates / stand);
f. Operate the computer that monitors the plate temperature (Trend Reader software), and save the data following each condition with the assistance of the fluid technician; and
g. Be able to complete the forms; complete the General Form For Each Condition (FORM 4), the Chamber Settings For Each Condition (FORM 8).

1.2.3 Weigh Scale Technician

The Weigh Scale Technician shall be trained so as to be able to complete all of the required tasks listed in Section 1.1.3 as well as the following:

a. To manage the rate pan Exit/Entry Rate Management Form (FORM 9);
b. To bring in and take out the fluid collection pans;
c. To be able to record information about stand positions (FORM 2);
d. To be able to assist the Computer Technician to complete the General Form For Each Condition (FORM 4); and
e. To learn how to operate the "Print" function on the scale, each time a pan is weighed and the indicated weight is stable.

1.2.4 Fluid Technician

The Fluid Technician shall be trained to accomplish all of the tasks listed in Section 1.1.4 and the following tasks:

a. To ensure that the fluid temperature is correct prior to the test;
b. To be able to pour the fluid from the barrels into the smaller containers used for the test;
c. To be able to properly pour the fluids onto the test plates;
d. To be competent to clean the test plates as per ATTACHMENT 5;
e. Be able to mix type I fluids to the correct freeze points;
f. To be able to ensure that the temperature loggers are operational;
g. To be able to ensure that the video camera is operational; and
h. Be able to bring in and to take out the rate pans when required.

2. NATURAL SNOW

The personnel requirements for the holdover time tests are as follows: test site leader, end condition tester, meteo tester and video tester (optional).

2.1 PERSONNEL – NATURAL SNOW

2.1.1 Test Site Leader

a. Call personnel to conduct tests;
b. Ensure test site is safe, functional and operational at all times;
c. Supervise site personnel during the conduct of tests;
d. Ensure site is opened and closed properly;

e. Monitor weather forecasts on a daily basis and during test period;
f. Report to project manager on site activities on daily basis;
g. Review data forms upon completion of test for completeness and correctness;
h. Decide what fluids should be tested;
i. Ensure results are reasonable;
j. Ensure all clocks are synchronized at all times;
k. Ensure fluids are available and verify fluids being used for test are correct;
l. Ensure computers are all operational;
m. Ensure electronic data is being collected for all tests;
n. Ensure proper documentation of tapes, diskettes, cassettes;
o. Verify test procedure is correct (e.g. stand into wind); and
p. Ensure all materials are available (pens, paper, batteries, etc.).

2.1.2 End Condition Tester

a. Monitor the progression of failures on the plates;
b. Record end condition times for each crosshair;
c. Communicate to video operator the end condition times;
d. Apply fluids onto test panels;
e. Complete and sign Data Form (FORM 10);
f. Prepare fluids for each test.

2.1.3 Meteo Tester

a. Record meteo for both stands;
b. Rotate and measure plate pan weights;
c. Squeegee plates prior the fluid application;
d. Complete and sign Data Form (FORM 11); and
e. Assist end condition tester when failure times occur quickly.

2.1.4 Video Tester (optional)

a. Sign and fill in cassette #'s, etc. in data form (FORM 11);
b. Video all tests (see procedure);
c. Verify all equipment is on;
d. Document and mark all cassettes used for all electronic equipment;
e. Ensure camera batteries are recharged and available;
f. Ensure lighting is appropriate; and
g. Video fluid application (capture fluid name on container).

2.2 TRAINING – NATURAL SNOW

2.2.1 Test Site Leader

The Test Site Leader will be trained in all the aspects of operations contained in this procedure, including, but not limited to:

a. To ensure test site safety and functionality at all times;
b. To supervise site personnel during the tests;
c. To ensure site is opened and closed properly;
d. To report to project manager on site activities on daily basis;
e. To review data forms upon completion of test for completeness and correctness;
f. To decide what fluids should be tested;
g. To ensure results are reasonable;
h. To ensure all clocks are synchronized at all times; and
i. To ensure electronic data is being collected for all tests.

2.2.2 End Condition Tester

The End Condition Tester shall be trained to accomplish all of the tasks listed in Section 2.1.2 and the following tasks:

a. To monitor the progression of failures on the plates;
b. To record end condition times for each crosshair;
c. To apply fluids onto test panels;
d. To complete and sign Data Form (FORM 10); and
e. To prepare fluids for each test.

2.2.3 Meteo Tester

The Meteo Tester shall be trained to accomplish all of the tasks listed in Section 2.1.3 and the following tasks:

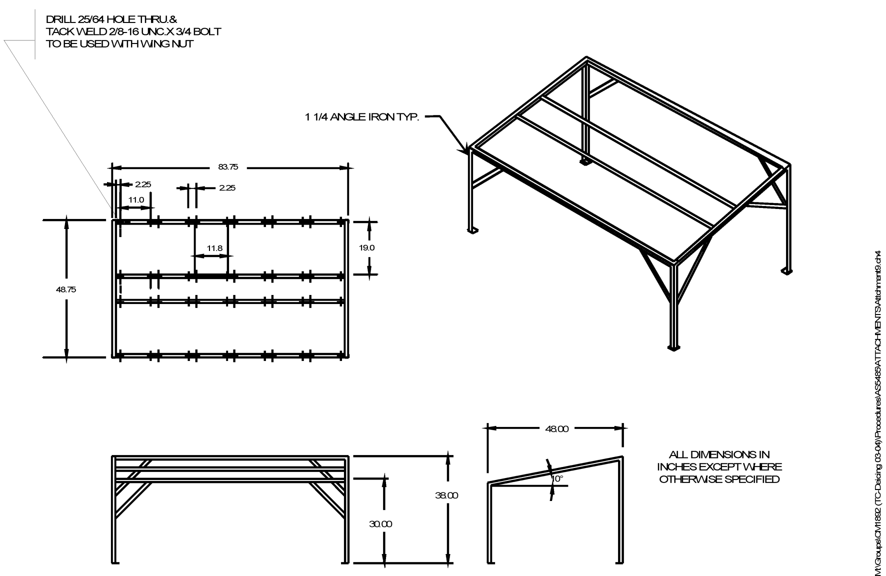
a. To record meteo information;
b. To rotate and measure plate pan weights;
c. To squeegee plates prior the fluid application; and
d. To complete and sign Data Form (FORM 11).

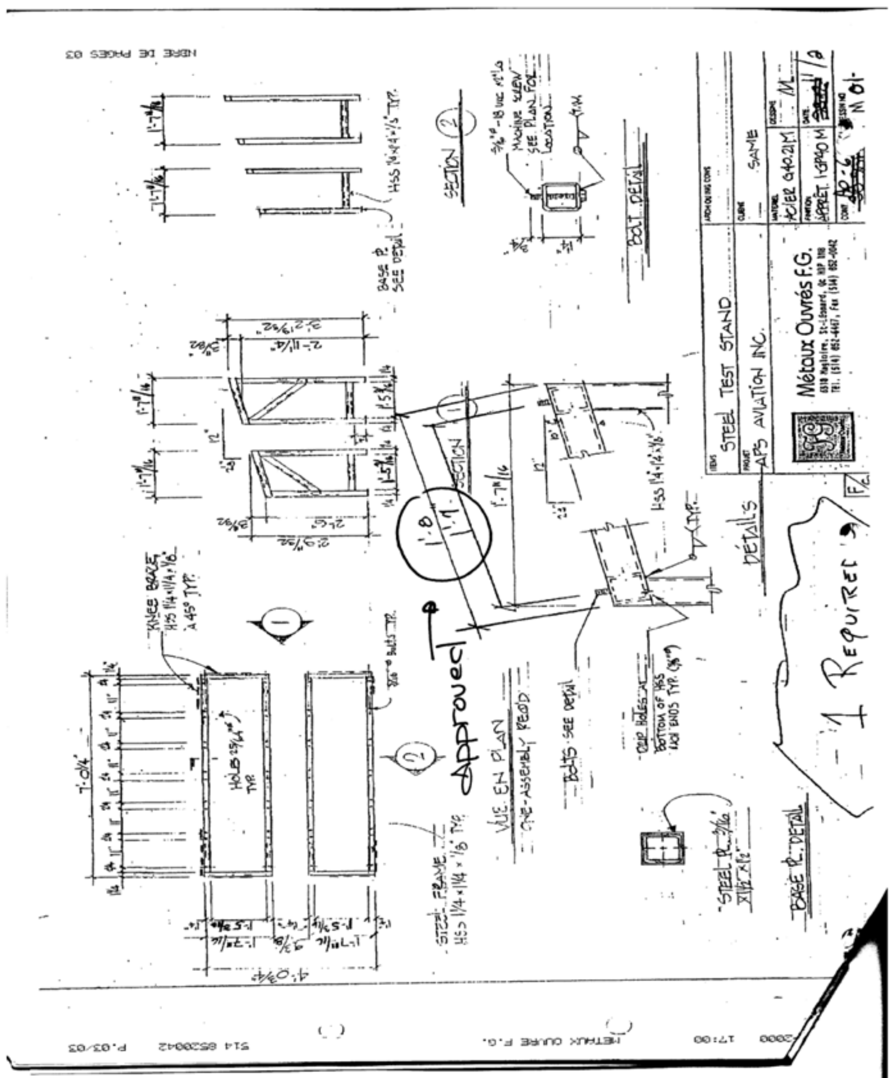
2.2.4 Video Tester (optional)

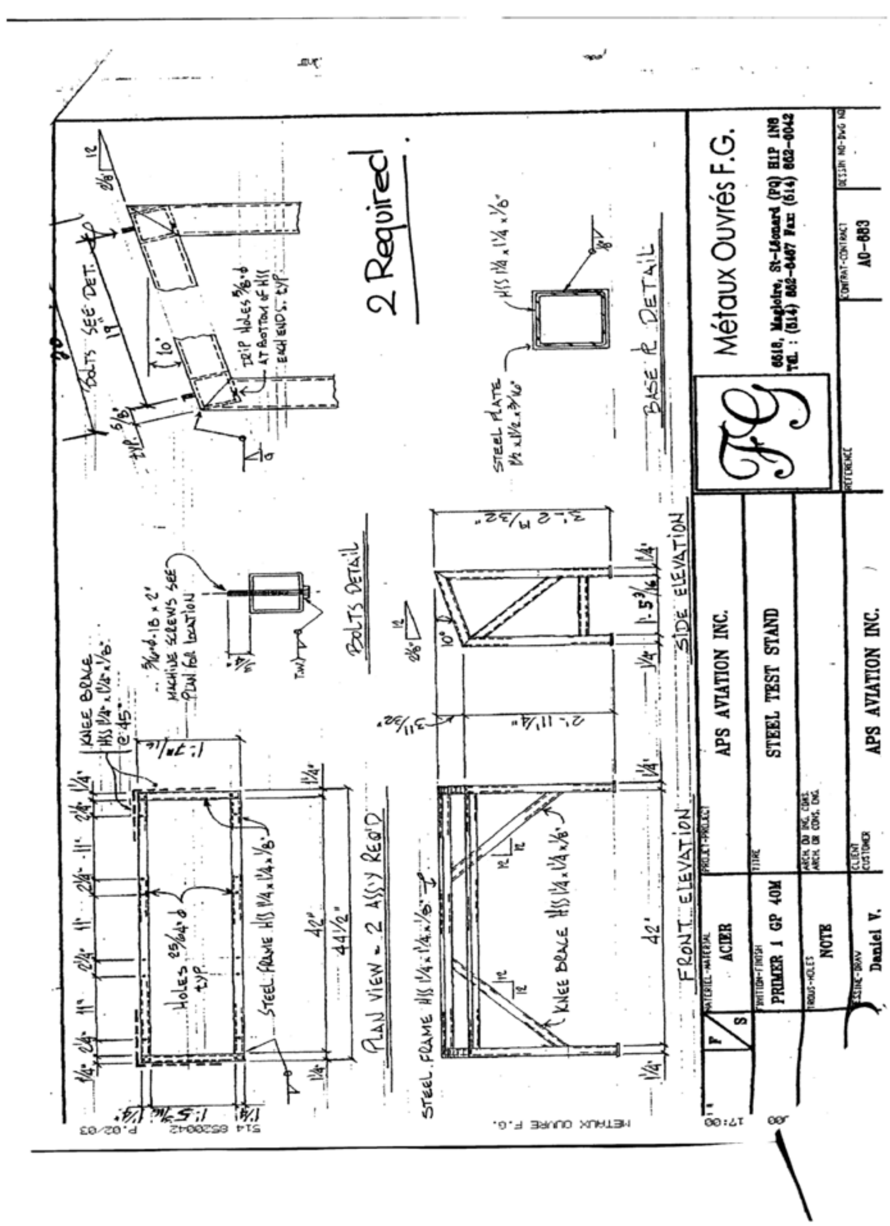
The Video Tester shall be trained to accomplish all of the tasks listed in Section 2.1.4 and the following tasks:

a. To sign and fill in cassette #'s, etc. in data form (FORM 11);
b. To document and mark all cassettes used for all electronic equipment;
c. To ensure lighting does not interfere with testing; and
d. To video fluid application (capture fluid name on container).

ATTACHMENT 9
EXAMPLE OF TEST STAND



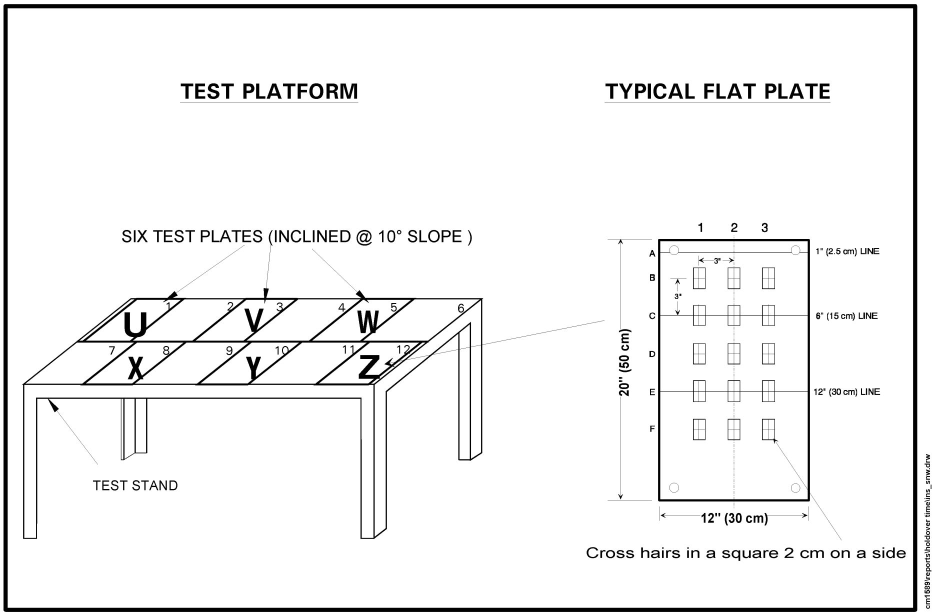

STEEL TEST STAND
APS AVIATION INC.
Métaux Ouvrés F.G.
SAME
SECTION
BOLT DETAIL
DÉTAILS
BASE PL. DETAIL
VUE EN PLAN
Approved
1 REQUIRED


2 Required
PLAN VIEW - 2 ASS'Y REQ'D
FRONT ELEVATION
SIDE ELEVATION
BOLTS DETAIL
BASE PL DETAIL
Métaux Ouvrés F.G.
APS AVIATION INC.
STEEL TEST STAND
ACIER
PRIMER 1 GP 40M
NOTE
Daniel V.
AO-883

ATTACHMENT 10
PROCEDURE FOR MEASUREMENT OF PRECIPITATION RATES AT NRC

A flat plate test set-up is shown in Figure 1.

FIGURE 1



Verify the test schedule and consult the Detailed Test Plan (ATTACHMENT 2) for setup and adjustments required. Prior to the start of the rate collection period, verify that the proper needles and nozzles are installed in the spraying device.

1. Icing Intensity Measurement

Turn on the scale and connect it to the computer. Open the "Excel Spreadsheet" (ATTACHMENT 11). Open the SoftwareWedge program and make sure that the computer has readings from the scale. Create a new folder on the computer for the day's date. Create a new envelope (for each condition), update the day/date/conditions/temperature and have the collection pans ready for calibration. Fill in the Condition Checklist Form, Form 14.

Initially, place ice-catch pans (27.7 cm x 54 cm) on the test plate support at each test location (typically 12 locations). Each pan is marked with a number identifying the collection location on the test plate support. The individual pans are weighed prior to exposure to precipitation and the weights are recorded on the spreadsheet. At the start of the ice-catch period, the exact time (hh:mm:ss) is recorded on the spreadsheet. The pans are then placed on the test plate support for a period of at least 10 minutes. The pans are re-weighed following this period and the ice-catch rate for each pan is calculated (R1).

$$R1 = (W_{a1}-W_{b1})/\text{Area-of-pan}*(T_{a1}-T_{b1})$$

Where:

W_{a1} = weight after of the 1st measurement
W_{b1} = weight before of the 1st measurement
T_{a1} = time at the end of the 1st measurement
T_{b1} = time at the beginning of the 1st measurement

Compare the Ice Catch collection results with the desired Ice Catch Rates. If the rates are not the desired Ice Catch recalibration of water spray is required.

When the rates have been deemed acceptable, the pans are weighed for a second collection period. Then, the pans are placed on the test plate support and the second ice-catch rate is calculated (R2). A fluid test begins following the second ice-catch rate collection period. Following the failure of a test plate, an ice-catch pan placed at the plate location for at least 10 minutes and the third ice-catch rate is calculated (R3). Another ice-catch is done to get a fourth ice-catch rate (R4). More ice-catch runs before or after a fluid test may be performed at the discretion of the experimenter.

The rate of precipitation (icing intensity) for any location on the stand is calculated by averaging at least two rates measured immediately prior to the test (more than 2 rates may be run) and at least two rates measured immediately following the test (more than 2 rates may be run). In order for the test to be valid, the average rate and the standard deviation must be within the limits shown in Table 3 in the body of the procedure.

At the end of the condition fill in the Condition Checklist Form (Form 14).

2. APS Method for Fluid Endurance Time Determination

At a given temperature, two tests are conducted at the lower icing intensity (e.g., FOG –A) and two tests are conducted at the upper icing intensity (e.g., FOG-B). If the endurance time at one of the icing intensities lies outside ± 10 % from the average, two additional tests are run, for a total of 4 data points at that icing intensity. All the data points are used for the regression analysis—no data points shall be rejected.

The endurance times are obtained by producing a best-fit regression curve using a power law transformation based on all the data collected at the lower and upper rates. A minimum of four data points are required to generate the regression curve for any fluid, at least two at each icing intensity.

The equation used to treat the data is as follows:

$$t = cR^{a}$$

where

t = time (minutes)
R = rate of precipitation ($g/dm^2/h$)
a, c = coefficients determined from the regression

The upper and lower fluid endurance time values are determined from the points at which the best-fit curve intersects the lower (e.g., at 2.0 $g/dm^2/h$ for FOG-A) and upper icing intensity (e.g., at 5.0 $g/dm^2/h$ for FOG-B).

3. Continuous Rate Monitoring

During a test, rates are continuously monitored to ensure that icing intensity remains within specification. One continuous monitoring pan is required when conducting 1 to 6 fluid tests, and two continuous monitoring pans are required for 7 to 12 tests. For this purpose, ice collection pans are weighed and placed on each designated location. The continuous monitoring pans are re-weighed at 15-minute intervals during the test and the icing intensity calculated (called RC1 for the first 15 minute interval, RC2 for the second 15 minute interval, etc.). For any given test to be valid, the continuous rates of the selected monitoring position (including R1, R2, all the RCs, R3 and R4 at this position) must be within 1.5 times the standard deviation limits in Table 3 (in the body of the procedure).

For a better understanding on how the process flows, an **EXAMPLE** is shown below:

This is a typical test stand used for the conduct of holdover time tests. Each number represents a test location (plate location) on the test stand. The test is conducted in light freezing rain conditions. The desired rate of precipitation for this run is 25 $g/dm^2/h$.

1	2	3	4	5	6
7	8	9	10	11	12

Prior to the start of the test, collection pans are placed at each of the locations on the stand. Following a collection period, the pans are re-weighed. The following rates were recorded.

Rate collection #1

1 24.5 g/dm^2/hr	2 24.6 g/dm^2/hr	3 24.2 G/dm^2/hr	4 23.9 g/dm^2/hr	5 25.0 g/dm^2/hr	6 26.4 g/dm^2/hr
7 26.2 g/dm^2/hr	8 25.6 g/dm^2/hr	9 25.3 G/dm^2/hr	10 25.1 g/dm^2/hr	11 25.7 g/dm^2/hr	12 26.1 g/dm^2/hr

The rates are deemed to be acceptable, and therefore the pans are immediately returned to the test stand and a second rate collection period is initiated. Following the collection period, the pans are again re-weighed.

Rate collection #2

1 25.1 g/dm^2/hr	2 24.8 g/dm^2/hr	3 24.9 G/dm^2/hr	4 25.9 g/dm^2/hr	5 25.8 g/dm^2/hr	6 25.4 g/dm^2/hr
7 25.9 g/dm^2/hr	8 25.3 g/dm^2/hr	9 25.2 G/dm^2/hr	10 25.0 g/dm^2/hr	11 25.1 g/dm^2/hr	12 26.4 g/dm^2/hr

A calculation of the precipitation rates reveals that the rates are consistent As a result, holdover time tests will be conducted on plates 1, 2, 3, 4, 5, 6, 8, 9, 10 and 11. Collection pans will be re-weighed and placed on locations 7 and 12 in order to provide continuous monitoring of the rates during the test period.

Following the failure of the plates, the collection pans are weighed and once again placed on the test stand at their respective locations. Following the precipitation collection period, the pans are re-weighed.

Rate collection #3 (following plate failure)

1 25.4 $g/dm^2/hr$	2 24.9 $g/dm^2/hr$	3 25.5 $G/dm^2/hr$	4 26.7 $g/dm^2/hr$	5 25.2 $g/dm^2/hr$	6 26.5 $g/dm^2/hr$
7 26.3 $g/dm^2/hr$	8 25.4 $g/dm^2/hr$	9 24.6 $G/dm^2/hr$	10 25.5 $g/dm^2/hr$	11 24.3 $g/dm^2/hr$	12 26.3 $g/dm^2/hr$

The pans are returned to the stand. Following another collection period, they are re-weighed for the final time.

Rate collection #4 (following plate failure)

1 25.2 $g/dm^2/hr$	2 25.7 $g/dm^2/hr$	3 25.1 $g/dm^2/hr$	4 24.3 $g/dm^2/hr$	5 25.7 $g/dm^2/hr$	6 26.9 $g/dm^2/hr$
7 26.7 $g/dm^2/hr$	8 25.4 $g/dm^2/hr$	9 24.6 $g/dm^2/hr$	10 25.5 $g/dm^2/hr$	11 24.3 $g/dm^2/hr$	12 26.3 $g/dm^2/hr$

The rate of precipitation for any location on the stand may be calculated by averaging the four rates obtained for this location. Below are the calculated precipitation rates for the example run.

Average Precipitation Rates

1 25.1 g/dm^2/hr	2 25.0 g/dm^2/hr	3 24.9 g/dm^2/hr	4 25.2 g/dm^2/hr	5 25.4 g/dm^2/hr	6 26.3 g/dm^2/hr
7 26.3 g/dm^2/hr	8 25.4 g/dm^2/hr	9 24.9 g/dm^2/hr	10 25.3 g/dm^2/hr	11 24.9 g/dm^2/hr	12 26.3 g/dm^2/hr

The normal procedure is to conduct two tests at about 25 g/dm^2/hr and two tests at about 13 g/dm^2/hr for light freezing rain. Each of these tests are conducted at the same temperature (i.e. −3°C). The average values obtained for precipitation rate at each position is used for each test. The HOT value at the required precipitation rate (for example at 25 g/dm^2/hr) is obtained by producing a "best fit" regression curve through the points using a "log-log" transformation based on the test points collected at around 13 g/dm^2/hr and 25 g/dm^2/hr. Similarly, the HOT value at 13 g/dm^2/h is obtained using the same curve.

This method is repeated for all other conditions (freezing fog, freezing drizzle and rain on cold soaked wing) and associated temperatures.

ATTACHMENT 11
RATE PROGRAM SPREADSHEET GUIDE

The spreadsheet contains several macros. When run, these macros will create a summary page listing the tests run, the plate number, the four relevant rates, the average and standard deviation of the four rates as well as a calculation of the most extreme rate from the mean value. Space will be available for entering the fluid type and any comments but these will not be entered automatically.

The program is set up so that the main program is run in a normal version of Excel with macros added to perform certain repetitive tasks. As such, since page protection cannot be enabled when a macro is run, any portion of the program can be changed. This allows for new calculations and corrections to be made at any time. It also allows formatting to be changed that would affect the ability of the macro to run. It is important that aspects such as cell locations and page names be kept constant, particularly on the 'output' page.

In order to use the summary macros, a letter "t" (case insensitive) must be entered in the appropriate row in the column titled "RATE" on the individual forms. This is the place where an individual rate would appear. A sample location is marked with a comment on on each form. The summary page can be updated at any time during the day or at the end, after all the results are in.

The macros copy the values from the summary sheets and copy them to an area of hidden cells at the top of the "output" page. They then search for occurrences of the letter "t" in this area. Due to limitations on the acceptable length of macros within Excel, each macro deals with only four forms with the first two forms (used for calibration) being omitted. When an instance of "t" is found, the plate number, the two previous and two following rates are pasted into the next row of the summary page. Formulas in the page then calculate the average, standard deviation and most extreme value from the average rate. Links in the page update the date and chamber conditions provided those facts are changed on other pages. If new calculations are to be added, this should be done by means of additional columns in the output table.

Correcting errors

There are two possible types of errors:

The first involves a miscalculation or typing error that causes a single rate value to be in error. If this happens, the value should be changed at the location of the error either immediately or later when the error is found. The next time the summary macros are run, the error will be corrected on the summary sheet.

Since when the macros are run, they review all the values, if the macro for a certain form is run twice, some tests could be entered in duplicate. It is suggested that while the page can be updated throughout the day for use with other projects, at the end of the day, the page should be cleared using 'clear page' and then the values should be re-entered. This should not take more than a minute at the end of the day.

The second error concerns an abnormal number of rates being run between tests. If less than two previous and two following rates are performed, the macros will paste the value in the previous and following cells to the summary sheet. If the space is blank or contains another test, the statistics will ignore them in the calculations. If more than 4 rates are completed, the macros will only account for the closest four. An area has been provided at the bottom of the "output" page for values to be entered manually. If an account is to taken for more than four rates, the values should be entered here.

Instructions for use have been included as a comment in cell B1 on the "output" page.

Also included is an average and standard deviation calculation to the summary pages and each form that will be printed each time a set of tests is run.

ATTACHMENT 12
COLD SOAK BOX PREPARATION PROCEDURE

EXAMPLE

1. Put containers (20 l) of CSW box fluid (propylene 65/35) in cold (-30 ± 5°C) freezer overnight. Freezers to be kept in large end of the chamber.

2. Put all filled CSW boxes in warmer (-11 ± 1°C) freezer overnight.

3. Next morning, if freezer in step (2) does not provide fluid and box temperature of -11 ± 1°C, then empty boxes in pail and achieve fluid at -12 ± 1°C in pail.

4. Prepare step (3) in corner of large chamber that is at + 1°C; ensure boxes are cooled to about -11°C. Go to step (6).

5. After first series of tests, empty fluid from boxes into separate pail. Put empty boxes in freezer to keep cool at -11 ± 2°C.

6. Prepare fluid to -12 ± 1°C by mixing (use small amounts of hot water and/or cold fluid). Agitate fluid mixture frequently.

7. Fill boxes, ensure -11 ± 1°C on surface of box. This process shall be done while rates are being measured.

8. Position on stand with cover, but no insulation on top surface. Connect thermocouples.

9. Allow warming to -10 ± 0.5°C. This process needs monitoring with rates measurement to not overshoot temperature (place insulation on top surface if required).

10. Start test.

11. At end of test, remove box from stand, measure rates, and go to step (5).

The process shall be managed as per Figure 1.

FIGURE 1
CSW PROCESS MANAGEMENT FORM

1	2	3	4	5
6	7	8	9	10

1. A typical box position can be in one of the following stages:
   - Rate
   - Not used
   - Available for test (approx. Rate)
   - Warming
   - Test
2. Denote the stage in the appropriate square

1. LIST OF CALIBRATION INSTRUCTIONS

This is only included for the purpose of having a complete procedure. The most recent calibration instructions are located at the APS office.

Date: January 15, 2004

CALIBRATION INSTRUCTION “C”

Calibration Procedure for WAHL Hand-Held Digital Thermometer

1. Use calibration attachment to calibrate.
2. Plug in attachment and note attachment dial position.
3. Confirm that temperature reading is the same as the dial, after obtaining a stabilized reading.
4. Repeat for all dial settings.
5. If readings vary more than +/- 0.5 ° C return unit to manufacturer for repair.

CALIBRATION INSTRUCTION "D"

Calibration Procedure for all Immersion and Surface Temperature Probes

1. Prepare an ice bath (An ice bath consists of a half water and half crushed ice mixture in a thermally insulated container. Stir the water ice mixture continuously for 1 minute to assure good temperature distribution).
2. Submerse the probe to be calibrated and a minimum of two thermistor probes into the ice bath.
3. Allow temperature reading to stabilize (about 30 seconds).
4. Confirm that the temperature readings from all the probes are 0°C ± 0.5 (if all are not within tolerance, discard the ice bath and restart the process; if only the temperature reading for the probe being calibrated is not within tolerance, return the temperature probe to the manufacturer).

CALIBRATION INSTRUCTION "E"

Calibration Procedure for Sartorius Balance 0.2g

Method 1

1. Obtain two (2) known weights, a 2g and a 100g weight which have traceable documents of calibration and a calibration tolerance of equal or better accuracy that 0.2g.
2. Level and zero the balance.
3. Place the 2g/100g weight on the balance.
4. Confirm the balance reading is within ±0.3g of the known weight used.

   e.g. Know weight readings 2.003g/ 100.053g

   Acceptable balance readings
   should be within: 2.303g to 1.703g
   100.353g to 99.753g
5. Repeat steps 2 to 4 for a second confirmation, for the weight used. Record these repeat test values only if they differ from the first weights.
6. If tolerances are exceed on two consecutive trials, return the balance to the manufacturer for calibration.

Method 2

1. Obtain two (2) known weights, a 2g and a 100g weight.
2. Confirm the known weight reading: use a balance with a readability of equal or better accuracy than 0.2g.
3. Level and zero the Sartorius weigh scale.
4. Place the 2g/100g weight on the balance.
5. Confirm the balance reading is within ± 0.3g of the known weight used.

   e.g. Know weight readings 2.003g/ 100.053g

   Acceptable balance readings
   should be within: 2.303g to 1.703g
   100.353g to 99.753g
6. Repeat steps 3 to 5 for a second confirmation, for the weight used. Record these repeat test values only if they differ from the first weights.
7. If tolerances are exceed on two consecutive trials, return the balance to the manufacturer for calibration.

CALIBRATION INSTRUCTION "G"

Calibration Procedure for Free Thermistors

1. Prepare an ice bath (An ice bath consists of half water and half crushed ice mixture in a thermally insulated container. Stir the water ice mixture continuously for 1 minute to assure good temperature distribution).
2. Submerse a minimum of three probes into the ice bath.
3. Allow temperature reading to stabilize for 30 seconds.
4. Confirm that the temperature readings of all the probes are 0° C ± 0.5 (If all are not within tolerance, discard the ice bath and restart process; if only the temperature reading of 1 probe is not within tolerance, discard probe.

CALIBRATION INSTRUCTION "H"

Calibration Procedure for Imbedded Plate Thermistors and Thermocouples

1. Expose two plates indoor, each with two imbedded thermistors or thermocouples, to ambient air (not under direct lighting or sun).
2. Allow plate temperatures & reading to stabilize.
3. Confirm that all temperature readings are recording and the tolerance will be ±0.8°C from the average of the four readings (If a temperature reading is not within this tolerance, discard the temperature probe).
4. Note the (minimum 4) temperature probe readings, if all (minimum 4) are not within tolerance, re-evaluate set-up and redo the procedure.
5. If second trial, again does not show correlation between the (minimum four) temperature probe readings and the tolerances, discard probes.

CALIBRATION INSTRUCTION "J"

Calibration Procedure for Denver (NCAR) Balance 0.1g

Method 1

1. Obtain two (2) known weights, a 2g and a 100g weight which have traceable documents of calibration and a calibration tolerance of equal or better accuracy that 0.1g.
2. Level and zero the balance, with the NCAR test bucket.
3. Place the 2g/100g weight on the balance.
4. Confirm the balance reading is within ±0.2g of the known weight used.
   e.g. Know weight readings 2.003g/ 100.057g
   Acceptable balance readings should be within 2.203g to 1.803g
   100.257g to 99.857g
5. Repeat steps 2 to 4 for a second confirmation, for the weight used. Record these repeat test values only if they differ from the first weights.
6. If tolerances are exceed on two consecutive trials, return the balance to the manufacturer for calibration.

Method 2

1. Obtain two (2) known weights, a 2g and a 100g weight.
2. Confirm the known weight reading: use a balance with a readability of equal or better accuracy than 0.1g.
3. Level and zero the balance, with the NCAR test bucket.
4. Place the 2g/100g weight on the balance.
5. Confirm the balance reading is within ± 0.2g of the known weight used.
   e.g. Know weight readings 2.003g/ 100.057g
   Acceptable balance readings should be within 2.203g to 1.803g
   100.257g to 99.857g
6. Repeat steps 3 to 5 for a second confirmation, for the weight used. Record these repeat test values only if they differ from the first weights.
7. If tolerances are exceed on two consecutive trials, return the balance to the manufacturer for calibration.

CALIBRATION INSTRUCTION "U"

Calibration Procedure For Digital Clock

Method 1

1. Have the digital clock recalibrated by Manufacturer.

Method 2

1. Set the clock to atomic time. Take the atomic time from the following Internet address: www.time.gov;
2. If in a 24-hour period the time deviation between the atomic time and the digital clock time is greater than ±5 seconds send the clock for calibration according Method 1.

CALIBRATION INSTRUCTION “W”

Calibration Procedure For RH/Temperature Sensor

1. Have the RH/temperature sensor recalibrated by Manufacturer.

2. LIST OF VERIFICATION INSTRUCTIONS

The following pages contain the verification instructions as follows:

VERIFICATION PROCEDURE "E-VERIF"

Verification Procedure for Sartorius HOT Balance 0.2g

Verification should be done before each new session.

1. Place the balance in the work environment.
2. Level the balance.
3. Turn the balance on. Wait 30 minutes for warm-up.
4. Tare the balance. Ensure a zero 0.0g reading is displayed.
5. Put one white ice-catch pan on the scale and record the value.
6. Place the known weight (2g) on the ice-catch pan and record the value.
7. The shown value should be between 1.8 and 2.2 above the value recorded at step 5 (ice-catch pan weight).
8. Remove the known weight from the ice-catch pan.
9. Place the known weight (50g) on the ice-catch pan and record the value.
10. The shown value should be between 49.8 and 50.2 above the value recorded at step 5 (ice-catch pan weight).
11. If readings do not correspond, go thru calibration instructions "E"of the APS Calibration Plan, to confirm the balance out of calibration situation.
12. If the scale is still off, it should be sent for calibration.

VERIFICATION PROCEDURE “J-VERIF”

Verification Procedure for NCAR Balance 0.1g

Verification should be done before each new session.

1. Place the balance in the work environment.
2. Level the balance.
3. Turn the balance on. Wait 30 minutes for warm-up.
4. Tare the balance. Ensure a zero 0.0g reading is displayed.
5. Put one white ice-catch pan on the scale and record the value.
6. Place the known weight (2g) on the ice-catch pan and record the value.
7. The shown value should be between 1.9 and 2.1 above the value recorded at step 5 (ice-catch pan weight).
8. Remove the known weight from the ice-catch pan.
9. Place the known weight (50g) on the ice-catch pan and record the value.
10. The shown value should be between 49.9 and 50.1 above the value recorded at step 5 (ice-catch pan weight).
11. If readings do not correspond, go thru calibration instructions “J”of the APS Calibration Plan, to confirm the balance out of calibration situation.
12. If the scale is still off, it should be sent for calibration.

PROCEDURE:
DETERMINATION OF ENDURANCE TIMES OF TYPE I FLUIDS UNDER NATURAL SNOW PRECIPITATION AT DORVAL

CM2103.001 (07-08)

EXPERIMENTAL PROGRAM

DETERMINATION OF ENDURANCE TIMES OF TYPE I FLUIDS UNDER NATURAL SNOW PRECIPITATION AT DORVAL

Winter 2007-08

Prepared for

Transportation Development Centre
Transport Canada

Prepared by: John D'Avirro

Reviewed by: John D'Avirro

APS Aviation Inc.

December 14, 2007
Version 1.0

EXPERIMENTAL PROGRAM
DETERMINATION OF ENDURANCE TIMES OF TYPE I FLUIDS
UNDER NATURAL SNOW PRECIPITATION AT DORVAL
Winter 2007-08

1. BACKGROUND

From the early 1990s, the Type I fluid holdover time range for snow conditions was 6 to 15 minutes. Based on a series of SAE Type I fluid endurance time trials on flat plates conducted in the 1999-2000 winter and discussions at a SAE G-12 Holdover Time Subcommittee meeting held in Toulouse, France in May 2000, the holdover times for snow were reduced to values significantly shorter than 6 to 15 minutes. The reduction in fluid endurance times coincided with the general realization that the test methodology was suspect.

As a result, APS was directed to develop a test protocol for measuring endurance times for SAE Type I fluids that would reflect real field operations. Following examination of several test surfaces and various procedures for fluid application, it was concluded that an insulated 7.5 cm cold-soak box, empty, when treated with 0.5 L of fluid at 60ºC, was found to be a reasonable representation of the temperature decay rate demonstrated by wings in natural outdoor conditions. The fluid was applied along the top edge of the test surface using a specially designed 12-hole fluid spreader.

In the winter of 2001-02, a series of natural snow tests was conducted at Dorval Airport and at Chicoutimi, Quebec using the newly developed Type I protocol. Based on these tests, holdover time tables were produced and presented to the industry at the SAE G-12 Holdover Time Subcommittee meeting in Frankfurt, Germany in June 2002. A full account of these tests can be found in TP 13994E, *Generation of Holdover Times Using the New Type I Fluid Test Protocol*, November 2002.

2. OBJECTIVES

The objective of this project is to ensure that new Type I fluids do not behave inferior, from an endurance time perspective, to the fluids used to generate the currently accepted values in the holdover time table.

To achieve this objective, a series of tests will be conducted using new SAE Type I fluids, on the empty aluminum box surfaces.

3. PURPOSE

As stated in the objective, this project is to ensure new Type I fluids have endurance times greater than or equal to currently accepted holdover times. ARP 5945 describes procedures to carry out Type I tests in natural snow. While these tests are material, the tester cannot determine early on whether the fluid has reasonable performance or not.

This document describes additional tests that provide this missing information during testing. Comparing the new fluid, on a side-by-side basis, with a "grandfather" provides ongoing analysis of the performance of the new fluid,

4. PROCEDURE/TEST REQUIREMENTS

The 7.5 cm cold-soak box, insulated on all sides but the top, empty, will be used as the test surface for the outdoor tests.

The fluid temperature will be 60ºC with an acceptance range of +2ºC and -0ºC. The fluid quantity will be 0.5 L, and the fluid will be applied on the surface through a 12-hole spreader. The fluid used will be diluted to a freeze point 10ºC below ambient temperature, unless otherwise specified by the fluid manufacturer.

For this experiment, two cold-soak boxes will be placed on the stand at the same time. In an attempt to keep the precipitation rate and temperature as constant as possible, the new fluids and the reference fluid will be run simultaneously. At least 20 tests will be conducted.

The tests will be conducted until the last fluid on the stand fails, and repeated following the same procedure.

In order to have a more accurate representation of the holdover time obtained in real field deicing operations, the trials need to be performed at different temperatures and rates, over several snowstorms.

The steps to be followed in conducting these tests are:

1. Synchronize computer and test clocks to atomic clock;
2. Follow standard procedures for ET tests except as described below;
3. Prepare surfaces on the stand in accordance with Table 3.1;
4. Prepare fluid (Section 4.2) for testing. The types of surfaces, positions and fluid amounts to be tested are shown in Table 3.1;

Table 3.1

Test Stand Positions

STAND POS.	SURFACE TYPE	FLUID AMOUNT (L)	FLUID TEMP (°C)	Fluid Conc.	Fluid Type
1	RATE PAN				
2	7.5 cm box (empty)	0.5	60	10° Buffer	Battelle D3 ADF Type I
3	7.5 cm box (empty)	0.5	60	10° Buffer	Reference Fluid (E or P)*

* E – Ethylene (UCAR EG ADF)
P – Propylene (PG ADF)

5. Pour required amount of heated fluid into thermos containers for application;

6. Apply the fluid to the cold-soak boxes on the stand. Pour the fluid on the test surfaces in quick succession to avoid cooling of the spreader between pours. The spreader is modified (taped) to allow fluid to come out through only 12 holes. Just before pouring, the box surfaces should be cleaned according to the following procedure:

   - Clean the surface of all contamination with scraper and squeegee; and
   - Whenever surface wetting is found to be deficient, a clean wiper cloth with fluid at ambient temperature can be used to wipe the plate over its entire surface. (This is intended to ensure that the surface is wetted as well as clean, to assist in complete coverage with the applied fluid.)

7. Standing behind the stand, place a shield device to deflect the air and pour the test fluid from the thermos into the spreader. Remove the shield when the spreader has emptied;

8. Determine failure times on test surfaces, and record using standard ET data forms (Attachment I);

9. Measure precipitation rates and record using the Meteo/Plate data form (Attachment II); and

10. Record rates. As per Table 3.1, position 1 on the stand will be used for measuring snow deposition rates. Use two rate pans in a 5 minute routine. At the time that a measurement is required, the pan that needs to be weighed will be replaced on the stand by the other pan. This cycle will continue until the last surface failed. While pouring the fluid on the test surfaces care should be taken that no contamination falls in the rate pans (use a shield device if necessary). The bottom and sides of the pan MUST BE WETTED (before each pre-test weighing) with Type IV anti-icing fluid to prevent blowing snow from escaping the pan.

5. EQUIPMENT AND FLUIDS

5.1 Equipment

Use the same equipment that is used for ET trials. Candidate test surfaces used for these trials will be:

- Two 7.5 cm cold-soak boxes (empty)

A wind shield and fluid spreader device will be used for applying fluids.

5.2 Fluids

Tests shall be conducted with the following Type I fluids:

- Battelle D3 ADF Type I; and
- PG ADF or UCAR EG ADF (reference fluid).

Fluids are to be mixed to a freeze point 10ºC below OAT. The dilution table for these three fluids is presented in Attachment III.

Fluids to be applied to the cold soak box test surfaces will be heated to 60ºC.

6. PERSONNEL

Three technicians are needed to conduct the tests:

- First calls failures, prepares fluid samples;
- Second helps prepare and pour fluids; and
- Third measures rates and wind.

7. DATA FORMS

Use end condition forms from standard Endurance Time procedure (Attachment I). For rate measurements, see Attachment II.

DETERMINATION OF ENDURANCE TIMES OF TYPE I FLUIDS UNDER NATURAL SNOW PRECIPITATION AT DORVAL

ATTACHMENT I
END CONDITION DATA FORM

REMEMBER TO SYNCHRONIZE TIME WITH ATOMIC CLOCK - USE REAL TIME

VERSION 1.0 Winter 2002/2003

LOCATION: DORVAL TEST SITE DATE: RUN #: STAND # :

LOCATION OF SURFACES ON THE STAND

Rate Pan	ColdSoak BOX	ColdSoak BOX	ColdSoak BOX	ColdSoak BOX
1	2	3	4	5

OTHER COMMENTS (Fluid Batch, etc):

FAILURES CALLED BY : PRINT ______ SIGN ______

*TIME (After Fluid Application) TO FAILURE FOR INDIVIDUAL CROSSHAIRS (hr:min)

Time of Fluid Application: ______ hr:min:ss ______ hr:min:ss ______ hr:min:ss

	BOX ____			BOX ____			BOX ____		
FLUID NAME									
B1 B2 B3									
C1 C2 C3									
D1 D2 D3									
F1 F2 F3									
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA									
CALCULATED FAILURE TIME (MINUTES)									
BRIX / FLUID TEMPERATURE AT START	/			/			/		

Time of Fluid Application: ______ hr:min:ss ______ hr:min:ss ______ hr:min:ss

	BOX ____			BOX ____			BOX ____		
FLUID NAME									
B1 B2 B3									
C1 C2 C3									
D1 D2 D3									
E1 E2 E3									
F1 F2 F3									
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA									
CALCULATED FAILURE TIME (MINUTES)									
BRIX / FLUID TEMPERATURE AT START	/			/			/		

Cm1747\Procedures\Type I protocol\Type I ET\Attachment I

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Version 1.0,December 07

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DETERMINATION OF ENDURANCE TIMES OF TYPE I FLUIDS UNDER NATURAL SNOW PRECIPITATION AT DORVAL

ATTACHMENT II
METEO/PLATE PAN DATA FORM

REMEMBER TO SYNCHRONIZE TIME WITH ATOMIC CLOCK - USE REAL TIME

VERSION 1.0 Winter 2002/2003

LOCATION: DORVAL TEST SITE DATE: RUN # : STAND # :

PLATE PAN WEIGHT MEASUREMENTS

PAN #	t TIME BEFORE (hh:mm:ss)	BUFFER TIME (Seconds)	t TIME AFTER (hh:mm:ss)	BUFFER TIME (Seconds)	w WEIGHT BEFORE (grams)	w WEIGHT AFTER (grams)	COMPUTE RATE (Δw*4.7/ Δt) (g/dm^2/h)

Precipitation rate will be measured every 5 minutes.

METEO OBSERVATIONS *

TIME (hr:min)	TYPE ZR, ZLS, SG IP, IC, BS, SP	SNOW CLASSIF. (See Fig. 3)

*observations at beginning, end, and every 5 min. intervals. Additional observations when there are significant changes.

Cm1747\Procedures\Type I protocol\Type I ET\Attachment 2

COMMENTS : ______________________

PRINT SIGN

WRITTEN & PERFORMED BY : ____________ ____________

PHOTO BY : ____________ ____________

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Version 1.0,December 07

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ATTACHMENT III
FLUID DILUTION FOR TYPE I TESTING

OAT (°C)	FFP (°C)	Octagon Octaflo / EF				UCAR ADF (EG)				Battelle D3 1006A			
		% Glycol	Brix	Glycol for 8 Litres	Water for 8 Litres	% Glycol	Brix	Glycol for 8 Litres	Water for 8 Litres	% Glycol	Brix	Glycol for 8 Litres	Water for 8 Litres
5	-5	15	9.75	12.0	6.8	12	8	1.0	7.0				
4	-6					14.5	9.5	1.2	6.8	20	14.75	1.6	6.4
3	-7					16	10.5	1.3	6.7	25.9	18.50	2.1	5.9
2	-8					18.5	12	1.5	6.5	28	20	2.24	5.76
1	-9	27.5	18.5	2.2	5.8	21.5	13.5	1.7	6.3	29	21.25	2.32	5.68
0	-10	29	19	2.3	5.7	22	14	1.8	6.2	30	22.75	2.4	5.6
-1	-11	30	20	2.4	5.6	23	15	1.8	6.2	33	24	2.64	5.36
-2	-12	31	20.5	2.5	5.5	24.5	16	2.0	6.0	35	25.5	2.8	5.2
-3	-13	32	21.25	2.6	5.4	26	17	2.1	5.9	37	26.75	2.96	5.04
-4	-14	34	22.5	2.7	5.3	28	18	2.2	5.8	38	28	3.04	4.96
-5	-15	35	23	2.8	5.2	30	19	2.4	5.6	39	29	3.12	4.88
-6	-16	36	23.5	2.9	5.1	31	19.75	2.5	5.5	40	29.75	3.2	4.8
-7	-17	37	24	3.0	5.0	32	20.5	2.6	5.4	44	31.5	3.52	4.48
-8	-18	38.5	25	3.1	4.9	33.5	21.25	2.7	5.3	45	32.5	3.6	4.4
-9	-19	40	26	3.2	4.8	34.5	21.75	2.8	5.2	47	33.75	3.76	4.24
-10	-20	42	27	3.4	4.6	36	22.5	2.9	5.1	48	34.75	3.84	4.16
-11	-21	44	28	3.5	4.5	37	23	3.0	5.0	49	35.75	3.92	4.08
-12	-22	45	28.5	3.6	4.4	38	23.75	3.0	5.0	50	36.5	4	4
-13	-23	46	29	3.7	4.3	39	24.5	3.1	4.9	52	37.5	4.16	3.84
-14	-24	47	29.5	3.8	4.2	40	25	3.2	4.8	53	38.5	4.24	3.76
-15	-25	47.5	30	3.8	4.2	41	25.5	3.3	4.7	54	39.5	4.32	3.68
-16	-26	48.5	30.5	3.9	4.1	42	26	3.4	4.6	55	39.5	4.4	3.6
-17	-27	49	31	3.9	4.1	43	26.5	3.4	4.6	57	41	4.56	3.44
-18	-28	50	31.5	4.0	4.0	44	27	3.5	4.5	58	41.75	4.64	3.36
-19	-29	51	32	4.1	3.9	45	27.5	3.6	4.4	60	42.25	4.8	3.2
-20	-30	52	32.5	4.2	3.8	45.75	28	3.7	4.3	61	43	4.88	3.12
-22	-32	53.5	33.5	4.3	3.7	47	28.75	3.8	4.2	62	44.25	4.96	3.04
-25	-35	56	34.5	4.5	3.5	49	30	3.9	4.1	65	46	5.2	2.8
-30	-40	60	37	4.8	3.2	53	32	4.2	3.8	70	48.25	5.6	2.4

PM2020 (TC-Deicing 05-06)\Procedures\Type I ET\Fluid Dilution for Type I Testing

PROCEDURE:
ENDURANCE TIME TESTING IN FROST WITH TYPE I, II, III AND IV FLUIDS

CM1892.001

EXPERIMENTAL PROGRAM
ENDURANCE TIME TESTING IN FROST WITH TYPE I, II, III AND IV FLUIDS

2003-04

Prepared for

Transportation Development Centre
Transport Canada

for Prepared by: Nicoara Moc

Reviewed by: John D'Avirro

November 13, 2003
Version 1.0

EXPERIMENTAL PROGRAM
ENDURANCE TIME TESTING IN FROST WITH TYPE I, II, III AND IV FLUIDS

Winter 2003-04

1. BACKGROUND

This project has been developed to substantiate the HOTs in frost conditions of Type I, Type II, Type III and Type IV fluids.

The SAE G–12 HOT Subcommittee determined the need to test fluids for frost endurance time. During winter 1999-00, APS conducted preliminary calibration tests in simulated frost conditions at the Institut de Recherche d'Hydro–Québec (IREQ) cold chamber in Varennes.

The tests showed that the environmental conditions specified in AS 5485 were not appropriate for producing the required frost rates, and that further research was necessary. The objective of the subsequent research was to establish test parameters that reflect natural environment conditions for active frost and to document rates of natural frost accretion to enable specifying frost intensity rates for fluid endurance testing in a laboratory.

The research program documented wing–to–air temperature differential (delta T) over a range of temperatures. Historical weather data was reviewed to ascertain a range of values for relative humidity (RH) typically experienced during frost conditions in nature. A field test was conducted on an operational aircraft in natural frost conditions. This test enabled selection of a test surface representative of aircraft surfaces for frost generation purposes. The test also showed that heated Type I fluids enriched substantially after application on the wing due to the evaporation of water from the water/glycol mix. The fluid enrichment contributed greatly to the fluid endurance time, and it was concluded that laboratory test procedures must be redesigned to include this feature. Field measurements of on–wing fluid enrichment following actual frost sprays were conducted.

Frost rates were measured during both winter seasons over a range of conditions and temperatures. Endurance times for Type I fluid were measured in natural frost conditions. All of the times measured exceeded the current HOT values.

From the consolidated data collected over two seasons, a new set of laboratory test parameters for Type I, Type II, Type III and Type IV fluids was recommended.

Based on the findings of the natural frost endurance tests on SAE Type I Fluid, different approaches were considered for finalizing the test process for these fluids. These alternative recommendations were presented at a meeting of the SAE G–12 HOT working group, September 03-04, 2003. The recommendation agreed upon was to supplement the current endurance time data base developed from tests in natural conditions by additional low–cost field tests during the 2003-04 winter, with attention given to testing in mild conditions when high frost intensity rates may occur.

Similar to the potential alternatives discussed for SAE Type I Fluid, different approaches were considered for finalizing the test process for Type II and IV Fluids. The approach agreed upon at the meeting was to substantiate the current frost HOT values through a series of one–time tests, in natural frost. Low–cost testing would be conducted in natural conditions.

2. OBJECTIVES

The objective of this procedure is to substantiate the current frost HOT values for Type I, II, III and IV fluids. To achieve this objective a series of endurance time tests will be conducted in natural frost conditions at the APS test site during the 2003-04 winter. Testing will be conducted overnight during suitable frost conditions with representative Type I, II, III and IV fluids, both ethylene and propylene based. Tests shall be conducted over extended frost forecast periods with all dilutions. Tests on seven nights are anticipated. One run of tests would involve the use of about 12 plates run simultaneously.

Type I endurance time testing in frost will be conducted with attention given to testing in mild conditions when high frost intensity rates are more predominant. The desired relative humidity for this purpose is 80% and above. Data on test surface temperature, ambient temperature and relative humidity will be collected simultaneously.

3. TEST REQUIREMENTS

The following data are to be collected throughout the test session:

a) OAT using three thermistor probes installed in a Stevenson radiation shield attached to the 2–position stand (see Figure 1), and linked to a thermistor logger; and

b) Test surface temperature using a thermistor probe installed on the test plate surface and rate–measuring surface, and linked to a thermistor logger.

A printout of the Environment Canada Weather Trends for the test location covering the test session period (Attachment C) is to be attached to the data sheet. This will provide a record of wind and sky condition, and weather data. The website for Montreal is:

http://weatheroffice.ec.gc.ca/forecast/24_hour_conditions_e.html?yul&unit=m

As a backup, an alternative method for measuring frost accumulation, outside air temperature and relative humidity can be implemented using the Campbell Scientific system. Using this setup, frost accumulation data from an electronic balance with a digital output, and OAT and RH from the Vaisala meter are recorded by a CR10X datalogger.

The white–painted aluminum test plate will be used as a frost–collecting surface as it has been shown to be a good representation of fluid–covered aircraft wings, for frost generation purposes.

4. PROCEDURE

Two procedures are provided below:

a) Frost rate data collection, and
b) Fluid endurance tests in frost.

4.1 Procedure for Frost Data Collection

1) Monitor weather forecasts to select a time for testing. The ideal conditions for the development of frost are:
   a) OAT near or below 0°C
   b) Less than 10 km of wind; and
   c) Clear sky overnight.
2) At the beginning of the data gathering session:
   a) Ensure the test surface is clean;
   b) Clear the data logger and ensure that new data is logging. Synchronize time on all data collection devices. Label loggers and computer files indicating date of test;
   c) Initiate the data sheet, recording times when the loggers have been cleared and reset (see Attachment B); and
   d) Zero the scale and record the time on the data sheet.
3) At 30–minute intervals, record data as follows:
   a) Verify the surface temperature from the real time readings displayed on the computer screen, prior to removing the plate from the stand for weighing;
   b) After recording the surface temperature, reweigh the test surface, recording weight and time; and

c) The two surfaces collecting frost will be used in a staggered routine.

4) Every 2 or 3 hours, depending on the frost rate, the surface collecting frost should be replaced by a clean surface that was maintained at ambient temperature.

5) At the end of the data gathering session:

a) Download the data from data logger to the PC, and check to ensure that data is saved. Label files indicating date of test;

b) Provide a copy of data files (by diskette or e–mail) to APS for project record where they will be saved to the network;

c) Download the Environment Canada Weather Trend for the data collection period, print a copy and attach it to the data sheet. Forward a copy from the website to APS for project record;

d) Complete the data sheet (see Attachment B); and

e) A complete set of test records for each session includes:

- Computer files of downloaded surface temperature logger data;
- Completed data sheets (Attachment B); and
- Printed copy of the Environment Canada Weather Trend.

4.2 Procedure For Fluid Endurance Tests

Tests will be conducted on white–painted aluminum test surfaces, mounted at a 10º slope on a test stand. Each test surface will have a thermistor probe installed at the 15 cm line, inset 1/3 of the width. The test stand is to be located near the frost rate test setup, as shown in Figure 1.

The temperature channels of the three data loggers used for testing will be labelled in the computer according to the *italic characters* shown in Figure 1.

As mentioned in Section 2, testing will be conducted with representative Type I, II, III and IV fluids, both ethylene and propylene based. Tests on seven nights are anticipated. One run of tests would involve the use of all 12 plates simultaneously. Type I endurance time testing in frost will be conducted with attention given to testing in mild conditions when high frost intensity rates are more predominant. It is recommended that about 15 Type I tests be conducted during several sessions. SAE Type I fluid, EG and PG–based, will be applied at 20ºC with the standard 12–hole spreader. Fluids will be mixed to a 10ºC freeze point buffer, and the quantity will be 0.5 L. Fluid strength will be measured and recorded on the fluid dilution data form (Attachment D). The brix value will originally be measured in the container before pouring. The second measurement will be taken at failure time. The sample for the second measurement will be collected at the failure “front” location.

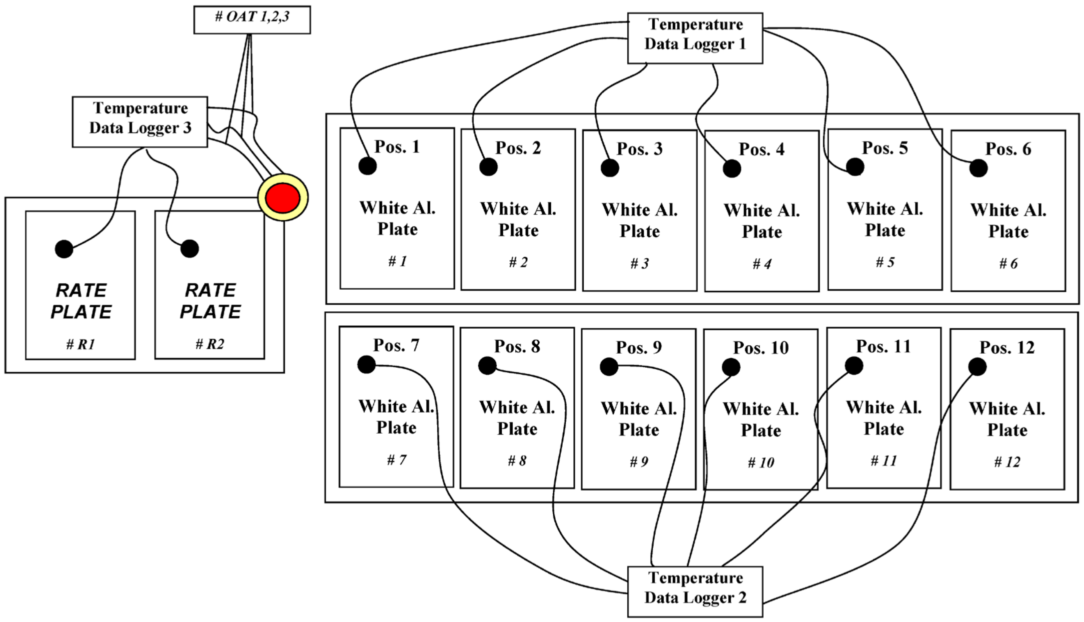

Figure 1: Test Stand Positions

SAE Type II/IV fluids, EG and PG–based, will be applied at outside air temperature by pouring. Fluids will be tested "as ready" at neat, 75/25 and 50/50 concentration, and the recommended quantity is 1.0 L. Fluid strength will be measured and recorded on the fluid dilution data form (Attachment D). The brix value will originally be measured in the container before pouring. The second measurement will be taken at failure time. The sample for the second measurement will be collected at the failure "front" location.

For each test run the following fluid types and dilutions are to be used:

- Type I EG – 10°C Buffer;
- Type I PG – 10°C Buffer;
- Type II PG – Neat;
- Type II PG – 75/25;
- Type II PG – 50/50;
- Type IV EG – Neat;
- Type IV PG – Neat;
- Type IV PG – 75/25; and
- Type IV PG – 50/50.

The fluids to be tested should be taken from the following list of low viscosity fluids: Clariant Safewing Protect 2012, Clariant MP IV 2001, Clariant Safewing MP II 2025, Clariant Safewing MP IV 2030, Kilfrost ABC–II Plus, Kilfrost ABC–S, Kilfrost ABC 2000, Octagon Maxflight, Octagon E Max II, SPCA Ecowing 26, SPCA AD–480, UCAR Ultra+.

The remainder of the stand (3 positions) will be used to conduct tests with either Type II PG (all three dilutions), Type IV PG (all three dilutions), or Type III fluids. Whenever a test is repeated, a different brand name should be used.

The 50/50–dilution fluid shall not be tested if the OAT is forecast to be below -3°C. The 75/25–dilution fluid shall not be tested if the OAT is forecast to be below -14°C.

5. EQUIPMENT

5.1 Equipment for Frost Data Collection

The equipment required to collect frost rates includes:

a) An electronic balance;
b) Two white–painted aluminum test plates with one thermistor probe installed at the 15 cm line, linked to the thermistor logger. The aluminum speed tape used to secure the probes tape is to be painted white to match the emissivity property of the white–painted plates. A small bottle of automotive touch–up paint can be used for this;
c) Three screened thermistor probes to measure air temperature linked to the thermistor logger;
d) An electronic balance with a digital output (optional); and
e) The Vaisala meter (optional) to measure RH and OAT.

5.2 Equipment for Frost Endurance Tests

Standard equipment used for Type I and Type II/IV fluid endurance tests outdoors will be used, with the exception that the test surface will be the white–painted insulated aluminum surface used for frost rates. The surfaces will be instrumented with a thermistor probe installed at the 15 cm line, linked to the logger.

5.3 Equipment List

See Attachment A.

6. DATA FORMS

For frost rate data collection, see Attachments B and C.

For fluid endurance tests in frost, see Attachment D.

7. PERSONNEL

One person required. A second person may be required for initial setup.

ATTACHMENT A
EQUIPMENT LIST

FROST RATE DATA COLLECTION	**Number**
2–position test stand	1
White–painted aluminum test plate with insulated backing	3
Thermistor probes to be installed at the 15 cm line, one on each plate	3
Thermistor probes with shield, for air temperature	3
Thermistor probe logger	1
Thermistor probe logger/PC cable	1
Weigh scale (accuracy of 0.1 g or better)	1
Vaisala meter	1
Data forms	
PC or laptop	1
Electrical extension cord for weigh scale and Vaisala meter	1
FLUID ENDURANCE TESTS IN FROST	
White–painted aluminum test plate with insulated backing	12
6–position test stand	2
Thermistor probes to be installed at the 15 cm line, one on each plate	12
Thermistor probe logger	2
Brixometer	1
SAE Type I fluid, EG and PG–based	
Fluid mixing charts	
Fluid spreader	1
Fluid thermometer	1
SAE Type I, II and IV fluids, EG and PG–based	

ATTACHMENT B
DATA FORM
FROST RATES ON TEST SURFACES

Date ________________ **Location** ________________

Recorded by ________________ **Signature** ________________

Logger Start Time____________ **Weather Trend Printed at (time)**________

Logger Save Time____________

Surface	Time (Hr:min)	Weight (g)
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		

Surface	Time (Hr:min)	Weight (g)
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		

Surface	Time (Hr:min)	Weight (g)
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		
1		
2		

INSTRUCTIONS:

1. Confirm test surface temperature and OAT logging throughout the testing session by checking the real time readings displayed on the computer screen;
2. Check online the availability of Environment Canada weather summary every hour. If unavailable, fill in the form in ATTACHMENT B1;
3. Weigh one plate at a time.

ATTACHMENT B1
DATA FORM
FROST RATES ON TEST SURFACES

Date ________________ **Location** ________________

Recorded by ________________ **Signature** ________________

Surface	Time (Hr:min)	OAT (°C)	RH (%)	Wind Speed (km/h)	Sky Clear (C) or Overcast (O)
1					
2					
1					
2					
1					
2					
1					
2					
1					
2					
1					
2					
1					
2					
1					
2					
1					
2					
1					
2					

INSTRUCTIONS:

1. Measure wind with handheld anemometer at 2 m above ground.
2. Measure OAT and RH with Vaisala instrument.

ATTACHMENT C
SAMPLE OF WEATHER TRENDS FOR MONTRÉAL

[Imperial Units]

Date	Hour	Weather	Temp. (°C)	Humidity (%)	DewPoint (°C)	Wind (km/h)	Pressure (kPa)	Visibility (km)
08 Oct. 2002	06:00 EDT	Clear	2	72	-3	WNW 6	102.4	24
08 Oct. 2002	05:00 EDT	Clear	3	72	-1	W 7	102.3	24
08 Oct. 2002	04:00 EDT	Clear	2	79	-1	WNW 7	102.2	24
08 Oct. 2002	03:00 EDT	Clear	3	74	-1	WNW 11	102.1	24
08 Oct. 2002	02:00 EDT	Clear	4	71	0	NW 11	102.0	24
08 Oct. 2002	01:00 EDT	Mainly Clear	5	68	-1	W 11	102.0	24
08 Oct. 2002	00:00 EDT	Mainly Clear	6	64	-1	W 7	101.9	24
07 Oct. 2002	23:00 EDT	Mainly Clear	6	65	0	NW 13	101.8	24
07 Oct. 2002	22:00 EDT	Mainly Clear	7	59	0	NW 13	101.8	24
07 Oct. 2002	21:00 EDT	Clear	8	59	1	NW 11	101.7	24
07 Oct. 2002	20:00 EDT	Clear	9	54	0	NW 15	101.7	24
07 Oct. 2002	19:00 EDT	Mainly Clear	11	47	0	WNW 20 gusting to 30	101.5	24
07 Oct. 2002	18:00 EDT	Mainly Sunny	13	44	1	WNW 28 gusting to 46	101.4	48

ATTACHMENT D
END CONDITION DATA FORM

REMEMBER TO SYNCHRONIZE TIME 2003-04

LOCATION: Dorval Test Site **DATE:** **RUN NUMBER:** **STAND # :**

TIME TO FAILURE FOR INDIVIDUAL CROSSHAIRS (real time)

	Plate 1	Plate 2	Plate 3	Plate 4	Plate 5	Plate 6
Time of Fluid Application:						
FLUID NAME/DILUTION						
B1 B2 B3						
C1 C2 C3						
D1 D2 D3						
E1 E2 E3						
F1 F2 F3						
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA						
FLUID DILUTION (BRIX)	*INITIAL*	*INITIAL*	*INITIAL*	*INITIAL*	*INITIAL*	*INITIAL*
	AT FAILURE	*AT FAILURE*	*AT FAILURE*	*AT FAILURE*	*AT FAILURE*	*AT FAILURE*

	Plate 7	Plate 8	Plate 9	Plate 10	Plate 11	Plate 12
Time of Fluid Application:						
FLUID NAME/DILUTION						
B1 B2 B3						
C1 C2 C3						
D1 D2 D3						
E1 E2 E3						
F1 F2 F3						
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA						
FLUID DILUTION (BRIX)	*INITIAL*	*INITIAL*	*INITIAL*	*INITIAL*	*INITIAL*	*INITIAL*
	AT FAILURE	*AT FAILURE*	*AT FAILURE*	*AT FAILURE*	*AT FAILURE*	*AT FAILURE*

AMBIENT TEMPERATURE: ________ °C

COMMENTS:

FAILURES CALLED BY: ____________________

LEADER / MANAGER: ____________________

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Ar. 2002-03

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PROCEDURE:
ENDURANCE TIME TEST REQUIREMENTS FOR SIMULATED SNOW FLAT PLATE TESTING—TYPE II, III, AND IV FLUIDS

CM2103.001 (07-08)

PROCEDURE: ENDURANCE TIME TEST REQUIREMENTS FOR SIMULATED SNOW FLAT PLATE TESTING

TYPE II,III, AND IV FLUIDS

2007-08

Prepared for

Transportation Development Centre
Transport Canada

for Prepared by: George Balaban

Reviewed by: John D'Avirro

APS Aviation Inc.

January 23, 2008
Final Version 1.2

ENDURANCE TIME TEST REQUIREMENTS FOR SIMULATED SNOW FLAT PLATE TESTING

TYPE II, III, AND IV FLUIDS

This set of tests will produce snow endurance time using the NCAR snow generation system.

1. OBJECTIVES

This document provides a brief summary of the test requirements and data forms needed for simulated snow flat plate testing in the 2007-08 winter season. SAE ARP 5485 contains a detailed description of the test equipment, test parameters, snow measurement methods, snow test conditions, and snow test procedure for conducting endurance time tests for SAE Type II, III and IV de/anti-icing fluids. This procedure is an alternate procedure to the natural snow endurance time test procedure.

2. TEST REQUIREMENTS

Indoor snow tests may be conducted in a climactic chamber such as CRIQ in Montreal, PMG in Blainville, the NRC in Ottawa, or a suitable refrigerated trailer.

All Type II, III and Type IV fluids must be tested at the condition temperature. If the cold chamber is not maintained at low temperatures over night, the fluids must be refrigerated to ensure temperature is according to requirements.

3. TEST PLAN

An extract from SAE ARP 5485 is included as Attachment I, outlining the snow test conditions that are performed using the snowmaker.

Attachments II and III show the test plans for Type II/IV and Type III fluids respectively.

It is estimated that 40 hours are required to test each fluid (not including duplicates) for an experienced research assistant; this includes some time for rate verification.

A detailed test plan will be developed based on the fluids available for testing in 2007-08.

4. EQUIPMENT

Attachment IV presents a list of required equipment for the endurance time tests with the NCAR snow machine.

All additional equipment required for the operation of the snowmaking system is included in the snowmaking machine operators' manual, supplied by NCAR (refer to TP 14148E, *Endurance Time Tests in Snow: Comparison of Indoor and Outdoor Data for 2002-03).*

5. PERSONNEL

One person is required to pour the fluids and to call the failure on the plate.

6. SUMMARY OF PROCEDURES

The ice core tubes must be filled with de-mineralized water and cooled to below 0°C, a minimum of twelve hours before testing begins. The ice cores must be stored in a separate freezer unit.

Proper steps should be taken to ensure the correct functioning of the machine as described in SAE ARP 5485.

The test panel will be set at the correct temperature for the test; this is done using a heating pad on the underside of the test panel.

The major steps in the artificial snow flat plate test procedure are:

1) Empty fluid collection bucket;
2) Prepare and secure ice core;
3) Begin precipitation and **set desired icing intensity**;
4) **Set desired plate temperature** on Omega controller;
5) Clean panels;
6) Apply one litre of fluid to test panel. Type II, III and Type IV fluids are at the test air temperature. Fluids are poured using a single-step fluid application;

7) Using Labview "*start experiment*" and **set linear rate function**;
8) Record the start of the endurance time test after fluid is applied;
9) Record crosshair end condition times;
10) Continue testing until at least five crosshairs or 30% of the plate has failed; and
11) In Labview "*end experiment*" and record pertinent data in Labview.

Attachment V details the setting of the snowmaker tests parameters.

The operation of the snowmaking system is detailed in the snowmaking machine operators' manual supplied by NCAR (refer to TP 14148E, *Endurance Time Tests in Snow: Comparison of Indoor and Outdoor Data for 2002-03*).

7. DATA FORM

The endurance time tests will only require the end condition data form modified for simulated snow trials. This form is included as Attachment VI.

8. SAFETY PRECAUTIONS

The following precautions will be taken when executing tests to ensure the safety of all personnel:

a) Pathways, stairs and test areas are to be cleared of snow regularly;
b) Appropriate footwear is to be worn by all personnel at the test site to prevent slipping;
c) Warm clothing is to be worn by all personnel to prevent frostbite;
d) Electrical appliances (including computers) are to be unplugged before any wires or connections are altered. If necessary, the affected breaker is to be turned off;
e) If fluid comes into contact with skin, rinse hands under running water;
f) If fluid comes into contact with eyes, flush with a portable eye wash station;
g) A hard hat is to be worn when inside the snow machine due to equipment above; and
h) Ensure that drill is off when changing the ice core.

Attachment I: Snow Test Conditions
(Extract of Proposed ARP 5485)

Test Condition	SNW-A	SNW-B	SNW-C	SNW-D	SNW-E	SNW-F	SNW-G	SNW-H
Types II and IV, neat	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Types II and IV, 75/25 (neat fluid/water)	Yes	Yes	No	No	Yes	Yes	No	No
Types II and IV, 50/50 (neat fluid/water)	Yes	Yes	No	No	No	No	No	No
Types III, neat	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Types III, 75/25 (neat fluid/water)	Yes	Yes	Yes	Yes	No	No	No	No
Types III, 50/50 (neat fluid/water)	Yes	Yes	No	No	No	No	No	No
Test condition temperature, °C	-3	-3	-10	-10	-14	-14	-25	-25
Snow intensity, $g/dm^2/h$	10 ± 0.6	25 ± 1.5	10 ± 0.6	25 ± 1.5	10 ± 0.6	25 ± 1.5	10 ± 0.6	25 ± 1.5
Snow intensity standard deviation	≤ 0.5	≤ 1.25	≤ 0.5	≤ 1.25	≤ 0.5	≤ 1.25	≤ 0.5	≤ 1.25
Minumum plate temperature (Example 1)	-4.2 ± 0.5	-5.1 ± 0.5	-11.2 ± 0.5	-12.1 ± 0.5	-15.2 ± 0.5	-16.1 ± 0.5	-26.2 ± 0.5	-27.1 ± 0.5
Plate temperature* (Example 2), ºC	-4.2 ± 0.5	-5.1 ± 0.5	-11.2 ± 0.5	-12.1 ± 0.5	-15.2 ± 0.5	-16.1 ± 0.5	-26.2 ± 0.5	-27.1 ± 0.5
Plate temperature standard deviation (example 2)	≤ 0.5	≤ 0.5	≤ 0.5	≤ 0.5	≤ 0.5	≤ 0.5	≤ 0.5	≤ 0.5
Snow intensity from the mean range across a test plate ($g/dm^2/h$)	2.0	5.0	2.0	5.0	2.0	5.0	2.0	5.0

*after stabilization, typically 5 minutes

Attachment II
Artificial Snow Test Matrix
Type II and IV Fluids

Test #	Dilution	Condition Temperature (°C)	Plate Temperature (°C)	Snow Intensity (g/dm²/hr)	Notes
1a	100	0	-1.2	10	Optional, as no HOT guidelines
1b	100	0	-1.2	10	Optional, as no HOT guidelines
2a	100	0	-2.1	25	Optional, as no HOT guidelines
2b	100	0	-2.1	25	Optional, as no HOT guidelines
3a	75	0	-1.2	10	Optional, as no HOT guidelines
3b	75	0	-1.2	10	Optional, as no HOT guidelines
4a	75	0	-2.1	25	Optional, as no HOT guidelines
4b	75	0	-2.1	25	Optional, as no HOT guidelines
5a	50	0	-1.2	10	Optional, as no HOT guidelines
5b	50	0	-1.2	10	Optional, as no HOT guidelines
6a	50	0	-2.1	25	Optional, as no HOT guidelines
6b	50	0	-2.1	25	Optional, as no HOT guidelines
7a	100	-3	-4.2	10	
7b	100	-3	-4.2	10	
8a	100	-3	-5.1	25	
8b	100	-3	-5.1	25	
9a	75	-3	-4.2	10	
9b	75	-3	-4.2	10	
10a	75	-3	-5.1	25	
10b	75	-3	-5.1	25	
11a	50	-3	-4.2	10	
11b	50	-3	-4.2	10	
12a	50	-3	-5.1	25	
12b	50	-3	-5.1	25	
13a	100	-14	-15.2	10	
13b	100	-14	-15.2	10	
14a	100	-14	-16.1	25	
14b	100	-14	-16.1	25	
15a	75	-14	-15.2	10	
15b	75	-14	-15.2	10	
16a	75	-14	-16.1	25	
16b	75	-14	-16.1	25	
17a	100	-25	-26.2	10	Optional, as generic values used in HOT
17b	100	-25	-26.2	10	Optional, as generic values used in HOT
18a	100	-25	-27.1	25	Optional, as generic values used in HOT
18b	100	-25	-27.1	25	Optional, as generic values used in HOT

Attachment III
Artificial Snow Test Matrix –Type III Fluids

Test #	Dilution	Condition Temperature (°C)	Plate Temperature (°C)	Snow Intensity (g/dm²/hr)	Notes
1a	100	0	-1.2	10	Optional, as no HOT guidelines
1b	100	0	-1.2	10	Optional, as no HOT guidelines
2a	100	0	-2.1	25	Optional, as no HOT guidelines
2b	100	0	-2.1	25	Optional, as no HOT guidelines
3a	75	0	-1.2	10	Optional, as no HOT guidelines
3b	75	0	-1.2	10	Optional, as no HOT guidelines
4a	75	0	-2.1	25	Optional, as no HOT guidelines
4b	75	0	-2.1	25	Optional, as no HOT guidelines
5a	50	0	-1.2	10	Optional, as no HOT guidelines
5b	50	0	-1.2	10	Optional, as no HOT guidelines
6a	50	0	-2.1	25	Optional, as no HOT guidelines
6b	50	0	-2.1	25	Optional, as no HOT guidelines
7a	100	-3	-4.2	10	
7b	100	-3	-4.2	10	
8a	100	-3	-5.1	25	
8b	100	-3	-5.1	25	
9a	75	-3	-4.2	10	
9b	75	-3	-4.2	10	
10a	75	-3	-5.1	25	
10b	75	-3	-5.1	25	
11a	50	-3	-4.2	10	
11b	50	-3	-4.2	10	
12a	50	-3	-5.1	25	
12b	50	-3	-5.1	25	
13a	100	-6	-7.2	10	Optional, as not described in ARP 5485
13b	100	-6	-7.2	10	Optional, as not described in ARP 5485
14a	100	-6	-8.1	25	Optional, as not described in ARP 5485
14b	100	-6	-8.1	25	Optional, as not described in ARP 5485
15a	75	-6	-7.2	10	Optional, as not described in ARP 5485
15b	75	-6	-7.2	10	Optional, as not described in ARP 5485
16a	75	-6	-8.1	25	Optional, as not described in ARP 5485
16b	75	-6	-8.1	25	Optional, as not described in ARP 5485
17a	100	-10	-11.2	10	
17b	100	-10	-11.2	10	
18a	100	-10	-12.1	25	
18b	100	-10	-12.1	25	
19a	75	-10	-11.2	10	
19b	75	-10	-11.2	10	
20a	75	-10	-12.1	25	
20b	75	-10	-12.1	25	
21a	100	-25	-26.2	10	Optional, as generic values used in HOT
21b	100	-25	-26.2	10	Optional, as generic values used in HOT
22a	100	-25	-27.1	25	Optional, as generic values used in HOT
22b	100	-25	-27.1	25	Optional, as generic values used in HOT

Attachment IV
Test Equipment Checklist

- Snow making machine and related equipment;
- Aluminum plates with heating pads;
- Aluminum Rate Pan 300mm X 500mm;
- Snow Distribution Pans 150mm X 167mm;
- Electronic balance for snow distribution trials;
- Electronic NCAR files;
- Fluid thickness gauge;
- Squeegee/scraper;
- Extension cord;
- 1L sample fluid bottles;
- Paper towels;
- Rags;
- Flood lights;
- Stopwatch;
- Wet vacuum;
- Brixometer;
- Data forms;
- Clipboard; and
- Photo camera.

Attachment V
NCAR Snowmaker Test Parameters Guidelines

ARP 5485 includes four requirements that relate the plate, enclosure and fluid temperatures. These are:

1. The PLATE TEMPERATURE (T_P) is determined by the following equation for icing intensities up to 25 g/dm^2/h:

$$T_P = T_T - 0.065 * R - 0.5$$

where:

T_P – Plate Temperature in °C;

T_T – Test Condition Temperature in °C;

R – Icing Intensity (g/dm^2/hr).

2. The ENCLOSURE TEMPERATURE (T_E) is always below -5°C:

$$T_E <= -5°C$$

3. The ECLOSURE TEMPERATURE (T_E) is TYPICALLY 2°C below the PLATE TEMPERATURE (T_P) DURING THE TEST (no tolerance specified):

$$T_E = T_P - 2°C$$

4. The FLUID APPLICATION TEMPERATURE (T_F) is within 3°C of the ENCLOSURE TEMPERATURE (T_E):

$$T_F = T_E \pm 3°C$$

Note 1: The enclosure and the plate temperatures should be within 0.5°C at the BEGINNING OF THE TEST.

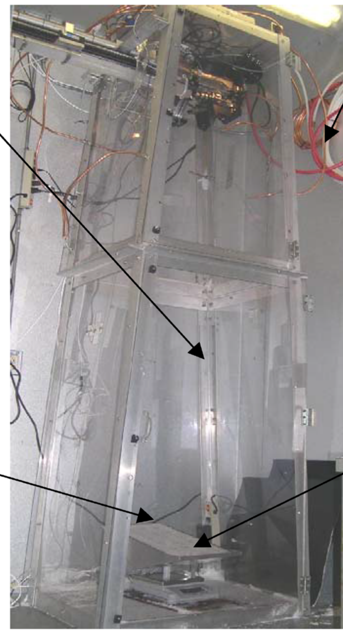
Note 2: There is no requirement for the chamber temperature. The chamber temperature is typically colder than the enclosure temperature.

EXAMPLE:

For a test performed at -14°C condition at a rate of 10 g/dm^2/h:

STEP 2: Enclosure Temp
Requirement:
The enclosure temperature is typically 2°C below the plate temperature (no tolerance specified).

Example:
T_E = -15.2°C- 2°C
T_E = -17.2°C



Note: Chamber Temp
- No specific requirement
- Typically below T_E

STEP 3: Fluid Temp:
Requirement:
The fluid temperature is within 3°C of the enclosure temperature.

Example:
T_F = -17.2°C ± 3°C

STEP 1: Plate Temp
Requirement:
The plate temperature is obtained with the equation shown below*.

Example:
T_P = -14°C –1.2°C
T_P = -15.2°C

***Plate Temperature Equation**

Requirement:
The plate temperature is obtained with the equation shown below:

$$T_P = T_T - 0.065 * R - 0.5$$

where:

T_P – Plate Temperature in °C;

T_T – Test Condition Temperature in °C;

R – Icing Intensity (g/dm^2/hr).

Attachment VI
End Condition Data Form – NCAR Snow Maker

Version 1.0 Winter 2003-04

LOCATION:	DATE:	RUN # :	STAND # :	NCAR

OUTPUT FILENAME:________________________.txt

OAT: ________°C

PRECIPITATION RATE: ________g/dm²/h

FLUID TEMPERATURE: ________°C

FLUID QUANTITY APPLIED: ________Litres

PLATE WASHING METHOD: ______________

PLATE TEMPERATURE (OMEGA): ____________ °C

OTHER COMMENTS (Fluid Batch, etc):

____

____

____

____

____

____

____

	PRINT	SIGN
FAILURES CALLED BY :	____________	____________
HAND WRITTTEN BY :	____________	____________
LEADER :	____________	____________

*TIME (After Fluid Application)
TO FAILURE FOR INDIVIDUAL CROSSHAIRS (h:min)

Time of Fluid Application: ________ h:min

FLUID NAME			
B1 B2 B3			
C1 C2 C3			
D1 D2 D3			
E1 E2 E3			
F1 F2 F3			

CALCULATED FAILURE TIME (MINUTES)	

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PROCEDURE:
DEVELOPMENT OF TYPE I PROTOCOL FOR INDOOR SNOW
(ARP5945)

CM2103.001 (07-08)

PROCEDURE: DEVELOPMENT OF TYPE I PROTOCOL FOR INDOOR SNOW (ARP 5945)

Winter 2007-08

Prepared for

Transportation Development Centre
Transport Canada

for Prepared by: George Balaban VZ

Reviewed by: John D'Avirro

APS Aviation Inc.

January 21, 2008
Version 1.0

DEVELOPMENT OF TYPE I PROTOCOL FOR INDOOR SNOW
(ARP 5945)

Winter 2007-08

1. BACKGROUND

As a result of the SAE G-12 Holdover Time Subcommittee meeting held in Toulouse, France in May 2000, a new test protocol (ARP 5945) was developed for measuring endurance times for SAE Type I fluids that closely reflects real field operations. The protocol outlines that tests in natural snow conditions are conducted on insulated 7.5 cm cold-soak box, empty, and treated with 0.5 L of fluid at 60ºC. This was found to be a reasonable representation of the temperature decay rate demonstrated by wings in natural outdoor conditions. The fluid was applied along the top edge of the test surface using a specially designed 12-hole fluid spreader.

ARP 5945 in its current form does not include a procedure for SAE Type I fluid testing in artificial snow.

The National Centre for Atmospheric Research (NCAR) performed a series of artificial snow Type I fluid tests using the NCAR snowmaker. The results of these tests were presented at the SAE G-12 meeting in Pittsburgh, USA in May 2005. For these tests, a procedure similar to that used for outdoor tests was used along with some minor modifications of the NCAR snowmaker. These preliminary tests showed that the NCAR snowmaker could adequately reproduce endurance times for Type I fluids.

APS conducted a series of Type I comparison tests in 2007 that proved the feasibility of NCAR Type I testing at the Dorval test site. These tests were however run on plates, not on boxes.

In 2007-08, a series Type I tests are planned in artificial snow with ethylene-glycol (EG), propylene-glycol (PG) and non-glycol based fluids to validate the capability of the snowmaker to perform Type I tests. The use of a standard cold-soak box and a snowmaker software upgrade will be the start points in this research project.

2. OBJECTIVE

The objective of this project is to establish a Type I testing protocol in simulated snow conditions that will be included in ARP 5945.

To achieve this objective, the software of the NCAR snowmaker will be upgraded and configured for tests using the cold soak box. A series of tests will be performed with EG, PG and non-glycol fluids to validate the results obtained in the past by NCAR and to provide direct comparison with the current holdover times. The test plan is included in Attachment I.

It is estimated that approximately 10-15 tests can be conducted during a regular day (including setup) in the refrigerated trailer at the Dorval test site. The test plan and the priorities may be altered based on the time available to conduct these tests. One week will be allocated for testing to evaluate the new NCAR setup for Type I tests.

3. PROCEDURE/TEST REQUIREMENTS

The ice core tubes must be filled with demineralised water and cooled to below 0°C, a minimum of twelve hours before testing begins. The ice cores must be stored in a separate freezer unit.

A snow distribution trial should be completed with every change in rate or temperature, to ensure the correct functioning of the machine.

The 7.5 cm cold-soak box, insulated on all sides but the top, empty, will be used as the test surface for the indoor tests. It will be fitted with a thermistor and will be installed on the collection bucket. The box temperature will be logged for subsequent analysis.

The major steps in the test procedure are:

1) Empty fluid collection bucket;
2) Prepare and secure ice core;
3) Apply small amount of fluid at ambient temperature to help spread the fluid over the entire plate;
4) 0.5 L[1] of fluid will be heated to 60°C with an acceptance range of +2°C and -0°C. The fluid will be applied on the surface through a 12-hole spreader. The fluid used will be diluted to a freeze point 10°C below ambient temperature, unless otherwise specified by the fluid manufacturer.
5) Begin precipitation and **set desired icing intensity**
6) Using Labview "*start experiment*" and **set linear rate function**;
7) Record the start of the endurance time test after fluid is applied;

1 Most of the tests will be conducted with 0.5L of Type I fluid. Two additional tests with 1L of fluid will be conducted to study the heat transfer effects of the excess fluid.

8) Determine failure times on test surface, and record using standard NCAR data form (Attachment II); and

9) In Labview "*end experiment*" and record pertinent data in Labview.

The operation of the snowmaking system is detailed in the snowmaking machine operators' manual supplied by NCAR (refer to TP 14148E, *Endurance Time Tests in Snow: Comparison of Indoor and Outdoor Data for 2002-03*).

4. EQUIPMENT AND FLUIDS

Attachment III presents a list of required equipment for the Type I artificial snow tests with the NCAR snow machine.

All additional equipment required for the operation of the snowmaking system is included in the snowmaking machine operators' manual, supplied by NCAR (refer to TP 14148E, *Endurance Time Tests in Snow: Comparison of Indoor and Outdoor Data for 2002-03).*

4.1 Fluids

One ethylene-glycol, one propylene-glycol and one non-glycol based Type I fluid will be used for these tests:

- UCAR EG ADF;
- Octagon Octaflo (PG); and
- Octagon Ecoflo (non-glycol).

Fluids are to be mixed to a freeze point 10°C below OAT. The dilution table for these three fluids is presented in Attachment IV.

Fluids to be applied to the cold soak box test surfaces will be heated to 60°C.

5. PERSONNEL

One person is required to pour the fluids and call the failure on the test plate.

6. DATA FORMS

The Type I simulated snow tests will only require the end condition data form modified for simulated snow trials. This form is included as Attachment II.

ATTACHMENT I
NCAR TEST MATRIX
TYPE I EG TESTS

Test #	Priority	Fluid	Buffer	Fluid Temp. (°C)	Fluid Quantity (L)	Condition Temp. (°C)	Precip. Rate (g/dm^2/h)	Estimated Room Set Temp (°C)	Previous NCAR ET (min)	HOT (min)
T1-1	1	Type I EG	10°C buffer	60	0.5	-3	3	-5	N/A	22
T1-2	1	Type I EG	10°C buffer	60	0.5	-3	4	-5	N/A	18
T1-3	1	Type I EG	10°C buffer	60	0.5	-3	10	-5	10	11
T1-4	1	Type I EG	10°C buffer	60	0.5	-3	25	-5	6	6
T1-5	1	Type I EG	10°C buffer	60	0.5	-6	3	-8	N/A	17
T1-6	1	Type I EG	10°C buffer	60	0.5	-6	4	-8	12	14
T1-7	1	Type I EG	10°C buffer	60	0.5	-6	10	-8	8	8
T1-8	1	Type I EG	10°C buffer	60	0.5	-6	25	-8	4	5
T1-9	1	Type I EG	10°C buffer	60	0.5	-10	3	-12	11	13
T1-10	1	Type I EG	10°C buffer	60	0.5	-10	4	-12	10	11
T1-11	1	Type I EG	10°C buffer	60	0.5	-10	10	-12	7	6
T1-12	1	Type I EG	10°C buffer	60	0.5	-10	25	-12	4	4
T1-13	1	Type I EG	10°C buffer	60	0.5	-14	3	-16	N/A	8
T1-14	1	Type I EG	10°C buffer	60	0.5	-14	4	-16	5	7
T1-15	1	Type I EG	10°C buffer	60	0.5	-14	10	-16	4	4
T1-16	1	Type I EG	10°C buffer	60	0.5	-14	25	-16	2	2
T1-17	2	Type I EG	10°C buffer	60	0.5	-3	3	-5	N/A	22
T1-18	2	Type I EG	10°C buffer	60	0.5	-3	4	-5	N/A	18
T1-19	2	Type I EG	10°C buffer	60	0.5	-3	10	-5	10	11
T1-20	2	Type I EG	10°C buffer	60	0.5	-3	25	-5	6	6
T1-21	2	Type I EG	10°C buffer	60	0.5	-6	3	-8	N/A	17
T1-22	2	Type I EG	10°C buffer	60	0.5	-6	4	-8	12	14
T1-23	2	Type I EG	10°C buffer	60	0.5	-6	10	-8	8	8
T1-24	2	Type I EG	10°C buffer	60	0.5	-6	25	-8	4	5
T1-25	2	Type I EG	10°C buffer	60	0.5	-10	3	-12	11	13
T1-26	2	Type I EG	10°C buffer	60	0.5	-10	4	-12	10	11
T1-27	2	Type I EG	10°C buffer	60	0.5	-10	10	-12	7	6
T1-28	2	Type I EG	10°C buffer	60	0.5	-10	25	-12	4	4
T1-29	2	Type I EG	10°C buffer	60	0.5	-14	3	-16	N/A	8
T1-30	2	Type I EG	10°C buffer	60	0.5	-14	4	-16	5	7
T1-31	2	Type I EG	10°C buffer	60	0.5	-14	10	-16	4	4
T1-32	2	Type I EG	10°C buffer	60	0.5	-14	25	-16	2	2

ATTACHMENT I (cont.)
NCAR TEST MATRIX
TYPE I PG TESTS

Test #	Priority	Fluid	Buffer	Fluid Temp. (°C)	Fluid Quantity (L)	Condition Temp. (°C)	Precip. Rate (g/dm²/h)	Estimated Room Set Temp (°C)	Previous NCAR ET (min)	HOT (min)
T1-33	1	Type I PG	10°C buffer	60	0.5	-3	3	-5	N/A	22
T1-34	1	Type I PG	10°C buffer	60	0.5	-3	4	-5	N/A	18
T1-35	1	Type I PG	10°C buffer	60	0.5	-3	10	-5	10	11
T1-36	1	Type I PG	10°C buffer	60	0.5	-3	25	-5	6	6
T1-37	1	Type I PG	10°C buffer	60	0.5	-6	3	-8	N/A	17
T1-38	1	Type I PG	10°C buffer	60	0.5	-6	4	-8	12	14
T1-39	1	Type I PG	10°C buffer	60	0.5	-6	10	-8	8	8
T1-40	1	Type I PG	10°C buffer	60	0.5	-6	25	-8	4	5
T1-41	1	Type I PG	10°C buffer	60	0.5	-10	3	-12	11	13
T1-42	1	Type I PG	10°C buffer	60	0.5	-10	4	-12	10	11
T1-43	1	Type I PG	10°C buffer	60	0.5	-10	10	-12	7	6
T1-44	1	Type I PG	10°C buffer	60	0.5	-10	25	-12	4	4
T1-45	1	Type I PG	10°C buffer	60	0.5	-14	3	-16	N/A	8
T1-46	1	Type I PG	10°C buffer	60	0.5	-14	4	-16	5	7
T1-47	1	Type I PG	10°C buffer	60	0.5	-14	10	-16	4	4
T1-48	1	Type I PG	10°C buffer	60	0.5	-14	25	-16	2	2
T1-49	2	Type I PG	10°C buffer	60	0.5	-3	3	-5	N/A	22
T1-50	2	Type I PG	10°C buffer	60	0.5	-3	4	-5	N/A	18
T1-51	2	Type I PG	10°C buffer	60	0.5	-3	10	-5	10	11
T1-52	2	Type I PG	10°C buffer	60	0.5	-3	25	-5	6	6
T1-53	2	Type I PG	10°C buffer	60	0.5	-6	3	-8	N/A	17
T1-54	2	Type I PG	10°C buffer	60	0.5	-6	4	-8	12	14
T1-55	2	Type I PG	10°C buffer	60	0.5	-6	10	-8	8	8
T1-56	2	Type I PG	10°C buffer	60	0.5	-6	25	-8	4	5
T1-57	2	Type I PG	10°C buffer	60	0.5	-10	3	-12	11	13
T1-58	2	Type I PG	10°C buffer	60	0.5	-10	4	-12	10	11
T1-59	2	Type I PG	10°C buffer	60	0.5	-10	10	-12	7	6
T1-60	2	Type I PG	10°C buffer	60	0.5	-10	25	-12	4	4
T1-61	2	Type I PG	10°C buffer	60	0.5	-14	3	-16	N/A	8
T1-62	2	Type I PG	10°C buffer	60	0.5	-14	4	-16	5	7
T1-63	2	Type I PG	10°C buffer	60	0.5	-14	10	-16	4	4
T1-64	2	Type I PG	10°C buffer	60	0.5	-14	25	-16	2	2

ATTACHMENT I (cont.)
NCAR TEST MATRIX
TYPE I SUPPLEMENTARY TESTS

Test #	Priority	Fluid	Buffer	Fluid Temp. (°C)	Fluid Quantity (L)	Condition Temp. (°C)	Precip. Rate ($g/dm^2/h$)	Estimated Room Set Temp (°C)	Previous NCAR ET (min)	HOT (min)
T1-65	3	Type I EG	10ºC buffer	60	1	-3	10	-5	10	11
T1-66	3	Type I EG	10ºC buffer	60	1	-6	4	-8	12	14
T1-67	3	Type I PG	10ºC buffer	60	1	-3	10	-5	10	11
T1-68	3	Type I PG	10ºC buffer	60	1	-6	4	-8	12	14
T1-69	4	Octagon Ecoflo	10ºC buffer	60	0.5	-3	3	-5	N/A	N/A
T1-70	4	Octagon Ecoflo	10ºC buffer	60	0.5	-3	10	-5	N/A	N/A
T1-71	4	Octagon Ecoflo	10ºC buffer	60	0.5	-3	25	-5	N/A	N/A
T1-72	4	Octagon Ecoflo	10ºC buffer	60	0.5	-10	3	-12	N/A	N/A
T1-73	4	Octagon Ecoflo	10ºC buffer	60	0.5	-10	25	-12	N/A	N/A
T1-74	4	Octagon Ecoflo	10ºC buffer	60	0.5	-14	10	-16	N/A	N/A

ATTACHMENT II
SIMULATED SNOW END CONDITION DATA FORM

Version 1.0 Winter 2003-04

LOCATION: DATE: RUN # : STAND # : NCAR

OUTPUT FILENAME:____________________.txt

OAT: ________°C

PRECIPITATION RATE: ________g/dm²/h

FLUID TEMPERATURE: ________°C

FLUID QUANTITY APPLIED: ________Litres

PLATE WASHING METHOD: ______________

PLATE TEMPERATURE (OMEGA): ______________ °C

OTHER COMMENTS (Fluid Batch, etc):

	PRINT	SIGN
FAILURES CALLED BY :		
HAND WRITTTEN BY :		
LEADER :		

*TIME (After Fluid Application)
TO FAILURE FOR INDIVIDUAL CROSSHAIRS (h:min)

Time of Fluid Application: ________ h:min

FLUID NAME			
B1 B2 B3			
C1 C2 C3			
D1 D2 D3			
E1 E2 E3			
F1 F2 F3			

CALCULATED FAILURE TIME (MINUTES)

M:\Groups\CM1892 (TC-Deicing 03-04)\Procedures\NCAR\Snow Maker Data Sheet

ATTACHMENT III
TEST EQUIPMENT CHECKLIST

- Snow making machine and related equipment;
- Aluminum cold soak box with thermister;
- Logger capability to record box temperature;
- 12-hole spreader;
- Thermoses;
- Microwave and containers used for fluid heating;
- Temperature probe;
- Aluminium Rate Pan 300mm X 500mm;
- Snow Distribution Pans 150mm X 165mm;
- Electronic balance for snow distribution trials;
- Electronic NCAR files;
- Fluid thickness gauge;
- Squeegee/scraper;
- Extension cord;
- 1L fluid bottles;
- Paper towels;
- Rags;
- Wet vacuum;
- Brixometer;
- Data forms;
- Clipboard; and
- Photo camera.

ATTACHMENT IV
FLUID DILUTION FOR TYPE I TESTING

OAT (°C)	FFP (°C)	Octagon Octaflo / EF (PG)				UCAR ADF (EG)				Octagon Ecoflo			
		% Glycol	Brix	Glycol for 8 Litres	Water for 8 Litres	% Glycol	Brix	Glycol for 8 Litres	Water for 8 Litres	% Glycol	Brix	Glycol for 8 Litres	Water for 8 Litres
5	-5	15	9.75	1.2	6.8	12	8	1.0	7.0				
4	-6					14.5	9.5	1.2	6.8	19.8	13.25	1.6	6.4
3	-7					16	10.5	1.3	6.7	21.6	14.75	1.7	6.3
2	-8					18.5	12	1.5	6.5	23.5	16	1.9	6.1
1	-9	27.5	18.5	2.2	5.8	21.5	13.5	1.7	6.3	25.3	17.5	2.0	6.0
0	-10	29	19	2.3	5.7	22	14	1.8	6.2	27.1	18.75	2.2	5.8
-1	-11	30	20	2.4	5.6	23	15	1.8	6.2	28.8	20	2.3	5.7
-2	-12	31	20.5	2.5	5.5	24.5	16	2.0	6.0	30.6	21.25	2.4	5.6
-3	-13	32	21.25	2.6	5.4	26	17	2.1	5.9	32.2	22.5	2.6	5.4
-4	-14	34	22.5	2.7	5.3	28	18	2.2	5.8	33.9	23.75	2.7	5.3
-5	-15	35	23	2.8	5.2	30	19	2.4	5.6	35.5	24.75	2.8	5.2
-6	-16	36	23.5	2.9	5.1	31	19.75	2.5	5.5	37.0	26	3.0	5.0
-7	-17	37	24	3.0	5.0	32	20.5	2.6	5.4	38.6	27	3.1	4.9
-8	-18	38.5	25	3.1	4.9	33.5	21.25	2.7	5.3	40.1	28	3.2	4.8
-9	-19	40	26	3.2	4.8	34.5	21.75	2.8	5.2	41.5	29	3.3	4.7
-10	-20	42	27	3.4	4.6	36	22.5	2.9	5.1	43.0	30	3.4	4.6
-11	-21	44	28	3.5	4.5	37	23	3.0	5.0	44.4	30.75	3.5	4.5
-12	-22	45	28.5	3.6	4.4	38	23.75	3.0	5.0	45.7	31.75	3.7	4.3
-13	-23	46	29	3.7	4.3	39	24.5	3.1	4.9	47.0	32.5	3.8	4.2
-14	-24	47	29.5	3.8	4.2	40	25	3.2	4.8	48.3	33.25	3.9	4.1
-15	-25	47.5	30	3.8	4.2	41	25.5	3.3	4.7	49.6	34	4.0	4.0
-16	-26	48.5	30.5	3.9	4.1	42	26	3.4	4.6	50.8	34.75	4.1	3.9
-17	-27	49	31	3.9	4.1	43	26.5	3.4	4.6	51.9	35.5	4.2	3.8
-18	-28	50	31.5	4.0	4.0	44	27	3.5	4.5	53.1	36	4.2	3.8
-19	-29	51	32	4.1	3.9	45	27.5	3.6	4.4	54.2	36.75	4.3	3.7
-20	-30	52	32.5	4.2	3.8	45.75	28	3.7	4.3	55.3	37.25	4.4	3.6
-22	-32	53.5	33.5	4.3	3.7	47	28.75	3.8	4.2	57.3	38.253	4.6	3.4
-25	-35	56	34.5	4.5	3.5	49	30	3.9	4.1	60.1	39.25	4.8	3.2
-30	-40	60	37	4.8	3.2	53	32	4.2	3.8	64.0	40.75	5.1	2.9

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OVERALL PROGRAM OF TESTS AT NRC, MARCH/APRIL 2016

CM2480.002 (15-16)

OVERALL PROGRAM OF TESTS AT NRC, MARCH/APRIL 2016

Winter 2015-16

Prepared for

Transportation Development Centre
Transport Canada

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Final Version 1.0

OVERALL PROGRAM OF TESTS AT NRC, MARCH/APRIL 2016

Winter 2015-16

1. INTRODUCTION

This document was prepared to bring together several projects that require testing at the National Research Council Climactic Engineering Facility (NRC) in Ottawa. Tests will be carried out from March 30 to April 8, 2016.

The primary objective of the test session is to measure the endurance times of new de/anti-icing fluids. Testing for several other related research projects will be scheduled around the endurance time tests as time and space permit. This document provides the schedule, personnel, fluid, and equipment requirements for each of the projects involved.

A tentative test schedule is included in Figure 1.

2. PROJECTS, PROCEDURES AND OBJECTIVES

The projects that will be carried out at the March/April 2016 NRC test session are listed in this section. Each project has been given a shortened name (shown in brackets following full title) which is used in subsequent sections of this document. A description of each project, its objective and its test procedure are provided. The test procedures for several projects are provided in separate detailed documents, which are referenced in the appropriate subsection and listed in Section 9.

General comments on procedures and setup:

- Endurance time tests will be carried out according to the protocol provided in Aerospace Recommended Practice (ARP) 5485, *Endurance Time Tests for Aircraft Deicing/Anti-Icing Fluids SAE Type II, III, and IV* (1), except as noted.
- There will be two test stands positioned under the sprayer (main stand with two 6-position stands and side stand with one 3-position stand) and a third stand that will be positioned outside the spray area in the small area of the climate chamber. The test stands should be situated in the cold chamber as per the measurements provided in Figure 2.
- A complex rate management program was developed in the early 2000s to assist in managing the measurement of precipitation rates. An update to the interface of this program was finalized in 2014. This program will be used. A guide to the rate management program is available to help with training of new rate station managers.

- To further assist in rate management, NRC has developed a precipitation rate monitoring system. This system will be positioned on Plate 1.

2.1 Endurance Times of New Fluids (New Fluid ETs)

The objective of this project is to measure endurance times of new fluids. This will include Type II and Type IV tests, as listed below. Each fluid will be tested over the entire range of freezing precipitation conditions encompassed by the Type II/IV tables.

- New Type II fluid: Coded as 2YB
- New Type IV fluid: Coded as AMC
- New Type IV fluid: Coded as NSC
- New Type IV fluid: Coded as VCA
- New Type IV fluid: Coded as DED (100/0 only, no dilutions)

The procedure for conducting endurance time tests is given in the document *Test Requirements for Simulated Freezing Precipitation Flat Plate Testing* (2). Cold soak boxes should be prepared using the procedure provided in Attachment 1.

The test plan for new fluid endurance time tests is given in Table 1. All tests will be conducted on the main test stand.

2.2 Special Type III Endurance Time Tests (Type III ETs)

AllClear Solutions submitted a sample of a Type III fluid (AeroClear MAX) for endurance time testing in March 2015. It was subsequently tested in freezing precipitation at the NRC Cold Chamber, and at the APS test site in natural snow (very limited data) and artificial snow. This fluid sample (CB1-PB8000A) was used to develop the Holdover Time Guidelines for AeroClear MAX for winter 2015-16. These included generic snow holdover times, as insufficient natural snow data was collected to provide fluid-specific holdover times.

A new sample of AeroClear MAX (CB1-PB8000A2) was provided to APS in the fall of 2015 so that natural snow data could be collected to determine fluid-specific holdover times. The viscosity of the sample was tested and found to be the same as CB1-PB8000A. Testing this winter has shown that, in general, the new fluid batch is providing lower endurance time results than the original batch. As a result, tests with sample CB1-PB8000A2 will be carried out at the March/April 2016 NRC test session. The objective of these tests is to measure endurance times of sample CB1-PB8000A2 in freezing precipitation.

The procedure for conducting endurance time tests is given in the document *Test Requirements for Simulated Freezing Precipitation Flat Plate Testing* (2).

The Type III tests are included in the New Fluid ETs test plan in Table 1. All tests will be conducted on the main test stand.

2.3 Thickness of New Fluids (ET Thickness)

The objective of these tests is to measure the thickness of new fluids on flat plates. The procedure for these tests is entitled *Experimental Program to Establish Film Thickness Profiles for De-Icing and Anti-Icing Fluids on Flat Plates* (3) and can be found in Transport Canada Report TP 13991E, Appendix I. All tests will be conducted with fluid at -3°C.

The test plan for Fluid Thickness tests is given in Table 2. The tests will be conducted at the small end of the chamber outside of the spray area.

2.4 Endurance Times on Airfoil with Flaps/Slats (Airfoil)

The objective of these tests is to compare endurance times on an airfoil with flaps/slats to endurance times on 10º and 20º test plates.

The procedure for these tests is provided in the document *Evaluation of Endurance Times on Deployed Flaps/Slats – Natural Snow, Addendum for Additional Airfoil Testing* (4), which documents testing for outdoor natural snow tests. Several changes will be made to the procedure for indoor testing:

- Testing indoors will simulate zero-wind conditions; therefore, rotating the model will not be necessary.
- Tests will be conducted in high and low rates of light freezing rain and freezing drizzle at different temperatures using various types of fluids/dilutions.
- The experimental set-ups are shown in Figure 3.
- Prior to running these tests, rates will be conducted in the spray area using the experimental set-up shown in Figure 3, with three rate pans in the test stand area and two rate pans on the airfoil. If the tests are conducted immediately following holdover time testing in the same condition, this rate cycle will be omitted.

These tests will be conducted in conjunction with the vertical stabilizer protection times tests (Subsection 2.5) and will be conducted in the main stand area with the main stand removed. The combined test plan for airfoil and vertical stabilizer tests is given in Table 3.

2.5 Evaluation of Fluid Protection Times on a Vertical Stabilizer (V-Stab PTs)

APS has acquired a full-scale vertical stabilizer taken from a Piper Seneca II aircraft. This vertical stabilizer model will be used for this activity and the one described in Subsection 2.6.

The objective of this activity is to conduct tests to compare protection times (PTs) of de/anti-icing fluids on a vertical stabilizer to those on 10º and 80º plates. The objective will be accomplished by conducting endurance time tests on different test surfaces.

The detailed procedure is provided in the document *Procedure: Vertical Surfaces Testing – Pre and Post De/Anti-icing* (5) which documents testing for outdoor natural snow tests. Several changes will be made to the procedure for indoor testing:

- Testing indoors will simulate zero-wind conditions; therefore, rotating the model will not be necessary.
- Tests will be conducted in high and low rates of light freezing rain and freezing drizzle at different temperatures using various types of fluids/dilutions.
- The experimental set-ups are shown in Figure 3.
- Prior to running these tests, rates will be conducted in the spray area using the experimental set-up shown in Figure 3, with three rate pans in the test stand area and two rate pans on the airfoil. If the tests are conducted immediately following holdover time testing in the same condition, this rate cycle will be omitted.

These tests will be conducted in conjunction with the airfoil tests (Subsection 2.4) and will be conducted in the main stand area with the main stands removed. The combined test plan for vertical stabilizer PTs and airfoil tests is given in Table 3.

2.6 Evaluation of Fluid Thickness on a Vertical Stabilizer (V-Stab Thickness)

The objective of this activity is to conduct tests to compare fluid thickness decay profiles following de/anti-icing on a vertical stabilizer to those on a 10º plate and 80º plate. Tests will be conducted with Type I and Type IV fluid (one run each) and measurements will be taken over a 30 minute period. The standard thickness procedure will be followed (see Subsection 2.3). In addition:

- The angle of the vertical stabilizer shall be measured;
- Fluid will be applied to vertical stabilizer by hand-pouring on one side and by sprayer with the garden sprayer on the other side. This process is being employed to compare the thickness profiles generated by each application method;
- After fluid application, fluid thickness will be measured at 5, 10, 15 and 30 minutes;
- Fluid thickness will be measured on both sides of the vertical stabilizer; and
- Fluid thickness will be measured at the 15 cm line of the plates and at multiple points along the leading edge and top perimeter of the vertical stabilizer, as shown in Figure 4.

The test plan for the V-Stab Thickness tests is given in Table 4. The tests will be conducted at the small end of the chamber outside of the spray area. It should be noted that tests are planned for -3°C but could also be done at -10°C.

2.7 Effect of Fluid Colour on Endurance Times (Coloured vs. Uncoloured)

Previous industry discussions, and past research, have indicated it is a good practice to conduct select comparative tests with coloured and uncoloured samples to ensure fluids sold both ways have comparable holdover times. One manufacturer has indicated the fluid they have submitted for endurance time testing this year may be sold in both coloured and uncoloured versions. The objective of this project is to run select tests with coloured and uncoloured samples of the fluid to determine if dye affects endurance time performance. This research will build on similar research conducted with a commercial fluid last year.

A subset of the standard full set of endurance time tests will be conducted. Tests will be carried out using standard endurance time test protocols.

The test plan for the Coloured vs. Uncoloured tests is given in Table 5. All tests will be conducted on the main and/or side stands.

3. PERSONNEL REQUIREMENTS/RESPONSIBILITIES

The personnel requirements and responsibilities are provided in Table 6.

4. FLUIDS

The required fluids and fluid quantities are shown in Table 7. Type I fluids will be diluted prior to testing using the dilution table provided in Table 8. Fluids that will be used the first day of testing should be packed into coolers at the APS test site and plugged into power overnight. (In the event that the setup at NRC is done the day before testing, the coolers will not be required.)

5. EQUIPMENT

Table 9 provides a list of required equipment.

6. DATA FORMS

The data forms required for each project are listed below.

1. New Fluid ETs:
   - Freezing Precipitation Endurance Time Electronic Data Form
   - Rate Management Form (Figure 5)
   - NRC Continuous Rate Form (Figure 6)
2. Type III ETs:
   - Freezing Precipitation Endurance Time Electronic Data Form
3. ET Thickness:
   - Fluid Thickness Data Form (Figure 7)
4. Airfoil:
   - Freezing Precipitation Endurance Time Data Form (Figure 8)
   - Airfoil End Condition Data Form (Figure 9)
5. V-Stab PTs:
   - Freezing Precipitation Endurance Time Data Form (Figure 8)
   - Vertical Stabilizer End Condition Data Form (Figure 10)
6. V-Stab Thickness:

- Fluid Thickness on Vertical Stabilizer Data Form (Figure 4)

7. Coloured vs. Uncoloured:
    - Freezing Precipitation Endurance Time Electronic Data Form

7. PRE–TEST SET–UP ACTIVITIES

The following activities need to be completed prior to arrival at the NRC:

1. Mark plates with plate numbers on back and front. Also mark a set of half plates for positions 2 to 12 on back and front (if 11 sets not available, mark additional full plates that can be cut at NRC). Marking should be at bottom, half plates should be marked for example “4L and 4R” (RA/JD);
2. Locate rate pans: check quantity, check all pans are properly labelled, and verify spares are available (CB);
3. Ensure plates are equipped with operational and verified thermistors or smart buttons. Make sure they are set for logging the whole session (RA/DY);
4. Prepare labels for pour containers as per fluids list (CB);
5. Ensure fluids are prepared in advance according to Table 7 (RA);
6. Clean and label 1 litre pour containers (RA);
7. Check laptops (2) work for rate station (DY);
8. Rent cube van (EA);
9. Book hotel (EA);
10. Print data forms and procedures (CB);
11. Print chamber condition sheets (CB);
12. Contact Medhat (DY):
    - confirm availability of NRC camera system + black shelving unit;
    - waste tote + floor mats in chamber for setup day;
    - cold soak fluid + wooden stand + pump in chamber for setup day;
    - rate monitoring system;
    - update chamber settings file with the latest data available;

- make sure that the freezer works and is on the day before testing;
- set up test area temperature sensors for morning of test;
- have the desks in the test area and in NRC office cleaned-up and available to avoid mixing up NRC/APS equipment;
- ensure hallways and chamber free of clutter;
- make sure dryer is operational and hooked up; and
- confirm daily start time (JD).

13. Ensure sufficient propylene glycol (PG) fluid is available for cold soak boxes and get more if necessary (DY);
14. Put CSW fluid into freezer at -40°C (DY);
15. Make all necessary purchases prior to NRC (CB);
16. Ensure fluids for research projects are available (RA/JD);
17. Remove sensitive equipment, 50/50 fluids, and 75/25 fluids if doing -25°C first day (CB);
18. Determine team travel plans (JD);
19. Confirm lowest operational use temperature (LOUT) of all Type II, III and IV fluids (JD). If any LOUTs are -30°C or lower, schedule testing in freezing fog at the LOUT (CB/SB);
20. Provide final test plan to data form programmer (CB);
21. Make an easy prop to give plates a 20° incline (MR);
22. Bring notes from last year for -35°C failure calls (CB); and
23. Gather equipment and pack truck (JD/RA).

8. SAFETY ISSUES

Managers of each subproject must ensure that personnel involved in the set-up and conduct of their respective projects are aware of the following:

1. Fluid MSDS sheets are available for review;
2. Waterproof clothing and gloves are available;

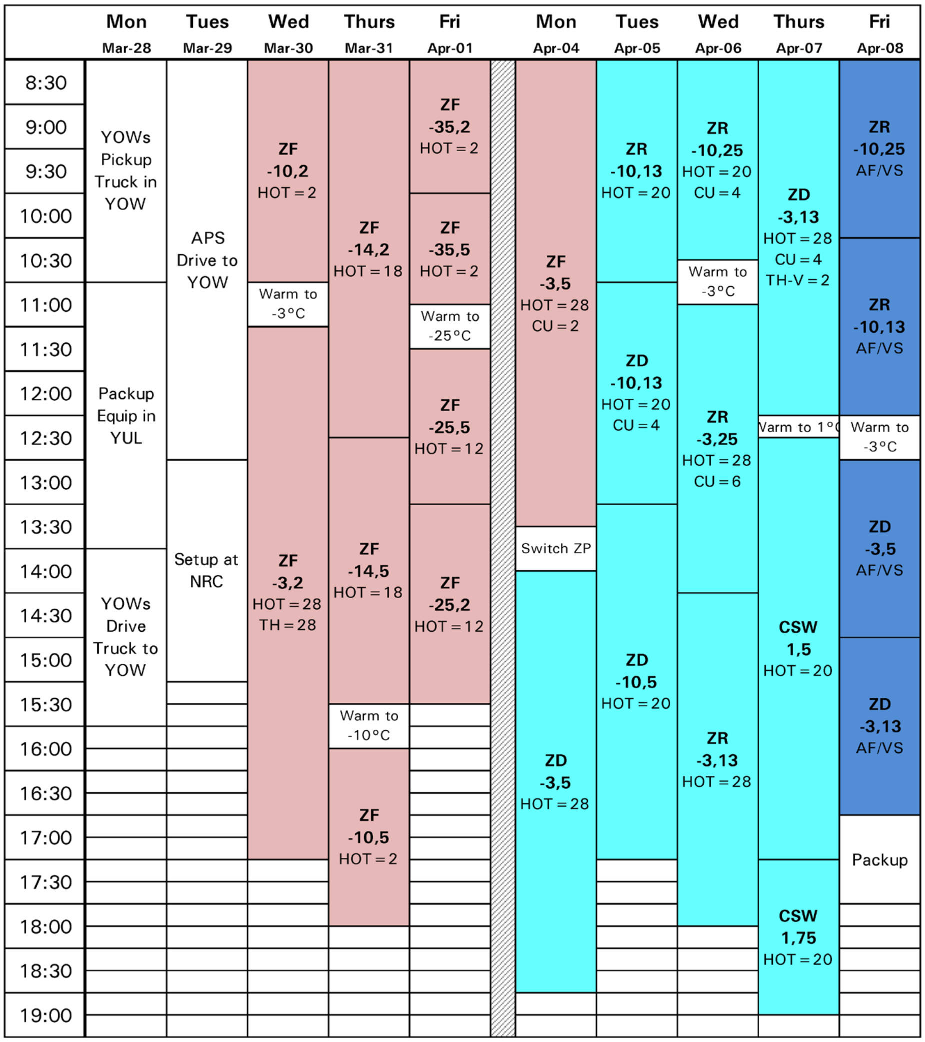
3. Rubber mats must be properly placed in and around the test area and cleaned as necessary;
4. Care should be taken when circulating near the test stand due to slipperiness;
5. First aid kit, water and fire extinguisher are available; and
6. All NRC safety guidelines must be followed.

9. REFERENCES

1. SAE Aerospace Recommended Practice 5485, Endurance Time Tests for Aircraft Deicing/Anti-icing Fluids SAE Type II, III, and IV, July 2007.
2. Test Requirements for Simulated Freezing Precipitation Flat Plate Testing, Version 1.0, January 15, 2004.
3. Experimental Program to Establish Film Thickness Profiles for De-Icing and Anti-Icing Fluids on Flat Plates, Version 1.0, April 3, 2002.
4. Evaluation of Endurance Times on Deployed Flaps/Slats – Natural Snow, Addendum for Additional Airfoil Testing, Final Version 1.0, November, 2015.
5. Vertical Surfaces Testing – Pre and Post De/Anti-icing, Final Version 1.0, December, 2015.

OVERALL PROGRAM OF TESTS AT NRC, MARCH/APRIL 2016

FIGURE 1: TEST SCHEDULE



Project Abbreviations	
HOT = HOT of New Fluids	TH = Thicknesses of New Fluids
AF = Airfoil PT Testing	TH-V = Thicknesses on Vertical Stabilizer
VS = Vertical Stabilizer PT Testing	CU = Coloured vs. Uncoloured

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Final Version 1.0, March 16

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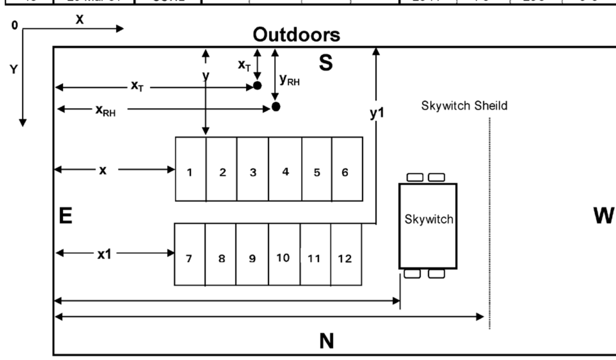
FIGURE 2: TEST STAND LOCATION MEASUREMENTS

LOCATION: CEF (Ottawa) **DATE:** **CONDITION: ZR3H ZR3L ZR10H ZR10L ZD3H ZD3L ZD10H ZD10L ZF3H ZF3L ZF10H ZF10L ZF14H ZF14L ZF25H ZF25L CSWH CSWL**

Test	Date of Final Position	Condition	Sensor Position				Stand Position				Skywitch Position	Skywitch Sheild Position (*)	Nozzle Position (**)	Rate	Height of nozzle over plate	Comments
			X_T	Y_T	X_{RH}	Y_{RH}	x	y	x1	y1						
1	4-Apr-01	ZR3H					24' 2"	7'	22' 7"	9' 10"				Very Good		Top Stand 19' from snow fence
2	4-Apr-01	ZR3L					24' 2"	7'	22' 7"	9' 10"				Very Good		Top Stand 19' from snow fence
3	4/2/2001	ZR10H					24'	6' 9"	24' 5"	9' 6"				Very Good		Top stand is 20 ft. from snow fence
4	2-Apr-01	ZR10L					24'	6' 9"	24' 5"	9' 6"				Very Good		Top stand is 20 ft. from snow fence
5	27-Mar-01	ZD3H					24' 5"	6'6"	22'	10'4"				Very Good		
6	28-Mar-01	ZD3L					25' 3"	7'3"	25' 3"	9' 6"				Good		
7	2-Apr-01	ZD10H					24'	7'11"	25' 3"	9' 6"				Very Good		
8	2-Apr-01	ZD10L					24'	7' 7"	24' 7"	9' 11"				Good		20 ft. from Snow Fence
9	10-Apr-01	ZFog3H					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
10	10-Apr-01	ZFog3L					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
11	10-Apr-01	ZFog10H					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
12	10-Apr-01	ZFog10L					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
13	9-Apr-01	ZFog14H					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
14	9-Apr-01	ZFog14L					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
15	6-Apr-01	ZFog25H					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
16	6-Apr-01	ZFog25L					24'	6'6"	21'11"	8'10"	34' 2"from x	40'2" from x	top of plate 11	Good	144"	
17	29-Mar-01	CSWH					25'3"		25'3"	9' 6"						
18	29-Mar-01	CSWL					23'11"	7'3"	25'3"	9' 6"						



Notes:

* - "From X" refers to the distance from the East wall.
** - The nozzle should be between positions 5 and 11
RH - Relative Humidity Sensor
T - Temperature Sensor

WEIGH SCALE TECHNICIAN: ____________________

LEADER: ____________________

NEW VALUES (IF DIFFERENT)

Test	Date of Final Position	Condition	Sensor Position				Stand Position				Skywitch Position	Skywitch Sheild Position (*)	Nozzle Position (**)	Rate	Height of nozzle over plate	Comments
			X_T	Y_T	X_{RH}	Y_{RH}	x	y	x1	y1						
							24'	**7'**	**24'**	**9'**						

ATTACHMENT 1: COLD SOAK BOX PREPARATION PROCEDURE

1. Put containers (20 L) of CSW box fluid (propylene 65/35) in cold (-30±5°C) freezer overnight. Freezers to be kept in large end of the chamber.

2. Put all filled CSW boxes in warmer (-11±1°C) freezer overnight.

3. Next morning, if freezer in step (2) does not provide fluid and box temperature of -11±1°C, then empty boxes in pail and achieve fluid at -12±1°C in pail.

4. Prepare step (3) in corner of large chamber that is at +1°C; ensure boxes are cooled to about -11°C. Go to step (6).

5. After first series of tests, empty fluid from boxes into separate pail. Put empty boxes in freezer to keep cool at -11±2°C.

6. Prepare fluid to -12±1°C by mixing (use small amounts of hot water and/or cold fluid). Agitate fluid mixture frequently.

7. Fill boxes, ensure -11±1°C on surface of box. This process shall be done while rates are being measured.

8. Position on stand with cover, but no insulation on top surface. Connect thermocouples.

9. Allow warming to -10±0.5°C. This process needs monitoring with rates measurement to not overshoot temperature (place insulation on top surface if required).

10. Start test.

11. At end of test, remove box from stand, measure rates, and go to step (5).

OVERALL PROGRAM OF TESTS AT NRC, MARCH/APRIL 2016

TABLE 1: NEW FLUID ENDURANCE TIMES TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Fluid Dilution (%)	Test Surface	Comments
1	Freezing Fog	-3	2	2YB	100	Al. Plate	
2	Freezing Fog	-3	2	2YB	100	Al. Plate	
3	Freezing Fog	-3	2	2YB	75	Al. Plate	
4	Freezing Fog	-3	2	2YB	75	Al. Plate	
5	Freezing Fog	-3	2	2YB	50	Al. Plate	
6	Freezing Fog	-3	2	2YB	50	Al. Plate	
7	Freezing Fog	-3	2	AeroClear MAX	100	Al. Plate	
8	Freezing Fog	-3	2	AeroClear MAX	100	Al. Plate	
9	Freezing Fog	-3	2	VCA	100	Al. Plate	
10	Freezing Fog	-3	2	VCA	100	Al. Plate	
11	Freezing Fog	-3	2	VCA	75	Al. Plate	
12	Freezing Fog	-3	2	VCA	75	Al. Plate	
13	Freezing Fog	-3	2	VCA	50	Al. Plate	
14	Freezing Fog	-3	2	VCA	50	Al. Plate	
15	Freezing Fog	-3	2	AMC	100	Al. Plate	
16	Freezing Fog	-3	2	AMC	100	Al. Plate	
17	Freezing Fog	-3	2	AMC	75	Al. Plate	
18	Freezing Fog	-3	2	AMC	75	Al. Plate	
19	Freezing Fog	-3	2	AMC	50	Al. Plate	
20	Freezing Fog	-3	2	AMC	50	Al. Plate	
21	Freezing Fog	-3	2	NSC	100	Al. Plate	
22	Freezing Fog	-3	2	NSC	100	Al. Plate	
23	Freezing Fog	-3	2	NSC	75	Al. Plate	
24	Freezing Fog	-3	2	NSC	75	Al. Plate	
25	Freezing Fog	-3	2	NSC	50	Al. Plate	
26	Freezing Fog	-3	2	NSC	50	Al. Plate	
27	Freezing Fog	-3	2	DED	100	Al. Plate	
28	Freezing Fog	-3	2	DED	100	Al. Plate	
29	Freezing Fog	-3	5	2YB	100	Al. Plate	
30	Freezing Fog	-3	5	2YB	100	Al. Plate	
31	Freezing Fog	-3	5	2YB	75	Al. Plate	
32	Freezing Fog	-3	5	2YB	75	Al. Plate	
33	Freezing Fog	-3	5	2YB	50	Al. Plate	
34	Freezing Fog	-3	5	2YB	50	Al. Plate	
35	Freezing Fog	-3	5	AeroClear MAX	100	Al. Plate	
36	Freezing Fog	-3	5	AeroClear MAX	100	Al. Plate	
37	Freezing Fog	-3	5	VCA	100	Al. Plate	
38	Freezing Fog	-3	5	VCA	100	Al. Plate	
39	Freezing Fog	-3	5	VCA	75	Al. Plate	
40	Freezing Fog	-3	5	VCA	75	Al. Plate	
41	Freezing Fog	-3	5	VCA	50	Al. Plate	
42	Freezing Fog	-3	5	VCA	50	Al. Plate	
43	Freezing Fog	-3	5	AMC	100	Al. Plate	
44	Freezing Fog	-3	5	AMC	100	Al. Plate	
45	Freezing Fog	-3	5	AMC	75	Al. Plate	
46	Freezing Fog	-3	5	AMC	75	Al. Plate	
47	Freezing Fog	-3	5	AMC	50	Al. Plate	
48	Freezing Fog	-3	5	AMC	50	Al. Plate	

OVERALL PROGRAM OF TESTS AT NRC, MARCH/APRIL 2016

TABLE 1: NEW FLUID ENDURANCE TIMES TEST PLAN (CONT'D)

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Fluid Dilution (%)	Test Surface	Comments
49	Freezing Fog	-3	5	NSC	100	Al. Plate	
50	Freezing Fog	-3	5	NSC	100	Al. Plate	
51	Freezing Fog	-3	5	NSC	75	Al. Plate	
52	Freezing Fog	-3	5	NSC	75	Al. Plate	
53	Freezing Fog	-3	5	NSC	50	Al. Plate	
54	Freezing Fog	-3	5	NSC	50	Al. Plate	
55	Freezing Fog	-3	5	DED	100	Al. Plate	
56	Freezing Fog	-3	5	DED	100	Al. Plate	
57	Freezing Fog	-10	2	AeroClear MAX	100	Al. Plate	
58	Freezing Fog	-10	2	AeroClear MAX	100	Al. Plate	
59	Freezing Fog	-10	5	AeroClear MAX	100	Al. Plate	
60	Freezing Fog	-10	5	AeroClear MAX	100	Al. Plate	
61	Freezing Fog	-14	2	2YB	100	Al. Plate	
62	Freezing Fog	-14	2	2YB	100	Al. Plate	
63	Freezing Fog	-14	2	2YB	75	Al. Plate	
64	Freezing Fog	-14	2	2YB	75	Al. Plate	
65	Freezing Fog	-14	2	VCA	100	Al. Plate	
66	Freezing Fog	-14	2	VCA	100	Al. Plate	
67	Freezing Fog	-14	2	VCA	75	Al. Plate	
68	Freezing Fog	-14	2	VCA	75	Al. Plate	
69	Freezing Fog	-14	2	AMC	100	Al. Plate	
70	Freezing Fog	-14	2	AMC	100	Al. Plate	
71	Freezing Fog	-14	2	AMC	75	Al. Plate	
72	Freezing Fog	-14	2	AMC	75	Al. Plate	
73	Freezing Fog	-14	2	NSC	100	Al. Plate	
74	Freezing Fog	-14	2	NSC	100	Al. Plate	
75	Freezing Fog	-14	2	NSC	75	Al. Plate	
76	Freezing Fog	-14	2	NSC	75	Al. Plate	
77	Freezing Fog	-14	2	DED	100	Al. Plate	
78	Freezing Fog	-14	2	DED	100	Al. Plate	
79	Freezing Fog	-14	5	2YB	100	Al. Plate	
80	Freezing Fog	-14	5	2YB	100	Al. Plate	
81	Freezing Fog	-14	5	2YB	75	Al. Plate	
82	Freezing Fog	-14	5	2YB	75	Al. Plate	
83	Freezing Fog	-14	5	VCA	100	Al. Plate	
84	Freezing Fog	-14	5	VCA	100	Al. Plate	
85	Freezing Fog	-14	5	VCA	75	Al. Plate	
86	Freezing Fog	-14	5	VCA	75	Al. Plate	
87	Freezing Fog	-14	5	AMC	100	Al. Plate	
88	Freezing Fog	-14	5	AMC	100	Al. Plate	
89	Freezing Fog	-14	5	AMC	75	Al. Plate	
90	Freezing Fog	-14	5	AMC	75	Al. Plate	
91	Freezing Fog	-14	5	NSC	100	Al. Plate	
92	Freezing Fog	-14	5	NSC	100	Al. Plate	
93	Freezing Fog	-14	5	NSC	75	Al. Plate	
94	Freezing Fog	-14	5	NSC	75	Al. Plate	
95	Freezing Fog	-14	5	DED	100	Al. Plate	
96	Freezing Fog	-14	5	DED	100	Al. Plate	

TABLE 1: NEW FLUID ENDURANCE TIMES TEST PLAN (CONT'D)

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Fluid Dilution (%)	Test Surface	Comments
97	Freezing Fog	-25	2	2YB	100	Al. Plate	
98	Freezing Fog	-25	2	2YB	100	Al. Plate	
99	Freezing Fog	-25	2	AeroClear MAX	100	Al. Plate	
100	Freezing Fog	-25	2	AeroClear MAX	100	Al. Plate	
101	Freezing Fog	-25	2	VCA	100	Al. Plate	
102	Freezing Fog	-25	2	VCA	100	Al. Plate	
103	Freezing Fog	-25	2	AMC	100	Al. Plate	
104	Freezing Fog	-25	2	AMC	100	Al. Plate	
105	Freezing Fog	-25	2	NSC	100	Al. Plate	
106	Freezing Fog	-25	2	NSC	100	Al. Plate	
107	Freezing Fog	-25	2	DED	100	Al. Plate	
108	Freezing Fog	-25	2	DED	100	Al. Plate	
109	Freezing Fog	-25	5	2YB	100	Al. Plate	
110	Freezing Fog	-25	5	2YB	100	Al. Plate	
111	Freezing Fog	-25	5	AeroClear MAX	100	Al. Plate	
112	Freezing Fog	-25	5	AeroClear MAX	100	Al. Plate	
113	Freezing Fog	-25	5	VCA	100	Al. Plate	
114	Freezing Fog	-25	5	VCA	100	Al. Plate	
115	Freezing Fog	-25	5	AMC	100	Al. Plate	
116	Freezing Fog	-25	5	AMC	100	Al. Plate	
117	Freezing Fog	-25	5	NSC	100	Al. Plate	
118	Freezing Fog	-25	5	NSC	100	Al. Plate	
119	Freezing Fog	-25	5	DED	100	Al. Plate	
120	Freezing Fog	-25	5	DED	100	Al. Plate	
121	Freezing Fog	-35	2	AeroClear MAX	100	Al. Plate	
122	Freezing Fog	-35	2	AeroClear MAX	100	Al. Plate	
123	Freezing Fog	-35	5	AeroClear MAX	100	Al. Plate	
124	Freezing Fog	-35	5	AeroClear MAX	100	Al. Plate	
125	Freezing Drizzle	-3	5	2YB	100	Al. Plate	
126	Freezing Drizzle	-3	5	2YB	100	Al. Plate	
127	Freezing Drizzle	-3	5	2YB	75	Al. Plate	
128	Freezing Drizzle	-3	5	2YB	75	Al. Plate	
129	Freezing Drizzle	-3	5	2YB	50	Al. Plate	
130	Freezing Drizzle	-3	5	2YB	50	Al. Plate	
131	Freezing Drizzle	-3	5	AeroClear MAX	100	Al. Plate	
132	Freezing Drizzle	-3	5	AeroClear MAX	100	Al. Plate	
133	Freezing Drizzle	-3	5	VCA	100	Al. Plate	
134	Freezing Drizzle	-3	5	VCA	100	Al. Plate	
135	Freezing Drizzle	-3	5	VCA	75	Al. Plate	
136	Freezing Drizzle	-3	5	VCA	75	Al. Plate	
137	Freezing Drizzle	-3	5	VCA	50	Al. Plate	
138	Freezing Drizzle	-3	5	VCA	50	Al. Plate	
139	Freezing Drizzle	-3	5	AMC	100	Al. Plate	
140	Freezing Drizzle	-3	5	AMC	100	Al. Plate	
141	Freezing Drizzle	-3	5	AMC	75	Al. Plate	
142	Freezing Drizzle	-3	5	AMC	75	Al. Plate	
143	Freezing Drizzle	-3	5	AMC	50	Al. Plate	
144	Freezing Drizzle	-3	5	AMC	50	Al. Plate	

OVERALL PROGRAM OF TESTS AT NRC, MARCH/APRIL 2016

TABLE 1: NEW FLUID ENDURANCE TIMES TEST PLAN (CONT'D)

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Fluid Dilution (%)	Test Surface	Comments
145	Freezing Drizzle	-3	5	NSC	100	Al. Plate	
146	Freezing Drizzle	-3	5	NSC	100	Al. Plate	
147	Freezing Drizzle	-3	5	NSC	75	Al. Plate	
148	Freezing Drizzle	-3	5	NSC	75	Al. Plate	
149	Freezing Drizzle	-3	5	NSC	50	Al. Plate	
150	Freezing Drizzle	-3	5	NSC	50	Al. Plate	
151	Freezing Drizzle	-3	5	DED	100	Al. Plate	
152	Freezing Drizzle	-3	5	DED	100	Al. Plate	
153	Freezing Drizzle	-3	13	2YB	100	Al. Plate	
154	Freezing Drizzle	-3	13	2YB	100	Al. Plate	
155	Freezing Drizzle	-3	13	2YB	75	Al. Plate	
156	Freezing Drizzle	-3	13	2YB	75	Al. Plate	
157	Freezing Drizzle	-3	13	2YB	50	Al. Plate	
158	Freezing Drizzle	-3	13	2YB	50	Al. Plate	
159	Freezing Drizzle	-3	13	AeroClear MAX	100	Al. Plate	
160	Freezing Drizzle	-3	13	AeroClear MAX	100	Al. Plate	
161	Freezing Drizzle	-3	13	VCA	100	Al. Plate	
162	Freezing Drizzle	-3	13	VCA	100	Al. Plate	
163	Freezing Drizzle	-3	13	VCA	75	Al. Plate	
164	Freezing Drizzle	-3	13	VCA	75	Al. Plate	
165	Freezing Drizzle	-3	13	VCA	50	Al. Plate	
166	Freezing Drizzle	-3	13	VCA	50	Al. Plate	
167	Freezing Drizzle	-3	13	AMC	100	Al. Plate	
168	Freezing Drizzle	-3	13	AMC	100	Al. Plate	
169	Freezing Drizzle	-3	13	AMC	75	Al. Plate	
170	Freezing Drizzle	-3	13	AMC	75	Al. Plate	
171	Freezing Drizzle	-3	13	AMC	50	Al. Plate	
172	Freezing Drizzle	-3	13	AMC	50	Al. Plate	
173	Freezing Drizzle	-3	13	NSC	100	Al. Plate	
174	Freezing Drizzle	-3	13	NSC	100	Al. Plate	
175	Freezing Drizzle	-3	13	NSC	75	Al. Plate	
176	Freezing Drizzle	-3	13	NSC	75	Al. Plate	
177	Freezing Drizzle	-3	13	NSC	50	Al. Plate	
178	Freezing Drizzle	-3	13	NSC	50	Al. Plate	
179	Freezing Drizzle	-3	13	DED	100	Al. Plate	
180	Freezing Drizzle	-3	13	DED	100	Al. Plate	
181	Freezing Drizzle	-10	5	2YB	100	Al. Plate	
182	Freezing Drizzle	-10	5	2YB	100	Al. Plate	
183	Freezing Drizzle	-10	5	2YB	75	Al. Plate	
184	Freezing Drizzle	-10	5	2YB	75	Al. Plate	
185	Freezing Drizzle	-10	5	AeroClear MAX	100	Al. Plate	
186	Freezing Drizzle	-10	5	AeroClear MAX	100	Al. Plate	
187	Freezing Drizzle	-10	5	VCA	100	Al. Plate	
188	Freezing Drizzle	-10	5	VCA	100	Al. Plate	
189	Freezing Drizzle	-10	5	VCA	75	Al. Plate	
190	Freezing Drizzle	-10	5	VCA	75	Al. Plate	
191	Freezing Drizzle	-10	5	AMC	100	Al. Plate	
192	Freezing Drizzle	-10	5	AMC	100	Al. Plate	

OVERALL PROGRAM OF TESTS AT NRC, MARCH/APRIL 2016

TABLE 1: NEW FLUID ENDURANCE TIMES TEST PLAN (CONT'D)

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Fluid Dilution (%)	Test Surface	Comments
193	Freezing Drizzle	-10	5	AMC	75	Al. Plate	
194	Freezing Drizzle	-10	5	AMC	75	Al. Plate	
195	Freezing Drizzle	-10	5	NSC	100	Al. Plate	
196	Freezing Drizzle	-10	5	NSC	100	Al. Plate	
197	Freezing Drizzle	-10	5	NSC	75	Al. Plate	
198	Freezing Drizzle	-10	5	NSC	75	Al. Plate	
199	Freezing Drizzle	-10	5	DED	100	Al. Plate	
200	Freezing Drizzle	-10	5	DED	100	Al. Plate	
201	Freezing Drizzle	-10	13	2YB	100	Al. Plate	
202	Freezing Drizzle	-10	13	2YB	100	Al. Plate	
203	Freezing Drizzle	-10	13	2YB	75	Al. Plate	
204	Freezing Drizzle	-10	13	2YB	75	Al. Plate	
205	Freezing Drizzle	-10	13	AeroClear MAX	100	Al. Plate	
206	Freezing Drizzle	-10	13	AeroClear MAX	100	Al. Plate	
207	Freezing Drizzle	-10	13	VCA	100	Al. Plate	
208	Freezing Drizzle	-10	13	VCA	100	Al. Plate	
209	Freezing Drizzle	-10	13	VCA	75	Al. Plate	
210	Freezing Drizzle	-10	13	VCA	75	Al. Plate	
211	Freezing Drizzle	-10	13	AMC	100	Al. Plate	
212	Freezing Drizzle	-10	13	AMC	100	Al. Plate	
213	Freezing Drizzle	-10	13	AMC	75	Al. Plate	
214	Freezing Drizzle	-10	13	AMC	75	Al. Plate	
215	Freezing Drizzle	-10	13	NSC	100	Al. Plate	
216	Freezing Drizzle	-10	13	NSC	100	Al. Plate	
217	Freezing Drizzle	-10	13	NSC	75	Al. Plate	
218	Freezing Drizzle	-10	13	NSC	75	Al. Plate	
219	Freezing Drizzle	-10	13	DED	100	Al. Plate	
220	Freezing Drizzle	-10	13	DED	100	Al. Plate	
221	Light Freezing Rain	-3	13	2YB	100	Al. Plate	
222	Light Freezing Rain	-3	13	2YB	100	Al. Plate	
223	Light Freezing Rain	-3	13	2YB	75	Al. Plate	
224	Light Freezing Rain	-3	13	2YB	75	Al. Plate	
225	Light Freezing Rain	-3	13	2YB	50	Al. Plate	
226	Light Freezing Rain	-3	13	2YB	50	Al. Plate	
227	Light Freezing Rain	-3	13	AeroClear MAX	100	Al. Plate	
228	Light Freezing Rain	-3	13	AeroClear MAX	100	Al. Plate	
229	Light Freezing Rain	-3	13	VCA	100	Al. Plate	
230	Light Freezing Rain	-3	13	VCA	100	Al. Plate	
231	Light Freezing Rain	-3	13	VCA	75	Al. Plate	
232	Light Freezing Rain	-3	13	VCA	75	Al. Plate	
233	Light Freezing Rain	-3	13	VCA	50	Al. Plate	
234	Light Freezing Rain	-3	13	VCA	50	Al. Plate	
235	Light Freezing Rain	-3	13	AMC	100	Al. Plate	
236	Light Freezing Rain	-3	13	AMC	100	Al. Plate	
237	Light Freezing Rain	-3	13	AMC	75	Al. Plate	
238	Light Freezing Rain	-3	13	AMC	75	Al. Plate	
239	Light Freezing Rain	-3	13	AMC	50	Al. Plate	
240	Light Freezing Rain	-3	13	AMC	50	Al. Plate	

TABLE 1: NEW FLUID ENDURANCE TIMES TEST PLAN (CONT'D)

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Fluid Dilution (%)	Test Surface	Comments
241	Light Freezing Rain	-3	13	NSC	100	Al. Plate	
242	Light Freezing Rain	-3	13	NSC	100	Al. Plate	
243	Light Freezing Rain	-3	13	NSC	75	Al. Plate	
244	Light Freezing Rain	-3	13	NSC	75	Al. Plate	
245	Light Freezing Rain	-3	13	NSC	50	Al. Plate	
246	Light Freezing Rain	-3	13	NSC	50	Al. Plate	
247	Light Freezing Rain	-3	13	DED	100	Al. Plate	
248	Light Freezing Rain	-3	13	DED	100	Al. Plate	
249	Light Freezing Rain	-3	25	2YB	100	Al. Plate	
250	Light Freezing Rain	-3	25	2YB	100	Al. Plate	
251	Light Freezing Rain	-3	25	2YB	75	Al. Plate	
252	Light Freezing Rain	-3	25	2YB	75	Al. Plate	
253	Light Freezing Rain	-3	25	2YB	50	Al. Plate	
254	Light Freezing Rain	-3	25	2YB	50	Al. Plate	
255	Light Freezing Rain	-3	25	AeroClear MAX	100	Al. Plate	
256	Light Freezing Rain	-3	25	AeroClear MAX	100	Al. Plate	
257	Light Freezing Rain	-3	25	VCA	100	Al. Plate	
258	Light Freezing Rain	-3	25	VCA	100	Al. Plate	
259	Light Freezing Rain	-3	25	VCA	75	Al. Plate	
260	Light Freezing Rain	-3	25	VCA	75	Al. Plate	
261	Light Freezing Rain	-3	25	VCA	50	Al. Plate	
262	Light Freezing Rain	-3	25	VCA	50	Al. Plate	
263	Light Freezing Rain	-3	25	AMC	100	Al. Plate	
264	Light Freezing Rain	-3	25	AMC	100	Al. Plate	
265	Light Freezing Rain	-3	25	AMC	75	Al. Plate	
266	Light Freezing Rain	-3	25	AMC	75	Al. Plate	
267	Light Freezing Rain	-3	25	AMC	50	Al. Plate	
268	Light Freezing Rain	-3	25	AMC	50	Al. Plate	
269	Light Freezing Rain	-3	25	NSC	100	Al. Plate	
270	Light Freezing Rain	-3	25	NSC	100	Al. Plate	
271	Light Freezing Rain	-3	25	NSC	75	Al. Plate	
272	Light Freezing Rain	-3	25	NSC	75	Al. Plate	
273	Light Freezing Rain	-3	25	NSC	50	Al. Plate	
274	Light Freezing Rain	-3	25	NSC	50	Al. Plate	
275	Light Freezing Rain	-3	25	DED	100	Al. Plate	
276	Light Freezing Rain	-3	25	DED	100	Al. Plate	
277	Light Freezing Rain	-10	13	2YB	100	Al. Plate	
278	Light Freezing Rain	-10	13	2YB	100	Al. Plate	
279	Light Freezing Rain	-10	13	2YB	75	Al. Plate	
280	Light Freezing Rain	-10	13	2YB	75	Al. Plate	
281	Light Freezing Rain	-10	13	AeroClear MAX	100	Al. Plate	
282	Light Freezing Rain	-10	13	AeroClear MAX	100	Al. Plate	
283	Light Freezing Rain	-10	13	VCA	100	Al. Plate	
284	Light Freezing Rain	-10	13	VCA	100	Al. Plate	
285	Light Freezing Rain	-10	13	VCA	75	Al. Plate	
286	Light Freezing Rain	-10	13	VCA	75	Al. Plate	
287	Light Freezing Rain	-10	13	AMC	100	Al. Plate	
288	Light Freezing Rain	-10	13	AMC	100	Al. Plate	

TABLE 1: NEW FLUID ENDURANCE TIMES TEST PLAN (CONT'D)

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Fluid Dilution (%)	Test Surface	Comments
289	Light Freezing Rain	-10	13	AMC	75	Al. Plate	
290	Light Freezing Rain	-10	13	AMC	75	Al. Plate	
291	Light Freezing Rain	-10	13	NSC	100	Al. Plate	
292	Light Freezing Rain	-10	13	NSC	100	Al. Plate	
293	Light Freezing Rain	-10	13	NSC	75	Al. Plate	
294	Light Freezing Rain	-10	13	NSC	75	Al. Plate	
295	Light Freezing Rain	-10	13	DED	100	Al. Plate	
296	Light Freezing Rain	-10	13	DED	100	Al. Plate	
297	Light Freezing Rain	-10	25	2YB	100	Al. Plate	
298	Light Freezing Rain	-10	25	2YB	100	Al. Plate	
299	Light Freezing Rain	-10	25	2YB	75	Al. Plate	
300	Light Freezing Rain	-10	25	2YB	75	Al. Plate	
301	Light Freezing Rain	-10	25	AeroClear MAX	100	Al. Plate	
302	Light Freezing Rain	-10	25	AeroClear MAX	100	Al. Plate	
303	Light Freezing Rain	-10	25	VCA	100	Al. Plate	
304	Light Freezing Rain	-10	25	VCA	100	Al. Plate	
305	Light Freezing Rain	-10	25	VCA	75	Al. Plate	
306	Light Freezing Rain	-10	25	VCA	75	Al. Plate	
307	Light Freezing Rain	-10	25	AMC	100	Al. Plate	
308	Light Freezing Rain	-10	25	AMC	100	Al. Plate	
309	Light Freezing Rain	-10	25	AMC	75	Al. Plate	
310	Light Freezing Rain	-10	25	AMC	75	Al. Plate	
311	Light Freezing Rain	-10	25	NSC	100	Al. Plate	
312	Light Freezing Rain	-10	25	NSC	100	Al. Plate	
313	Light Freezing Rain	-10	25	NSC	75	Al. Plate	
314	Light Freezing Rain	-10	25	NSC	75	Al. Plate	
315	Light Freezing Rain	-10	25	DED	100	Al. Plate	
316	Light Freezing Rain	-10	25	DED	100	Al. Plate	
317	Cold Soak Box	1	5	2YB	100	Al. Box	
318	Cold Soak Box	1	5	2YB	100	Al. Box	
319	Cold Soak Box	1	5	2YB	75	Al. Box	
320	Cold Soak Box	1	5	2YB	75	Al. Box	
321	Cold Soak Box	1	5	AeroClear MAX	100	Al. Box	
322	Cold Soak Box	1	5	AeroClear MAX	100	Al. Box	
323	Cold Soak Box	1	5	VCA	100	Al. Box	
324	Cold Soak Box	1	5	VCA	100	Al. Box	
325	Cold Soak Box	1	5	VCA	75	Al. Box	
326	Cold Soak Box	1	5	VCA	75	Al. Box	
327	Cold Soak Box	1	5	AMC	100	Al. Box	
328	Cold Soak Box	1	5	AMC	100	Al. Box	
329	Cold Soak Box	1	5	AMC	75	Al. Box	
330	Cold Soak Box	1	5	AMC	75	Al. Box	
331	Cold Soak Box	1	5	NSC	100	Al. Box	
332	Cold Soak Box	1	5	NSC	100	Al. Box	
333	Cold Soak Box	1	5	NSC	75	Al. Box	
334	Cold Soak Box	1	5	NSC	75	Al. Box	
335	Cold Soak Box	1	5	DED	100	Al. Box	
336	Cold Soak Box	1	5	DED	100	Al. Box	

TABLE 1: NEW FLUID ENDURANCE TIMES TEST PLAN (CONT'D)

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Fluid Dilution (%)	Test Surface	Comments
337	Cold Soak Box	1	75	2YB	100	Al. Box	
338	Cold Soak Box	1	75	2YB	100	Al. Box	
339	Cold Soak Box	1	75	2YB	75	Al. Box	
340	Cold Soak Box	1	75	2YB	75	Al. Box	
341	Cold Soak Box	1	75	AeroClear MAX	100	Al. Box	
342	Cold Soak Box	1	75	AeroClear MAX	100	Al. Box	
343	Cold Soak Box	1	75	VCA	100	Al. Box	
344	Cold Soak Box	1	75	VCA	100	Al. Box	
345	Cold Soak Box	1	75	VCA	75	Al. Box	
346	Cold Soak Box	1	75	VCA	75	Al. Box	
347	Cold Soak Box	1	75	AMC	100	Al. Box	
348	Cold Soak Box	1	75	AMC	100	Al. Box	
349	Cold Soak Box	1	75	AMC	75	Al. Box	
350	Cold Soak Box	1	75	AMC	75	Al. Box	
351	Cold Soak Box	1	75	NSC	100	Al. Box	
352	Cold Soak Box	1	75	NSC	100	Al. Box	
353	Cold Soak Box	1	75	NSC	75	Al. Box	
354	Cold Soak Box	1	75	NSC	75	Al. Box	
355	Cold Soak Box	1	75	DED	100	Al. Box	
356	Cold Soak Box	1	75	DED	100	Al. Box	

TABLE 2: ET THICKNESS TEST PLAN

Test #	Fluid Code	Fluid Dilution	Fluid Temp	Test Surface	Ambient Air Temp
TH1	2YB	100/0	-3°C	Al. Plate	-3°C
TH2	2YB	100/0	-3°C	Al. Plate	-3°C
TH3	2YB	75/25	-3°C	Al. Plate	-3°C
TH4	2YB	75/25	-3°C	Al. Plate	-3°C
TH5	2YB	50/50	-3°C	Al. Plate	-3°C
TH6	2YB	50/50	-3°C	Al. Plate	-3°C
TH7	VCA	100/0	-3°C	Al. Plate	-3°C
TH8	VCA	100/0	-3°C	Al. Plate	-3°C
TH9	VCA	75/25	-3°C	Al. Plate	-3°C
TH10	VCA	75/25	-3°C	Al. Plate	-3°C
TH11	VCA	50/50	-3°C	Al. Plate	-3°C
TH12	VCA	50/50	-3°C	Al. Plate	-3°C
TH13	AMC	100/0	-3°C	Al. Plate	-3°C
TH14	AMC	100/0	-3°C	Al. Plate	-3°C
TH15	AMC	75/25	-3°C	Al. Plate	-3°C
TH16	AMC	75/25	-3°C	Al. Plate	-3°C
TH17	AMC	50/50	-3°C	Al. Plate	-3°C
TH18	AMC	50/50	-3°C	Al. Plate	-3°C
TH19	NSC	100/0	-3°C	Al. Plate	-3°C
TH20	NSC	100/0	-3°C	Al. Plate	-3°C
TH21	NSC	75/25	-3°C	Al. Plate	-3°C
TH22	NSC	75/25	-3°C	Al. Plate	-3°C
TH23	NSC	50/50	-3°C	Al. Plate	-3°C
TH24	NSC	50/50	-3°C	Al. Plate	-3°C
TH25	DED	100/0	-3°C	Al. Plate	-3°C
TH26	DED	100/0	-3°C	Al. Plate	-3°C
TH27	AeroClear MAX	100/0	-3°C	Al. Plate	-3°C
TH28	AeroClear MAX	100/0	-3°C	Al. Plate	-3°C

Notes:

- The quantity of fluid that will be poured for each test is 1.0 L
- Measurements should be made at the 15-cm line at the time of fluid application, and after 2 minutes, 5 minutes, 15 minutes, and 30 minutes.
- If the results for one fluid vary by more than 10% repeat the two tests and disregard the highest and lowest values

FIGURE 3: COMBINED AIRFOIL AND WINGLET EXPERIMENTAL SET-UPS

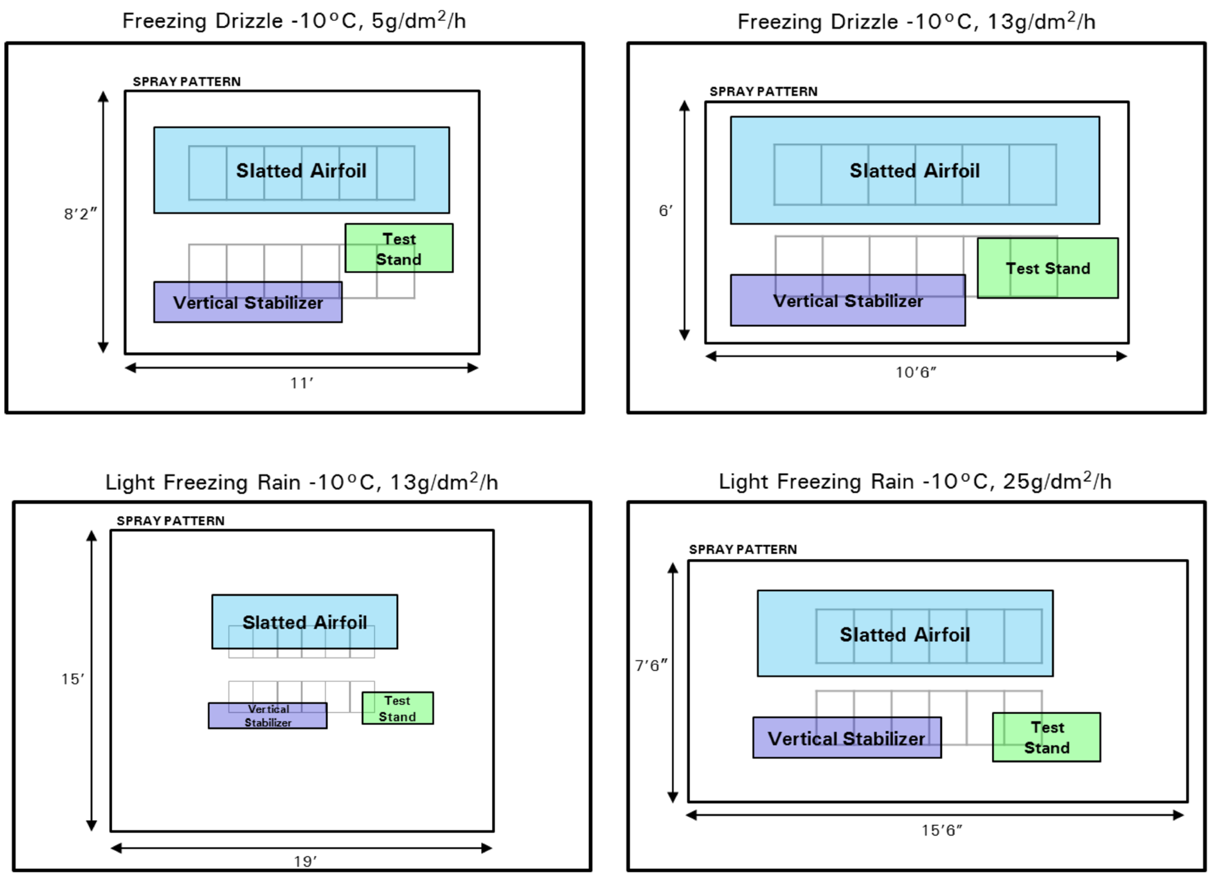


TABLE 3: COMBINED AIRFOIL AND VERTICAL STABILIZER PROTECTION TIMES TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Fluid Dilution (%)	Test Surface	Comments
AF1	Light Freezing Rain	-10	13	Kilfrost ABC-S Plus	75	10° Al. Plate	Fluid to be diluted from neat stock
AF2	Light Freezing Rain	-10	13	Kilfrost ABC-S Plus	75	20° Al. Plate.	Fluid to be diluted from neat stock
V1	Light Freezing Rain	-10	13	Kilfrost ABC-S Plus	75	80° Al. Plate.	Fluid to be diluted from neat stock
AF3	Light Freezing Rain	-10	13	Kilfrost ABC-S Plus	75	Slatted Airfoil	Fluid to be diluted from neat stock
V2	Light Freezing Rain	-10	13	Kilfrost ABC-S Plus	75	Vertical Stabilizer	Fluid to be diluted from neat stock
AF4	Light Freezing Rain	-10	13	LNT E188	10°B (B=23.0)	10° Box	Spray fluid at 20°C
AF5	Light Freezing Rain	-10	13	LNT E188	10°B (B=23.0)	20° Box	Spray fluid at 20°C
V3	Light Freezing Rain	-10	13	LNT E188	10°B (B=23.0)	80° Box	Spray fluid at 20°C
AF6	Light Freezing Rain	-10	13	LNT E188	10°B (B=23.0)	Slatted Airfoil	Spray fluid at 20°C
V4	Light Freezing Rain	-10	13	LNT E188	10°B (B=23.0)	Vertical Stabilizer	Spray fluid at 20°C
AF7	Light Freezing Rain	-10	25	Clariant Max Flight 04	100	10° Al. Plate	
AF8	Light Freezing Rain	-10	25	Clariant Max Flight 04	100	20° Al. Plate.	
V5	Light Freezing Rain	-10	25	Clariant Max Flight 04	100	80° Al. Plate.	
AF9	Light Freezing Rain	-10	25	Clariant Max Flight 04	100	Slatted Airfoil	
V6	Light Freezing Rain	-10	25	Clariant Max Flight 04	100	Vertical Stabilizer	
AF10	Freezing Drizzle	-3	5	ABAX Ecowing AD-49	50	10° Al. Plate	Fluid to be diluted from neat stock
AF11	Freezing Drizzle	-3	5	ABAX Ecowing AD-49	50	20° Al. Plate.	Fluid to be diluted from neat stock
V7	Freezing Drizzle	-3	5	ABAX Ecowing AD-49	50	80° Al. Plate.	Fluid to be diluted from neat stock
AF12	Freezing Drizzle	-3	5	ABAX Ecowing AD-49	50	Slatted Airfoil	Fluid to be diluted from neat stock
V8	Freezing Drizzle	-3	5	ABAX Ecowing AD-49	50	Vertical Stabilizer	Fluid to be diluted from neat stock
AF13	Freezing Drizzle	-3	13	LNT E188	10°B (B=18.25)	10° Box	Spray fluid at 20°C
AF14	Freezing Drizzle	-3	13	LNT E188	10°B (B=18.25)	20° Box	Spray fluid at 20°C
V9	Freezing Drizzle	-3	13	LNT E188	10°B (B=18.25)	80° Box	Spray fluid at 20°C
AF15	Freezing Drizzle	-3	13	LNT E188	10°B (B=18.25)	Slatted Airfoil	Spray fluid at 20°C
V10	Freezing Drizzle	-3	13	LNT E188	10°B (B=18.25)	Vertical Stabilizer	Spray fluid at 20°C

TABLE 3: COMBINED AIRFOIL AND VERTICAL STABILIZER PROTECTION TIMES TEST PLAN (CONT'D)

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm2/h)	Fluid	Fluid Dilution (%)	Test Surface	Comments
AF16	Freezing Drizzle	-3	13	Kilfrost ABC-Ice Clear II	100	10° Al. Plate	
AF17	Freezing Drizzle	-3	13	Kilfrost ABC-Ice Clear II	100	20° Al. Plate.	
V11	Freezing Drizzle	-3	13	Kilfrost ABC-Ice Clear II	100	80° Al. Plate.	
AF18	Freezing Drizzle	-3	13	Kilfrost ABC-Ice Clear II	100	Slatted Airfoil	
V12	Freezing Drizzle	-3	13	Kilfrost ABC-Ice Clear II	100	Vertical Stabilizer	

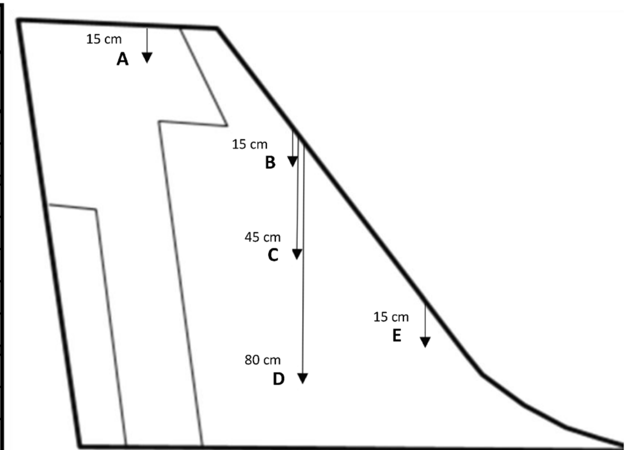
FIGURE 4: FLUID THICKNESS ON VERTICAL STABILIZER DATA FORM

DATE: ______ TEMPERATURE °C: ______ PERFORMED BY: ______

TEST #: ___ to ___ APPLICATION TIME: ______ WRITTEN BY: ______

FLUID: ______ LOCATION: CEF (NRC)

Thickness Measurement (mil)					
Test #	Timing: (hh:mm)	5 min :	10 min :	15 min :	30 min :
	10° Plate				
	80° Plate				
	A (spray side)				
	B (spray side)				
	C (spray side)				
	D (spray side)				
	E (spray side)				
	A (pour side)				
	B (pour side)				
	C (pour side)				
	D (pour side)				
	E (pour side)				



COMMENTS:

NOTES:
- Fluid thickness to be measured at 15cm line of plate
- Fluid thickness to be measured at multiple points on the vertical stabilizer (see diagram)
- Fluid thickness to be measured on both sides
- Fluid thickness to be measured at 5, 10, 15 and 30 minutes after pouring

TABLE 4: VERTICAL STABILIZER THICKNESS TEST PLAN

Test #	Fluid	Fluid Dilution	Fluid Temp	Test Surface	Ambient Air Temp	Fluid Quantity
VT1	LNT E188	10°B (B=18.25)	20°C	10° Al. Plate	-3°C	0.5 L
VT2	LNT E188	10°B (B=18.25)	20°C	80° Al. Plate	-3°C	0.5 L
VT3	LNT E188	10°B (B=18.25)	20°C	Vertical Stabilizer	-3°C	9 L
VT4	Clariant Max Flight 04	75	-3°C	10° Al. Plate	-3°C	1 L
VT5	Clariant Max Flight 04	75	-3°C	80° Al. Plate	-3°C	1 L
VT6	Clariant Max Flight 04	75	-3°C	Vertical Stabilizer	-3°C	13.5 L

Notes:

- **Fluid thickness to be measured at 15cm from the top of the vertical stabilizer (multiple points, see diagram). Thickness to be measured on both sides**
- **Fluid thickness to be measured at 15cm line of plate**
- **Fluid thickness to be measured at 5, 10, 15 and 30 minutes after pouring**
- **Vertical stabilizer angle to be measured**

TABLE 5: COLOURED VS. UNCOLOURED TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Fluid Dilution (%)	Test Surface	Comments
CU1	Freezing Fog	-3	5	2YB Coloured	50	Al. Plate	
CU2	Freezing Fog	-3	5	2YB Uncoloured	50	Al. Plate	
CU3	Freezing Drizzle	-3	13	2YB Coloured	100	Al. Plate	
CU4	Freezing Drizzle	-3	13	2YB Uncoloured	100	Al. Plate	
CU5	Freezing Drizzle	-3	13	2YB Coloured	75	Al. Plate	
CU6	Freezing Drizzle	-3	13	2YB Uncoloured	75	Al. Plate	
CU7	Freezing Drizzle	-10	13	2YB Coloured	100	Al. Plate	
CU8	Freezing Drizzle	-10	13	2YB Uncoloured	100	Al. Plate	
CU9	Freezing Drizzle	-10	13	2YB Coloured	75	Al. Plate	
CU10	Freezing Drizzle	-10	13	2YB Uncoloured	75	Al. Plate	
CU11	Light Freezing Rain	-3	25	2YB Coloured	100	Al. Plate	
CU12	Light Freezing Rain	-3	25	2YB Uncoloured	100	Al. Plate	
CU13	Light Freezing Rain	-3	25	2YB Coloured	75	Al. Plate	
CU14	Light Freezing Rain	-3	25	2YB Uncoloured	75	Al. Plate	
CU15	Light Freezing Rain	-3	25	2YB Coloured	50	Al. Plate	
CU16	Light Freezing Rain	-3	25	2YB Uncoloured	50	Al. Plate	
CU17	Light Freezing Rain	-10	25	2YB Coloured	100	Al. Plate	
CU18	Light Freezing Rain	-10	25	2YB Uncoloured	100	Al. Plate	
CU19	Light Freezing Rain	-10	25	2YB Coloured	75	Al. Plate	
CU20	Light Freezing Rain	-10	25	2YB Uncoloured	75	Al. Plate	

TABLE 6: PERSONNEL REQUIREMENTS / RESPONSIBILITIES

PERSONNEL ASSIGNMENTS	MAIN STAND			STANDS REMOVED
	HOT	Type III	Coloured/ Uncoloured	Airfoil + Vertical Stabilizer PTs
Manager	JD	JD	JD	MR
Assistant	YOW2	YOW2	YOW2	BB/YOW2
Data Forms	CB	CB	CB	CB
Rate Station Manager	DY	DY	DY	DY
Rate Station Assistant	YOW1	YOW1	YOW1	YOW1

PERSONNEL ASSIGNMENTS	SMALL END CHAMBER	
	ET Thickness	V-Stab Thickness
Manager	JD/CB	MR
Assistant	JD/CB	BB
Data Forms	CB	MR/BB
Rate Station Manager	-	-
Rate Station Asst	-	-

PERSONNEL ASSIGNMENTS	OTHER TASKS
Pre-Test Setup	JD
Equipment Manager	JD
Fluid Management	JD/CB
Data Form Filing	CB
Box Prep (in CSW)	MR/BB
Fluid Collection + Filling	YOW1/YOW2
Relief Rate Station Mgr.	SB

TABLE 7: LIST OF FLUIDS

Fluid	Viscosity Type	Batch #	Fluid Temp	Fluid Dil or Brix (FFP)	Litres Required per Project					Total Litres	Pour Bottles	Large Containers	Notes
					ET/ TIII	TH-ET	TH-VS	AF/ VS	CU				
Type I (R&D)													
LNT E188 (B=18.25)	n/a	AeroMag (March 2,2016)	20°C	18.25 (-13°C)	-	-	10	7.5	-	**17.5**	**0**	**1 jug with 12 litres**	
LNT E188 (B=23.0)	n/a	AeroMag (March 2,2016)	20°C	23.0 (-20°C)	-	-	-	7.5	-	**7.5**	**0**	**1 jug with 16 litres**	
Type II, III, IV (HOT)													
AllClear AeroClear MAX	LOWV	CB1-PB8000A2	OAT	100	36	2	-	-	-	**38**	**6**	**1 x 14 litre jug**	**must use 1/2 plate**
DED	LOWV	160108D-CC	OAT	100	32	2	-	-	-	**34**	**6**	**2 x 20 litre jugs**	**leave 2 bottles at site**
2YB	LOWV	20151220	OAT	100	32	2	-	-	-	**34**	**6**	**2 x 20 litre jugs**	**leave 2 bottles at site**
2YB	LOWV	20151220	OAT	75	28	2	-	-	-	**30**	**6**	**2 x 20 litre jugs**	**leave 2 bottles at site**
2YB	LOWV	20151220	OAT	50	12	2	-	-	-	**14**	**6**	**1 x 20 litre jug**	**leave 2 bottles at site**
AMC	LOWV	TV 548	OAT	100	36	2	-	-	-	**38**	**6**	**2 x 20 litre jugs**	**leave 2 bottles at site**
AMC	LOWV	TV 548	OAT	75	28	2	-	-	-	**30**	**6**	**2 x 20 litre jugs**	**leave 2 bottles at site**
AMC	LOWV	TV 548	OAT	50	12	2	-	-	-	**14**	**6**	**1 x 20 litre jug**	**leave 2 bottles at site**
NSC	LOWV	TV 549	OAT	100	36	2	-	-	-	**38**	**6**	**2 x 20 litre jugs**	**leave 2 bottles at site**
NSC	LOWV	TV 549	OAT	75	28	2	-	-	-	**30**	**6**	**2 x 20 litre jugs**	**leave 2 bottles at site**
NSC	LOWV	TV 549	OAT	50	12	2	-	-	-	**14**	**6**	**1 x 20 litre jug**	**leave 2 bottles at site**
VCA	LOWV	15031901	OAT	100	32	2	-	-	-	**34**	**6**	**2 x 20 litre jugs**	**leave 2 bottles at site**
VCA	LOWV	15031901	OAT	75	28	2	-	-	-	**30**	**6**	**2 x 20 litre jugs**	**leave 2 bottles at site**
VCA	LOWV	15031901	OAT	50	12	2	-	-	-	**14**	**6**	**1 x 20 litre jug**	**leave 2 bottles at site**
Type II, III, IV (R&D)													
Kilfrost ABC-Ice Clear II	LOWV	X/1/2/15	OAT	100	-	-	-	35	-	**35**	**0**	**2 x 20 litre jugs**	
Kilfrost ABC-S Plus	Mid	P/282/12/10	OAT	75	-	-	-	22	-	**22**	**0**	**1 x 25 litre jug**	**Diluted from Neat, B=27.75**
Clariant Max Flight 04	Mid	U49E001966	OAT	100	-	-	-	38	-	**38**	**0**	**2 x 20 litre jugs**	
Clariant Max Flight 04	Mid	U49E001966	OAT	75	-	-	16	-	-	**15.5**	**0**	**1 x 20 litre jugs**	**Diluted from Neat, B=27.5**
ABAX Ecowing AD-49	Mid	Air France (May 2014)	OAT	50	-	-	-	20	-	**20**	**0**	**1 x 20 litre jug**	**Diluted from Neat, B=19.25**
2YB Coloured	LOWV	2016-01-27	OAT	100	-	-	-	-	4	**4**	**0**	**bring leftover jug**	**Fill 2 x 1 litre (leave outside)**
2YB Coloured	LOWV	2016-01-27	OAT	75	-	-	-	-	4	**4**	**0**	**bring leftover jug**	**Fill 1 x 1 litre (leave outside)**
2YB Coloured	LOWV	2016-01-27	OAT	50	-	-	-	-	2	**2**	**0**	**bring leftover jug**	**Fill 1 x 1 litre (put in fridge)**
2YB Uncoloured	LOWV	2016-01-27	OAT	100	-	-	-	-	4	**4**	**0**	**bring leftover jug**	**Fill 2 x 1 litre (leave outside)**
2YB Uncoloured	LOWV	2016-01-27	OAT	75	-	-	-	-	4	**4**	**0**	**bring leftover jug**	**Fill 1 x 1 litre (leave outside)**
2YB Uncoloured	LOWV	2016-01-27	OAT	50	-	-	-	-	2	**2**	**0**	**bring leftover jug**	**Fill 1 x 1 litre (put in fridge)**
All Fluids					**364**	**28**	**26**	**130**	**20**	**568**	**84**		

Warm storage fluids | Cold storage fluids

TABLE 8: TYPE I DILUTION TABLE

FFP (°C)	Test Temp (°C)	LNT Solutions LNT E188 (EG)			
		% Fluid	Brix	Fluid (L) for 4 L	Water (L) for 4 L
-13	-3	30.0	18.25	1.2	2.8
-20	-10	38.0	23.0	1.5	2.5

TABLE 9: EQUIPMENT LIST

HOT AND GENERAL EQUIPMENT
LOCATION: TEST SITE
Barrel Opener to open CSW fluids
Bins for mixing CSW fluid x 5 (60L rubbermaids)
Brixometer x 3
~~Calculators x 2~~
Camera x1 (small Canon) with accessories
Cart (IKEA) x2
Clipboards x 10
Clock (Large digital) x 2
Cold-soak boxes (aluminum) x 16
~~Cold-soak boxes (composite) x 3~~
Extension Cords x 4
Flashlights x 2
Fluids (separate table)
Folding table x 1 (small)
Freezers (portable) x2
Funnels x 4 (big and small)
Gloves - black and yellow x4
Gloves - cotton (1 large box)
Gloves - latex (2 boxes)
~~Hard water chemicals x 3 premixes~~
Ice Pic
Inclinometer (yellow level) x 2
Isopropyl x 15
Jigaloo x1 and Scotchguard x1
Lock for truck
Marker for Waste x 2
Measuring Cups x 3
~~Nuts to separate plates x 100 (full box)~~
Pails x 5 (Empty 18L cont. for -30C CSW fluid)
Paper Towels (4 packs)
Personnel clothing + SB box
Pour containers (1-litre) - 6 empty
Pour containers (1-litre) - see separate list
Power bars x 4
Printer & Ink Cartridge
Rain Suits (all)
Rate Pan (aluminum HOT) x1
Rate Pans(white plastic) x all
Sample bottles x 6
Scrapers x 14
Shop Vac + 2x18L open top pails

HOT AND GENERAL EQUIPMENT
LOCATION: TEST SITE
Smart button kits x 2 + extension wire
Speed tape x 1 and electrical tape x 5
Squeegees x 4 (small)
Tape measure (large yellow + small)
Temperature probes: immersion x 3
Temperature probes: surface x 3
Temperature readers (blue box)x 2
Test plate covers (white plastic) x 15
Test plate covers (wooden boards) x 12
Test Plates - Half plates x 11 (22 halves)
Test Plates (Aluminum): 12 w/buttons + 6 w/out
~~Test Plates (Composite):4 w/smart buttons~~
Test Stand Collection Pans (one per stand)
Test Stand Shims (poker chips) x 1 box
Test Stands: 1 x 6 position (small end)
Test Stands: 2 x 6-position (main stand)
Test Stands: 3 position (side stand) (2+1)
~~Test Stands: 3 position (spare) (2+1)~~
~~USB Extension cables x3~~
Vise grip (large) + rubber opener
~~Water (1 x 18L) for hard water~~
Weigh Scale x 2 (sartorius) + wiring
White poster board panels for water run-off
Yellow Carrying Cases x4
Thickness Gauges (4 x small 4 x large)
Tuques x10
~~Type I PG Concentrate (CSW) x 10L~~
Fridge for food at NRC

OTHER RESEARCH PROJECTS (Flaps/Slats (Airfoil) and Vertical Stabilizer)
LOCATION: TEST SITE
Slatted airfoil on stand
Small Fluid Collection Pan x 4 (if available)
3L pour container
Empty 1L pour containers to prop plates to 20° x 1
Measuring Cups x 2
Garden Sprayer
Vertical Stabilizer on stand
80° test stand x1 with plate
Small Canon camera with charger

TABLE 9: EQUIPMENT LIST (CONT'D)

HOT AND GENERAL EQUIPMENT
LOCATION: OFFICE
Accordian Folder
Blank Waterproof labels (1 page)
~~Camera Gear (2 suitcases + gopro)~~
Coffee x 140 (K-Cups)
Data Forms (on water phobic paper)
Envelopes (9x12) x box
Falling Ball Viscometer + Syringes
Hard Drive (if necessary)
iPads x 3
Laptop for smart button (MR)
Laptop x5 (CB, DY, SB, MR, BB)
Mouse for Rate Station and keypad
Paper for printer (1 pack)
Pencils (sharpened) + pens + markers
Test Procedures x 2 (1 sided)
Walkie Talkies x 4
Waterproof paper (40 sheets)
LOCATION: NRC
Cold-soak box filling stand
Cold-soak fluid pump
Copper tubing insulation (for passing wires)
Fluid for cold-soak boxes (barrel)
Rubber Mats
Shelving unit x 1 (black one)
Tie wraps
Tools
Tote for Waste Fluid
NRC Auto Rate Form with Historical #'s

Note: Pack coolers with first day fluids and plug into power overnight

FIGURE 5: NRC RATE MANAGEMENT FORM

DATE: ______________________

CONDITION: ______________________ TECHNICIAN: ______________________

PAN #	TAB	TIME OUT	1st or 2nd Rate

PAN #	TAB	TIME OUT	1st or 2nd Rate

Retired: 1 2 3 4 5 6 7 8 9 10 11 12

FIGURE 6: NRC CONTINUOUS RATE FORM

Condition	Date	Historical Average Calculated Rate (Pos. 1)	Standard Deviation of Historical Average Calculated Rate (Pos. 1)	Historical Average of Session Standard Deviation	Was Stand Moved? (Where?)	Suggested Start Position	Condition Difficulty Rating (1-5, 1 is easiest)	Historical Condition Difficulty Rating (1-5, 1 is easiest)	Comments
ZF, -3, 2		1.8	0.4	0.7		Nozzle centre Plate 3 (2'', 14'')		1.0	
ZF, -3, 5		4.7	0.4	0.8		Nozzle centre Plate 3 (2'', 14'')		3.0	
ZF, -10, 2		1.9	0.4	0.5		Nozzle centre Plate 3 (2'', 14'')		1.0	
ZF, -10, 5		5.2	1.3	0.9		Nozzle centre Plate 3 (2'', 14'')		n/a	
ZF, -14, 2		1.9	0.1	0.5		Nozzle centre Plate 3 (2'', 14'')		1.0	
ZF, -14, 5		4.7	0.3	1.0		Nozzle centre Plate 3 (2'', 14'')		1.0	
ZF, -25, 2		2.3	0.3	1.2		Nozzle centre Plate 3 (2'', 14'')		1.0	
ZF, -25, 5		4.7	0.6	1.2		Nozzle centre Plate 3 (2'', 14'')		5.0	
ZF, -35, 2		2.0	n/a	1.0		(24', 7'), (24', 9')		5.0	
ZD, -3, 5		5.5	0.2	0.9		(24', 7'), (24', 9')		1.0	
ZD, -3, 13		13.1	2.5	2.1		(24', 7'), (24', 9')		3.0	
ZD, -6, 5		n/a	n/a	n/a		n/a		n/a	
ZD, -6, 13		n/a	n/a	n/a		n/a		n/a	
ZD, -10, 5		5.7	0.2	0.8		(24', 7'), (24', 9')		1.0	
ZD, -10, 13		14.2	0.3	1.0		(24', 7'), (24', 9')		1.0	
ZR, -3, 13		13.3	0.3	1.1		(24', 7'), (24', 9')		1.0	
ZR, -3, 25		25.4	0.6	1.3		(24', 7'), (24', 9')		1.0	
ZR, -6, 13		n/a	n/a	n/a		n/a		n/a	
ZR, -6, 25		n/a	n/a	n/a		n/a		n/a	
ZR, -10, 13		13.9	0.9	0.9		(24', 7'), (24', 9')		5.0	
ZR, -10, 25		26.2	0.6	1.2		(24', 7'), (24', 9')		1.0	
CS, 1, 5		4.9	0.2	1.8		Nozzle centre Plate 3 (2'', 14'')		3.0	
CS, 1, 75		77.3	4.6	7.9		Nozzle centre Plate 3 (2'', 14'')		5.0	

FIGURE 7: FLUID THICKNESS DATA FORM

DATE: ______________ TEMPERATURE °C (beg.): ______________ PERFORMED BY: ______________

TEST #: ______ to ______ WIND SPEED, kph (beg.): ______________ WRITTEN BY: ______________

STAND: ______________ LOCATION: CEF (NRC)

THICKNESS (mil)											
Plate: **U** Run #: Fluid: Application Time:		Plate: **V** Run #: Fluid: Application Time:		Plate: **W** Run #: Fluid: Application Time:		Plate: **X** Run #: Fluid: Application Time:		Plate: **Y** Run #: Fluid: Application Time:		Plate: **Z** Run #: Fluid: Application Time:	
TIME	**6" LINE**	**TIME**	**6" LINE**	**TIME**	**6" LINE**	**TIME**	**6" LINE**	**TIME**	**6" LINE**	**TIME**	**6" LINE**

I:\Groups\Cm1680 (01-02)\Procedures\Thickness\Thickness Form

Notes:

- The quantity of fluid that will be poured for each test is 1.0 L
- Measurements should be made at the 15-cm line at the time of fluid application, and after 2, 5, 15 and 30 minutes
- If the results for one fluid vary by more than 10% repeat the two tests and disregard the highest and lowest values

FIGURE 8: FREEZING PRECIPITATION ENDURANCE TIME DATA FORM

REMEMBER TO SYNCHRONIZE TIME

LOCATION: CEF (Ottawa) DATE: RUN NUMBER: STAND # :

TIME TO FAILURE FOR INDIVIDUAL CROSSHAIRS (real time)

Time of Fluid Application:

Initial Plate Temperature (°C)
(NEEDS TO BE WITHIN 0.5°C OF AIR TEMP)

Initial Fluid Temperature (°C)
(NEEDS TO BE WITHIN 3°C OF AIR TEMP)

	Plate 1	Plate 2	Plate 3	Plate 4	Plate 5	Plate 6
FLUID NAME/BATCH						
B1 B2 B3						
C1 C2 C3						
D1 D2 D3						
E1 E2 E3						
F1 F2 F3						
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA						
FAILURE CALL (circle)	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy
HRZ. AIR VELOCITY * (circle)	A B C	A B C	A B C	A B C	A B C	A B C

Time of Fluid Application:

Initial Plate Temperature (°C)
(NEEDS TO BE WITHIN 0.5°C OF AIR TEMP)

Initial Fluid Temperature (°C)
(NEEDS TO BE WITHIN 3°C OF AIR TEMP)

	Plate 7	Plate 8	Plate 9	Plate 10	Plate 11	Plate 12
FLUID NAME/BATCH						
B1 B2 B3						
C1 C2 C3						
D1 D2 D3						
E1 E2 E3						
F1 F2 F3						
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA						
FAILURE CALL (circle)	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy	V. Difficult Difficult. Easy
HRZ. AIR VELOCITY * (circle)	A B C	A B C	A B C	A B C	A B C	A B C

PRECIP (circle): ZF , ZD , ZR-, MOD

AMBIENT TEMPERATURE: ________°C

COMMENTS:

NOTE:
* A: HORIZONTAL AIR VELOCITY ≤ 0.4 m/s
B: 0.4 m/s < HORIZONTAL AIR VELOCITY ≤ 1.0 m/s
C: HORIZONTAL AIR VELOCITY > 1.0 m/s

LEADER / MANAGER: ____________________

FIGURE 9: AIRFOIL END CONDITION DATA FORM

DEPLOYED FLAPS

AIRFOIL END CONDITION DATA FORM

FORM __________ OF __________

DATE ______________

TEST MGR ______________

TEST SURFACE (check box) ☐ **Standard Airfoil** ☐ **Flap/Slat Airfoil**

TIME OF FLUID APPLICATION ____________

EC HOURLY DATA

RECORDED AT END OF POUR TIME

TIME OF EC OBSERVATION __________

TEMP _____ °C

WIND SPEED ____km/h

WIND DIRECTION _____.

FLUID INFORMATION

Fluid Name: _______________

Fluid Type / DILUTION: ______ /______

Liters used: _______________

Initial Brix: _______________

Initial Temp: _______________

ROTATION SEQUENCE

H = Headwind, C = Crosswind, T= Tailwind

	Direction (H, C, or T)	Time	Check
Start:	______	______	☐
Rotation 1	______	______	☐
Rotation 2	______	______	☐
Rotation 3	______	______	☐

Check that rotation was actually completed

EXPECTED HOLDOVER TIME __________

First Failure Time = _______ **10% Failure Time =** _______ **End of Test Time =** _______

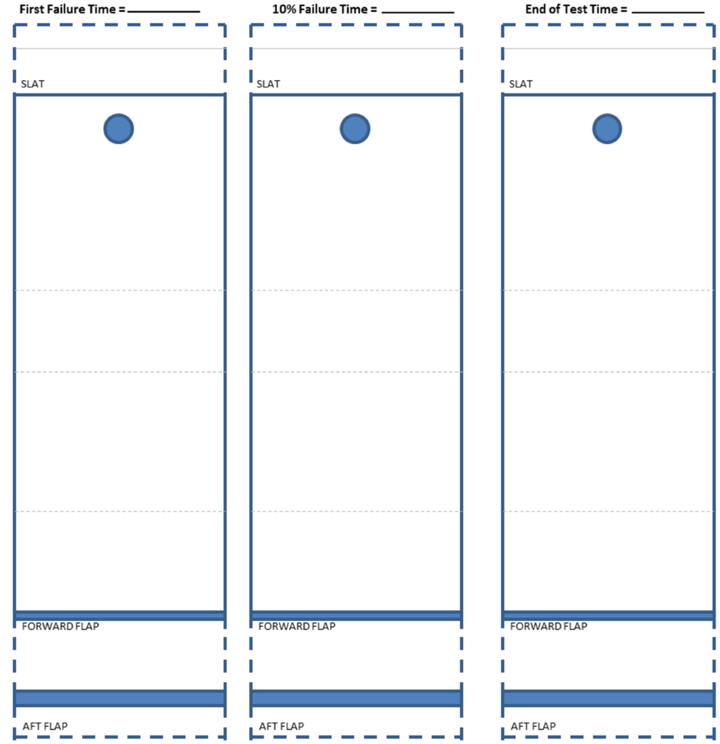
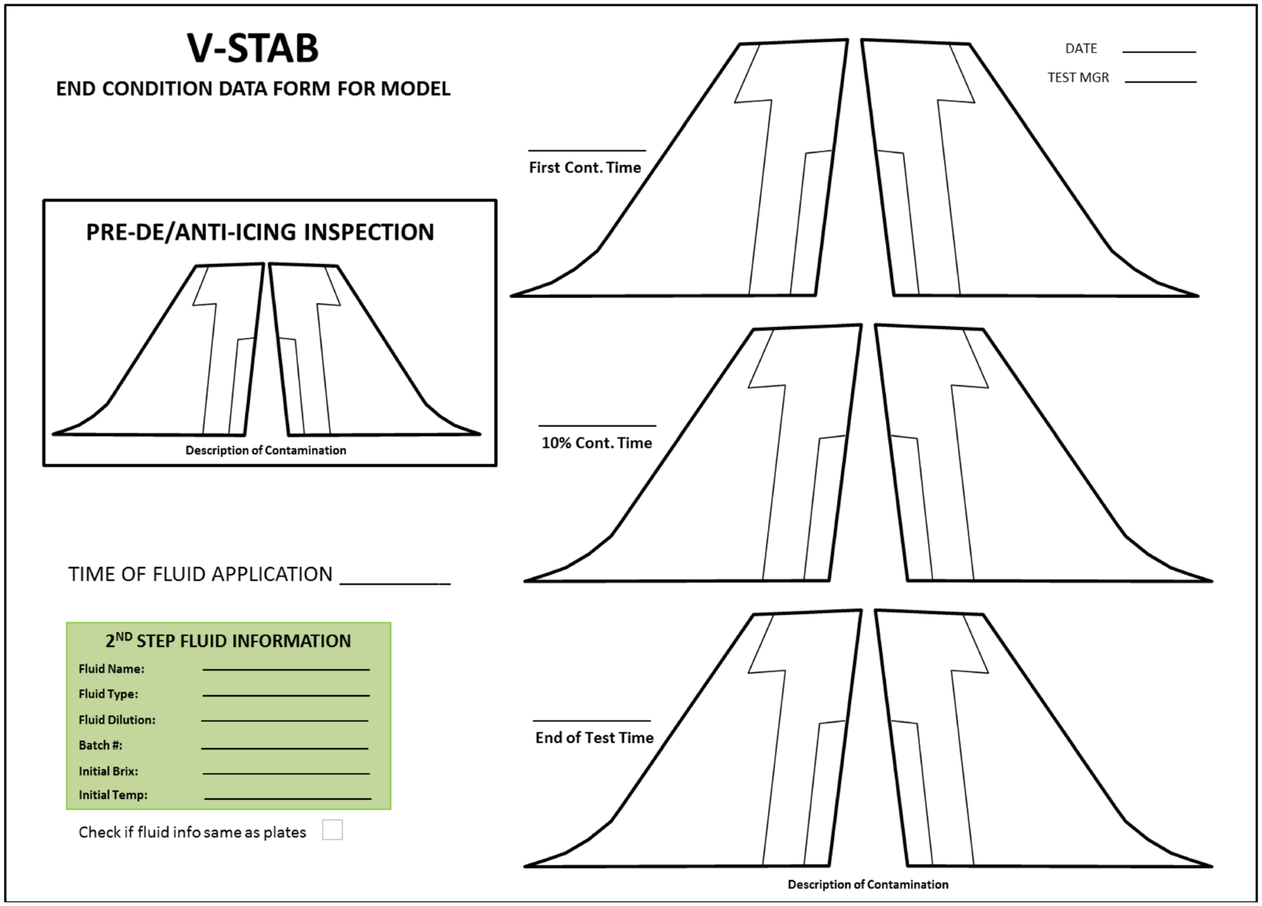


FIGURE 10: VERTICAL STABILIZER END CONDITION DATA FORM


V-STAB

END CONDITION DATA FORM FOR MODEL

DATE ________

TEST MGR ________

First Cont. Time ________

PRE-DE/ANTI-ICING INSPECTION

Description of Contamination

10% Cont. Time ________

TIME OF FLUID APPLICATION ________

End of Test Time ________

2ND STEP FLUID INFORMATION

Fluid Name: ________

Fluid Type: ________

Fluid Dilution: ________

Batch #: ________

Initial Brix: ________

Initial Temp: ________

Check if fluid info same as plates ☐

Description of Contamination

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APPENDIX C

FLUID MANUFACTURER REPORT: METHODOLOGY FOR ENDURANCE TIME TESTING OF TYPE II, III AND IV FLUIDS WINTER 2015-16

METHODOLOGY FOR ENDURANCE TIME TESTING OF TYPE II, III AND IV FLUIDS

Winter 2015-16

Prepared by

APS Aviation Inc.

These tests were made possible with the guidance, participation and contribution of the Transportation Development Centre of Transport Canada and the Federal Aviation Administration.

August 2016
Version 1.0
Report No. M-2015-16

METHODOLOGY FOR ENDURANCE TIME TESTING OF TYPE II, III AND IV FLUIDS

Winter 2015-16

Prepared by: Stephanie Bendickson, Senior Project Leader — Date: August 26, 2016

Reviewed by: John D'Avirro, Eng., Program Manager — Date: August 26, 2016

These tests were made possible with the guidance, participation and contribution of the Transportation Development Centre of Transport Canada and the Federal Aviation Administration.

August 2016
Version 1.0
Report No. M-2015-16

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SUMMARY

This report documents the key aspects of the testing and analysis methodologies employed by APS Aviation Inc. (APS) to carrying out endurance time testing with Type II, III and IV fluids in the winter of 2015-16.

The testing and analysis methodologies used are based on the protocols provided in Aerospace Recommended Practice (ARP) 5485. This report includes detailed information on:

- Test Sites;
- Test Equipment;
- Test Procedures;
- Test Conditions (precipitation rate limits, ambient temperatures, freezing precipitation droplet sizes); and
- Analysis Methodologies.

This report is intended to be used as a companion document to the reports written to document the individual performance of each Type II, III and IV fluid tested in the winter of 2015-16. The data, analysis and results provided in those reports are a function of the test and analysis methodologies described in this report and therefore should be used in conjunction with the information contained herein.

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GLOSSARY

APS	APS Aviation Inc.
ARP	Aerospace Recommended Practice
CEF	Climatic Engineering Facility
FAA	Federal Aviation Administration
HOT	Holdover Time
ISO	International Organization for Standardization
LOUT	Lowest Operational Use Temperature
LUPR	Lowest Usable Precipitation Rate
MVD	Median Volume Diameter
NRC	National Research Council Canada
TC	Transport Canada
TDC	Transportation Development Centre

1. INTRODUCTION

This report has been created with the support of the fluid manufacturers, the Transport Development Centre (TDC) of Transport Canada (TC) and the Federal Aviation Administration (FAA).

Aircraft ground de/anti-icing has been the subject of concentrated industry attention in recent years due to the occurrence of several fatal icing-related aircraft accidents. Notably, attention has been placed on the enhancement of anti-icing fluids in order to provide an extended period of protection against further contamination following initial deicing. This emphasis has led to the development of fluid-specific de/anti-icing fluid holdover time (HOT) tables for Type II, Type III and Type IV fluids. These tables, accepted by regulatory authorities, are used by aircraft operators for departure planning in adverse winter conditions. Specifically, they provide the duration of time that fluids provide protection against ice formation under specific weather conditions.

New anti-icing formulations continue to be developed by leading manufacturers with the specific objective of prolonging fluid holdover times without compromising the aerodynamic features of the airfoil. The purpose of the endurance time testing program is to measure the endurance times of these new fluids and develop fluid-specific HOT tables that provide guidance for their use.

Endurance time tests, conducted in natural and simulated precipitation, are used to develop HOT values for new fluids. These tests are carried out according to SAE Aerospace Recommended Practice (ARP) ARP5485, which provides the test protocols for measuring endurance times of Type II, III and IV fluids.

This report documents the key aspects of the testing and analysis methodologies employed by APS Aviation Inc. (APS) to carrying out endurance time testing with Type II, III and IV fluids in the winter of 2015-16. It includes information on:

1) Chapter 2 – Test Sites;
2) Chapter 3 – Test Equipment;
3) Chapter 4 – Test Procedures;
4) Chapter 5 – Test Conditions (precipitation rate limits, ambient temperatures, freezing precipitation droplet sizes); and
5) Chapter 6 – Analysis Methodologies.

This report is intended to be used as a companion document to the reports on individual fluid performance. The data, analysis and results provided in those reports are a function of the test and analysis methodologies described in this report and therefore should be used in conjunction with the information contained herein.

2. TEST SITES

This section documents the test sites where APS conducted endurance time testing with Type II, III and IV fluids during the winter of 2015-16.

2.1 Natural Snow, Natural Frost and Artificial Snow

Natural snow, natural frost and artificial snow testing is typically and predominantly performed at the APS test site located at the Montréal Pierre-Elliott-Trudeau International Airport. The test site is located near Environment Canada's Meteorological Services of Canada automated weather observation station, as shown in Figure 2.1 on a plan view of the airport.

The APS test site consists of two trailers and three outdoor locations for test stands. One of the trailers is equipped with a refrigeration unit to enable indoor testing at controlled temperatures; artificial snow testing is conducted inside this trailer. Photos 2.1 and 2.2 show the test site as seen from the test pads and main trailer, respectively.

In winter 2015-16, additional natural snow testing was conducted using a mobile test site in St-Adèle, Quebec; Schefferville, Quebec; and Iqaluit, Nunavut.

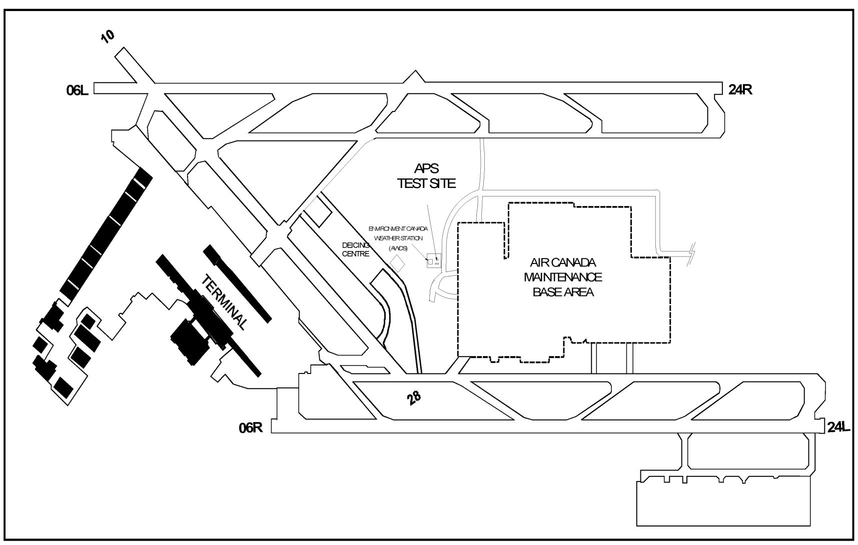


Figure 2.1: APS Test Site at Montréal-Pierre-Elliott-Trudeau International Airport

In winter 2015-16, additional artificial snow testing was conducted at PMG Technologies in Blainville, Quebec.

2.2 Freezing Precipitation

Tests under conditions of freezing fog, rain on cold-soaked surface, freezing drizzle, and light freezing rain were conducted indoors at the National Research Council Canada (NRC) Climatic Engineering Facility (CEF), where precipitation was artificially produced.

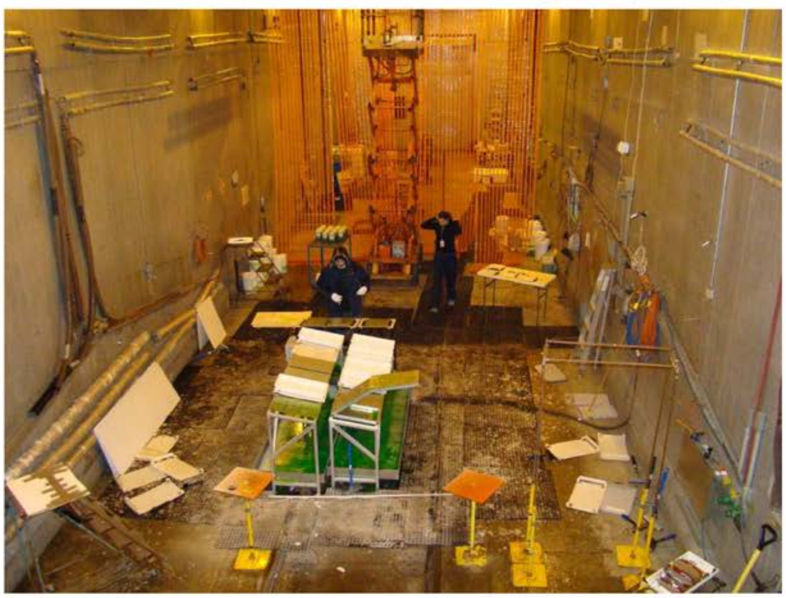
Photo 2.3 provides an outdoor view of the facility giving a general indication of its size (30 m by 5.4 m, height 8 m). The facility was originally designed for the testing of locomotives; Photo 2.4 provides an interior view of the CEF set up for endurance time testing. The lowest temperature achievable in the CEF is -46°C.

Photo 2.1: APS Test Site - View from Test Pad

Photo 2.2: APS Test Site - View from Trailer

Photo 2.3: Outdoor View of NRC Climatic Engineering Facility

Photo 2.4: Inside View of NRC Climatic Engineering Facility



3. TEST EQUIPMENT

The key equipment used in endurance time testing is described in this section, as are the calibration procedures APS follows for ensuring the accuracy of its test equipment.

3.1 Calibration

APS measurement instruments and test equipment are calibrated and/or verified on an annual basis. This calibration is carried out according to a calibration plan based upon approved International Organization for Standardization (ISO) 9001:2000 standards, and developed internally by APS.

3.2 Environmental Chamber Equipment

The general environmental chamber equipment used during tests (including air temperature sensor, data acquisition system, temperature control equipment, etc.) was as stipulated in the requirements set out in ARP5485.

3.3 Test Surface Structures

3.3.1 Flat Plates

The majority of endurance time testing is carried out on standard flat plates. A schematic of a standard flat plate is provided in Figure 3.1. It depicts the size and surface markings of a standard flat plate. Three parallel lines are positioned at 2.5 cm (1″), 15 cm (6″) and 30 cm (12″) from the top of the plate. The plates are marked with 15 crosshairs, which are used in determining when end conditions (see Subsection 4.5) are achieved. Photo 3.1, taken outdoors at the APS test site, shows six test plates mounted on a test stand.

3.3.2 Cold-Soak Boxes

Figure 3.2 shows a schematic of the sealed boxes used for tests simulating a cold soaked wing. The top of the box consists of a flat plate identical to the standard flat plate. An insulated box shaped reservoir is welded to the bottom of the plate. Photo 3.2 shows a picture of a sealed box, which is referred to as a cold-soak box when filled for simulated rain on cold soaked wing tests.

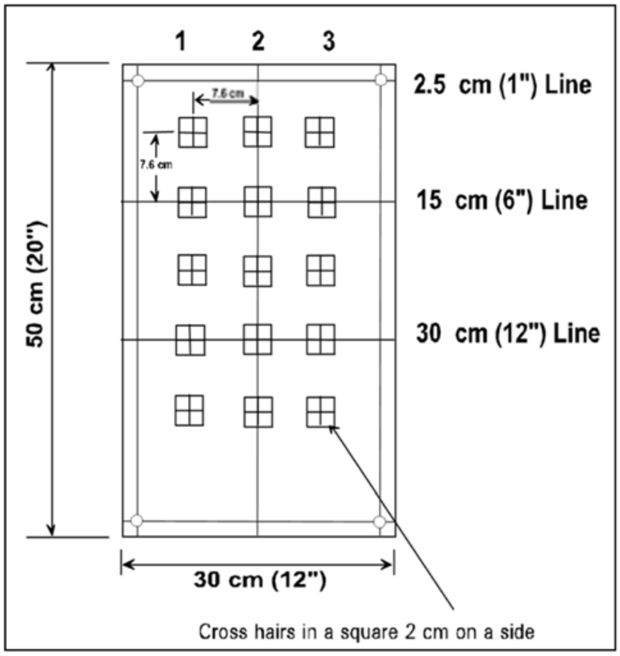


Figure 3.1: Standard Test Plate Schematic

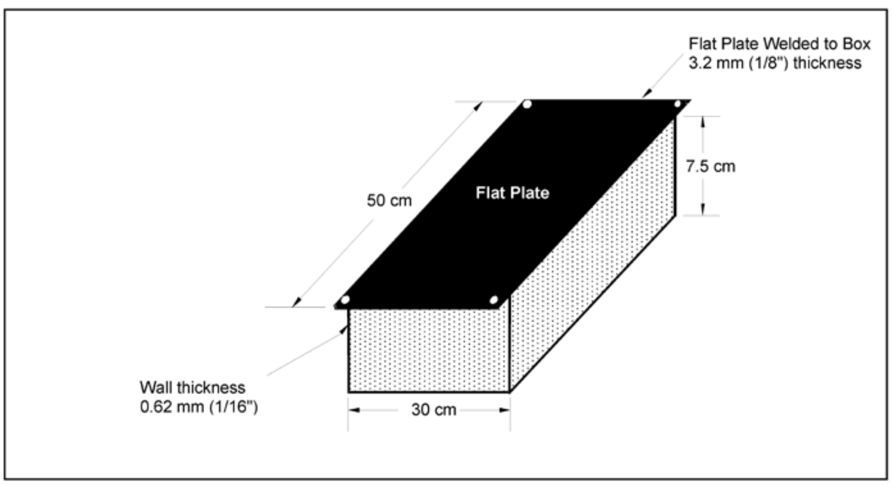


Figure 3.2: Cold Soak Box Schematic

3.3.3 Frosticator Plates

In natural frost, tests are conducted on frosticator plates, which are the current standard test surface used in frost holdover time testing. The frosticator plates were constructed by attaching a Styrofoam insulation backing to the back of the test surface (either aluminum or composite). The insulation prevents heat exchange via the underside of the flat plate and allows for effective radiative cooling during active frost conditions. Photo 3.3 shows a white-painted aluminum frosticator plate.

3.3.4 Artificial Snowmaker Test Plate

In artificial snow, tests are conducted on a standard flat plate that has been mounted onto a specialized scale. This setup is shown in Photo 3.4.

3.4 Test Surface Materials

Testing of Type II, III and IV fluids is carried out exclusively on aluminum surfaces. The aluminum used is 0.32 cm thick Alclad 2024 T3 aluminum.

3.5 Test Stands

Figure 3.3 shows a schematic of the test platform used for HOT testing. For natural snow tests, six test plates are normally mounted on the test stand, which has a working surface inclined at 10° to the horizontal. During normal winter operations two six-position stands are used in combination. Each plate represents a flat plate test. For simulated freezing precipitation tests at the NRC, 12 plates are mounted on 2 six-position stands. Photo 3.1 shows the test stands set up for testing.

3.6 Collection Pans

Figure 3.4 shows a schematic of the collection pan used for precipitation rate measurement in outdoor testing. It is the same size as a standard flat plate and is used to make precipitation rate measurements during outdoor tests. Photo 3.5 shows the collection pans used for measuring precipitation rates indoors at the NRC.

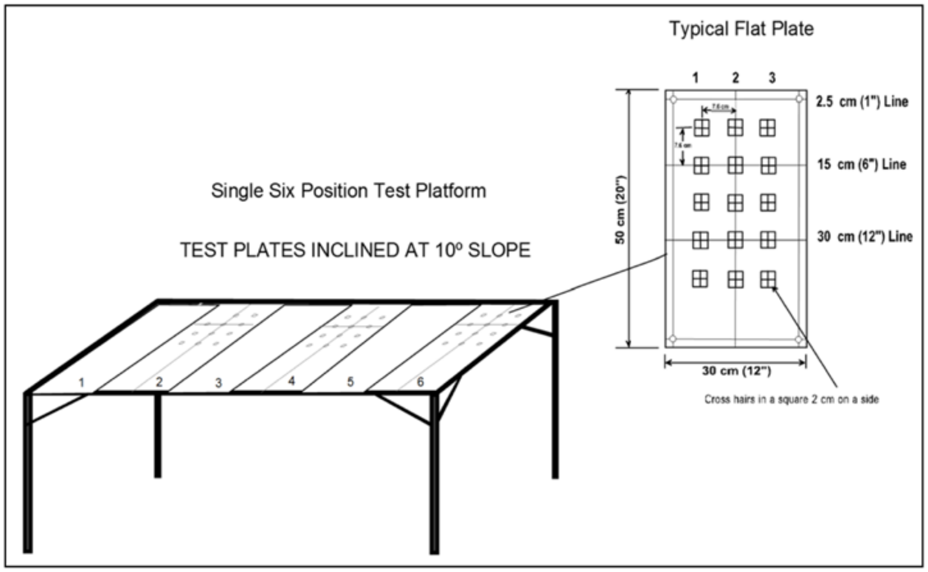


Figure 3.3: Test Stand Setup Schematic

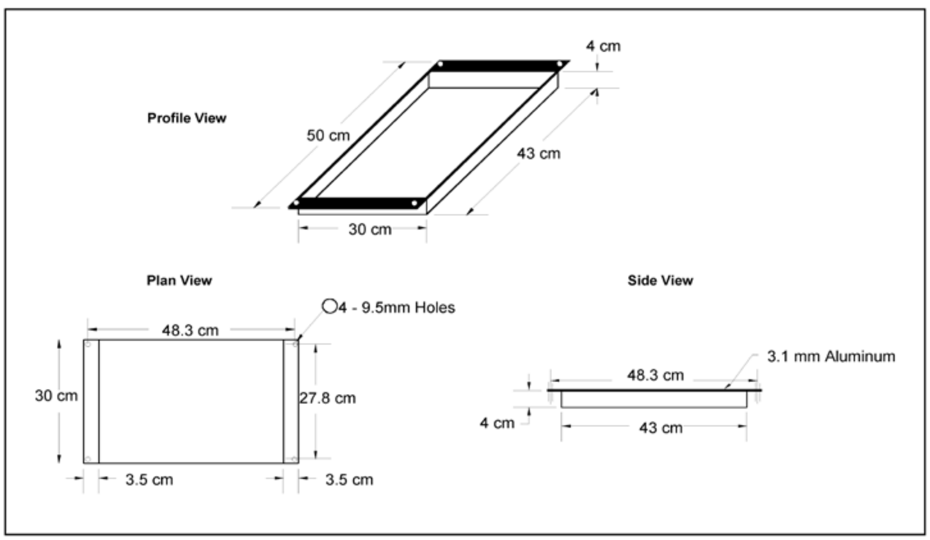


Figure 3.4: Schematic of Outdoor Precipitation Measurement Pan

3.7 NRC Sprayer Assembly

NRC developed an improved sprayer assembly, shown in Photos 3.6 and 3.7, in 1997-98. The improved sprayer provides a larger scan area and improved spray uniformity over the test bed area. The scanner consists of a horizontal main shaft supported by two bearings. The actual spray head assembly is shaft-mounted on a rotating scanner, so that one scan covers a lateral running strip of the test bed area. A stepper motor is synchronized to index the relative angle of the spray head between scans along an axis perpendicular to the scan axis. This provides two axes of rotation, essentially an x-y plane; one along each axis. Each scan is consecutively indexed in order to complete the precipitation coverage of the test bed area. This defines one cycle of the spray unit. The scan rate, index angle, and the number of scans per cycle are adjusted, along with the fluid delivery pressures (water and air) to obtain appropriate droplet sizes and precipitation rates. The spray nozzle is shown in Photo 3.8.

3.8 Fluids

In most cases, testing was carried out with Type II, III and IV fluids in the standard Type II, III and IV fluid dilutions: neat, 75/25 and 50/50. Diluted fluids were prepared by the manufacturer; APS does not prepare diluted samples for new fluid holdover time testing.

Photo 3.1: Test Plates Mounted on Stand

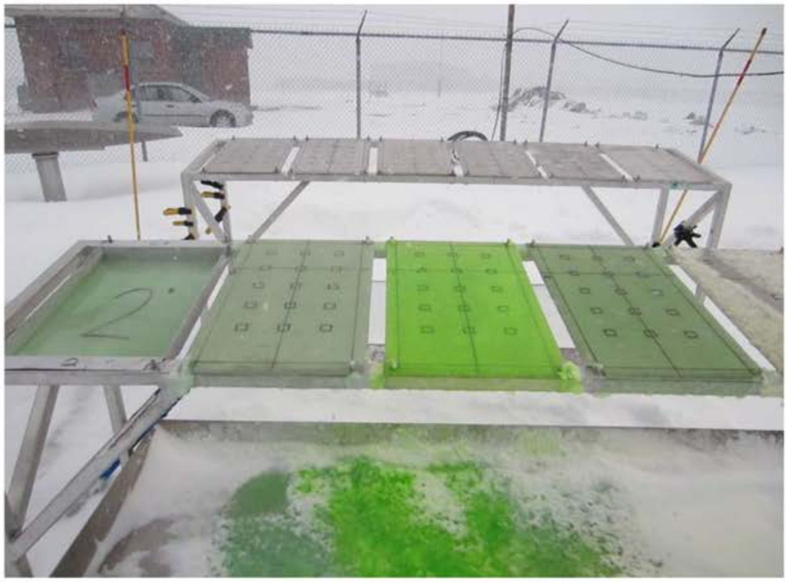


Photo 3.2: Cold-Soak / Leading Edge Thermal Equivalent Box

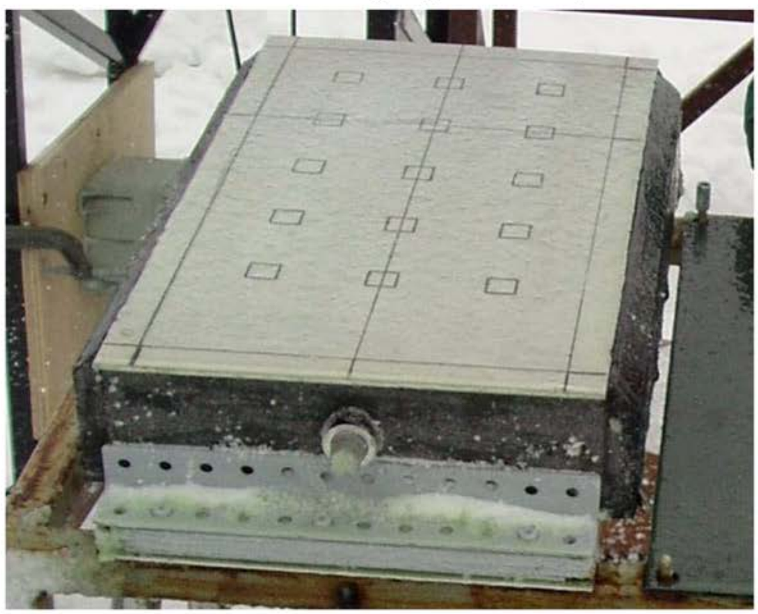


Photo 3.3: Frost Plate with Insulated Backing

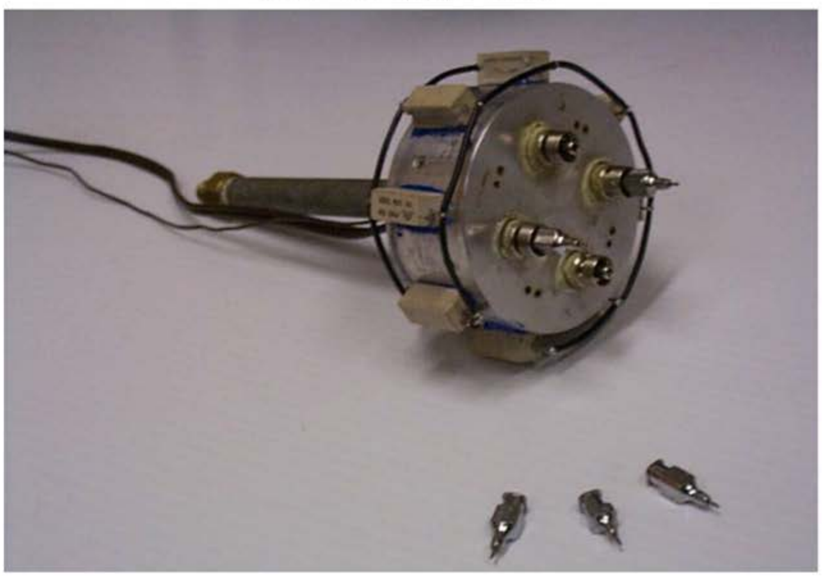
Photo 3.4: Standard Plate Setup for Testing with Artificial Snowmaker

Photo 3.5: Collection Pans Used Indoors at the NRC

Photo 3.6: Sprayer Assembly

Photo 3.7: Sprayer Assembly in Use

Photo 3.8: Sprayer Nozzle



4. TEST PROCEDURES

ARP5485 provides the standard procedure for endurance time testing of Type II, III and IV fluids under natural and simulated precipitation conditions.

The procedure generally consists of pouring de/anti-icing fluids onto clean flat plates exposed to various winter precipitation conditions, and recording the elapsed time for the test to reach the defined end condition (see Subsection 4.5), when a specified degree of freezing occurs. The following subsections provide summaries of the test procedures followed for natural snow, natural frost, artificial snow and simulated freezing precipitation testing.

4.1 Test Procedure – Natural Snow Tests

APS developed a specific procedure for Type II, III and IV fluid testing in natural snow based on the requirements outlined in ARP5485. Key details of the procedure include:

- Tests are conducted are conducted on standard flat plates (see Section 3.3.1);
- Fluid is applied at ambient temperature; and
- 1 L of fluid is hand-poured on the test surface.

4.2 Test Procedure – Natural Frost Tests

APS developed a specific procedure for Type II/III/IV testing in natural frost. Key details of the procedure include:

- Tests are conducted on frosticator plates (see Section 3.3.33.3);
- Fluid is applied at ambient temperature; and
- 1 L of fluid is hand-poured on the test surface.

4.3 Test Procedure – Artificial Snow Tests

APS developed a specific procedure for testing in artificial snow based on the requirements outlined in ARP5485. Key details of the procedure include:

- Tests are conducted on a standard plate mounted on the snowmaker scale (see Section 3.3.4);
- Fluid is applied at ambient temperature; and
- 1 L of fluid is hand-poured on the test surface.

4.4 Test Procedure – Simulated Precipitation Tests

APS developed a specific procedure for Type II/III/IV testing in simulated precipitation based on the requirements outlined in ARP5485. Key details of the procedure include:

- Freezing fog, freezing drizzle and light freezing rain tests are conducted on standard flat plates (see Section 3.3.1);
- Rain on cold-soak surface tests are conducted on filled cold-soak boxes (see Section 3.3.2);
- Fluid is applied at ambient temperature; and
- 1 L of fluid is hand-poured on the test surface.

4.5 End Condition Definitions

Failure is called when 30 percent (1/3) of the plate or 5 cross-hairs are covered with frozen contamination. Appearance of this frozen contamination includes, but is not limited to:

a) Ice front;
b) Ice sheet;
c) Slush, in clusters or as a front;
d) Disseminated fine ice crystals;
e) Frost on surface;
f) Clear ice pieces partially or totally imbedded in fluid; and
g) Snow bridges on top of the fluid.

4.6 Precipitation Rate Measurement Procedures

The procedures for measuring and determining precipitation rates during simulated precipitation and natural precipitation conditions are provided below.

4.6.1 Simulated Precipitation Conditions

Prior to the start of the rate collection period, the proper needles and nozzles are installed in the spray unit, and both the air and water pressures are adjusted. Water spray calibration is performed by placing catch pans on the test stand, each pan marked with a number identifying the collection location on the test stand, and exposing the pans to a predetermined precipitation collection period.

The pans are weighed prior to exposure to precipitation and the weights are recorded in a customized Excel spreadsheet by using the print function on the digital weigh scale. Prior to the start of the precipitation catch period, the exact time (hh:mm:ss) is recorded using a pre-programmed time macro in the Excel spreadsheet. The pans are re-weighed following this collection period and the precipitation rates over the area of the test stand are examined. If the rates are unacceptable, re-calibration of the water spray is necessary. If the rates are deemed to be acceptable, the pans are weighed and placed on the stand for a second collection period. After the second collection period has expired, the pans are again re-weighed and the rates computed.

Once two rates have been collected at each test location, the catch rates of the first and second collection are compared. If the average catch rate for any location is deemed to be acceptable for the test condition, then the pouring of fluids may begin at this location.

Rates are continuously monitored at a minimum of two locations during a test in order to ensure there are no significant rate fluctuations. Pans will be placed at these locations and be re-weighed at fixed intervals (15 minutes, typically) during the course of a test. If a rate fluctuation occurs, the test is stopped.

Following the failure of a test plate, a rate collection pan is weighed and placed at the plate location for a predetermined time interval. It is then re-weighed and placed again on the stand to collect a minimum of two additional rates at this location.

The rate of precipitation for any location on the stand is calculated by averaging the two rates collected prior to the test and the two rates collected following the test.

4.6.2 Natural Precipitation Conditions

Two rate collection pans per test stand are typically used to determine precipitation rates in natural conditions. Prior to the rate collection period, both pans are marked (upper and lower), and the inner bottom and sides of the each pan are wetted with Type IV fluid to prevent blowing snow from escaping the pan. The wetted pans are then weighed to the nearest gram. The start time of the rate collection period is recorded (h/min/sec) using a customized Excel spreadsheet in which the weight is also recorded by pressing the print function on the digital weigh scale.

The pans are positioned in locations 6 and 7 and allowed to collect precipitation for 10-minute intervals in normal conditions and 5-minute intervals in periods of high precipitation rates and high winds. In frost the collection interval is half hour to one hour depending on the frost accretion intensity.

Prior to removal of the plate pans from the test stand for re-weighing, any accumulated precipitation on the lips and outer sides of each plate pan is carefully removed. The plate pans are then carried to the rate station for re-weighing. Upon entering the trailer, the exact time is noted. The new weights of the plate pans are recorded and the pans are brought back outside. This procedure is continued until the final plate on the test stand fails.

The rate for any HOT test in natural snow or frost is obtained by computing the time-weighted average of the rates collected in the upper and lower pans over the duration of the particular test.

An example of the rate calculation method for tests in natural conditions is displayed in Figure 4.1. Typically, two collections pans are used for each test. The start and end times of the test shown in Figure 4.1 are 10:15 and 10:45, respectively. Precipitation rates for one pan were collected at three periods during this test, indicated by t1, t2, and t3 (minutes). The calculated rates for each collection period are indicated by R1, R2, and R3 (g/dm²/h).

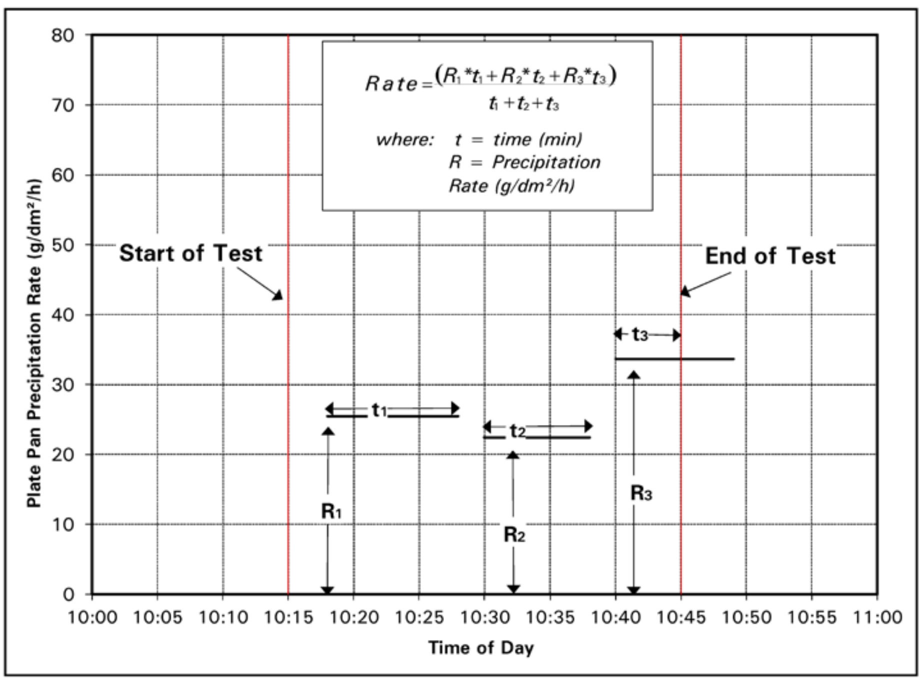


Figure 4.1: Calculation of Outdoor Precipitation Rate

In order to calculate the average rate for this pan, the following formula is then used:

$$\frac{(R_1 \times t_1 + R_2 \times t_2 + R_3 \times t_3)}{t_1 + t_2 + t_3}$$

In the example shown in Figure 4.1, the rate is calculated as follows:

$$\frac{(25 \times 10 + 22 \times 8 + 34 \times 5)}{10 + 8 + 5}$$

The calculated average rate for this pan is 25.9 g/dm²/h. The average rate for the other collection pan is calculated in similar fashion, and the average of the two rates is then taken.

5. TEST CONDITIONS

The conditions under which endurance time testing is conducted with Type II, III and IV fluids are outlined in this section. Details are provided for precipitation rates, ambient temperatures and droplet sizes.

5.1 Precipitation Rate Limits

Upper and lower precipitation rate limits are an important part of the test methodology for measuring fluid endurance times. Table 5.1 provides the meteorologically accepted definitions of weather phenomenon / precipitation types. It also includes the criteria used to determine precipitation intensity.

Table 5.1: Definition of Weather Phenomenon

Weather Phenomenon*	Definition*
FROST (No METAR code) Note: No Intensity is assigned to FROST.	Ice crystals that form from ice-saturated air at temperatures below 0°C (32°F) by direct sublimation on the ground or other exposed objects.
FREEZING FOG (FZFG) Note: No Intensity is assigned to FRZ FOG	A suspension of numerous minute water droplets which freezes upon impact with ground or other exposed objects, generally reducing the horizontal
SNOW (SN)	Precipitation of ice crystals, most of which are branched, star-shaped, or mixed with unbranched crystals. At temperatures higher than about -5°C
FRZING DRIZZLE (FZDZ)	Fairly uniform precipitation composed exclusively of fine drops [diameter less than 0.5 mm (0.02 in.)] very close together which freezes upon impact with
FREEZING RAIN (FZRA)	Precipitation of liquid water particles which freezes upon impact with the ground or other exposed objects, either in the form of drops of more than 0.5
RAIN (RA)	Precipitation of liquid water particles either in the form of drops of more than 0.5 mm (0.02 in.) diameter or of smaller widely scattered drops.
SNOW PELLETS (GS) and/or SMALL HAIL	Precipitation of white and opaque grains of ice. These grains are spherical or sometimes conical; their diameter
SNOW GRAINS (SG)	Precipitation of very small white and opaque grains of ice. These grains are fairly flat or elongated; their diameter is
HAIL (GR)	Precipitation of small balls or pieces of ice with a diame-
ICE PELLETS (PE)	Precipitation of transparent (sleet or grains of ice), or translucent (small hail) pellets of ice, which are spherical or irregular, and which have a diameter of 5 mm (0.2 in.)

Intensity Criteria**

	Snow(SN),Pellets(GS),Grains(SG)		Ice Pellets (PE)
Estimated Intensity	**Horizontal Visibility (statute mile)**	**Liquid Equivalent Snow (SN) Intensity*****	**Definition and Horizontal Visibility**
Light (-)	If visibility is: ≥ 5/8 mi (≥ 1.0 km)	**Trace to 0.05 in/hr** (≤ 1.0 mm/hr or 10 gr/dm²/hr)	Scattered pellets on the ground. Visibility not affected.
Moderate	If visibility is: < 5/8 to 5/16 mi (< 1.0 to 0.5 km)	**> 0.05 to 0.10 in/hr** (> 1.0 to 2.5 mm/hr) (> 10.0 to 25.0 gr/dm²/hr)	Slow accumulation on the ground. Visibility reduced to less than 7 mi.
Heavy (+)	If visibility is: < 5/16 mi (< 0.5 km)	**More than 0.10 in/hr** (> 2.5 mm/hr or 25 gr/dm²/hr)	Rapid accumulation on the ground. Visibility reduced to less than 3 mi.
Note: Horizontal visibility is only an estimation of snow and freezing drizzle intensity. Measurements and observations have			

	Drizzle Intensity (FZDZ)
Light(-)	Trace to 0.01 in/hr (0.254 mm/hr or 2.54 gr/dm²/hr)
Moderate	From 0.01 to 0.02 in/hr (2.54 to 5.08 gr/dm²/hr)
Heavy(+)	More than 0.02 in/hr (> 5.08 gr/dm²/hr) Note: Drizzle > 0.04 in/hr is usually in the form of rain.

		Rain (RA), Freezing Rain (FZRA), Ice Pellets (PE)
Light (-)	Measured Intensity	Up to 0.10 in/hr (2.5 mm/hr or 25 gr/dm²/hr) Maximum 0.01 inch in 6 minutes
	Estimated Intensity	From scattered drops that, regardless of duration, do not completely wet an
Moderate	Measured Intensity	0.11 in to 0.30 in/hr (7.6 mm/hr or 76 gr/dm²/hr) More than 0.01 to 0.03 inch in 6 minutes
	Estimated Intensity	Individual drops are not clearly identifiable; spray is observable just above
Heavy (+)	Measured Intensity	More than 0.30 in/hr (7.6 mm/hr or 76 gr/dm²/hr) More than 0.03 inch in 6 minutes
	Estimated Intensity	Rain seemingly falls in sheets; individual drops are not identifiable; heavy

* From World Meteorological Organization Guide to Meteorological Instruments and Methods of Observation (1983)
** From American Meteorological Society, Glossary of Meteorology WSOH #7 MANOBS (3/94)
*** NCAR/SAE Proposed Definition for Liquid Equivalent Snowfall Intensity

1) gr/dm² = 0.01 cm = 0.1 mm = 0.0039 in
2) in = 2.54 cm = 25.4 mm = 254 gr/dm²

Compiled by Jeff Cole and Roy Rasmussen of NCAR/RAP Sept 8, 1999 (Updated for METAR codes)

Table 5.1 was compiled by the National Centre for Atmospheric Research (NCAR) from the *World Meteorological Organization Guide to Meteorological Instruments and Methods of Observation* (1983) and from the *American Meteorological Society, Glossary of Meteorology WSOH # 7 Manual of Surface Weather Observations (MANOBS)* (3/94).

The precipitation rate limits established for Type II/III/IV endurance time testing are provided in ARP5485 and represented graphically in Figure 5.1. Subsections 5.1.1 to 5.1.5 provide detailed definitions and explanations of the precipitation types and rate boundaries used in Type II/III/IV endurance time testing. It should be noted that in many cases these limits are not the same as the meteorologically accepted definitions provided in Table 5.1.

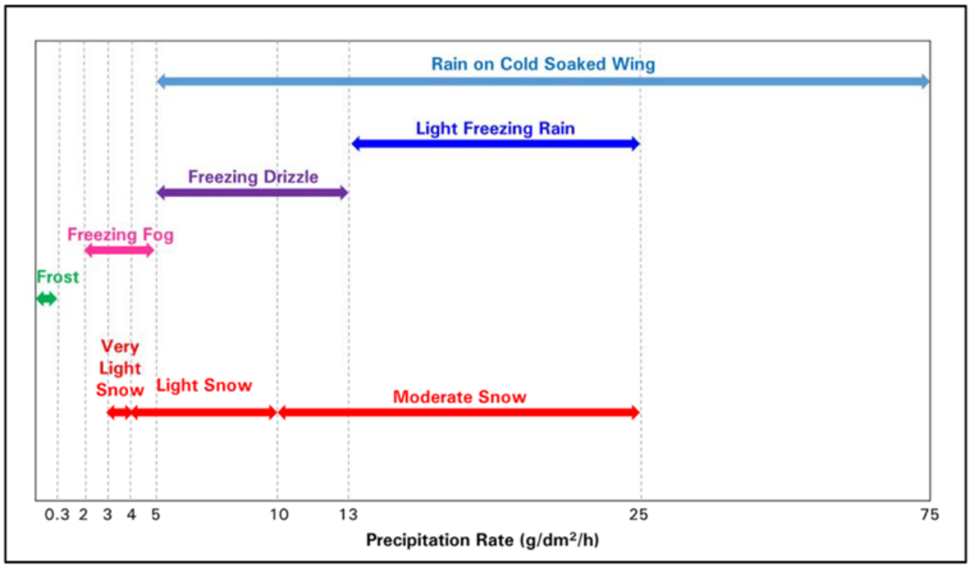


Figure 5.1: Precipitation Rate Limits Used in Endurance Time Testing

5.1.1 Freezing Fog

The precipitation rate limits for endurance time testing in freezing fog were set in 1997 at rates of 2 and 5 g/dm^2/h. These limits were determined with input from NRC meteorologists, who helped define an important parameter in the study of fog referred to as the *Liquid Water Content* (LWC). This quantity, expressed in density terms as the mass of water in grams contained in one cubic meter of air, can generally assume values in the range of 0.2 to 0.6 g/m^3.

5.1.2 Freezing Drizzle

The precipitation rate limits for endurance time testing in freezing drizzle are 5 and 13 g/dm^2/h. The upper limit in this range was adopted based on discussions with meteorological experts and aircraft operators on the SAE G-12 HOT Committee. This range corresponds to heavy drizzle and has been chosen to provide aircraft operators with a greater margin of safety.

5.1.3 Light Freezing Rain

The precipitation rate limits for endurance time testing in light freezing rain are 13 and 25 g/dm^2/h. This range corresponds to the category of light freezing rain and is the only freezing rain category considered, as operations in periods of moderate or heavy freezing rain are deemed unsafe.

5.1.4 Rain on a Cold-Soaked Surface

The precipitation rate limits for rain on cold soaked surface are 5 and 75 g/dm^2/h. This range encompasses drizzle (5 to 13 g/dm^2/h), light rain (13 to 25 g/dm^2/h), and moderate rain (25 to 75 g/dm^2/h).

5.1.5 Snow

The precipitation rate limits used to determine holdover times for Type II/III/IV fluids in snow are 3, 4, 10 and 25 g/dm^2/h. These rate limits encompass very light, light and moderate snow.

5.2 Ambient Temperatures in Type II/III/IV Endurance Time Testing

Holdover times are provided for three temperature bands in Type II, III and IV holdover time tables. These bands cover temperatures from the fluid's lowest operational use temperature (LOUT) and warmer.

For Type II/IV fluids the temperature bands are:

- -3°C and above (rain on cold soak surface limited to +1°C);
- Below -3 to -14°C (freezing drizzle/light freezing limited to -10°C); and
- Below -14°C to LOUT.

For Type III fluids the temperature bands are:

- -3°C and above (rain on cold soak surface limited to +1°C);
- Below -3 to -10°C; and
- Below -10°C to LOUT.

For fluids with extremely low LOUTs (below -29°C), the third temperature band may be limited to -25°C and a fourth temperature band (below -25°C to LOUT) may be added.

In natural snow and natural frost testing, endurance time testing is carried out under a range of temperatures. In simulated freezing precipitation and artificial snow testing, endurance time testing is typically conducted at the lower limit of each temperature band.

- Freezing Fog: -3°C, -10°C (Type III) / -14°C (Type II/IV), -25°C;
- Freezing Drizzle: -3°C and -10°C;
- Light Freezing Rain: -3°C and -10°C;
- Rain on Cold Soaked Surface: +1°C;
- Artificial Snow: -3, -10°C (Type III) / -14°C (Type II/IV), -25°C.

5.3 Freezing Precipitation Droplet Sizes

Research has shown that median volume diameter (MVD) of rain droplets is related to rate of precipitation as follows:

- MVD = (precipitation rate/10) $^{0.23}$, where MVD is in mm and rate of precipitation is in g/dm²/h

The theoretical MVDs for rain at various rates of precipitation were determined based on this equation. These values are listed in Table 5.2 beside the experimental MVDs for each precipitation condition.

To determine whether droplets produced at the NRC resembled droplets from natural precipitation, a test was conducted during natural light freezing rain conditions in 1997-98 at the APS test site. The droplet sizes were compared to those obtained in simulated light freezing rain at the NRC. The results of these tests are shown below.

a) *For the outdoor test:*
Location: Montreal International Airport
Precipitation: Natural Light Freezing Rain
Precipitation Rate: 20 g/dm²/h
Calibrated MVD: 1.0 mm

b) *For the indoor test:*
Location: National Research Council CEF
Precipitation: Simulated Light Freezing Rain
Precipitation Rate: 25 g/dm²/h
Calibrated MVD: 1.0 mm

The MVD for both natural and simulated light freezing rain was 1 mm, indicating that the NRC produced droplets simulate natural precipitation.
As a result of this testing, the MVDs for freezing precipitation testing were established as follows:

- Freezing Fog, high precipitation rate (5 g/dm²/h): 30 μm
- Freezing Fog, low precipitation rate (2 g/dm²/h): 30 μm

- Freezing Drizzle, high precipitation rate (13 g/dm²/h): 350 μm
- Freezing Drizzle, low precipitation rate (5 g/dm²/h): 250 μm

- Light Freezing Rain, high precipitation rate (25 g/dm²/h): 1,000 μm
- Light Freezing Rain, low precipitation rate (13 g/dm²/h): 1,000 μm

- Rain on Cold-Soaked Surface, low precipitation rate (5 g/dm²/h): 250 μm
- Rain on Cold-Soaked Surface, high precipitation rate (75 g/dm²/h): 1,400 μm

Table 5.2: Theoretical and Experimental MVDs

Precipitation Condition	Experimental MVD (mm)	Theoretical MVD (mm)
Moderate Rain (High rate: 75 g/dm²/h)	1.4	1.6
Light Rain (Low rate: 13 g/dm²/h)	1.0	< 1.1
Light Rain (High rate: 25 g/dm²/h)	1.0	1.2
Drizzle (Low rate: 5 g/dm²/h)	0.25	< 0.5
Drizzle (High rate: 13 g/dm²/h)	0.35	< 0.5
Fog		< 0.1

5.4 Summary of Freezing Precipitation Test Conditions

The precipitation types/rates, ambient temperatures and droplet sizes for freezing precipitation testing with Type II/III/IV fluids were described in the previous subsections. In summary, freezing precipitation tests are carried out under each of the 16 weather conditions listed in Table 5.3.

Table 5.3: Summary of Freezing Precipitation Test Conditions

Precipitation Type	Ambient Temperature	Precipitation Rate (Droplet Size)
Freezing Fog	-3°C	2 g/dm²/h (30 μm)
		5 g/dm²/h (30 μm)
	-14°C (Type II/IV) -10°C (Type III)	2 g/dm²/h (30 μm)
		5 g/dm²/h (30 μm)
	-25°C	2 g/dm²/h (30 μm)
		5 g/dm²/h (30 μm)
Freezing Drizzle	-3°C	5 g/dm²/h (250 μm)
		13 g/dm²/h (350 μm)
	-10°C	5 g/dm²/h (250 μm)
		13 g/dm²/h (350 μm)
Light Freezing Rain	-3°C	13 g/dm²/h (1,000 μm)
		25 g/dm²/h (1,000 μm)
	-10°C	13 g/dm²/h (1,000 μm)
		25 g/dm²/h (1,000 μm)
Rain on Cold-Soaked Surface	+1°C	5 g/dm²/h (250 μm)
		75 g/dm²/h (1,400 μm)

6. ANALYSIS METHODOLOGIES

A multi-variable regression procedure is used to derive fluid-specific holdover times for Type II/III/IV fluids. The procedure is based on the refinement of an equation for a curve which best represents the test data, and then solving that equation at the upper and lower limits established for the precipitation type. These precipitation rate limits, set by the SAE G-12 HOT Committee and detailed in ARP5485, were described in Subsection 5.1. This approach was developed in the winter of 1996-97 (see TC report, TP 13131E) and has since been used to derive fluid holdover times. There are some differences in the way the methodology is applied to freezing precipitation and natural snow data.

6.1 Freezing Precipitation Data

For each related freezing precipitation HOT table cell, four tests are conducted at the most restrictive (lowest) temperature in the temperature range for that cell: two tests at the low precipitation rate limit and two tests at the high precipitation rate limit (limits are detailed in Subsection 5.1). The equation used to treat freezing precipitation data is:

- $t = 10^{I}R^{a}$, where

  t = Time (minutes)
  R = Rate of precipitation (g/dm²/h)
  I, a = coefficients determined from the regression.

The upper and lower HOT values for each cell are determined from the points at which the best-fit curve intersects the lower and upper precipitation limits, respectively. The calculated holdover times derived from this analysis are subject to the rounding and capping rules detailed in Subsection 6.4.

6.2 Natural Snow Data

As outside air temperature and precipitation rate can not be controlled under natural test conditions, natural snow tests are carried out at a variety of temperatures and precipitation rates. An attempt is made to gather data under all temperatures and precipitation rates encompassed by the HOT tables.

The general form of the regression equation is modified for natural snow to incorporate the variable of temperature and also to prevent taking the log of a negative number as natural snow can occur at temperatures approaching 2°C. The equation used to treat natural snow data is:

- $t = 10^{I} R^{a} (2\text{-}T)^{b}$, where

  t = Time (minutes)
  R = Rate of precipitation (g/dm²/h)
  I, a, b = coefficients determined from the regression.

The upper and lower HOT values for each cell are determined from the points at which the best-fit curve intersects the lower and upper precipitation limits, using the most restrictive (lowest) temperature for that cell. The calculated holdover times derived from this analysis are subject to the rounding and capping rules detailed in Subsection 6.4.

6.3 Natural Frost Data

Regression analysis is not used in the determination of frost holdover times. The current Type II/III/IV generic frost holdover times were determined based on several years of testing using all fluids which were commercially available at the time. A "minimum values" analysis methodology was used to determine appropriate holdover times from the test data.

The purpose of natural frost testing with new fluids is to verify the fluids can be used with the generic frost holdover times. The analysis methodology is to compare the frost test data collected with the new fluid to the current generic holdover times. If the test data provides holdover times equal to or greater than the generic holdover times then the generic holdover times have been validated for the new fluid.

As outside air temperature and precipitation rate can not be controlled under natural test conditions, natural frost tests are carried out at a variety of temperatures and precipitation rates. An attempt is made to gather several data points with each fluid/dilution.

6.4 Rounding and Capping Protocols

Regression-generated holdover times are subject to the rounding and capping protocols detailed below.

6.4.1 Rounding Protocols

All holdover times are rounded to the nearest whole "5" minute, i.e. 55.1 to 57.4 minutes is rounded down to 55 minutes; 57.5 to 59.9 minutes is rounded up to 60 minutes. The only exceptions are:

- In cases where the regression-generated holdover times for Type II/IV fluids are below 10 minutes, the numbers are rounded down to the nearest whole minute as a precautionary measure (e.g. 9.6 minutes is rounded down to 9 minutes); and
- In cases where the regression-generated holdover times for Type III fluids are below 20 minutes, the numbers are rounded down to the nearest whole minute as a precautionary measure (e.g. 19.6 minutes is rounded down to 19 minutes).

6.4.2 Capping Protocols

All holdover time values are capped at maximum values. The caps differ by precipitation type, and in the case of snow, by regulator. The caps are as follows:

- Freezing Fog holdover time values are capped at 4 hours;
- Freezing Drizzle, Light Freezing Rain, Rain on Cold Soaked Wing holdover times are capped at 2 hours; and
- Snow holdover times are capped at 2 hours by TC and 3 hours by FAA.

6.5 Regression Example

Sample plots of **Log t** versus **Log R** are shown in Figure 6.1. The plots contain data for one Neat Type IV fluid, in one temperature range (-10°C), in light freezing rain conditions. The best-fit regression line is superimposed onto the plot and was obtained from the analysis using the lowest temperature in the temperature range from which the data were chosen.

The same data plotted on a linear scale (failure time **t** versus precipitation rate **R**) are shown in Figure 6.2. The curve, generated from the power law form of the equation using the coefficients determined from the fit, is superimposed onto the plot. The HOT range is determined from the intersections of the curve with the precipitation rate limits defined for light freezing rain.

The holdover times for this fluid at -10°C are 20 minutes at 13 g/dm^2/h and 35 minutes at 25 g/dm^2/h, establishing the HOT range for this particular fluid in the light freezing rain, neat fluid, below -3 to -10°C cell. This illustrates the general approach used in the determination of a fluid HOT range for any given cell in the HOT table.

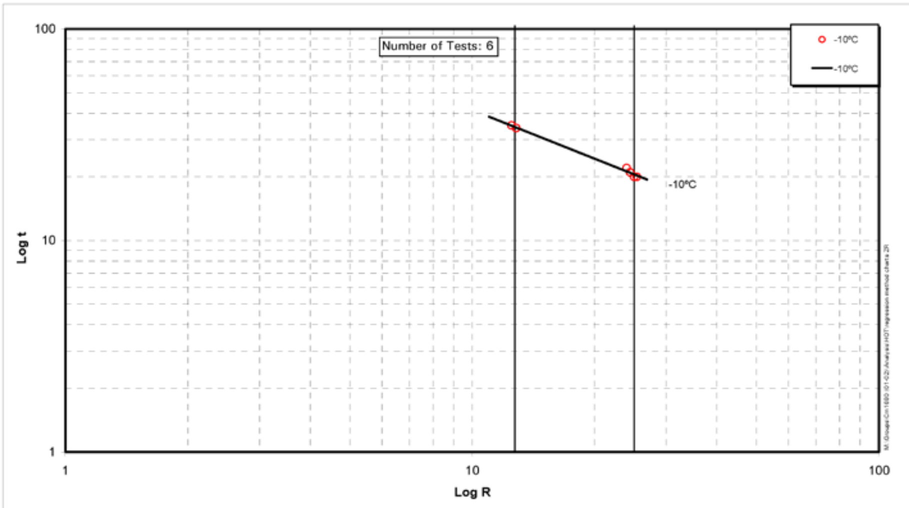


Figure 6.1: Regression Method on Log-Log Chart – Type IV Neat, Freezing Rain

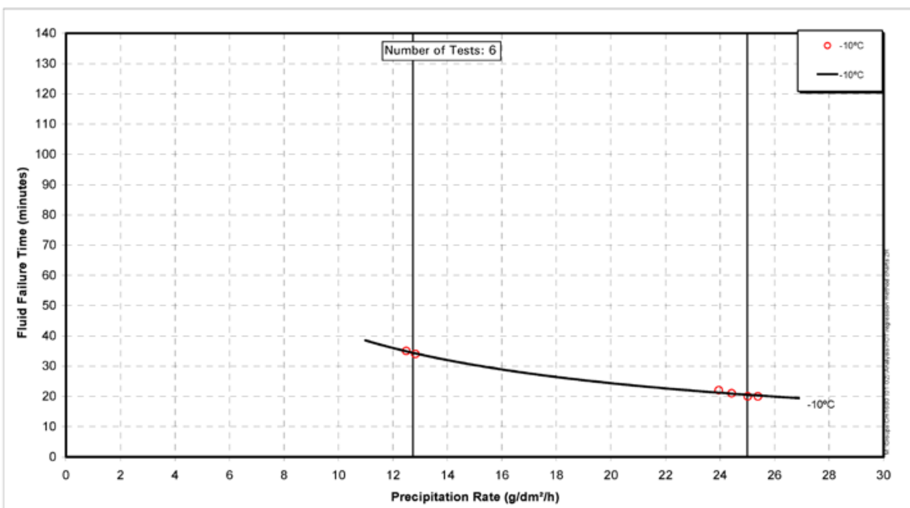


Figure 6.2: Regression Method on Standard Chart – Type IV Neat, Freezing Rain

6.6 Lowest Usable Precipitation Rates in Snow

A detailed analysis methodology was developed to determine if a snow data set is sufficient to determine holdover times for light and very light snow. Specifically, the analysis determines the lowest usable precipitation rate (LUPR), which is the lowest rate at which the data set is considered robust.

The methodology is a five-factor weighted analysis. The five factors are:

1. Total number of data points;
2. Number of data points with air temperatures below -3°C;
3. Number of data points with precipitation rates below 10 g/dm²/h;
4. Number of data points with precipitation rates less than or equal to 0.5 g/dm²/h above the precipitation rate being examined; and
5. Scatter from regression curve of low precipitation rate data points (average absolute percent difference between fail time and regression calculated fail time for all points less than or equal to 10 g/dm²/h).

The weights given to each of the five factors are:

1. Total Data Points = 5%;
2. Data Points Below -3°C = 20%;
3. Data Points Below 10 g/dm²/h = 20%;
4. Data Points ≤ Precipitation Rate = 40%; and
5. Low Rate Data Scatter = 15%.

Each data set is given a score of 0, 10, 20, 30 or 40 for each factor. The scoring system is shown in Table 6.1.

This approach provides a score for each data set for each precipitation rate below 10 g/dm²/h. The scores are compared to the minimum acceptance scores:

- 100/0 = 28
- 75/25 = 28
- 50/50 = 19 (lower due to a 0 score for data points below -3°C)

The LUPR is the lowest precipitation rate at which a data set has a passing score.

Table 6.1: LUPR Factor Scoring System

Factor #1: Total Data Points (Weight = 5%)	
Rating = 40	≥20 data points in data set
Rating = 30	15-19 data points in data set
Rating = 20	10-14 data points in data set
Rating = 10	5-9 data points in data set
Rating = 0	<5 data points in data set

Factor #2: Data Points Below -3°C (Weight = 20%)	
Rating = 40	≥15 data points below -3°C
Rating = 30	12-14 data points below -3°C
Rating = 20	9-11 data points below -3°C
Rating = 10	6-8 data points below -3°C
Rating = 0	<6 data points below -3°C

Factor #3: Data Points Below 10 g/dm²/h (Weight = 20%)	
Rating = 40	≥10 data points <10 g/dm²/h
Rating = 30	7-9 data points <10 g/dm²/h
Rating = 20	5-6 data points <10 g/dm²/h
Rating = 10	3-4 data points <10 g/dm²/h
Rating = 0	<3 data points <10 g/dm²/h

Factor #4: Data Points ≤ Precipitation Rate (Weight = 40%)	
Rating = 40	≥3 data points ≤ rate limit +0.5
Rating = 30	2 data points ≤ rate limit +0.5
Rating = 20	1 data points ≤ rate limit +0.5
Rating = 10	n/a
Rating = 0	0 data points ≤ rate limit +0.5

Factor #5: Low Rate Data Scatter (Weight = 15%)	
Rating = 40	Average actual-calculated error <10%
Rating = 30	Average actual-calculated error 10-19%
Rating = 20	Average actual-calculated error 20-29%
Rating = 10	Average actual-calculated error 30-39%
Rating = 0	Average actual-calculated error ≥40%

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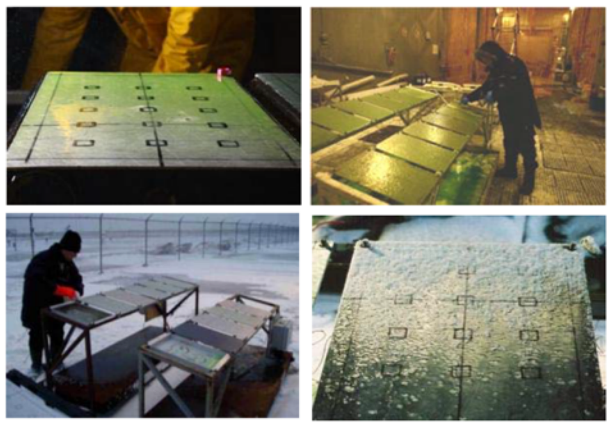
APPENDIX D

FLUID MANUFACTURER REPORT:
BEIJING YADILITE AVIATION ADVANCED MATERIALS CORPORATION
YD-102 TYPE II (TYPE II)

AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

Beijing Yadilite Advanced Materials Corporation



Prepared for

Beijing Yadilite Aviation Advanced Materials Corporation

by

APS Aviation Inc.

These tests were made possible with the guidance, participation and contribution of the Transportation Development Centre of Transport Canada and the Federal Aviation Administration.

August 2016
Version 1.0
Report No. Y-YD2 2015-16

AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

Beijing Yadilite Advanced Materials Corporation YD-102 (Type II)

Prepared for

Beijing Yadilite Advanced Materials Corporation

Prepared by:

Benjamin Bernier
Project Analyst

August 29, 2016
Date

Reviewed by:

Stephanie Bendickson
Senior Project Leader

August 29, 2016
Date

These tests were made possible with the guidance, participation and contribution of the Transportation Development Centre of Transport Canada and the Federal Aviation Administration.

August 2016
Version 1.0
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FLUID IDENTIFICATION AND CHARACTERISTICS

Manufacturer:	Beijing Yadilite Aviation Advanced Materials Corporation
Fluid Test Name:	YD-102
Fluid Commercial Name:	YD-102 Type II
Fluid Type / Base / Colour:	Type II / Propylene Glycol / Water White
Batch #:	20151220
Date of Receipt:	January 6, 2016

Brix (Measured):	Neat fluid:	35.25°
	75/25 dilution:	27.75°
	50/50 dilution:	19.0°
Freeze Point (Stated):	Neat fluid:	-38.0°C
	75/25 dilution:	-24.0°C
	50/50 dilution:	-13.0°C
Aerodynamic LOUT (AMIL):	Neat fluid:	-29.0°C
	75/25 dilution:	-19.5°C
	50/50 dilution:	-9.5°C

Viscosity:	**Manufacturer Method**	**Stated**	**Measured**
	Neat fluid[1]:	8,140 cP	4,500 cP
	75/25 dilution[1]:	17,500 cP	12,850 cP
	50/50 dilution[1]:	800 cP	820 cP
	AS 9968 Method	**Stated**	**Measured**
	Neat fluid[1]:	8,140 cP	4,500 cP
	75/25 dilution[1]:	17,500 cP	12,850 cP
	50/50 dilution[2]:	not provided	300 cP
WSET (from AMIL):	Neat fluid:	56 minutes	

[1] Spindle LV1, 600 mL low form beaker, 575 mL of fluid, 20°C, 0.3 rpm, for 10.0 minutes
[2] Spindle LV0, UL adapter, 16 mL of fluid, 20°C, 0.3 rpm, for 10.0 minutes

SUMMARY

The primary objective of this project was to measure the endurance time performance of **Beijing Yadilite Aviation Advanced Materials Corporation (Beijing Yadilite) YD-102 Type II** over the entire range of conditions encompassed by the Holdover Time (HOT) tables. This report contains the results of these measurements and was completed with the support of the fluid manufacturer, the Transport Development Centre (TDC) of Transport Canada (TC) and the Federal Aviation Administration (FAA).

Tests were carried out according to the protocol provided in Aerospace Recommended Practice (ARP) 5485. The test procedure consisted of pouring fluids onto clean aluminum test surfaces inclined at 10°; the onset of failure was recorded as a function of time in natural and simulated precipitation.

Tests were performed at the APS Aviation Inc. (APS) test facility at Montréal-Pierre-Elliott-Trudeau International Airport and the National Research Council Canada (NRC) Climatic Engineering Facility (CEF) in Ottawa.

De/anti-icing fluid endurance times were derived from the data collected using multi-variable regression analysis. This resulted in the generation of the fluid-specific holdover times shown below. These holdover times will be published by regulators for use in the winter 2016-17 operating season.

Beijing Yadilite YD-102 Type II Fluid Holdover Times

Outside Air Temperature (°C)	Type II Fluid Concentration Neat Fluid/ Water (Vol %/Vol %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets*			Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
			Very Light	Light	Moderate				
-3 and above	100/0	1:10-2:00	1:40-2:00	0:50-1:40	0:25-0:50	0:40-1:15	0:35-0:40	0:10-1:00	
	75/25	0:25-0:55	0:50-1:05	0:25-0:50	0:15-0:25	0:15-0:40	0:10-0:20	0:04-0:25	
	50/50	0:15-0:25	0:25-0:30	0:10-0:25	0:05-0:10	0:08-0:15	0:07-0:09	CAUTION: No holdover time guidelines exist	
below -3 to -14	100/0	0:45-1:30	1:00-1:15	0:30-1:00	0:15-0:30	0:35-0:50	0:25-0:25		
	75/25	0:30-0:50	0:35-0:45	0:20-0:35	0:08-0:20	0:15-0:25	0:09-0:15		
below -14 to -29	100/0	0:20-0:45	0:20-0:25	0:10-0:20	0:08-0:10				

**FAA values shown, Transport Canada will publish only the lower values for very light snow and caps all snow HOTs at two hours*

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GLOSSARY

APS	APS Aviation Inc.
ARP	Aerospace Recommended Practice
CEF	Climatic Engineering Facility
FAA	Federal Aviation Administration
HOT	Holdover Time
LOUT	Lowest Operational Use Temperature
LOWV	Lowest On-Wing Viscosity
LUPR	Lowest Usable Precipitation Rate
NRC	National Research Council Canada
TC	Transport Canada
TDC	Transportation Development Centre

1. INTRODUCTION

This report has been created with the support of the fluid manufacturer, the Transport Development Centre (TDC) of Transport Canada (TC) and the Federal Aviation Administration (FAA).

Aircraft ground de/anti-icing has been the subject of concentrated industry attention in recent years due to the occurrence of several fatal icing-related aircraft accidents. Notably, attention has been placed on the enhancement of anti-icing fluids in order to provide an extended period of protection against further contamination following initial deicing. This emphasis has led to the development of fluid-specific de/anti-icing fluid holdover time (HOT) tables for Type II, Type III and Type IV fluids. These tables, accepted by regulatory authorities, are used by aircraft operators for departure planning in adverse winter conditions. Specifically, they provide the duration of time that qualified fluids provide protection against ice formation under specific weather conditions.

New anti-icing formulations continue to be developed by leading manufacturers with the specific objective of prolonging fluid holdover times without compromising the aerodynamic features of the airfoil. The purpose of the endurance time testing program is to measure the endurance times of these new fluids and develop fluid-specific HOT tables that provide guidance for their use.

Flat plate tests, conducted in natural and simulated precipitation, are used to develop HOT values for new fluids. These tests are carried out according to SAE Aerospace Recommended Practice (ARP) ARP5485, which provides the test protocols for measuring endurance times of Type II, III and IV fluids. Along with its counterpart for measuring endurance times of Type I fluids ARP5945, ARP5485 has evolved into a refined procedure for measuring the duration of de/anti-icing fluid protection against ice formation.

The current data analysis protocol for developing HOT values from endurance time data was developed in 1996-97 and uses multi-variable regression to obtain HOT values. HOT values are derived for the majority of cells in Type II/III/IV HOT tables using this protocol and are used to create a fluid-specific HOT table for each Type II/III/IV fluid tested.

This report provides a detailed account of the endurance time testing conducted by APS Aviation Inc. (APS) with **Beijing Yadilite Aviation Advanced Materials Corporation (Beijing Yadilite) YD-102 Type II**, a new Type II fluid. It describes the test methodology used, endurance time data collected, and analysis completed to derive fluid-specific holdover times for the fluid.

2. METHODOLOGY

Tests were carried out according to SAE Aerospace Recommended Practice (ARP) 5485, which provides the procedure and requirements for endurance time testing with Type II, III, and IV fluids under natural and simulated conditions.

The test methodology for endurance time testing carried out in the winter of 2015-16 is documented in detail in the report "*Methodology for Endurance Time Testing of Type II, III and IV Fluids – Winter 2015-16.*" A copy of this report is provided as an annex to this document.

The methodology report summarizes the key aspects of the test methodology, including some aspects included in ARP5485 and some aspects which are not included in ARP54855. It includes sections on:

a) Test Sites;

b) Test Equipment;

c) Test Procedures;

d) Precipitation Rates used in Type I, II, III and IV Endurance Time Testing;

e) Ambient Temperatures used in Type I, II, III and IV Endurance Time Testing;

f) Freezing Precipitation Droplet Sizes; and

g) Analysis Methodologies.

The data, analysis and results provided in this report are a function of the test and analysis methodologies described in the methodology report. They should only be used in conjunction with the methodologies described therein.

3. DESCRIPTION OF DATA

This section provides a summary of the number of tests conducted. Breakdowns are provided for the number of tests performed by test type, precipitation type, fluid dilution and test temperature.

3.1 Natural and Artificial Snow Tests

Tests were conducted in natural snow conditions at the APS test site and at several mobile test sites (refer to the report annex for details). No artificial snow tests were conducted. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

Fluid Dilution	Natural Snow			Artificial Snow		
	≥ -3°C	-3 to -14°C	<-14°C	-3°C	-14°C	-25°C
Neat	7	27	5	0	0	0
75/25	10	33	0	0	0	0
50/50	11	8	0	0	0	0

3.2 Freezing Precipitation Tests

Tests were conducted in freezing drizzle, light freezing rain, freezing fog and rain on cold-soaked surface conditions at the NRC CEF. The number of tests conducted is summarized below by precipitation type, fluid dilution and test temperature.

Fluid Dilution	Freezing Drizzle		Light Freezing Rain		Freezing Fog			Cold Soak
	-3°C	-10°C	-3°C	-10°C	-3°C	-14°C	-25°C	+1°C
Neat	6	4	4	4	4	4	4	4
75/25	4	4	4	4	4	4	0	4
50/50	4	0	4	0	4	0	0	0

3.3 Natural Frost Tests

Tests were conducted in natural frost at the APS test site. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

Fluid Dilution	Natural Frost			
	≥-1°C	<-1 to -3°C	<-3 to -10°C	<-10°C
Neat	0	0	1	1
75/25	0	0	1	1
50/50	1	0	0	0

3.4 Fluid Thickness Tests

Fluid thickness tests were conducted to measure the film thickness profiles of the fluid under dry conditions. Two tests were performed for each dilution. For each test, 1 litre of fluid was poured onto a flat plate mounted on a test stand inclined by 10°. Thickness measurements were taken at the 15-cm (6") line at select time intervals over a 30-minute period. Tests were conducted at -3°C.

3.5 Supplemental Tests – Impact of Dye on Endurance Time Performance

At the request of the manufacturer, supplemental tests were conducted to evaluate the impact of dye on endurance time performance. Tests were conducted with a unique sample that was prepared separately from the endurance time testing sample. Dye was added to half of the sample to make a coloured version of the fluid; the dyed (coloured) and undyed (colourless) fluids were then submitted for testing.

Tests were conducted in a subset of standard endurance time testing conditions. The breakdown of tests by precipitation type and fluid dilution is shown below.

Each test listed in the table represents one comparison tests comprised of a non-dyed fluid test and a dyed fluid test. In natural conditions, the two tests were run concurrently to ensure they were subjected to the same environmental conditions.

Fluid Dilution	Precipitation Type			
	Natural Snow	Freezing Fog	Freezing Drizzle	Light Freezing Rain
Neat	5	0	2	2
75/25	3	0	2	2
50/50	3	1	0	1

3.6 Test Logs

Details of each test conducted are provided in the test logs included as Table 3.1 (snow), Table 3.2 (freezing precipitation), Table 3.3 (frost), and Table 3.4 (supplemental tests).

Table 3.1: Summary of Tests Performed (Snow)

Test No.	Date	Snow Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
184	12-Jan-16	Natural Snow	YD-102	100%	-4.9	1.6	199.7
185	12-Jan-16	Natural Snow	YD-102	75%	-5.6	2.3	59.8
195	12-Jan-16	Natural Snow	YD-102	100%	-4.6	1.9	171.8
196	12-Jan-16	Natural Snow	YD-102	75%	-4.6	1.0	129.4
197	12-Jan-16	Natural Snow	YD-102	100%	-4.3	2.9	141.2
198	12-Jan-16	Natural Snow	YD-102	75%	-4.6	3.7	42.8
203	12-Jan-16	Natural Snow	YD-102	100%	-4.2	3.2	123.5
204	12-Jan-16	Natural Snow	YD-102	75%	-4.3	1.4	80.1
211	12-Jan-16	Natural Snow	YD-102	100%	-4.2	10.5	40.3
215	12-Jan-16	Natural Snow	YD-102	75%	-4.2	11.4	18.7
227	16-Jan-16	Natural Snow	YD-102	100%	-4.2	2.5	152.2
228	16-Jan-16	Natural Snow	YD-102	75%	-4.2	1.8	90.4
230	16-Jan-16	Natural Snow	YD-102	100%	-4.2	3.6	112.6
231	16-Jan-16	Natural Snow	YD-102	75%	-4.2	3.0	81.7
233	16-Jan-16	Natural Snow	YD-102	75%	-4.1	1.9	84.3
237	16-Jan-16	Natural Snow	YD-102	75%	-4.1	1.1	129.9
244	17-Jan-16	Natural Snow	YD-102	100%	-8.7	3.2	109.7
245	17-Jan-16	Natural Snow	YD-102	75%	-8.5	2.3	62.5
250	18-Jan-16	Natural Snow	YD-102	75%	-8.9	4.1	25.4
253	18-Jan-16	Natural Snow	YD-102	75%	-8.9	5.9	17.2
255	18-Jan-16	Natural Snow	YD-102	75%	-8.9	4.4	21.3
256	18-Jan-16	Natural Snow	YD-102	100%	-8.8	4.8	73.5
262	18-Jan-16	Natural Snow	YD-102	100%	-8.5	4.3	69.9
264	3-Feb-16	Natural Snow	YD-102	100%	-4.8	3.4	156.2
265	3-Feb-16	Natural Snow	YD-102	75%	-4.8	2.9	123.8
273	3-Feb-16	Natural Snow	YD-102	50%	-4.3	21.4	5.0
277	3-Feb-16	Natural Snow	YD-102	75%	-4.5	6.3	41.4
278	3-Feb-16	Natural Snow	YD-102	100%	-4.5	11.5	58.9
283	3-Feb-16	Natural Snow	YD-102	50%	-4.4	8.7	9.8
286	3-Feb-16	Natural Snow	YD-102	100%	-4.5	26.9	26.2
287	3-Feb-16	Natural Snow	YD-102	75%	-4.5	23.4	15.1
294	9-Feb-16	Natural Snow	YD-102	100%	-7.5	1.0	248.3
295	9-Feb-16	Natural Snow	YD-102	75%	-7.3	0.6	195.4
305	12-Feb-16	Natural Snow	YD-102	100%	-7.1	6.7	60.3
306	12-Feb-16	Natural Snow	YD-102	75%	-7.1	10.7	18.8
313	12-Feb-16	Natural Snow	YD-102	100%	-6.7	5.1	81.4
314	12-Feb-16	Natural Snow	YD-102	75%	-6.9	3.8	50.9

Table 3.1 (cont'd): Summary of Tests Performed (Snow)

Test No.	Date	Snow Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
317	12-Feb-16	Natural Snow	YD-102	100%	-6.7	3.1	140.7
318	12-Feb-16	Natural Snow	YD-102	75%	-6.4	4.9	44.3
320	12-Feb-16	Natural Snow	YD-102	75%	-7.7	14.9	19.8
327	12-Feb-16	Natural Snow	YD-102	100%	-8.2	10.6	34.2
328	12-Feb-16	Natural Snow	YD-102	75%	-10.0	12.0	13.3
329	12-Feb-16	Natural Snow	YD-102	100%	-10.7	9.2	41.3
331	16-Feb-16	Natural Snow	YD-102	100%	-6.9	13.8	34.8
332	16-Feb-16	Natural Snow	YD-102	75%	-6.0	14.1	20.6
341	16-Feb-16	Natural Snow	YD-102	100%	-7.5	13.0	39.0
342	16-Feb-16	Natural Snow	YD-102	75%	-7.5	12.1	23.6
344	16-Feb-16	Natural Snow	YD-102	100%	-7.3	8.9	52.7
345	16-Feb-16	Natural Snow	YD-102	75%	-7.3	8.1	30.7
347	16-Feb-16	Natural Snow	YD-102	100%	-6.9	20.1	30.0
348	16-Feb-16	Natural Snow	YD-102	75%	-7.0	21.3	12.8
350	16-Feb-16	Natural Snow	YD-102	100%	-6.5	30.9	20.7
351	16-Feb-16	Natural Snow	YD-102	75%	-6.5	33.2	12.2
357	19-Feb-16	Natural Snow	YD-102	100%	0.3	9.3	70.5
358	19-Feb-16	Natural Snow	YD-102	75%	0.3	8.7	68.6
360	19-Feb-16	Natural Snow	YD-102	50%	0.4	2.7	60.8
367	19-Feb-16	Natural Snow	YD-102	50%	-0.2	37.9	7.1
370	19-Feb-16	Natural Snow	YD-102	100%	-0.3	56.9	11.1
371	19-Feb-16	Natural Snow	YD-102	75%	-0.3	54.9	7.3
382	19-Feb-16	Natural Snow	YD-102	50%	-0.8	11.7	15.8
386	19-Feb-16	Natural Snow	YD-102	75%	-0.6	5.2	46.0
388	19-Feb-16	Natural Snow	YD-102	50%	-0.6	4.4	23.8
394	19-Feb-16	Natural Snow	YD-102	50%	-0.5	4.5	24.4
398	24-Feb-16	Natural Snow	YD-102	100%	-3.8	2.8	147.6
399	24-Feb-16	Natural Snow	YD-102	75%	-3.8	1.9	126.2
400	24-Feb-16	Natural Snow	YD-102	50%	-3.8	1.6	92.3
411	24-Feb-16	Natural Snow	YD-102	50%	-3.9	6.1	17.6
412	24-Feb-16	Natural Snow	YD-102	75%	-3.5	9.2	32.5
414	24-Feb-16	Natural Snow	YD-102	100%	-3.0	6.5	66.9
416	24-Feb-16	Natural Snow	YD-102	75%	-2.7	6.5	39.0
417	24-Feb-16	Natural Snow	YD-102	50%	-2.6	5.0	24.9
422	24-Feb-16	Natural Snow	YD-102	100%	-1.6	16.9	38.3
423	24-Feb-16	Natural Snow	YD-102	75%	-1.6	16.6	23.4
424	24-Feb-16	Natural Snow	YD-102	50%	-1.8	16.1	11.2

Table 3.1 (cont'd): Summary of Tests Performed (Snow)

Test No.	Date	Snow Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
437	24-Feb-16	Natural Snow	YD-102	75%	-1.3	20.5	20.1
439	24-Feb-16	Natural Snow	YD-102	75%	-1.1	16.7	31.1
441	22-Mar-16	Natural Snow	YD-102	100%	0.2	10.1	54.8
442	22-Mar-16	Natural Snow	YD-102	75%	0.2	10.5	33.0
443	22-Mar-16	Natural Snow	YD-102	50%	0.2	11.8	18.8
447	23-Mar-16	Natural Snow	YD-102	100%	0.1	8.6	54.8
448	23-Mar-16	Natural Snow	YD-102	75%	0.2	8.6	30.6
449	23-Mar-16	Natural Snow	YD-102	50%	0.2	8.9	16.2
452	23-Mar-16	Natural Snow	YD-102	100%	0.1	7.9	52.0
453	23-Mar-16	Natural Snow	YD-102	75%	0.1	8.3	23.2
454	23-Mar-16	Natural Snow	YD-102	50%	0.1	8.3	15.9
455	23-Mar-16	Natural Snow	YD-102	50%	0.1	8.4	13.8
457	24-Mar-16	Natural Snow	YD-102	100%	-5.6	6.0	55.6
458	24-Mar-16	Natural Snow	YD-102	75%	-5.7	5.6	24.0
459	24-Mar-16	Natural Snow	YD-102	50%	-5.3	8.1	8.2
461	24-Mar-16	Natural Snow	YD-102	100%	-5.2	12.1	35.8
462	24-Mar-16	Natural Snow	YD-102	75%	-5.2	13.7	13.7
463	24-Mar-16	Natural Snow	YD-102	50%	-5.3	16.0	5.0
470	24-Mar-16	Natural Snow	YD-102	50%	-6.6	26.0	3.4
473	24-Mar-16	Natural Snow	YD-102	75%	-6.6	26.6	8.8
483	24-Mar-16	Natural Snow	YD-102	75%	-6.4	41.2	7.8
489	24-Mar-16	Natural Snow	YD-102	50%	-6.4	44.3	3.3
C10	4-Feb-16	Natural Snow	YD-102	100%	-22.7	2.0	37.8
C34	4-Feb-16	Natural Snow	YD-102	100%	-22.0	2.2	30.0
C59	26-Feb-16	Natural Snow	YD-102	100%	-23.8	2.1	49.4
C79	27-Feb-16	Natural Snow	YD-102	100%	-22.6	5.1	32.8
C107	27-Feb-16	Natural Snow	YD-102	100%	-23.0	8.6	25.5

Table 3.2: Summary of Tests Performed (Freezing Precipitation)

Test No.	Date	Precipitation Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
1	30-Mar-16	Freezing Fog	YD-102	100%	-3.2	1.7	130.6
2	30-Mar-16	Freezing Fog	YD-102	100%	-3.2	1.7	132.3
3	30-Mar-16	Freezing Fog	YD-102	75%	-3.1	1.7	66.4
4	30-Mar-16	Freezing Fog	YD-102	75%	-3.1	1.7	59.0
5	30-Mar-16	Freezing Fog	YD-102	50%	-3.1	1.9	27.4
6	30-Mar-16	Freezing Fog	YD-102	50%	-3.1	1.9	27.4
29	4-Apr-16	Freezing Fog	YD-102	100%	-3.1	5.4	67.0
30	4-Apr-16	Freezing Fog	YD-102	100%	-3.1	5.1	66.9
31	4-Apr-16	Freezing Fog	YD-102	75%	-3.3	5.0	25.7
32	4-Apr-16	Freezing Fog	YD-102	75%	-3.3	4.9	25.6
33	4-Apr-16	Freezing Fog	YD-102	50%	-3.3	5.0	16.2
34	4-Apr-16	Freezing Fog	YD-102	50%	-3.3	4.9	16.2
61	31-Mar-16	Freezing Fog	YD-102	100%	-14.2	1.8	108.7
62	31-Mar-16	Freezing Fog	YD-102	100%	-14.2	1.8	91.5
63	31-Mar-16	Freezing Fog	YD-102	75%	-14.2	1.8	53.7
64	31-Mar-16	Freezing Fog	YD-102	75%	-14.2	1.8	54.4
79	31-Mar-16	Freezing Fog	YD-102	100%	-14.2	5.2	44.9
80	31-Mar-16	Freezing Fog	YD-102	100%	-14.2	4.8	44.2
81	31-Mar-16	Freezing Fog	YD-102	75%	-14.3	5.2	27.8
82	31-Mar-16	Freezing Fog	YD-102	75%	-14.3	5.3	27.7
97	1-Apr-16	Freezing Fog	YD-102	100%	-25.2	1.9	49.6
98	1-Apr-16	Freezing Fog	YD-102	100%	-25.2	1.8	49.2
109	1-Apr-16	Freezing Fog	YD-102	100%	-25.2	4.7	23.5
110	1-Apr-16	Freezing Fog	YD-102	100%	-25.2	4.7	21.2
125	4-Apr-16	Freezing Drizzle	YD-102	100%	-3.2	4.7	78.1
126	4-Apr-16	Freezing Drizzle	YD-102	100%	-3.2	4.7	82.7
127	4-Apr-16	Freezing Drizzle	YD-102	75%	-3.2	5.3	34.2
128	4-Apr-16	Freezing Drizzle	YD-102	75%	-3.2	5.2	40.0
129	4-Apr-16	Freezing Drizzle	YD-102	50%	-3.2	5.2	14.9
130	4-Apr-16	Freezing Drizzle	YD-102	50%	-3.2	5.3	13.4
153	7-Apr-16	Freezing Drizzle	YD-102	100%	-3.1	13.2	43.0
154	7-Apr-16	Freezing Drizzle	YD-102	100%	-3.2	13.0	34.2
155	7-Apr-16	Freezing Drizzle	YD-102	75%	-3.2	13.4	16.4
156	7-Apr-16	Freezing Drizzle	YD-102	75%	-3.1	13.0	14.9
157	7-Apr-16	Freezing Drizzle	YD-102	50%	-3.1	13.5	8.2
158	7-Apr-16	Freezing Drizzle	YD-102	50%	-3.1	13.5	7.4
181	5-Apr-16	Freezing Drizzle	YD-102	100%	-10.2	5.1	50.4

Table 3.2 (cont'd): Summary of Tests Performed (Freezing Precipitation)

Test No.	Date	Precipitation Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
182	5-Apr-16	Freezing Drizzle	YD-102	100%	-10.2	4.9	51.4
183	5-Apr-16	Freezing Drizzle	YD-102	75%	-10.2	5.1	23.7
184	5-Apr-16	Freezing Drizzle	YD-102	75%	-10.2	4.9	25.0
201	5-Apr-16	Freezing Drizzle	YD-102	100%	-10.2	13.1	32.6
202	5-Apr-16	Freezing Drizzle	YD-102	100%	-10.2	12.5	33.1
203	5-Apr-16	Freezing Drizzle	YD-102	75%	-10.0	13.4	12.8
204	5-Apr-16	Freezing Drizzle	YD-102	75%	-10.0	13.4	12.9
221	6-Apr-16	Light Freezing Rain	YD-102	100%	-3.2	13.1	42.3
222	6-Apr-16	Light Freezing Rain	YD-102	100%	-3.2	12.9	38.5
223	6-Apr-16	Light Freezing Rain	YD-102	75%	-3.2	13.1	20.8
224	6-Apr-16	Light Freezing Rain	YD-102	75%	-3.2	13.1	19.9
225	6-Apr-16	Light Freezing Rain	YD-102	50%	-3.2	13.1	9.9
226	6-Apr-16	Light Freezing Rain	YD-102	50%	-3.2	13.1	9.3
249	6-Apr-16	Light Freezing Rain	YD-102	100%	-3.3	25.1	33.1
250	6-Apr-16	Light Freezing Rain	YD-102	100%	-3.3	24.5	33.0
251	6-Apr-16	Light Freezing Rain	YD-102	75%	-3.2	25.0	10.8
252	6-Apr-16	Light Freezing Rain	YD-102	75%	-3.2	25.0	11.5
253	6-Apr-16	Light Freezing Rain	YD-102	50%	-3.2	25.5	6.7
254	6-Apr-16	Light Freezing Rain	YD-102	50%	-3.2	24.8	7.3
277	5-Apr-16	Light Freezing Rain	YD-102	100%	-10.0	12.8	25.1
278	5-Apr-16	Light Freezing Rain	YD-102	100%	-10.0	13.3	25.5
279	5-Apr-16	Light Freezing Rain	YD-102	75%	-10.0	12.8	13.7
280	5-Apr-16	Light Freezing Rain	YD-102	75%	-10.0	12.9	11.9
297	6-Apr-16	Light Freezing Rain	YD-102	100%	-9.9	25.1	26.0
298	6-Apr-16	Light Freezing Rain	YD-102	100%	-9.9	25.6	24.6
299	6-Apr-16	Light Freezing Rain	YD-102	75%	-9.8	25.1	9.9
300	6-Apr-16	Light Freezing Rain	YD-102	75%	-9.7	25.6	9.6
317	7-Apr-16	Cold Soak Box	YD-102	100%	1.0	5.0	58.2
318	7-Apr-16	Cold Soak Box	YD-102	100%	1.0	5.2	65.2
319	7-Apr-16	Cold Soak Box	YD-102	75%	1.0	5.4	22.5
320	7-Apr-16	Cold Soak Box	YD-102	75%	1.0	4.8	22.0
337	7-Apr-16	Cold Soak Box	YD-102	100%	1.0	78.0	10.4
338	7-Apr-16	Cold Soak Box	YD-102	100%	1.0	76.9	9.6
339	7-Apr-16	Cold Soak Box	YD-102	75%	1.0	76.9	4.5
340	7-Apr-16	Cold Soak Box	YD-102	75%	1.0	76.0	4.3
153R	7-Apr-16	Freezing Drizzle	YD-102	100%	-3.1	13.2	40.5
154R	7-Apr-16	Freezing Drizzle	YD-102	100%	-3.1	13.2	35.4

Table 3.3: Summary of Tests Performed (Natural Frost)

Test No.	Date	Precip. Type	Fluid Name	Fluid Dilution	Test Duration (min.)	Average Rate (g/dm²/h)	Temp (°C)	Wind Speed (km/h)	Average RH (%)	Comments
21	Jan-07-16	Natural Frost	Yadilite YD-102	100%	599	0.18	-5.4	9	90	Did Not Fail
28	Jan-07-16	Natural Frost	Yadilite YD-102	75%	473	0.17	-5.3	9	89	Failed
32	Feb-18-16	Natural Frost	Yadilite YD-102	75%	178	0.16	-11.9	7	83	Failed
37	Feb-18-16	Natural Frost	Yadilite YD-102	100%	425	0.15	-12.5	6	85	Did Not Fail
50	Apr-17-16	Natural Frost	Yadilite YD-102	50%	388	0.02	4.8	5	66	Did Not Fail

Table 3.4: Summary of Tests Performed (Supplemental Tests)

Test No.	Date	Precipitation Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)	Endurance Time Difference (Coloured vs. Uncoloured)
S1	16-Feb-16	Natural Snow	YD-102 Coloured	100%	-7.2	13.9	40.2	12%
S2	16-Feb-16	Natural Snow	YD-102 Uncoloured	100%	-7.2	13.9	35.9	
S3	16-Feb-16	Natural Snow	YD-102 Coloured	75%	-6.1	14.0	18.6	6%
S4	16-Feb-16	Natural Snow	YD-102 Uncoloured	75%	-6.1	14.0	17.6	
S7	24-Feb-16	Natural Snow	YD-102 Coloured	50%	-3.5	11.6	10.3	-2%
S8	24-Feb-16	Natural Snow	YD-102 Uncoloured	50%	-3.5	11.7	10.6	
S9	22-Mar-16	Natural Snow	YD-102 Coloured	100%	0.2	10.0	71.6	0%
S10	22-Mar-16	Natural Snow	YD-102 Uncoloured	100%	0.2	10.0	71.6	
S11	22-Mar-16	Natural Snow	YD-102 Coloured	75%	0.2	9.5	36.6	-5%
S12	22-Mar-16	Natural Snow	YD-102 Uncoloured	75%	0.2	9.6	38.4	
S13	22-Mar-16	Natural Snow	YD-102 Coloured	50%	0.2	8.6	18.8	1%
S14	22-Mar-16	Natural Snow	YD-102 Uncoloured	50%	0.2	8.6	18.6	
S15	23-Mar-16	Natural Snow	YD-102 Coloured	100%	0.1	7.9	87.7	3%
S16	23-Mar-16	Natural Snow	YD-102 Uncoloured	100%	0.1	7.9	85.1	
S17	24-Mar-16	Natural Snow	YD-102 Coloured	100%	-5.5	6.3	80.6	-3%
S18	24-Mar-16	Natural Snow	YD-102 Uncoloured	100%	-5.5	6.4	83.3	
S19	24-Mar-16	Natural Snow	YD-102 Coloured	75%	-5.7	5.3	41.2	-14%
S20	24-Mar-16	Natural Snow	YD-102 Uncoloured	75%	-5.6	5.4	47.7	
S21	24-Mar-16	Natural Snow	YD-102 Coloured	50%	-5.3	8.2	7.8	0%
S22	24-Mar-16	Natural Snow	YD-102 Uncoloured	50%	-5.3	10.1	7.7	
S23	24-Mar-16	Natural Snow	YD-102 Coloured	100%	-5.1	14.8	46.3	4%
S24	24-Mar-16	Natural Snow	YD-102 Uncoloured	100%	-5.1	14.6	44.8	
CU1	4-Apr-16	Freezing Fog	YD-102 Coloured	50%	-3.5	5.2	14.8	-2%
CU2	4-Apr-16	Freezing Fog	YD-102 Uncoloured	50%	-3.5	5.2	15.1	

Table 3.4 (cont'd): Summary of Tests Performed (Supplemental Tests)

Test No.	Date	Precipitation Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)	Endurance Time Difference (Coloured vs. Uncoloured)
CU3	7-Apr-16	Freezing Drizzle	YD-102 Coloured	100	-3.1	12.1	46.7	3%
CU4	7-Apr-16	Freezing Drizzle	YD-102 Uncoloured	100	-3.1	12.1	45.4	
CU5	7-Apr-16	Freezing Drizzle	YD-102 Coloured	75	-3.2	11.8	24.0	0%
CU6	7-Apr-16	Freezing Drizzle	YD-102 Uncoloured	75	-3.2	11.8	24.1	
CU7	5-Apr-16	Freezing Drizzle	YD-102 Coloured	100	-10.3	14.0	37.2	0%
CU8	5-Apr-16	Freezing Drizzle	YD-102 Uncoloured	100	-10.3	14.0	37.2	
CU9	5-Apr-16	Freezing Drizzle	YD-102 Coloured	75	-10.3	14.2	14.6	-2%
CU10	5-Apr-16	Freezing Drizzle	YD-102 Uncoloured	75	-10.3	14.2	14.9	
CU11	6-Apr-16	Light Freezing Rain	YD-102 Coloured	100	-3.2	24.8	41.8	-1%
CU12	6-Apr-16	Light Freezing Rain	YD-102 Uncoloured	100	-3.2	24.8	42.5	
CU13	6-Apr-16	Light Freezing Rain	YD-102 Coloured	75	-3.2	24.5	16.1	1%
CU14	6-Apr-16	Light Freezing Rain	YD-102 Uncoloured	75	-3.2	24.5	16.8	
CU15	6-Apr-16	Light Freezing Rain	YD-102 Coloured	50	-3.3	24.6	6.3	-1%
CU16	6-Apr-16	Light Freezing Rain	YD-102 Uncoloured	50	-3.3	24.6	6.4	
CU17	6-Apr-16	Light Freezing Rain	YD-102 Coloured	100	-9.9	24.9	27.3	-2%
CU18	6-Apr-16	Light Freezing Rain	YD-102 Uncoloured	100	-9.9	24.9	27.8	
CU19	6-Apr-16	Light Freezing Rain	YD-102 Coloured	75	-10.1	25.1	12.2	-4%
CU20	6-Apr-16	Light Freezing Rain	YD-102 Uncoloured	75	-10.1	25.1	12.7	

4. RESULTS AND DISCUSSION

The methods used to evaluate the test data are provided in the report "*Methodology for Endurance Time Testing of Type II, III and IV Fluids – Winter 2015-16,*" which is provided as an annex to this report. The results of the data analyses and a discussion of the findings are presented in this section.

4.1 Results

The results of the endurance time and thickness tests are described in this section.

4.1.1 Endurance Time Tests – Natural Snow and Freezing Precipitation

Figures 4.1 to 4.14 present the endurance time data collected in natural snow and freezing precipitation (freezing drizzle, light freezing rain, freezing fog and rain on cold-soaked surface).

These figures show the effect of temperature, precipitation type and precipitation rate on fluid endurance time in the conditions encompassed by the Type II HOT guidelines. The figures include the current Type II generic holdover times for comparative purposes.

Multi-variable regression analysis was performed on these data sets as described in the annex. Table 4.1 provides the outputs from the multi-variable regression analyses. These outputs were used to derive fluid-specific holdover times for all conditions encompassed by Type II fluid-specific HOT tables. One exception is the coldest temperature band snow cells (see Subsection 4.3.2).

4.1.2 Endurance Time Tests – Natural Frost

The natural frost data was presented in Table 3.3. The test durations were compared to the Type II generic holdover times. Tests that were not completed (due to active frost ending before fluid failure could occur) surpassed the generic holdover times. This analysis indicates the Type II generic frost holdover times can be considered substantiated for Beijing Yadilite YD-102 Type II.

4.1.3 Fluid Thickness Tests

Figure 4.15 shows the fluid thickness test data. As described in Subsection 3.4, two tests were conducted at an ambient temperature of -3°C. The final fluid thicknesses are displayed in Figure 4.16.

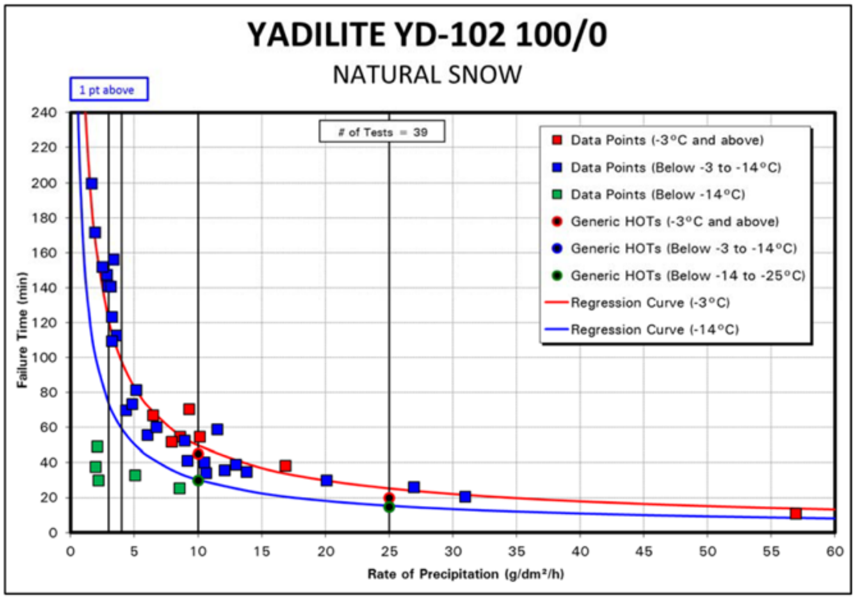


Figure 4.1: Type II Neat – Natural Snow

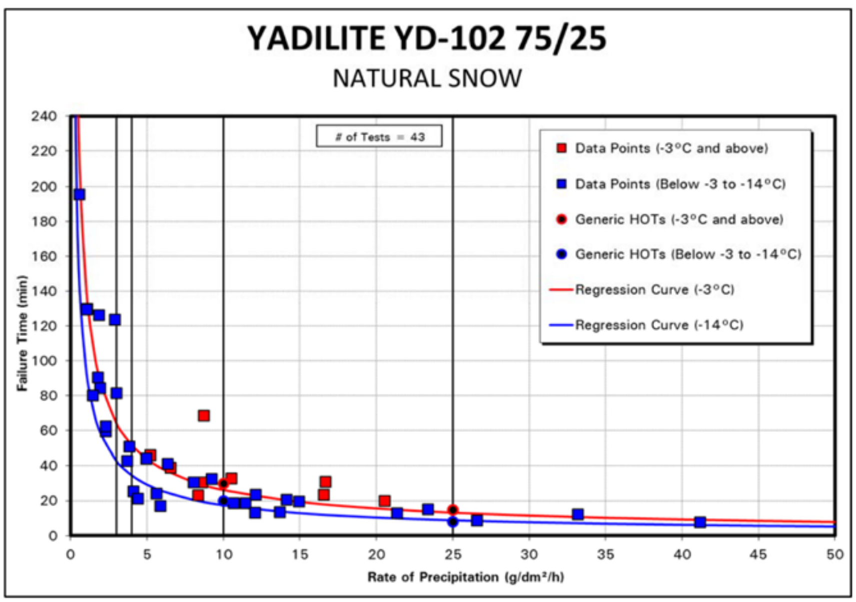


Figure 4.2: Type II 75/25 – Natural Snow

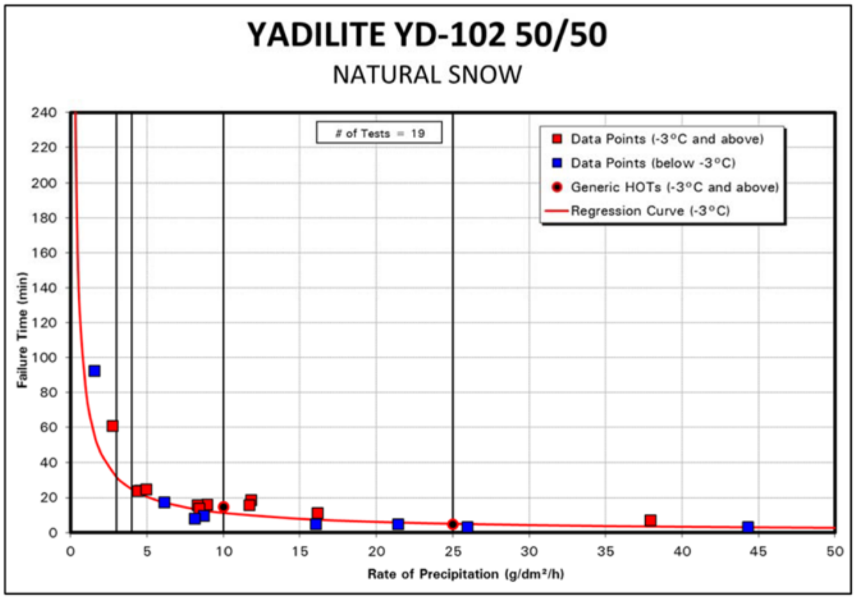


Figure 4.3: Type II 50/50 – Natural Snow

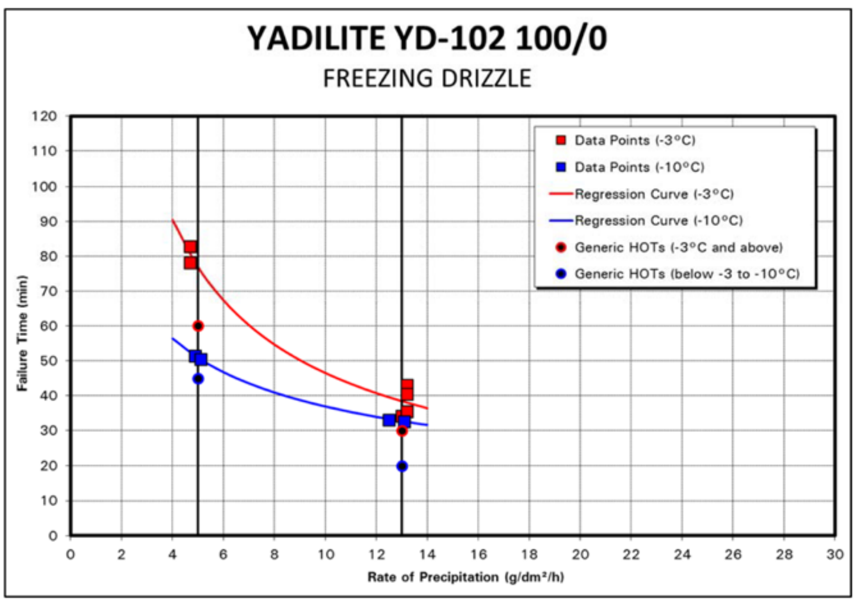


Figure 4.4: Type II Neat – Freezing Drizzle

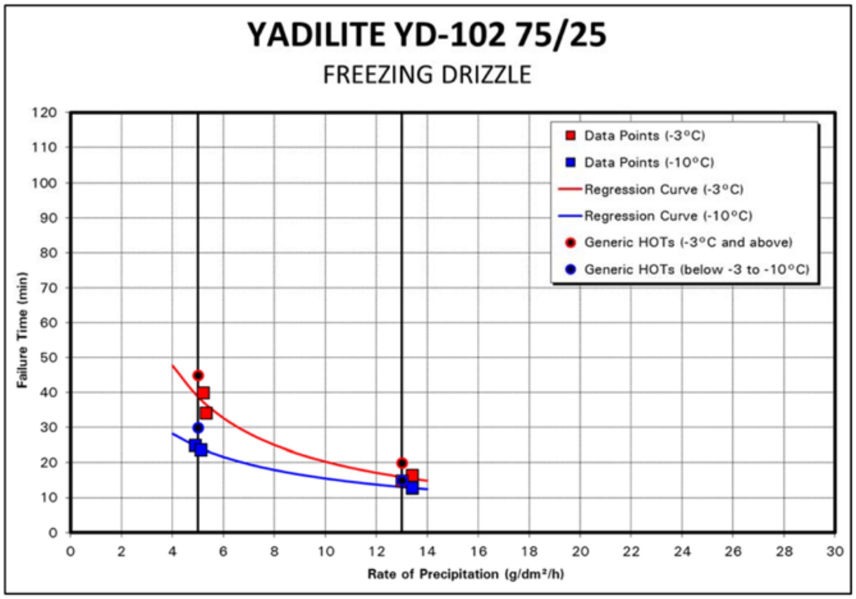


Figure 4.5: Type II 75/25 – Freezing Drizzle

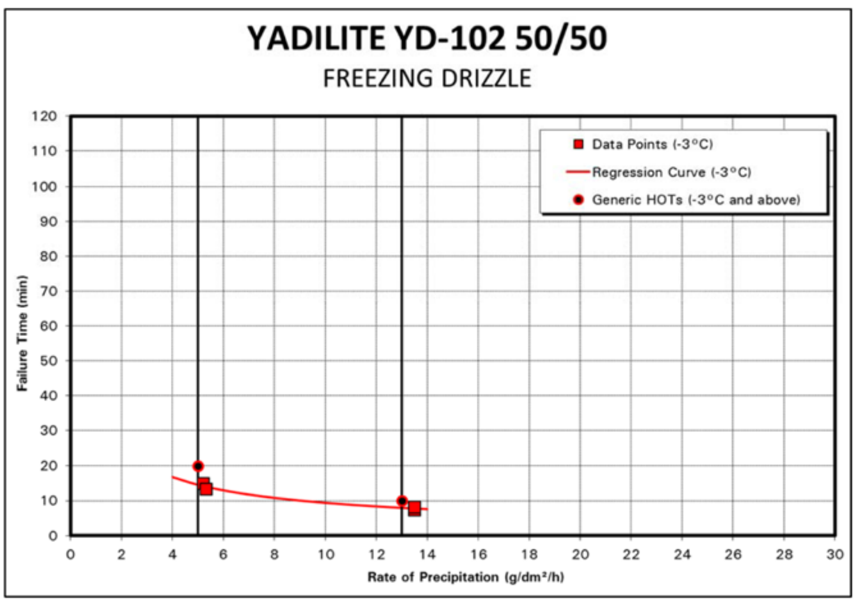


Figure 4.6: Type II 50/50 – Freezing Drizzle

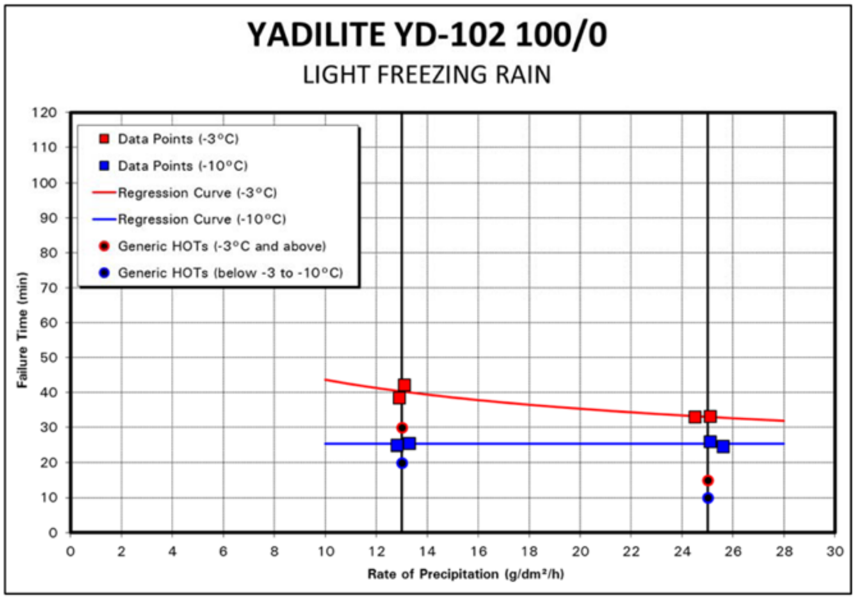


Figure 4.7: Type II Neat – Light Freezing Rain

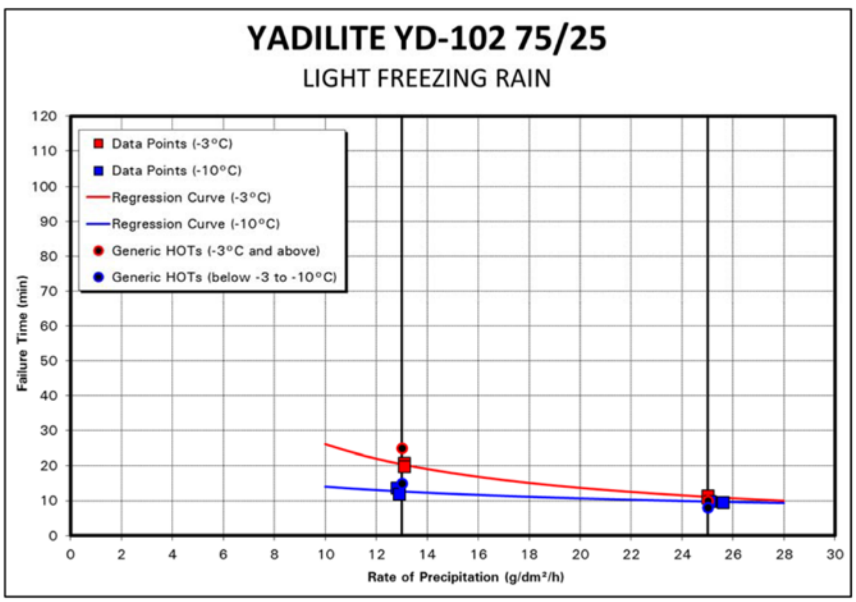


Figure 4.8: Type II 75/25 – Light Freezing Rain

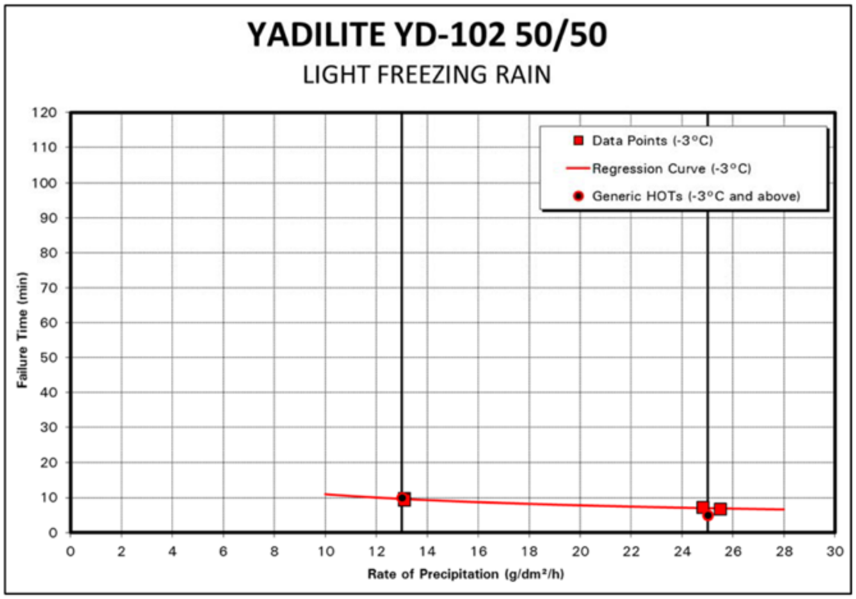


Figure 4.9: Type II 50/50 – Light Freezing Rain

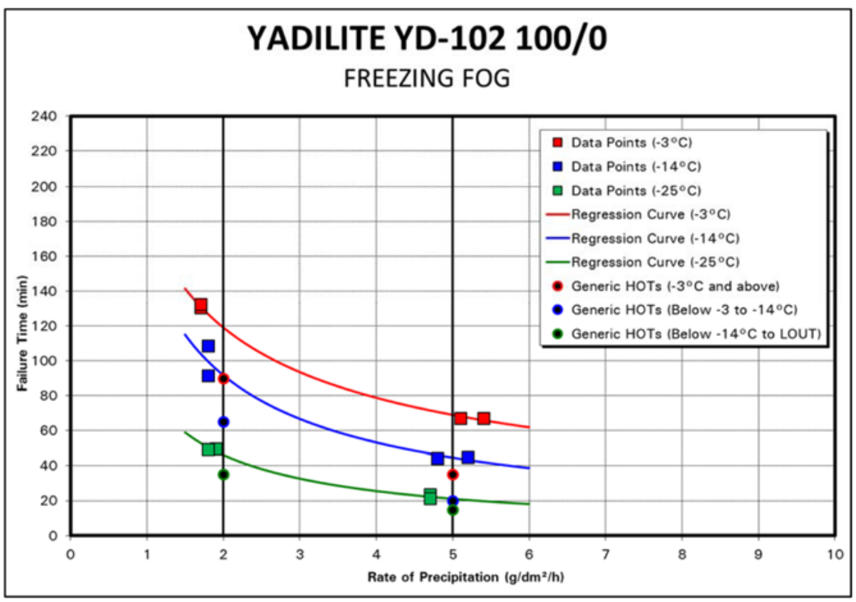


Figure 4.10: Type II Neat – Freezing Fog

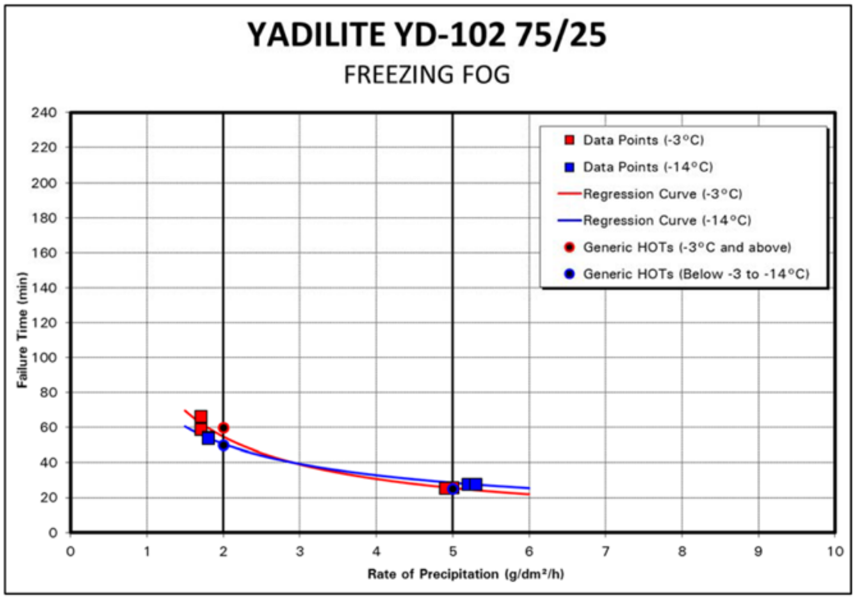


Figure 4.11: Type II 75/25 – Freezing Fog

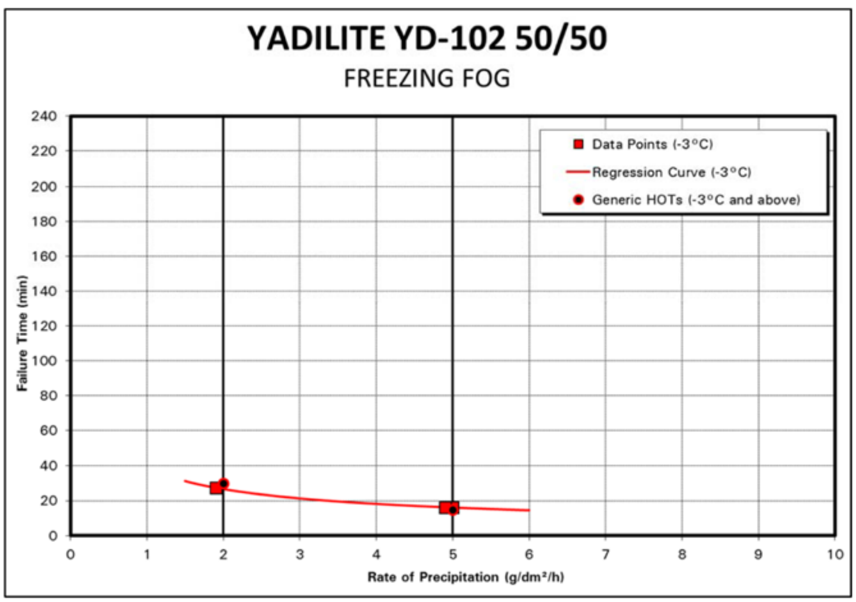


Figure 4.12: Type II 50/50 – Freezing Fog

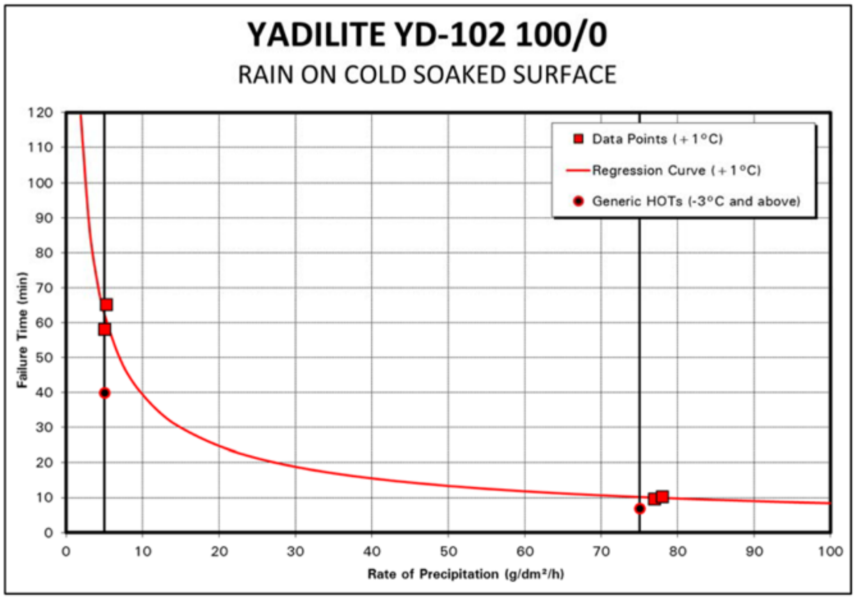


Figure 4.13: Type II Neat – Rain on Cold-Soaked Surface

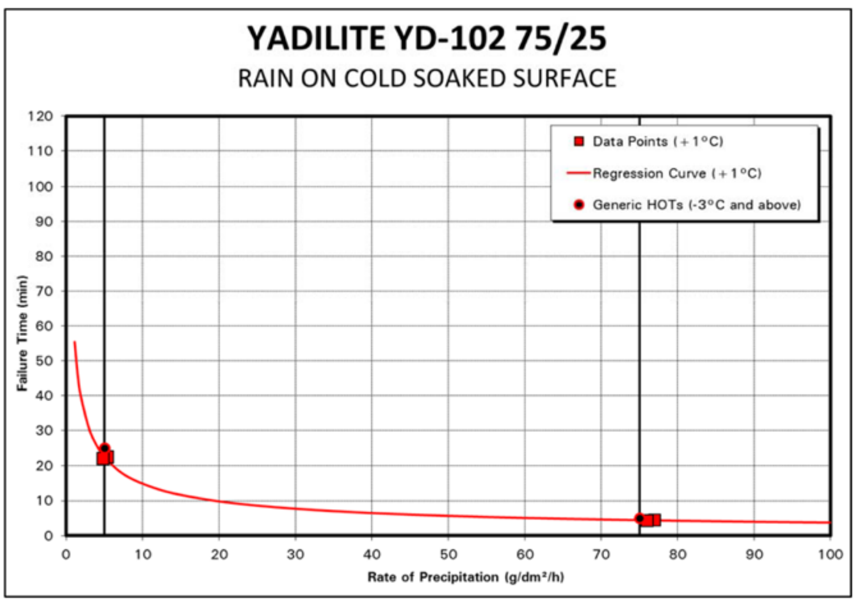


Figure 4.14: Type II 75/25 – Rain on Cold-Soaked Surface

Table 4.1: Regression Equation Coefficients for Beijing Yadilite YD-102 Type II

Natural Snow

Fluid	Dil	R^2	Intercept (I)	Coeff. Rate (A)	Coeff. Tem (B)	Total Pts.
Beijing Yadilite YD-102 Type II	Neat	78%	2.7385	-0.7402	-0.4299	39
Beijing Yadilite YD-102 Type II	75%	88%	2.4080	-0.7439	-0.3491	43
Beijing Yadilite YD-102 Type II	50%	91%	2.1960	-0.8600	-0.3992	19

General Equation $t = 10^{I}\, R^{A}\, (2\text{-}T)^{B}$

Simulated Freezing Fog

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Beijing Yadilite YD-102 Type II	Neat	-3°C	100%	2.2562	-0.5977	4
Beijing Yadilite YD-102 Type II	75/25	-3°C	99%	1.9892	-0.8353	4
Beijing Yadilite YD-102 Type II	50/50	-3°C	100%	1.5895	-0.5473	4
Beijing Yadilite YD-102 Type II	Neat	-14°C	97%	2.1988	-0.7861	4
Beijing Yadilite YD-102 Type II	75/25	-14°C	100%	1.8916	-0.6222	4
Beijing Yadilite YD-102 Type II	Neat	-25°C	99%	1.9202	-0.8505	4

General Equation $t = 10^{I}\, R^{A}$

Simulated Freezing Drizzle

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Beijing Yadilite YD-102 Type II	Neat	-3°C	95%	2.3920	-0.7249	6
Beijing Yadilite YD-102 Type II	75/25	-3°C	98%	2.2407	-0.9340	4
Beijing Yadilite YD-102 Type II	50/50	-3°C	97%	1.6035	-0.6300	4
Beijing Yadilite YD-102 Type II	Neat	-10°C	100%	2.0314	-0.4651	4
Beijing Yadilite YD-102 Type II	75/25	-10°C	100%	1.8407	-0.6501	4

General Equation $t = 10^{I}\, R^{A}$

Simulated Light Freezing Rain

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Beijing Yadilite YD-102 Type II	Neat	-3°C	89%	1.9465	-0.3059	4
Beijing Yadilite YD-102 Type II	75/25	-3°C	99%	2.3425	-0.9259	4
Beijing Yadilite YD-102 Type II	50/50	-3°C	96%	1.5230	-0.4848	4
Beijing Yadilite YD-102 Type II	Neat	-10°C	0%	1.4027	0.0002	4
Beijing Yadilite YD-102 Type II	75/25	-10°C	89%	1.5490	-0.3996	4

General Equation $t = 10^{I}\, R^{A}$

Simulated Rain on Cold Soaked Wing

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Beijing Yadilite YD-102 Type II	Neat	+1°C	100%	2.2622	-0.6682	4
Beijing Yadilite YD-102 Type II	75%	+1°C	100%	1.7678	-0.5942	4

General Equation $t = 10^{I}\, R^{A}$

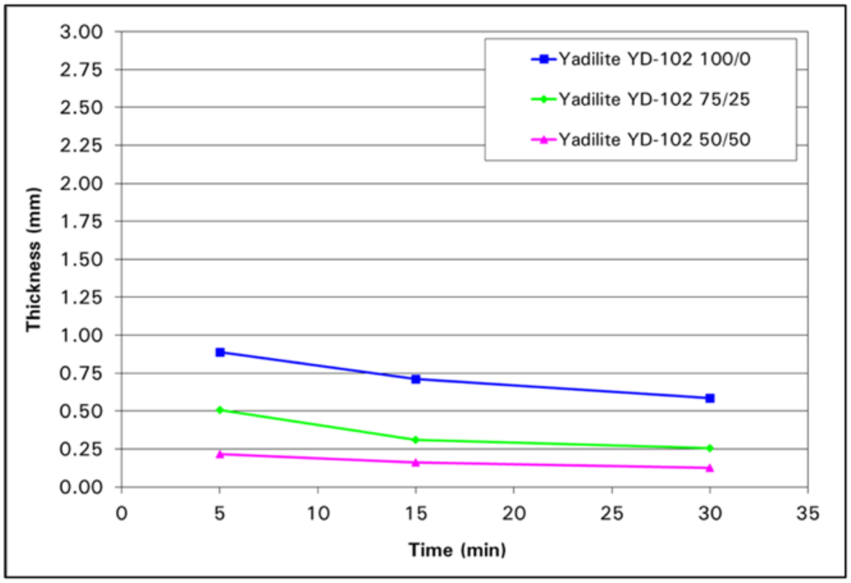


Figure 4.15: Fluid Thickness Profiles of Beijing Yadilite YD-102 Type II

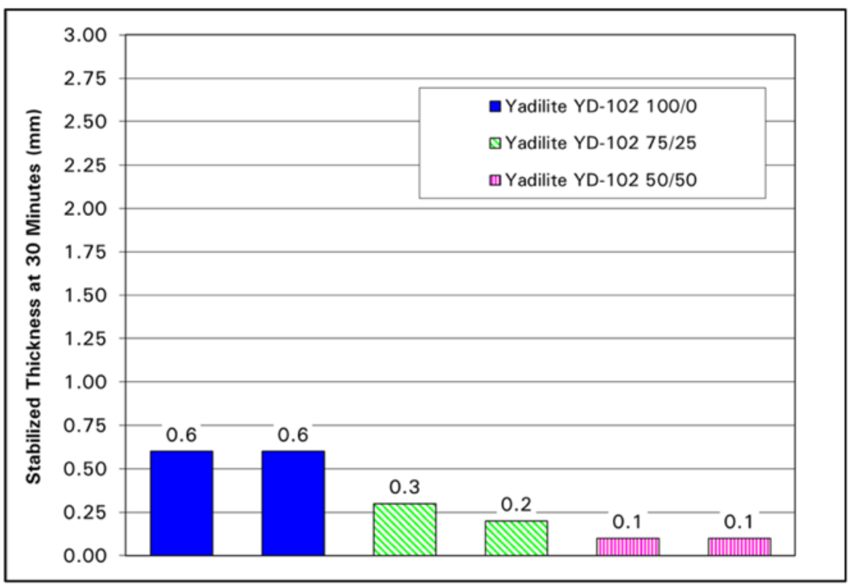


Figure 4.16: Final Fluid Thickness of Beijing Yadilite YD-102 Type II

4.2 Supplemental Tests – Impact of Dye on Endurance Time Performance

The results of the dyed vs. undyed comparative endurance time tests are shown in Figure 4.17. No significant differences were seen in the samples with dye relative to those without; the average difference in endurance time for the dyed sample relative to the undyed sample was -1%.

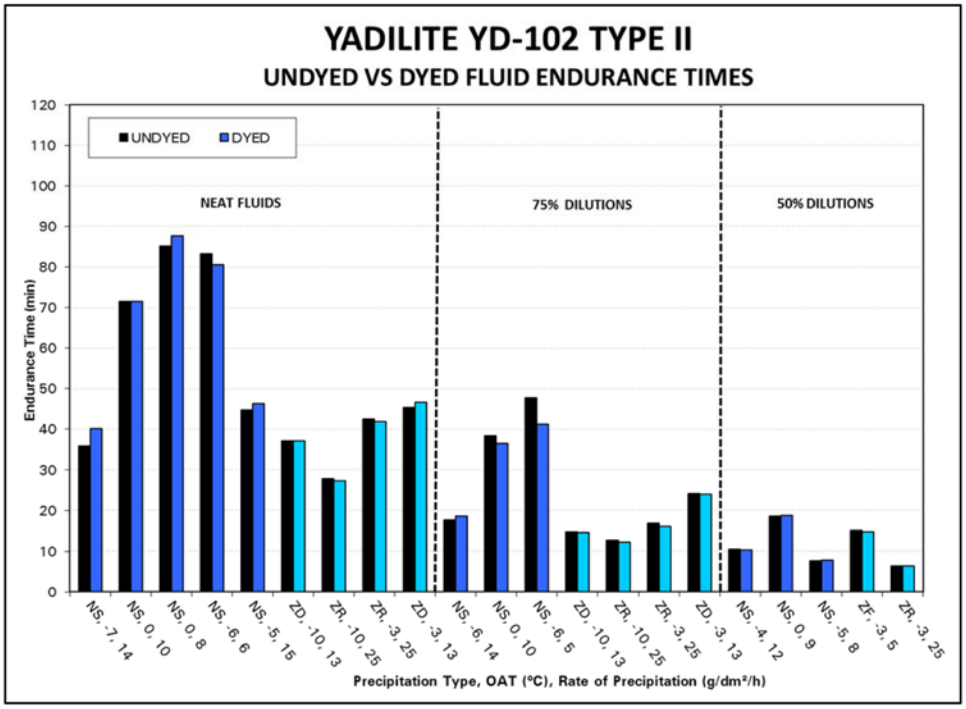


Figure 4.17: Dyed vs. Undyed Fluid Sample Endurance Times

4.3 Discussion

4.3.1 Holdover Time Table

The holdover times described in Subsection 4.1 were used to populate a fluid-specific HOT table for Beijing Yadilite YD-102 Type II. The HOT table is shown in both the TC format (Table 4.2) and FAA format (Table 4.3) at the end of this chapter.

4.3.2 Holdover Times in Snow, Below -14°C to LOUT

Very little endurance time data has been collected in natural snow at temperatures below -14°C. In the winter of 2003-04, testing was conducted with artificial snowmakers to collect additional data below -14°C. As a result of this testing, it was decided all Type II/IV fluids would be given generic values in the "Below -14 to LOUT" snow cells. Further testing in the winters of 2014-15 and 2015-16 in both natural and artificial snow determined the current Type II/IV generic HOTs for the "Below -14 to LOUT" snow cells. Accordingly, Beijing Yadilite YD-102 Type II has been given generic values in the "Below -14°C to LOUT" snow cells.

4.3.3 Holdover Times in Frost

It should be noted that frost holdover times are not included in the fluid-specific HOT tables. This is due to a decision made by TC and the FAA in May 2009 to move frost holdover times from the generic and fluid-specific HOT tables to a separate frost HOT table. Accordingly, frost holdover times have not been included in the Beijing Yadilite YD-102 Type II fluid-specific HOT table.

4.3.4 Fluid Viscosity

The viscosities of the fluid samples used in this testing were measured using both the AS9968 method and the manufacturer's designated method. The APS measured viscosities appear at the beginning of this document and will be published as the lowest on-wing viscosity (LOWV) values for the fluid. In order for the fluid-specific holdover times provided in this document to be valid, operators must ensure that the viscosity of the fluid being used is equal or greater than the published LOWV.

4.3.5 Lowest Operational Use Temperatures (LOUTs)

The LOUT for Type II/III/IV fluids is determined by the higher of:

a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type;

b) The actual freezing point of the fluid plus its freezing point buffer of 7°C (13°F); and

c) For fluid dilutions, the LOUT may also be limited by the coldest temperature for which holdover times are published (-3°C for 50/50; -14°C for 75/25).

The aerodynamic acceptance and freezing point information for this fluid is provided at the beginning of this document. The LOUTs for Beijing Yadilite YD-102 Type II are:

- 100/0: -29°C (-20.2°F)
- 75/25: -14°C (7°F)
- 50/50: -3°C (27°F)

4.3.6 Lowest Usable Precipitation Rates in Snow

The LUPRs for Beijing Yadilite YD-102 Type II were determined by analysing the natural snow data sets using the analysis methodology described in the report "*Methodology for Endurance Time Testing of Type II, III and IV Fluids – Winter 2015-16*," which is provided as an annex to this report. The resulting statistics are shown in Table 4.4. The analysis determined the LUPRs for Beijing Yadilite YD-102 Type II are:

- 100/0 = 2 g/dm²/h;
- 75/25 = 2 g/dm²/h; and
- 50/50 = 2 g/dm²/h.

4.3.7 Impact of Dye on Endurance Times

As no significant differences in endurance time were seen in the sample with dye relative to the sample without dye, it can be concluded that:

1) The dye used to prepare the coloured sample does not impact the endurance time performance of the fluid; and

2) The holdover times provided in this report are valid for both undyed (colourless) and dyed (coloured) versions of this fluid.

4.3.8 Publication of Holdover Times

As Beijing Yadilite intends to commercialize YD-102 Type II, TC and FAA will publish its fluid-specific HOT table in their 2016-17 Holdover Time Guidelines. The guidelines will also include the LOWV and LOUT information; the regression and LUPR data will be published in the related TC and FAA Regression Information documents.

Table 4.2: Fluid Specific Holdover Time Guidelines – Beijing Yadilite YD-102 Type II (TC Format)

TABLE 2-BY-YD-II

TYPE II FLUID HOLDOVER TIME GUIDELINES
BEIJING YADILITE AVIATION YD-102 TYPE II

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	1:10 – 2:00	1:40	0:50 – 1:40	0:25 – 0:50	0:40 – 1:15	0:35 – 0:40	0:10 – 1:00	CAUTION: No holdover time guidelines exist
		75/25	0:25 – 0:55	0:50	0:25 – 0:50	0:15 – 0:25	0:15 – 0:40	0:10 – 0:20	0:04 – 0:25	
		50/50	0:15 – 0:25	0:25	0:10 – 0:25	0:05 – 0:10	0:08 – 0:15	0:07 – 0:09		
below -3 to -14	below 27 to 7	100/0	0:45 – 1:30	1:00	0:30 – 1:00	0:15 – 0:30	0:35 – 0:50[7]	0:25 – 0:25[7]		
		75/25	0:30 – 0:50	0:35	0:20 – 0:35	0:08 – 0:20	0:15 – 0:25[7]	0:09 – 0:15[7]		
below -14 to -29	below 7 to -20.2	100/0	0:20 – 0:45	0:20	0:10 – 0:20	0:08 – 0:10				

NOTES

1. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2. To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3. Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7. No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Table 4.3: Fluid Specific Holdover Time Guidelines – Beijing Yadilite YD-102 Type II (FAA Format)

TABLE 2C. TYPE II HOLDOVER TIME GUIDELINES FOR
BEIJING YADILITE AVIATION YD-102 TYPE II

Outside Air Temperature[1]		Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
			Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
Degrees Celsius	Degrees Fahrenheit			Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	1:10-2:00	1:40-2:00	0:50-1:40	0:25-0:50	0:40-1:15	0:35-0:40	0:10-1:00	CAUTION: No holdover time guidelines exist
		75/25	0:25-0:55	0:50-1:05	0:25-0:50	0:15-0:25	0:15-0:40	0:10-0:20	0:04-0:25	
		50/50	0:15-0:25	0:25-0:30	0:10-0:25	0:05-0:10	0:08-0:15	0:07-0:09		
below -3 to -14	below 27 to 7	100/0	0:45-1:30	1:00-1:15	0:30-1:00	0:15-0:30	0:35-0:50[7]	0:25-0:25[7]		
		75/25	0:30-0:50	0:35-0:45	0:20-0:35	0:08-0:20	0:15-0:25[7]	0:09-0:15[7]		
Below -14 to -29	Below 7 to -20.2	100/0	0:20-0:45	0:20-0:25	0:10-0:20	0:08-0:10				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

Table 4.4: LUPR Statistics – Beijing Yadilite YD-102 Type II

Data Measure	100/0		75/25		50/50	
	Stat	Rating	Stat	Rating	Stat	Rating
Total Data Points	39	40	43	40	19	30
Data Points -3 to -14°C	33	40	33	40	n/a	0
Data Points <10.0	27	40	26	40	11	40
Data Points <=9.5	27	40	26	40	11	40
Data Points <=8.5	22	40	23	40	9	40
Data Points <=7.5	21	40	21	40	6	40
Data Points <=6.5	20	40	21	40	6	40
Data Points <=5.5	18	40	17	40	5	40
Data Points <=4.5	15	40	15	40	4	40
Data Points <=3.5	13	40	11	40	2	30
Data Points <=2.5	7	40	9	40	1	20
Scatter 0-10 g	26%	20	25%	20	23%	20

Rate	100/0		75/25		50/50	
	Score	Pass/Fail	Score	Pass/Fail	Score	Pass/Fail
9 g/dm²/h	37	pass	37	pass	29	pass
8 g/dm²/h	37	pass	37	pass	29	pass
7 g/dm²/h	37	pass	37	pass	29	pass
6 g/dm²/h	37	pass	37	pass	29	pass
5 g/dm²/h	37	pass	37	pass	29	pass
4 g/dm²/h	37	pass	37	pass	29	pass
3 g/dm²/h	37	pass	37	pass	25	pass
2 g/dm²/h	37	pass	37	pass	21	pass

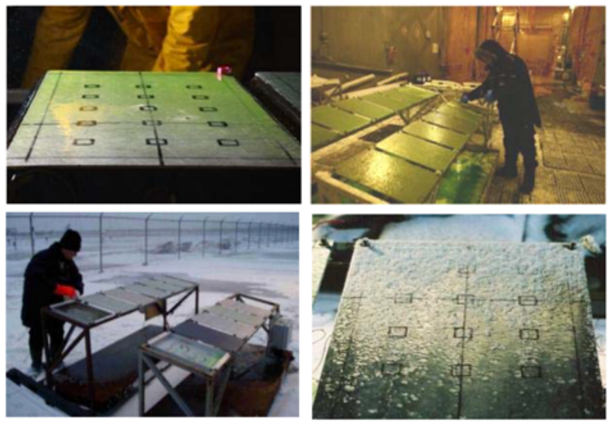
LUPR	100/0	75/25	50/50
	2 g/dm²/h	2 g/dm²/h	2 g/dm²/h

APPENDIX E

FLUID MANUFACTURER REPORT: ALLCLEAR AEROCLEAR MAX (TYPE III)

AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

AllClear AeroClear MAX (Type III) Batch # CB1-PB8000A2



Prepared for

AllClear Systems LLC

by

APS Aviation Inc.

These tests were made possible with the guidance, participation and contribution of the Transportation Development Centre of Transport Canada and the Federal Aviation Administration.

August 2016
Version 1.0
Report No. AC-ACMX 2015-16

AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

AllClear AeroClear MAX (Type III) Batch # CB1-PB8000A2

Prepared for

AllClear Systems LLC

Prepared by: Benjamin Bernier, Project Analyst — August 29, 2016 (Date)

Reviewed by: Stephanie Bendickson, Senior Project Leader — August 29, 2016 (Date)

These tests were made possible with the guidance, participation and contribution of the Transportation Development Centre of Transport Canada and the Federal Aviation Administration.

August 2016
Version 1.0
Report No. AC-ACMX 2015-16

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FLUID IDENTIFICATION AND CHARACTERISTICS

Manufacturer:	AllClear Systems LLC
Fluid Test Name:	CB1-PB8000A2
Fluid Commercial Name:	AeroClear MAX
Fluid Type / Base / Colour:	Type III / Ethylene Glycol / Bright Yellow
Dilutions Submitted:	100/0
Batch #:	CB1-PB8000A-2
Date of Receipt:	September 21, 2015
Brix (Measured):	Neat fluid: 33.75°
Freeze Point (Stated):	Neat fluid: -44.0°C

Aerodynamic LOUT (AMIL):

Low Speed Test:	-16.0°C
High Speed Test:	-35.5°C

Viscosity:	**Stated**	**Measured**
Manufacturer Method[1]	7,400 cP	7,300 cP

[1]Spindle SC4-31, SSA, 9 mL, 0°C, 0.3 rpm, 30 mins

SUMMARY

The primary objective of this project was to measure the endurance time performance of **AllClear AeroClear MAX** batch CB1-PB8000A2 over the entire range of conditions encompassed by the Holdover Time (HOT) tables. This report contains the results of these measurements and was completed with the support of the fluid manufacturer, the Transport Development Centre (TDC) of Transport Canada (TC) and the Federal Aviation Administration (FAA).

Tests were carried out according to the protocol provided in Aerospace Recommended Practice (ARP) 5485. The test procedure consisted of pouring fluids onto clean aluminum test surfaces inclined at 10°; the onset of failure was recorded as a function of time in natural and simulated precipitation.

Tests were performed at the APS Aviation Inc. (APS) test facility at Montréal-Pierre-Elliott-Trudeau International Airport and the National Research Council Canada (NRC) Climatic Engineering Facility (CEF) in Ottawa.

De/anti-icing fluid endurance times were derived from the data collected using multi-variable regression analysis. This resulted in the generation of fluid-specific holdover times.

As CB1-PB8000A2 is the second sample of AeroClear MAX with the same lowest on-wing viscosity (LOWV) to be tested, the lowest test data from the two samples must be used to calculate its fluid-specific holdover times (as per SAE ARP5718 §5.5.4). These holdover times are shown below and will be published by regulators for use in the winter 2016-17 operating season.

High Speed AllClear AeroClear MAX Type III Fluid Holdover Times

Outside Air Temperature (°C)	Type III Fluid Concentration Neat Fluid/ Water (Vol %/Vol %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets*			Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
			Very Light	Light	Moderate				
-3 and above	100/0	0:45-1:10	1:00-1:15	0:30-1:00	0:14-0:30	0:20-0:45	0:14-0:20	0:06-0:40	
	75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	50/50	N/A	N/A	N/A	N/A	N/A	N/A	CAUTION: No holdover time guidelines exist	
below -3 to -10	100/0	0:45-1:25	1:00-1:15	0:30-1:00	0:14-0:30	0:20-0:40	0:15-0:25		
	75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -10 to -25	100/0	0:30-1:05	1:00-1:15	0:30-1:00	0:14-0:30				
below -25 to -35	100/0	0:15-0:40	0:40-0:50	0:19-0:40	0:09-0:19				

**FAA values shown, Transport Canada will publish only the lower values for very light snow and caps all snow HOTs at two hours*

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GLOSSARY

APS	APS Aviation Inc.
ARP	Aerospace Recommended Practice
CEF	Climatic Engineering Facility
FAA	Federal Aviation Administration
HOT	Holdover Time
LOUT	Lowest Operational Use Temperature
LOWV	Lowest On-Wing Viscosity
LUPR	Lowest Usable Precipitation Rate
NRC	National Research Council Canada
TC	Transport Canada
TDC	Transportation Development Centre

1. INTRODUCTION

This report has been created with the support of the fluid manufacturer, the Transport Development Centre (TDC) of Transport Canada (TC) and the Federal Aviation Administration (FAA).

Aircraft ground de/anti-icing has been the subject of concentrated industry attention in recent years due to the occurrence of several fatal icing-related aircraft accidents. Notably, attention has been placed on the enhancement of anti-icing fluids in order to provide an extended period of protection against further contamination following initial deicing. This emphasis has led to the development of fluid-specific de/anti-icing fluid holdover time (HOT) tables for Type II, Type III and Type IV fluids. These tables, accepted by regulatory authorities, are used by aircraft operators for departure planning in adverse winter conditions. Specifically, they provide the duration of time that qualified fluids provide protection against ice formation under specific weather conditions.

New anti-icing formulations continue to be developed by leading manufacturers with the specific objective of prolonging fluid holdover times without compromising the aerodynamic features of the airfoil. The purpose of the endurance time testing program is to measure the endurance times of these new fluids and develop fluid-specific HOT tables that provide guidance for their use.

Flat plate tests, conducted in natural and simulated precipitation, are used to develop HOT values for new fluids. These tests are carried out according to SAE Aerospace Recommended Practice (ARP) ARP5485, which provides the test protocols for measuring endurance times of Type II, III and IV fluids. Along with its counterpart for measuring endurance times of Type I fluids ARP5945, ARP5485 has evolved into a refined procedure for measuring the duration of de/anti-icing fluid protection against ice formation.

The current data analysis protocol for developing HOT values from endurance time data was developed in 1996-97 and uses multi-variable regression to obtain HOT values. HOT values are derived for the majority of cells in Type II/III/IV HOT tables using this protocol and are used to create a fluid-specific HOT table for each Type II/III/IV fluid tested.

This report provides a detailed account of the endurance time testing conducted by APS Aviation Inc. (APS) with **AllClear AeroClear MAX Batch CB1-PB8000A2**, a new sample of a previously tested Type III fluid. It describes the test methodology used, endurance time data collected, and analysis completed to derive fluid-specific holdover times for the fluid.

2. METHODOLOGY

Tests were carried out according to SAE Aerospace Recommended Practice (ARP) 5485, which provides the procedure and requirements for endurance time testing with Type II, III, and IV fluids under natural and simulated conditions.

The test methodology for endurance time testing carried out in the winter of 2015-16 is documented in detail in the report "*Methodology for Endurance Time Testing of Type II, III and IV Fluids – Winter 2015-16.*" A copy of this report is provided as an annex to this document.

The methodology report summarizes the key aspects of the test methodology, including some aspects included in ARP5485 and some aspects which are not included in ARP54855. It includes sections on:

a) Test Sites;
b) Test Equipment;
c) Test Procedures;
d) Precipitation Rates used in Type I, II, III and IV Endurance Time Testing;
e) Ambient Temperatures used in Type I, II, III and IV Endurance Time Testing;
f) Freezing Precipitation Droplet Sizes; and
g) Analysis Methodologies.

The data, analysis and results provided in this report are a function of the test and analysis methodologies described in the methodology report. They should only be used in conjunction with the methodologies described therein.

3. DESCRIPTION OF DATA

This section provides a summary of the number of tests conducted. Breakdowns are provided for the number of tests performed by test type, precipitation type, fluid dilution and test temperature.

3.1 Natural and Artificial Snow Tests

Tests were conducted in natural snow conditions at the APS test site and at several mobile test sites (refer to the report annex for details). Artificial snow tests were conducted at PMG Technologies. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

Fluid Dilution	Natural Snow			Artificial Snow	
	≥ -3°C	-3 to -10°C	< -10°C	-25°C	-35°C
Neat	9	20	10	6	7

3.2 Freezing Precipitation Tests

Tests were conducted in freezing drizzle, light freezing rain, freezing fog and rain on cold-soaked surface conditions at the NRC CEF. The number of tests conducted is summarized below by precipitation type, fluid dilution and test temperature.

Fluid Dilution	Freezing Drizzle		Light Freezing Rain	
	-3°C	-10°C	-3°C	-10°C
Neat	4	4	4	4

Fluid Dilution	Freezing Fog				Cold Soak
	-3°C	-10°C	-25°C	-33°C	+1°C
Neat	4	4	4	4	4

3.3 Natural Frost Tests

Tests were conducted in natural frost at the APS test site. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

Fluid Dilution	Natural Frost			
	≥-1°C	<-1 to -3°C	<-3 to -10°C	<-10°C
Neat	1	0	1	1

3.4 Fluid Thickness Tests

Fluid thickness tests were conducted to measure the film thickness profiles of the fluid under dry conditions. Two tests were performed for each dilution. For each test, 1 litre of fluid was poured onto a flat plate mounted on a test stand inclined by 10°. Thickness measurements were taken at the 15-cm (6") line at select time intervals over a 30-minute period. Tests were conducted at -3°C.

3.5 Test Logs

Details of each test conducted are provided in the test logs included as Table 3.1 (snow) Table 3.2 (freezing precipitation), and Table 3.3 (frost).

Table 3.1: Summary of Tests Performed (Snow)

Test No.	Date	Snow Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
12	27-Dec-15	Natural Snow	AeroClear MAX	100%	0.5	15.1	21.9
17	27-Dec-15	Natural Snow	AeroClear MAX	100%	0.4	19.0	17.5
31	27-Dec-15	Natural Snow	AeroClear MAX	100%	-0.3	36.4	12.1
48	29-Dec-15	Natural Snow	AeroClear MAX	100%	-11.3	19.5	18.3
57	29-Dec-15	Natural Snow	AeroClear MAX	100%	-11.7	33.0	12.3
68	29-Dec-15	Natural Snow	AeroClear MAX	100%	-11.9	22.4	17.0
77	29-Dec-15	Natural Snow	AeroClear MAX	100%	-10.6	33.3	11.2
80	29-Dec-15	Natural Snow	AeroClear MAX	100%	-8.8	51.5	5.7
90	29-Dec-15	Natural Snow	AeroClear MAX	100%	-8.0	20.7	16.2
99	29-Dec-15	Natural Snow	AeroClear MAX	100%	-8.0	25.8	14.7
109	29-Dec-15	Natural Snow	AeroClear MAX	100%	-8.6	23.5	14.6
123	29-Dec-15	Natural Snow	AeroClear MAX	100%	-8.3	4.6	38.0
132	30-Dec-15	Natural Snow	AeroClear MAX	100%	-5.4	9.8	26.6
137	30-Dec-15	Natural Snow	AeroClear MAX	100%	-5.5	9.6	25.8
152	2-Jan-16	Natural Snow	AeroClear MAX	100%	-1.1	9.0	24.6
155	3-Jan-16	Natural Snow	AeroClear MAX	100%	-1.1	3.1	77.0
177	3-Jan-16	Natural Snow	AeroClear MAX	100%	-0.4	5.0	51.0
179	3-Jan-16	Natural Snow	AeroClear MAX	100%	-0.3	2.6	95.6
194	12-Jan-16	Natural Snow	AeroClear MAX	100%	-5.5	2.1	71.0
202	12-Jan-16	Natural Snow	AeroClear MAX	100%	-4.5	2.5	68.7
218	12-Jan-16	Natural Snow	AeroClear MAX	100%	-4.2	11.5	22.7
229	16-Jan-16	Natural Snow	AeroClear MAX	100%	-4.2	2.2	103.0
234	16-Jan-16	Natural Snow	AeroClear MAX	100%	-4.1	1.5	119.8
248	17-Jan-16	Natural Snow	AeroClear MAX	100%	-8.6	2.5	76.0
251	18-Jan-16	Natural Snow	AeroClear MAX	100%	-8.9	5.4	33.5
263	18-Jan-16	Natural Snow	AeroClear MAX	100%	-8.6	4.0	46.4
272	3-Feb-16	Natural Snow	AeroClear MAX	100%	-4.8	2.5	120.4
279	3-Feb-16	Natural Snow	AeroClear MAX	100%	-4.5	6.7	39.5
301	9-Feb-16	Natural Snow	AeroClear MAX	100%	-7.3	0.6	194.5
304	12-Feb-16	Natural Snow	AeroClear MAX	100%	-7.1	10.9	26.4
339	16-Feb-16	Natural Snow	AeroClear MAX	100%	-6.1	14.2	21.4
366	19-Feb-16	Natural Snow	AeroClear MAX	100%	0.3	7.2	62.7
445	22-Mar-16	Natural Snow	AeroClear MAX	100%	0.2	10.4	31.4
C33	4-Feb-16	Natural Snow	AeroClear MAX	100%	-22.0	3.2	57.4
C65	26-Feb-16	Natural Snow	AeroClear MAX	100%	-23.7	1.1	189.0
C75	27-Feb-16	Natural Snow	AeroClear MAX	100%	-22.8	6.4	62.1
C91	27-Feb-16	Natural Snow	AeroClear MAX	100%	-23.4	9.6	43.5

Table 3.1 (cont'd): Summary of Tests Performed (Snow)

Test No.	Date	Snow Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
C104	27-Feb-16	Natural Snow	AeroClear MAX	100%	-22.9	5.7	72.3
C125	27-Feb-16	Natural Snow	AeroClear MAX	100%	-21.9	7.7	57.7
6	15-Mar-16	Artificial Snow	AeroClear MAX	100%	-23.0	5.7	70.0
7	16-Mar-16	Artificial Snow	AeroClear MAX	100%	-25.0	3.0	110.4
8	14-Mar-16	Artificial Snow	AeroClear MAX	100%	-25.0	4.0	103.6
9	14-Mar-16	Artificial Snow	AeroClear MAX	100%	-25.0	10.0	33.4
10	14-Mar-16	Artificial Snow	AeroClear MAX	100%	-25.0	25.0	18.0
11	14-Mar-16	Artificial Snow	AeroClear MAX	100%	-25.0	50.0	5.2
60	22-Mar-16	Artificial Snow	AeroClear MAX	100%	-35.0	3.0	107.0
61	22-Mar-16	Artificial Snow	AeroClear MAX	100%	-35.0	4.0	91.0
62	22-Mar-16	Artificial Snow	AeroClear MAX	100%	-35.0	10.0	29.6
62R	22-Mar-16	Artificial Snow	AeroClear MAX	100%	-35.0	10.0	27.2
63	22-Mar-16	Artificial Snow	AeroClear MAX	100%	-35.0	25.0	13.7
63R	22-Mar-16	Artificial Snow	AeroClear MAX	100%	-35.0	25.0	12.4
64	22-Mar-16	Artificial Snow	AeroClear MAX	100%	-35.0	50.0	4.9

Table 3.2: Summary of Tests Performed (Freezing Precipitation)

Test No.	Date	Precipitation Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
7	30-Mar-16	Freezing Fog	AeroClear MAX	100%	-3.3	1.7	76.1
8	30-Mar-16	Freezing Fog	AeroClear MAX	100%	-3.3	1.7	81.5
35	4-Apr-16	Freezing Fog	AeroClear MAX	100%	-3.0	5.4	38.9
36	4-Apr-16	Freezing Fog	AeroClear MAX	100%	-3.0	5.1	46.5
57	30-Mar-16	Freezing Fog	AeroClear MAX	100%	-10.2	1.9	89.9
58	30-Mar-16	Freezing Fog	AeroClear MAX	100%	-10.2	1.9	85.3
59	31-Mar-16	Freezing Fog	AeroClear MAX	100%	-10.3	5.0	49.3
60	31-Mar-16	Freezing Fog	AeroClear MAX	100%	-10.3	4.6	47.1
99	1-Apr-16	Freezing Fog	AeroClear MAX	100%	-25.2	1.9	85.3
100	1-Apr-16	Freezing Fog	AeroClear MAX	100%	-25.2	1.9	82.4
111	1-Apr-16	Freezing Fog	AeroClear MAX	100%	-25.2	4.7	37.8
112	1-Apr-16	Freezing Fog	AeroClear MAX	100%	-25.2	4.7	36.2
121	1-Apr-16	Freezing Fog	AeroClear MAX	100%	-33.8	1.9	43.7
122	1-Apr-16	Freezing Fog	AeroClear MAX	100%	-33.8	2.0	43.0
123	1-Apr-16	Freezing Fog	AeroClear MAX	100%	-33.7	4.6	17.5
124	1-Apr-16	Freezing Fog	AeroClear MAX	100%	-33.8	4.6	16.2
131	4-Apr-16	Freezing Drizzle	AeroClear MAX	100%	-2.9	4.7	50.0
132	4-Apr-16	Freezing Drizzle	AeroClear MAX	100%	-3.1	5.1	40.9
159	7-Apr-16	Freezing Drizzle	AeroClear MAX	100%	-3.1	13.2	20.8
160	7-Apr-16	Freezing Drizzle	AeroClear MAX	100%	-3.1	13.0	21.9
185	5-Apr-16	Freezing Drizzle	AeroClear MAX	100%	-10.2	5.0	39.3
186	5-Apr-16	Freezing Drizzle	AeroClear MAX	100%	-10.2	4.9	39.0
205	5-Apr-16	Freezing Drizzle	AeroClear MAX	100%	-10.3	12.5	22.1
206	5-Apr-16	Freezing Drizzle	AeroClear MAX	100%	-10.3	13.4	19.8
227	6-Apr-16	Light Freezing Rain	AeroClear MAX	100%	-3.2	13.0	21.6
228	6-Apr-16	Light Freezing Rain	AeroClear MAX	100%	-3.1	13.2	22.6
255	6-Apr-16	Light Freezing Rain	AeroClear MAX	100%	-3.2	25.4	15.2
256	6-Apr-16	Light Freezing Rain	AeroClear MAX	100%	-3.2	25.4	14.0
281	5-Apr-16	Light Freezing Rain	AeroClear MAX	100%	-10.1	12.8	23.7
282	5-Apr-16	Light Freezing Rain	AeroClear MAX	100%	-10.1	13.0	22.2
301	6-Apr-16	Light Freezing Rain	AeroClear MAX	100%	-9.9	25.1	15.3
302	6-Apr-16	Light Freezing Rain	AeroClear MAX	100%	-9.9	25.5	15.1
321	7-Apr-16	Cold Soak Box	AeroClear MAX	100%	1.0	4.8	38.7
322	7-Apr-16	Cold Soak Box	AeroClear MAX	100%	1.0	5.3	36.3
341	7-Apr-16	Cold Soak Box	AeroClear MAX	100%	1.0	76.3	6.5
342	7-Apr-16	Cold Soak Box	AeroClear MAX	100%	1.0	78.9	6.0

Table 3.3: Summary of Tests Performed (Natural Frost)

Test No.	Date	Precip. Type	Fluid Name	Fluid Dilution	Test Duration (min.)	Average Rate (g/dm²/h)	Temp (°C)	Wind Speed (km/h)	Average RH (%)	Comments
10	Jan-04-16	Natural Frost	AllClear AeroClear MAX	100%	577	0.08	-19.1	7	80	Did Not Fail
19	Jan-07-16	Natural Frost	AllClear AeroClear MAX	100%	395	0.14	-5.1	8	88	Failed
51	Apr-17-16	Natural Frost	AllClear AeroClear MAX	100%	388	0.02	4.8	5	66	Did Not Fail

4. RESULTS AND DISCUSSION

The methods used to evaluate the test data are provided in the report "*Methodology for Endurance Time Testing of Type II, III and IV Fluids – Winter 2015-16,*" which is provided as an annex to this report. The results of the data analyses and a discussion of the findings are presented in this section.

4.1 Results

The results of the endurance time and thickness tests are described in this section.

4.1.1 Endurance Time Tests – Snow and Freezing Precipitation

Figures 4.1 to 4.5 present the endurance time data collected in natural snow and freezing precipitation (freezing drizzle, light freezing rain, freezing fog and rain on cold-soaked surface). These figures show the effect of temperature, precipitation type and precipitation rate on fluid endurance time in the conditions encompassed by the Type III HOT guidelines.

Multi-variable regression analysis was performed on these data sets as described in the annex. Table 4.1 provides the outputs from the multi-variable regression analyses. These outputs were used to derive fluid-specific holdover times for all conditions encompassed by Type III fluid-specific HOT tables. One exception is the coldest temperature band snow cells (see Subsection 4.2.2).

Figure 4.6 shows the endurance time data collected in artificial snow. Table 4.2 shows the relative endurance time performance of the fluid at -25 vs. -35°C.

4.1.2 Endurance Time Tests – Natural Frost

The natural frost data was presented in Table 3.3. The test durations were compared to the Type III generic holdover times. Tests that were not completed (due to active frost ending before fluid failure could occur) surpassed the generic holdover times. This analysis indicates the Type III generic frost holdover times can be considered substantiated for AllClear AeroClear MAX.

4.1.3 Fluid Thickness Tests

Figure 4.7 shows the fluid thickness test data. As described in Subsection 3.4, two tests were conducted at an ambient temperature of -3°C. The final fluid thicknesses are displayed in Figure 4.8.

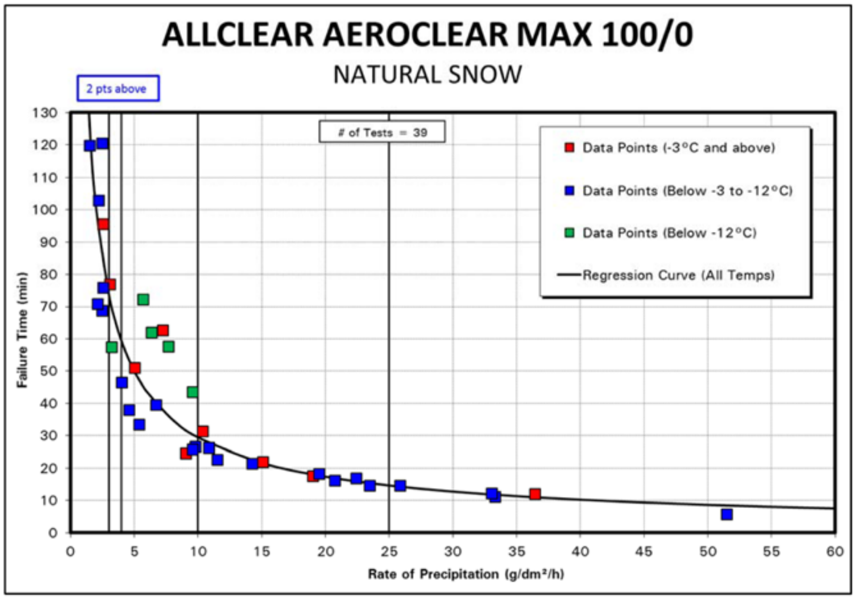


Figure 4.1: Type III Neat – Natural Snow

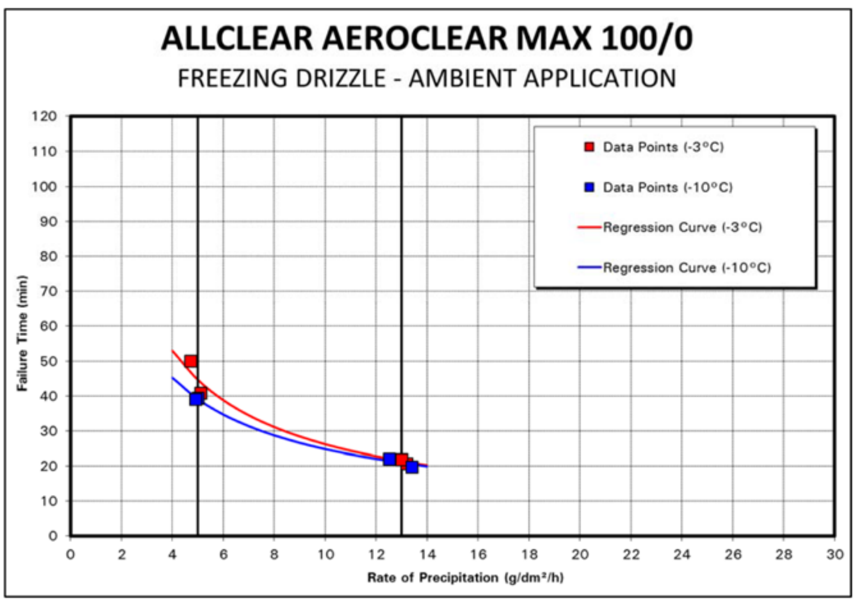


Figure 4.2: Type III Neat – Freezing Drizzle

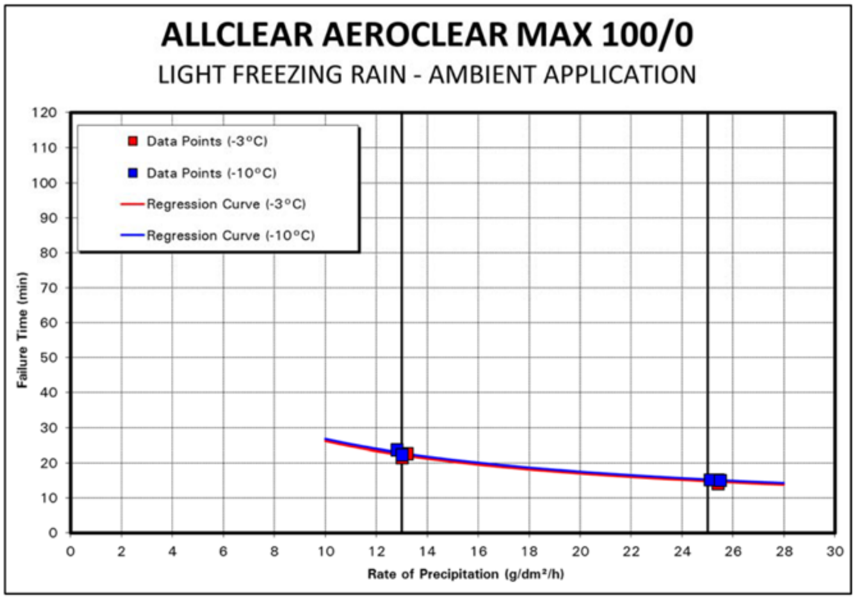


Figure 4.3: Type III Neat – Light Freezing Rain

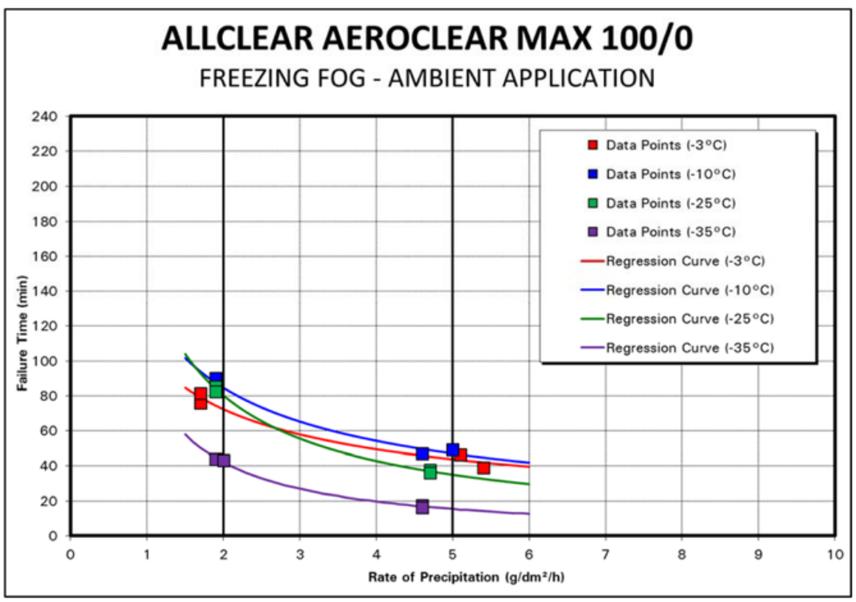


Figure 4.4: Type III Neat – Freezing Fog

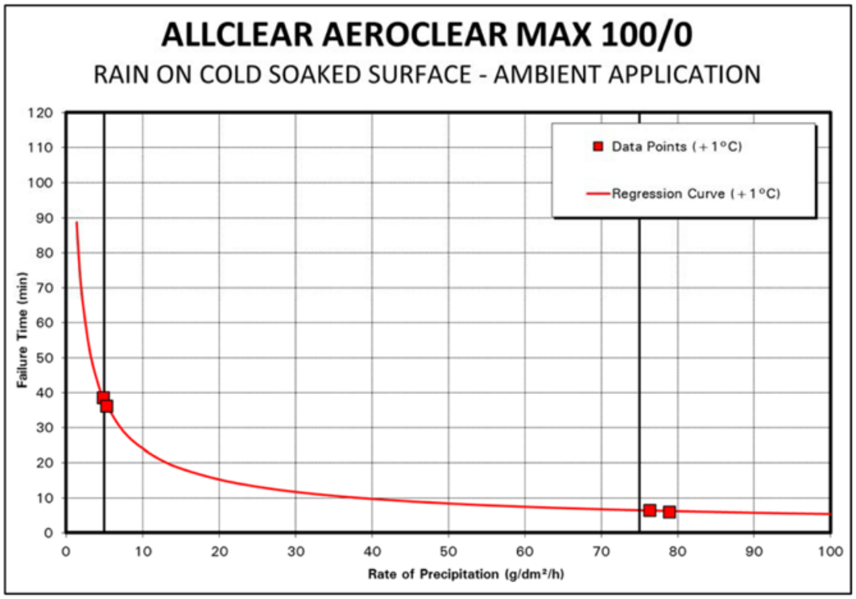


Figure 4.5: Type III Neat – Rain on Cold-Soaked Surface

Table 4.1: Regression Equation Coefficients for AllClear AeroClear MAX

Fluid	Dil	R^2	Intercept (I)	Coeff. Rate (A)	Coeff. Tem (B)	Points
Natural Snow *						
AllClear AeroClear MAX	Neat	92%	2.2296	-0.7601	0.0000	39

*General Equation $t = 10^{I} R^{A} (2\text{-}T)^{B}$

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Points
Simulated Freezing Fog**						
AllClear AeroClear MAX	Neat	-3°C	97%	2.0236	-0.5492	4
AllClear AeroClear MAX	Neat	-14°C	98%	2.1200	-0.6403	4
AllClear AeroClear MAX	Neat	-25°C	100%	2.1751	-0.9034	4
AllClear AeroClear MAX	Neat	-35°C	99%	1.9556	-1.1000	4
Simulated Freezing Drizzle**						
AllClear AeroClear MAX	Neat	-3°C	98%	2.1862	-0.7684	4
AllClear AeroClear MAX	Neat	-10°C	99%	2.0487	-0.6552	4
Simulated Light Freezing Rain**						
AllClear AeroClear MAX	Neat	-3°C	97%	2.0417	-0.6247	4
AllClear AeroClear MAX	Neat	-10°C	99%	2.0446	-0.6155	4
Simulated Rain on Cold Soaked Wing**						
AllClear AeroClear MAX	Neat	+1°C	100%	2.0334	-0.6545	4

**General Equation $t = 10^{I} R^{A}$

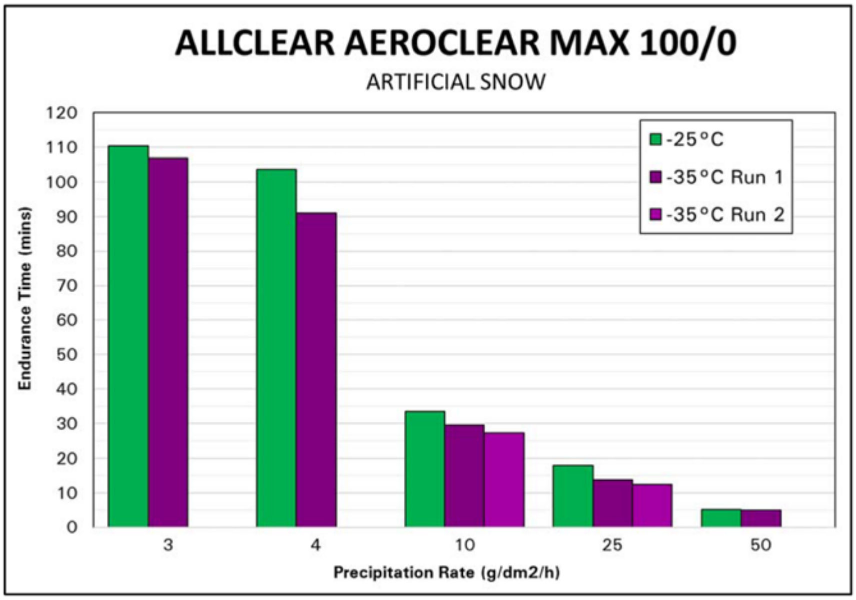


Figure 4.6: Type III Neat – Artificial Snow

Table 4.2: AllClear AeroClear MAX Performance at -25°C vs. -35°C

Rate ($g/dm^2/h$)	Fail Time at -25°C (min)	Fail Time at -35°C (min)	-35 HOT as % of -25 HOT
3	110.4	107.0	97%
4	103.6	91.0	88%
10	33.4	29.6	88%
		27.2	81%
25	18.0	13.7	76%
		12.4	69%
50	5.2	4.9	95%
Average			**85%**
Standard Deviation			**10%**

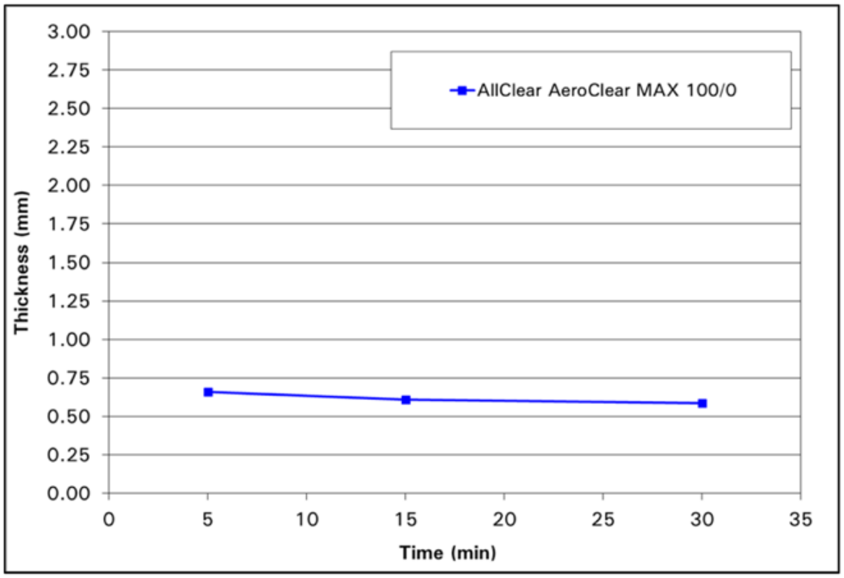


Figure 4.7: Fluid Thickness Profiles of AllClear AeroClear MAX

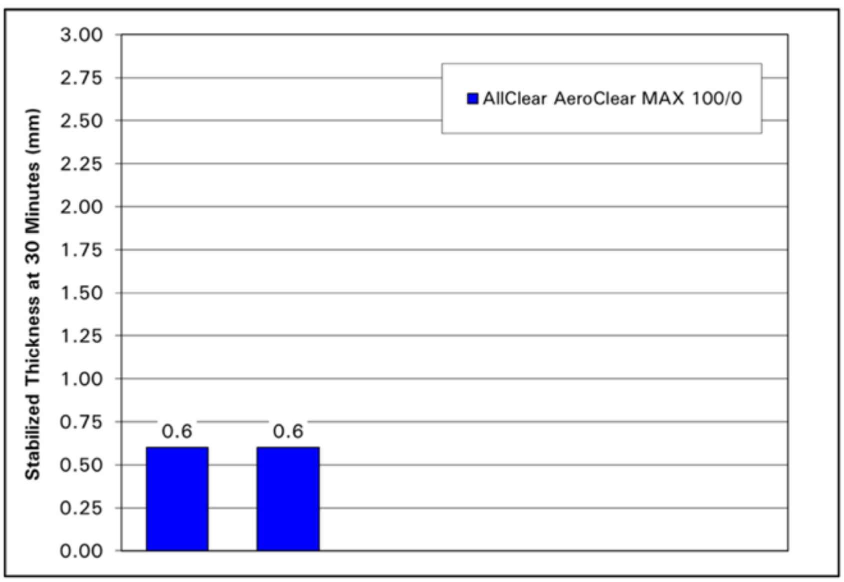


Figure 4.8: Final Fluid Thickness of AllClear AeroClear MAX

4.2 Discussion

4.2.1 Holdover Time Table

CB1-PB8000A2 is the second sample of AeroClear MAX to be tested with the same lowest on-wing viscosity (LOWV). According to SAE ARP5718 §5.5.4, in this situation, the lowest test data from the two samples shall be used to calculate the fluid-specific holdover times.

The holdover times described in Subsection 4.1 were compared to the holdover times derived from the previous sample tested (CB1-PB8000A) and the lowest test data was used to populate fluid-specific HOT tables for AllClear AeroClear MAX. The resulting HOT tables are shown in both the TC format (Tables 4.3 and 4.4) and FAA format (Tables 4.5 and 4.6) at the end of this chapter.

4.2.2 Holdover Times in Snow, Below -25°C to LOUT

In order to determine holdover times for AeroClear MAX in snow in the coldest temperature band (below -25 to LOUT), artificial snow testing was performed with AeroClear MAX at -25°C and its LOUT (-35°C). The performance of the fluid at -35°C relative to -25°C was then calculated (see Table 4.2).

On average, endurance times at -35°C were 85% of those at -25°C. For added safety, two standard deviations were subtracted from this statistic, resulting in a relative performance factor of 65%. This factor was applied to the natural snow holdover times calculated for -25°C; this provided the holdover times for snow in the coldest temperature band, below -25°C to LOUT (-35°C).

4.2.3 Holdover Times in Frost

It should be noted that frost holdover times are not included in the fluid-specific HOT tables. This is due to a decision made by TC and the FAA in May 2009 to move frost holdover times from the generic and fluid-specific HOT tables to a separate frost HOT table. Accordingly, frost holdover times have not been included in the AllClear AeroClear MAX fluid-specific HOT table.

4.2.4 Fluid Viscosity

The viscosities of the fluid samples used in this testing were measured using both the AS9968 method and the manufacturer's designated method. The APS measured viscosities appear at the beginning of this document and will be published as the lowest on-wing viscosity (LOWV) values for the fluid. In order for the fluid-specific holdover times provided in this document to be valid, operators must ensure that the viscosity of the fluid being used is equal or greater than the published LOWV.

4.2.5 Lowest Operational Use Temperatures (LOUTs)

The LOUT for Type II/III/IV fluids is determined by the higher of:

a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type;
b) The actual freezing point of the fluid plus its freezing point buffer of 7°C (13°F); and
c) For fluid dilutions, the LOUT may also be limited by the coldest temperature for which holdover times are published (-3°C for 50/50; -14°C for 75/25).

The aerodynamic acceptance and freezing point information for this fluid is provided at the beginning of this document. The LOUT for AllClear AeroClear MAX is -35°C (-31°F) for high speed aircraft and -16°C (3.2°F) for low speed aircraft.

4.2.6 Lowest Usable Precipitation Rates in Snow

The LUPR for AllClear AeroClear MAX for temperatures of -25°C and above was determined by analysing the natural snow data set using the analysis methodology described in the report "*Methodology for Endurance Time Testing of Type II, III and IV Fluids – Winter 2015-16*," which is provided as an annex to this report. The resulting statistics are shown in Table 4.7. The analysis determined the LUPR for AllClear AeroClear MAX for -25°C and above is 2 g/dm²/h.

Artificial snow tests were used to derive the AllClear AeroClear MAX holdover times for the "Below -25 to -35°C" temperature band. The lowest precipitation rate these tests were run at was 3 g/dm²/h. As a result, the LUPR for AllClear AeroClear MAX for below -25°C is 3 g/dm²/h.

4.2.7 Publication of Holdover Times

As AllClear intends to commercialize AeroClear MAX, TC and FAA will publish its fluid-specific HOT table in their 2016-17 Holdover Time Guidelines. The guidelines will also include the LOWV and LOUT information; the regression and LUPR data will be published in the related TC and FAA Regression Information documents.

Table 4.3: Fluid Specific Holdover Time Guidelines – AllClear AeroClear MAX (TC Format, Low Speed)

TABLE 3LS-A-ACM

LOW SPEED TYPE III FLUID HOLDOVER TIME GUIDELINES
ALLCLEAR AEROCLEAR MAX, APPLIED UNHEATED[1]

FOR AIRCRAFT CONFORMING TO THE SAE AS5900 LOW SPEED AERODYNAMIC TEST CRITERION

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3] Very Light[4]	Light[4]	Moderate	Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
-3 and above	27 and above	100/0	0:45 – 1:10	1:00	0:30 – 1:00	0:14 – 0:30	0:20 – 0:45	0:14 – 0:20	0:06 – 0:40	
		75/25								
		50/50								
below -3 to -10	below 27 to 14	100/0	0:45 – 1:25	1:00	0:30 – 1:00	0:14 – 0:30	0:20 – 0:40	0:15 – 0:25	CAUTION: No holdover time guidelines exist	
		75/25								
below -10 to -16	below 14 to 3.2	100/0	0:30 – 1:05	1:00	0:30 – 1:00	0:14 – 0:30				

NOTES
1 Fluid must be applied unheated to use these holdover times. No holdover times exist for this fluid applied heated.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type III fluid cannot be used.
3 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Table 4.4: Fluid Specific Holdover Time Guidelines – AllClear AeroClear MAX (TC Format, High Speed)

TABLE 3HS-A-ACM

HIGH SPEED TYPE III FLUID HOLDOVER TIME GUIDELINES
ALLCLEAR AEROCLEAR MAX, APPLIED UNHEATED[1]

FOR AIRCRAFT CONFORMING TO THE SAE AS5900 HIGH SPEED AERODYNAMIC TEST CRITERION

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3] Very Light[4]	Light[4]	Moderate	Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
-3 and above	27 and above	100/0	0:45 – 1:10	1:00	0:30 – 1:00	0:14 – 0:30	0:20 – 0:45	0:14 – 0:20	0:06 – 0:40	
		75/25								
		50/50								
below -3 to -10	below 27 to 14	100/0	0:45 –1:25	1:00	0:30 – 1:00	0:14 – 0:30	0:20 – 0:40	0:15 – 0:25	CAUTION: No holdover time guidelines exist	
		75/25								
below -10 to -25	below 14 to -13	100/0	0:30 – 1:05	1:00	0:30 – 1:00	0:14 – 0:30				
below -25 to -35	below -13 to -31	100/0	0:15 – 0:40	0:40	0:19 – 0:40	0:09 – 0:19				

NOTES
1 Fluid must be applied unheated to use these holdover times. No holdover times exist for this fluid applied heated.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type III fluid cannot be used.
3 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 5 provides allowance times for ice pellets and small hail).

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Table 4.5: Fluid Specific Holdover Time Guidelines – AllClear AeroClear MAX (FAA Format, Low Speed)

TABLE 3A-LS. LOW SPEED TYPE III HOLDOVER TIME GUIDELINES FOR ALLCLEAR AEROCLEAR MAX, APPLIED UNHEATED[1]

FOR AIRCRAFT CONFORMING TO THE SAE AS5900 LOW SPEED AERODYNAMIC TEST CRITERION

Outside Air Temperature[2]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
			Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
Degrees Celsius	Degrees Fahrenheit			Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	100/0	0:45-1:10	1:00-1:15	0:30-1:00	0:14-0:30	0:20-0:45	0:14-0:20	0:06-0:40	CAUTION: No holdover time guidelines exist
		75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		50/50	N/A	N/A	N/A	N/A	N/A	N/A		
below -3 to -10	below 27 to 14	100/0	0:45-1:25	1:00-1:15	0:30-1:00	0:14-0:30	0:20-0:40	0:15-0:25		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -10 to -16	below 14 to 3.2	100/0	0:30-1:05	1:00-1:15	0:30-1:00	0:14-0:30				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Fluid must be applied unheated to use these holdover times. No holdover times exist for this fluid when applied heated.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type III fluid cannot be used.
3 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

Table 4.6: Fluid Specific Holdover Time Guidelines – AllClear AeroClear MAX (FAA Format, High Speed)

TABLE 3A-HS. HIGH SPEED TYPE III HOLDOVER TIME GUIDELINES FOR
ALLCLEAR AEROCLEAR MAX, APPLIED UNHEATED[1]
FOR AIRCRAFT CONFORMING TO THE SAE AS5900 HIGH SPEED AERODYNAMIC TEST CRITERION

Outside Air Temperature[2]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3] Very Light[4]	Light[4]	Moderate	Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
-3 and above	27 and above	100/0	0:45-1:10	1:00-1:15	0:30-1:00	0:14-0:30	0:20-0:45	0:14-0:20	0:06-0:40	
		75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		50/50	N/A	N/A	N/A	N/A	N/A	N/A	CAUTION: No holdover time guidelines exist	
below -3 to -10	below 27 to 14	100/0	0:45-1:25	1:00-1:15	0:30-1:00	0:14-0:30	0:20-0:40	0:15-0:25		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -10 to -25	below 14 to -13	100/0	0:30-1:05	1:00-1:15	0:30-1:00	0:14-0:30				
below -25 to -35	below -13 to -31	100/0	0:15-0:40	0:40-0:50	0:19-0:40	0:09-0:19				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Fluid must be applied unheated to use these holdover times. No holdover times exist for this fluid when applied heated.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type III fluid cannot be used.
3 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 5 provides allowance times for ice pellets and small hail).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

Table 4.7: LUPR Statistics – AllClear AeroClear MAX

Data Measure	100/0	
	Stat	Rating
Total Data Points	39	40
Data Points -3 to -14°C	30	40
Data Points <10.0	24	40
Data Points <=9.5	21	40
Data Points <=8.5	20	40
Data Points <=7.5	19	40
Data Points <=6.5	17	40
Data Points <=5.5	15	40
Data Points <=4.5	12	40
Data Points <=3.5	11	40
Data Points <=2.5	8	40
Scatter 0-10 g	25%	20

Rate	100/0	
	Score	Pass/Fail
9 g/dm²/h	37	pass
8 g/dm²/h	37	pass
7 g/dm²/h	37	pass
6 g/dm²/h	37	pass
5 g/dm²/h	37	pass
4 g/dm²/h	37	pass
3 g/dm²/h	37	pass
2 g/dm²/h	37	pass

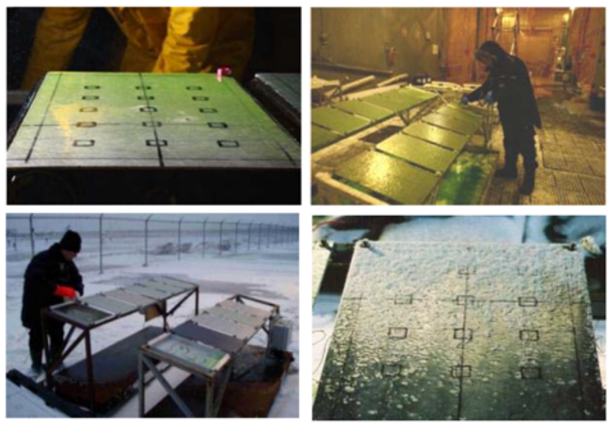
LUPR	100/0
	2 g/dm²/h

APPENDIX F

FLUID MANUFACTURER REPORT: CLARIANT MAX FLIGHT AVIA (TYPE IV)

AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

Clariant Max Flight AVIA (Type IV)



Prepared for

Clariant Produkte Deutschland GmbH

by

APS Aviation Inc.

These tests were made possible with the guidance, participation and contribution of the Transportation Development Centre of Transport Canada and the Federal Aviation Administration.

August 2016
Version 1.0
Report No. C-MFA 2015-16

AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

Clariant Max Flight AVIA (Type IV)

Prepared for

Clariant Produkte Deutschland GmbH

Prepared by:

Benjamin Bernier
Project Analyst

August 29, 2016
Date

Reviewed by:

Stephanie Bendickson
Senior Project Leader

August 29, 2016
Date

These tests were made possible with the guidance, participation and contribution of the Transportation Development Centre of Transport Canada and the Federal Aviation Administration.

August 2016
Version 1.0
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FLUID IDENTIFICATION AND CHARACTERISTICS

Manufacturer:	Clariant Produkte Deutschland GmbH		
Fluid Test Name:	Max Flight AVIA		
Fluid Commercial Name:	Max Flight AVIA		
Fluid Type / Base / Colour:	Type IV / Ethylene Glycol / Green		
Batch #:	TV 548		
Date of Receipt:	December 22, 2015		
Brix (Measured):	Neat fluid:	31.75°	
	75/25 dilution:	24.75°	
	50/50 dilution:	17.25°	
Freeze Point (Stated):	Neat fluid:	-39.9°C	
	75/25 dilution:	-23.5°C	
	50/50 dilution:	-12.6°C	
Aerodynamic LOUT (AMIL):	Neat fluid:	-28.5°C	
	75/25 dilution:	-19.5°C	
	50/50 dilution:	-9.5°C	
Viscosity:	**Manufacturer Method**	**Stated**	**Measured**
	Neat fluid[1]:	876 cP	1,000 cP
	75/25 dilution[1]:	438 cP	N/A[2]
	50/50 dilution[1]:	108 cP	N/A[2]
	AS 9968 Method	**Stated**	**Measured**
	Neat fluid[1]:	876 cP	1,000 cP
	75/25 dilution[1]:	438 cP	N/A[2]
	50/50 dilution[1]:	108 cP	N/A[2]
WSET (from AMIL):	Neat fluid:	>120 minutes	

[1] Spindle LV0, UL adapter, 16 mL of fluid, 20°C, 0.3 rpm, for 10.0 minutes
[2] Viscosity measurements for the 75/25 and 50/50 dilutions were not confirmed. Obtained results were not repeatable.

SUMMARY

The primary objective of this project was to measure the endurance time performance of **Clariant Max Flight AVIA** over the entire range of conditions encompassed by the Holdover Time (HOT) tables. This report contains the results of these measurements and was completed with the support of the fluid manufacturer, the Transport Development Centre (TDC) of Transport Canada (TC) and the Federal Aviation Administration (FAA).

Tests were carried out according to the protocol provided in Aerospace Recommended Practice (ARP) 5485. The test procedure consisted of pouring fluids onto clean aluminum test surfaces inclined at 10°; the onset of failure was recorded as a function of time in natural and simulated precipitation.

Tests were performed at the APS Aviation Inc. (APS) test facility at Montréal-Pierre-Elliott-Trudeau International Airport and the National Research Council Canada (NRC) Climatic Engineering Facility (CEF) in Ottawa.

De/anti-icing fluid endurance times were derived from the data collected using multi-variable regression analysis. This resulted in the generation of the fluid-specific holdover times. At the request of the manufacturer, only the 100/0 holdover times will be published by regulators. These holdover times, shown below, will be published for use in the winter 2016-17 operating season.

Clariant Max Flight AVIA Type IV Fluid Holdover Times

Outside Air Temperature (°C)	Type IV Fluid Concentration Neat Fluid/ Water (Vol %/Vol %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets*			Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
			Very Light	Light	Moderate				
-3 and above	100/0	3:05-4:00	3:00-3:00	1:45-3:00	1:00-1:45	1:25-2:00	0:55-1:10	0:09-2:00	
	75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	50/50	N/A	N/A	N/A	N/A	N/A	N/A	CAUTION: No holdover time guidelines exist	
below -3 to -14	100/0	1:45-3:55	2:10-2:35	1:15-2:10	0:40-1:15	1:10-2:00	0:55-1:30		
	75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -28.5	100/0	0:35-1:25	0:20-0:25	0:10-0:20	0:08-0:10				

**FAA values shown, Transport Canada will publish only the lower values for very light snow and caps all snow HOTs at two hours*

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GLOSSARY

APS	APS Aviation Inc.
ARP	Aerospace Recommended Practice
CEF	Climatic Engineering Facility
FAA	Federal Aviation Administration
HOT	Holdover Time
LOUT	Lowest Operational Use Temperature
LOWV	Lowest On-Wing Viscosity
LUPR	Lowest Usable Precipitation Rate
NRC	National Research Council Canada
TC	Transport Canada
TDC	Transportation Development Centre

1. INTRODUCTION

This report has been created with the support of the fluid manufacturer, the Transport Development Centre (TDC) of Transport Canada (TC) and the Federal Aviation Administration (FAA).

Aircraft ground de/anti-icing has been the subject of concentrated industry attention in recent years due to the occurrence of several fatal icing-related aircraft accidents. Notably, attention has been placed on the enhancement of anti-icing fluids in order to provide an extended period of protection against further contamination following initial deicing. This emphasis has led to the development of fluid-specific de/anti-icing fluid holdover time (HOT) tables for Type II, Type III and Type IV fluids. These tables, accepted by regulatory authorities, are used by aircraft operators for departure planning in adverse winter conditions. Specifically, they provide the duration of time that qualified fluids provide protection against ice formation under specific weather conditions.

New anti-icing formulations continue to be developed by leading manufacturers with the specific objective of prolonging fluid holdover times without compromising the aerodynamic features of the airfoil. The purpose of the endurance time testing program is to measure the endurance times of these new fluids and develop fluid-specific HOT tables that provide guidance for their use.

Flat plate tests, conducted in natural and simulated precipitation, are used to develop HOT values for new fluids. These tests are carried out according to SAE Aerospace Recommended Practice (ARP) ARP5485, which provides the test protocols for measuring endurance times of Type II, III and IV fluids. Along with its counterpart for measuring endurance times of Type I fluids ARP5945, ARP5485 has evolved into a refined procedure for measuring the duration of de/anti-icing fluid protection against ice formation.

The current data analysis protocol for developing HOT values from endurance time data was developed in 1996-97 and uses multi-variable regression to obtain HOT values. HOT values are derived for the majority of cells in Type II/III/IV HOT tables using this protocol and are used to create a fluid-specific HOT table for each Type II/III/IV fluid tested.

This report provides a detailed account of the endurance time testing conducted by APS Aviation Inc. (APS) with **Clariant Max Flight AVIA**, a new Type IV fluid. It describes the test methodology used, endurance time data collected, and analysis completed to derive fluid-specific holdover times for the fluid.

2. METHODOLOGY

Tests were carried out according to SAE Aerospace Recommended Practice (ARP) 5485, which provides the procedure and requirements for endurance time testing with Type II, III, and IV fluids under natural and simulated conditions.

The test methodology for endurance time testing carried out in the winter of 2015-16 is documented in detail in the report "*Methodology for Endurance Time Testing of Type II, III and IV Fluids – Winter 2015-16.*" A copy of this report is provided as an annex to this document.

The methodology report summarizes the key aspects of the test methodology, including some aspects included in ARP5485 and some aspects which are not included in ARP54855. It includes sections on:

a) Test Sites;

b) Test Equipment;

c) Test Procedures;

d) Precipitation Rates used in Type I, II, III and IV Endurance Time Testing;

e) Ambient Temperatures used in Type I, II, III and IV Endurance Time Testing;

f) Freezing Precipitation Droplet Sizes; and

g) Analysis Methodologies.

The data, analysis and results provided in this report are a function of the test and analysis methodologies described in the methodology report. They should only be used in conjunction with the methodologies described therein.

3. DESCRIPTION OF DATA

This section provides a summary of the number of tests conducted. Breakdowns are provided for the number of tests performed by test type, precipitation type, fluid dilution and test temperature.

3.1 Natural and Artificial Snow Tests

Tests were conducted in natural snow conditions at the APS test site and at several mobile test sites (refer to the report annex for details). No artificial snow tests were conducted. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

Fluid Dilution	Natural Snow			Artificial Snow		
	≥ -3°C	-3 to -14°C	<-14°C	-3°C	-14°C	-25°C
Neat	9	23	5	0	0	0
75/25	10	27	0	0	0	0
50/50	13	5	0	0	0	0

3.2 Freezing Precipitation Tests

Tests were conducted in freezing drizzle, light freezing rain, freezing fog and rain on cold-soaked surface conditions at the NRC CEF. The number of tests conducted is summarized below by precipitation type, fluid dilution and test temperature.

Fluid Dilution	Freezing Drizzle		Light Freezing Rain		Freezing Fog			Cold Soak
	-3°C	-10°C	-3°C	-10°C	-3°C	-14°C	-25°C	+1°C
Neat	4	4	6	4	4	4	4	4
75/25	6	4	6	4	4	4	0	4
50/50	6	0	4	0	4	0	0	0

3.3 Natural Frost Tests

Tests were conducted in natural frost at the APS test site. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

Fluid Dilution	Natural Frost			
	≥-1°C	<-1 to -3°C	<-3 to -10°C	<-10°C
Neat	0	0	1	2
75/25	0	0	1	1
50/50	1	0	0	0

3.4 Fluid Thickness Tests

Fluid thickness tests were conducted to measure the film thickness profiles of the fluid under dry conditions. Two tests were performed for each dilution. For each test, 1 litre of fluid was poured onto a flat plate mounted on a test stand inclined by 10°. Thickness measurements were taken at the 15-cm (6") line at select time intervals over a 30-minute period. Tests were conducted at -3°C.

3.5 Test Logs

Details of each test conducted are provided in the test logs included as Table 3.1 (snow) Table 3.2 (freezing precipitation), and Table 3.3 (frost).

Table 3.1: Summary of Tests Performed (Snow)

Test No.	Date	Snow Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
1	27-Dec-15	Natural Snow	Max Flight AVIA	100%	0.4	15.4	44.1
2	27-Dec-15	Natural Snow	Max Flight AVIA	75%	0.5	13.8	29.0
9	27-Dec-15	Natural Snow	Max Flight AVIA	50%	0.5	13.9	13.8
14	27-Dec-15	Natural Snow	Max Flight AVIA	50%	0.4	17.8	10.6
19	27-Dec-15	Natural Snow	Max Flight AVIA	75%	-0.1	20.2	24.5
22	27-Dec-15	Natural Snow	Max Flight AVIA	100%	-0.3	26.8	63.6
32	27-Dec-15	Natural Snow	Max Flight AVIA	100%	-0.4	26.6	51.8
34	27-Dec-15	Natural Snow	Max Flight AVIA	75%	-0.4	35.9	16.5
38	27-Dec-15	Natural Snow	Max Flight AVIA	50%	-0.4	19.4	10.8
44	29-Dec-15	Natural Snow	Max Flight AVIA	100%	-11.4	16.3	47.4
45	29-Dec-15	Natural Snow	Max Flight AVIA	75%	-11.3	18.1	26.8
53	29-Dec-15	Natural Snow	Max Flight AVIA	100%	-11.7	36.8	32.6
54	29-Dec-15	Natural Snow	Max Flight AVIA	75%	-11.7	41.6	10.6
64	29-Dec-15	Natural Snow	Max Flight AVIA	100%	-11.9	21.1	37.1
65	29-Dec-15	Natural Snow	Max Flight AVIA	75%	-11.9	30.7	14.2
73	29-Dec-15	Natural Snow	Max Flight AVIA	100%	-10.3	25.8	53.9
74	29-Dec-15	Natural Snow	Max Flight AVIA	75%	-10.6	31.0	22.9
83	29-Dec-15	Natural Snow	Max Flight AVIA	100%	-8.8	30.6	43.8
84	29-Dec-15	Natural Snow	Max Flight AVIA	75%	-8.8	52.1	7.9
88	29-Dec-15	Natural Snow	Max Flight AVIA	100%	-7.8	21.8	68.0
94	29-Dec-15	Natural Snow	Max Flight AVIA	75%	-7.8	20.5	23.9
97	29-Dec-15	Natural Snow	Max Flight AVIA	100%	-8.1	21.4	68.2
103	29-Dec-15	Natural Snow	Max Flight AVIA	75%	-8.1	27.4	18.2
107	29-Dec-15	Natural Snow	Max Flight AVIA	100%	-8.5	24.4	36.7
113	29-Dec-15	Natural Snow	Max Flight AVIA	75%	-8.5	23.6	19.1
116	29-Dec-15	Natural Snow	Max Flight AVIA	75%	-8.4	3.8	66.2
126	30-Dec-15	Natural Snow	Max Flight AVIA	100%	-5.4	6.6	157.6
127	30-Dec-15	Natural Snow	Max Flight AVIA	75%	-5.4	9.7	43.6
134	30-Dec-15	Natural Snow	Max Flight AVIA	75%	-5.4	4.8	99.8
140	2-Jan-16	Natural Snow	Max Flight AVIA	100%	-1.0	5.1	205.9
141	2-Jan-16	Natural Snow	Max Flight AVIA	75%	-1.1	10.9	38.8
148	2-Jan-16	Natural Snow	Max Flight AVIA	50%	-0.6	8.7	15.4
156	3-Jan-16	Natural Snow	Max Flight AVIA	75%	-0.9	3.2	151.5
159	3-Jan-16	Natural Snow	Max Flight AVIA	50%	-1.1	2.8	67.4
164	3-Jan-16	Natural Snow	Max Flight AVIA	100%	-0.6	5.6	195.5
166	3-Jan-16	Natural Snow	Max Flight AVIA	100%	-0.3	4.6	185.1
167	3-Jan-16	Natural Snow	Max Flight AVIA	75%	-0.4	6.7	85.2

Table 3.1 (cont'd): Summary of Tests Performed (Snow)

Test No.	Date	Snow Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
175	3-Jan-16	Natural Snow	Max Flight AVIA	50%	-0.4	4.6	38.1
180	3-Jan-16	Natural Snow	Max Flight AVIA	50%	-0.3	2.3	92.5
188	12-Jan-16	Natural Snow	Max Flight AVIA	100%	-4.7	2.0	334.2
189	12-Jan-16	Natural Snow	Max Flight AVIA	75%	-4.9	2.0	228.9
205	12-Jan-16	Natural Snow	Max Flight AVIA	75%	-4.2	3.9	132.9
206	12-Jan-16	Natural Snow	Max Flight AVIA	100%	-4.2	7.5	143.7
213	12-Jan-16	Natural Snow	Max Flight AVIA	75%	-4.2	10.1	58.6
219	16-Jan-16	Natural Snow	Max Flight AVIA	100%	-4.2	2.3	261.3
220	16-Jan-16	Natural Snow	Max Flight AVIA	75%	-4.2	2.6	124.0
238	17-Jan-16	Natural Snow	Max Flight AVIA	100%	-8.7	3.9	230.2
239	17-Jan-16	Natural Snow	Max Flight AVIA	75%	-8.7	3.2	113.1
257	18-Jan-16	Natural Snow	Max Flight AVIA	75%	-8.7	4.5	109.0
258	18-Jan-16	Natural Snow	Max Flight AVIA	100%	-8.6	5.6	135.8
266	3-Feb-16	Natural Snow	Max Flight AVIA	100%	-4.7	5.6	186.3
267	3-Feb-16	Natural Snow	Max Flight AVIA	75%	-4.8	3.6	164.9
274	3-Feb-16	Natural Snow	Max Flight AVIA	50%	-4.3	20.2	9.2
284	3-Feb-16	Natural Snow	Max Flight AVIA	50%	-4.5	14.7	9.7
290	3-Feb-16	Natural Snow	Max Flight AVIA	100%	-4.6	38.5	46.6
291	3-Feb-16	Natural Snow	Max Flight AVIA	75%	-4.5	35.1	21.6
297	9-Feb-16	Natural Snow	Max Flight AVIA	75%	-7.5	1.0	274.5
307	12-Feb-16	Natural Snow	Max Flight AVIA	100%	-6.7	6.1	155.8
308	12-Feb-16	Natural Snow	Max Flight AVIA	75%	-7.0	6.3	69.3
321	12-Feb-16	Natural Snow	Max Flight AVIA	100%	-8.8	11.9	68.0
322	12-Feb-16	Natural Snow	Max Flight AVIA	75%	-8.3	10.9	45.4
333	16-Feb-16	Natural Snow	Max Flight AVIA	100%	-7.3	13.3	88.1
334	16-Feb-16	Natural Snow	Max Flight AVIA	75%	-7.1	13.7	49.3
353	19-Feb-16	Natural Snow	Max Flight AVIA	100%	0.1	15.4	89.4
354	19-Feb-16	Natural Snow	Max Flight AVIA	75%	0.3	10.0	74.5
364	19-Feb-16	Natural Snow	Max Flight AVIA	50%	0.4	4.9	60.8
368	19-Feb-16	Natural Snow	Max Flight AVIA	50%	-0.2	40.0	5.0
372	19-Feb-16	Natural Snow	Max Flight AVIA	75%	-0.9	31.5	21.9
375	19-Feb-16	Natural Snow	Max Flight AVIA	100%	-0.7	11.4	99.7
380	19-Feb-16	Natural Snow	Max Flight AVIA	50%	-0.8	17.3	15.9
390	19-Feb-16	Natural Snow	Max Flight AVIA	50%	-0.6	4.1	32.5
401	24-Feb-16	Natural Snow	Max Flight AVIA	100%	-3.5	4.7	233.2
402	24-Feb-16	Natural Snow	Max Flight AVIA	75%	-3.7	3.6	167.5
403	24-Feb-16	Natural Snow	Max Flight AVIA	50%	-3.8	1.9	124.6

Table 3.1 (cont'd): Summary of Tests Performed (Snow)

Test No.	Date	Snow Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
418	24-Feb-16	Natural Snow	Max Flight AVIA	75%	-2.4	10.5	78.4
419	24-Feb-16	Natural Snow	Max Flight AVIA	50%	-2.6	5.6	31.1
426	24-Feb-16	Natural Snow	Max Flight AVIA	100%	-1.5	19.2	75.1
427	24-Feb-16	Natural Snow	Max Flight AVIA	75%	-1.5	17.8	47.7
428	24-Feb-16	Natural Snow	Max Flight AVIA	50%	-1.8	16.8	14.9
464	24-Mar-16	Natural Snow	Max Flight AVIA	100%	-5.1	16.5	84.3
465	24-Mar-16	Natural Snow	Max Flight AVIA	75%	-5.2	12.3	39.0
476	24-Mar-16	Natural Snow	Max Flight AVIA	50%	-6.6	29.4	6.1
477	24-Mar-16	Natural Snow	Max Flight AVIA	75%	-6.6	12.1	77.8
478	24-Mar-16	Natural Snow	Max Flight AVIA	100%	-6.6	12.7	113.4
480	24-Mar-16	Natural Snow	Max Flight AVIA	100%	-6.3	41.9	34.4
486	24-Mar-16	Natural Snow	Max Flight AVIA	75%	-6.4	42.0	22.0
487	24-Mar-16	Natural Snow	Max Flight AVIA	50%	-6.4	40.5	5.8
C15	4-Feb-16	Natural Snow	Max Flight AVIA	100%	-22.3	1.4	77.5
C39	4-Feb-16	Natural Snow	Max Flight AVIA	100%	-21.8	4.5	39.0
C53	26-Feb-16	Natural Snow	Max Flight AVIA	100%	-24.0	1.3	280.5
C77	27-Feb-16	Natural Snow	Max Flight AVIA	100%	-23.0	5.9	99.9
C103	27-Feb-16	Natural Snow	Max Flight AVIA	100%	-22.8	4.7	118.0

Table 3.2: Summary of Tests Performed (Freezing Precipitation)

Test No.	Date	Precipitation Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
15	30-Mar-16	Freezing Fog	Max Flight AVIA	100%	-3.2	1.9	>240
16	30-Mar-16	Freezing Fog	Max Flight AVIA	100%	-3.2	1.8	>240
17	30-Mar-16	Freezing Fog	Max Flight AVIA	75%	-3.2	1.9	>240
18	30-Mar-16	Freezing Fog	Max Flight AVIA	75%	-3.2	2.1	245.0
19	30-Mar-16	Freezing Fog	Max Flight AVIA	50%	-3.1	1.9	71.4
20	30-Mar-16	Freezing Fog	Max Flight AVIA	50%	-3.1	1.8	78.6
43	4-Apr-16	Freezing Fog	Max Flight AVIA	100%	-3.3	5.4	172.1
44	4-Apr-16	Freezing Fog	Max Flight AVIA	100%	-3.3	4.8	192.5
45	4-Apr-16	Freezing Fog	Max Flight AVIA	75%	-3.2	5.2	118.3
46	4-Apr-16	Freezing Fog	Max Flight AVIA	75%	-3.2	5.2	120.7
47	4-Apr-16	Freezing Fog	Max Flight AVIA	50%	-3.4	5.0	34.8
48	4-Apr-16	Freezing Fog	Max Flight AVIA	50%	-3.4	4.6	34.8
69	31-Mar-16	Freezing Fog	Max Flight AVIA	100%	-14.1	1.8	>240
70	31-Mar-16	Freezing Fog	Max Flight AVIA	100%	-14.1	1.9	>240
71	31-Mar-16	Freezing Fog	Max Flight AVIA	75%	-14.1	1.9	117.0
72	31-Mar-16	Freezing Fog	Max Flight AVIA	75%	-14.1	1.8	112.1
87	31-Mar-16	Freezing Fog	Max Flight AVIA	100%	-14.1	5.3	96.6
88	31-Mar-16	Freezing Fog	Max Flight AVIA	100%	-14.1	5.1	105.9
89	31-Mar-16	Freezing Fog	Max Flight AVIA	75%	-14.2	5.1	67.3
90	31-Mar-16	Freezing Fog	Max Flight AVIA	75%	-14.2	5.2	67.8
103	1-Apr-16	Freezing Fog	Max Flight AVIA	100%	-25.2	1.9	88.2
104	1-Apr-16	Freezing Fog	Max Flight AVIA	100%	-25.2	1.9	87.1
115	1-Apr-16	Freezing Fog	Max Flight AVIA	100%	-25.2	5.1	36.3
116	1-Apr-16	Freezing Fog	Max Flight AVIA	100%	-25.2	4.9	37.5
139	4-Apr-16	Freezing Drizzle	Max Flight AVIA	100%	-3.0	5.2	>120
140	4-Apr-16	Freezing Drizzle	Max Flight AVIA	100%	-3.0	5.3	>120
141	4-Apr-16	Freezing Drizzle	Max Flight AVIA	75%	-2.9	4.7	50.4
142	4-Apr-16	Freezing Drizzle	Max Flight AVIA	75%	-2.9	5.1	65.0
143	4-Apr-16	Freezing Drizzle	Max Flight AVIA	50%	-3.2	4.8	27.2
144	4-Apr-16	Freezing Drizzle	Max Flight AVIA	50%	-3.2	5.3	31.7
167	7-Apr-16	Freezing Drizzle	Max Flight AVIA	100%	-3.1	12.6	96.1
168	7-Apr-16	Freezing Drizzle	Max Flight AVIA	100%	-3.1	13.5	75.1
169	7-Apr-16	Freezing Drizzle	Max Flight AVIA	75%	-3.2	13.2	32.7
170	7-Apr-16	Freezing Drizzle	Max Flight AVIA	75%	-3.2	13.0	35.8
171	7-Apr-16	Freezing Drizzle	Max Flight AVIA	50%	-3.1	12.6	16.5
172	7-Apr-16	Freezing Drizzle	Max Flight AVIA	50%	-3.1	13.5	10.2
191	5-Apr-16	Freezing Drizzle	Max Flight AVIA	100%	-10.2	5.0	122.0

Table 3.2 (cont'd): Summary of Tests Performed (Freezing Precipitation)

Test No.	Date	Precipitation Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
192	5-Apr-16	Freezing Drizzle	Max Flight AVIA	100%	-10.2	4.9	135.0
193	5-Apr-16	Freezing Drizzle	Max Flight AVIA	75%	-10.2	5.1	55.8
194	5-Apr-16	Freezing Drizzle	Max Flight AVIA	75%	-10.2	5.1	51.6
211	5-Apr-16	Freezing Drizzle	Max Flight AVIA	100%	-10.3	13.3	68.6
212	5-Apr-16	Freezing Drizzle	Max Flight AVIA	100%	-10.3	13.4	66.6
213	5-Apr-16	Freezing Drizzle	Max Flight AVIA	75%	-10.3	12.9	33.3
214	5-Apr-16	Freezing Drizzle	Max Flight AVIA	75%	-10.3	13.2	34.7
235	6-Apr-16	Light Freezing Rain	Max Flight AVIA	100%	-3.2	13.2	53.4
236	6-Apr-16	Light Freezing Rain	Max Flight AVIA	100%	-3.2	13.0	78.0
237	6-Apr-16	Light Freezing Rain	Max Flight AVIA	75%	-3.2	13.0	43.2
238	6-Apr-16	Light Freezing Rain	Max Flight AVIA	75%	-3.2	13.4	31.3
239	6-Apr-16	Light Freezing Rain	Max Flight AVIA	50%	-3.2	13.0	13.8
240	6-Apr-16	Light Freezing Rain	Max Flight AVIA	50%	-3.2	13.3	11.7
263	6-Apr-16	Light Freezing Rain	Max Flight AVIA	100%	-3.3	25.5	59.7
264	6-Apr-16	Light Freezing Rain	Max Flight AVIA	100%	-3.3	25.0	52.9
265	6-Apr-16	Light Freezing Rain	Max Flight AVIA	75%	-3.4	25.4	22.8
266	6-Apr-16	Light Freezing Rain	Max Flight AVIA	75%	-3.4	25.4	19.3
267	6-Apr-16	Light Freezing Rain	Max Flight AVIA	50%	-3.1	24.5	8.0
268	6-Apr-16	Light Freezing Rain	Max Flight AVIA	50%	-3.2	25.1	6.9
287	5-Apr-16	Light Freezing Rain	Max Flight AVIA	100%	-10.0	12.5	98.3
288	5-Apr-16	Light Freezing Rain	Max Flight AVIA	100%	-10.0	12.5	91.4
289	5-Apr-16	Light Freezing Rain	Max Flight AVIA	75%	-10.0	12.9	23.3
290	5-Apr-16	Light Freezing Rain	Max Flight AVIA	75%	-10.0	12.9	27.1
307	6-Apr-16	Light Freezing Rain	Max Flight AVIA	100%	-10.0	25.3	57.7
308	6-Apr-16	Light Freezing Rain	Max Flight AVIA	100%	-10.0	24.4	56.5
309	6-Apr-16	Light Freezing Rain	Max Flight AVIA	75%	-9.8	24.8	19.8
310	6-Apr-16	Light Freezing Rain	Max Flight AVIA	75%	-9.8	25.1	16.8
327	7-Apr-16	Cold Soak Box	Max Flight AVIA	100%	1.1	4.8	>120
328	7-Apr-16	Cold Soak Box	Max Flight AVIA	100%	1.1	5.3	>120
329	7-Apr-16	Cold Soak Box	Max Flight AVIA	75%	1.1	4.9	45.0
330	7-Apr-16	Cold Soak Box	Max Flight AVIA	75%	1.2	5.3	38.8
347	7-Apr-16	Cold Soak Box	Max Flight AVIA	100%	1.0	76.7	9.6
348	7-Apr-16	Cold Soak Box	Max Flight AVIA	100%	1.0	76.2	9.0
349	7-Apr-16	Cold Soak Box	Max Flight AVIA	75%	1.0	77.4	6.9
350	7-Apr-16	Cold Soak Box	Max Flight AVIA	75%	1.0	75.8	6.6
141R	4-Apr-16	Freezing Drizzle	Max Flight AVIA	75%	-3.2	4.7	82.4
142R	4-Apr-16	Freezing Drizzle	Max Flight AVIA	75%	-3.2	5.1	76.5

Table 3.2 (cont'd): Summary of Tests Performed (Freezing Precipitation)

Test No.	Date	Precipitation Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
171R	7-Apr-16	Freezing Drizzle	Max Flight AVIA	50%	-3.1	13.2	12.6
172R	7-Apr-16	Freezing Drizzle	Max Flight AVIA	50%	-3.1	13.2	12.2
235R	6-Apr-16	Light Freezing Rain	Max Flight AVIA	100%	-3.2	13.2	69.5
236R	6-Apr-16	Light Freezing Rain	Max Flight AVIA	100%	-3.2	13.4	84.5
237R	6-Apr-16	Light Freezing Rain	Max Flight AVIA	75%	-3.1	13.0	26.9
238R	6-Apr-16	Light Freezing Rain	Max Flight AVIA	75%	-3.1	13.2	27.7

Table 3.3: Summary of Tests Performed (Natural Frost)

Test No.	Date	Precip. Type	Fluid Name	Fluid Dilution	Test Duration (min.)	Average Rate (g/dm²/h)	Temp (°C)	Wind Speed (km/h)	Average RH (%)	Comments
1	Jan-04-16	Natural Frost	Max Flight AVIA	100%	582	0.08	-19.1	7	80	Did Not Fail
15	Jan-07-16	Natural Frost	Max Flight AVIA	100%	631	0.18	-5.2	9	89	Did Not Fail
24	Jan-07-16	Natural Frost	Max Flight AVIA	75%	586	0.18	-5.4	9	90	Did Not Fail
33	Feb-18-16	Natural Frost	Max Flight AVIA	75%	417	0.15	-12.4	6	84	Failed
40	Feb-18-16	Natural Frost	Max Flight AVIA	100%	423	0.15	-12.5	6	85	Did Not Fail
47	Apr-17-16	Natural Frost	Max Flight AVIA	50%	390	0.02	4.8	5	66	Did Not Fail

4. RESULTS AND DISCUSSION

The methods used to evaluate the test data are provided in the report "*Methodology for Endurance Time Testing of Type II, III and IV Fluids – Winter 2015-16,*" which is provided as an annex to this report. The results of the data analyses and a discussion of the findings are presented in this section.

4.1 Results

The results of the endurance time and thickness tests are described in this section.

4.1.1 Endurance Time Tests – Natural Snow and Freezing Precipitation

Figures 4.1 to 4.14 present the endurance time data collected in natural snow and freezing precipitation (freezing drizzle, light freezing rain, freezing fog and rain on cold-soaked surface).

These figures show the effect of temperature, precipitation type and precipitation rate on fluid endurance time in the conditions encompassed by the Type IV HOT guidelines. The figures include the current Type IV generic holdover times for comparative purposes.

Multi-variable regression analysis was performed on these data sets as described in the annex. Table 4.1 provides the outputs from the multi-variable regression analyses. These outputs were used to derive fluid-specific holdover times for all conditions encompassed by Type IV fluid-specific HOT tables. One exception is the coldest temperature band snow cells (see Subsection 4.2.2).

4.1.2 Endurance Time Tests – Natural Frost

The natural frost data was presented in Table 3.3. The test durations were compared to the Type IV generic holdover times. Tests that were not completed (due to active frost ending before fluid failure could occur) surpassed the generic holdover times. This analysis indicates the Type IV generic frost holdover times can be considered substantiated for Clariant Max Flight AVIA.

4.1.3 Fluid Thickness Tests

Figure 4.15 shows the fluid thickness test data. As described in Subsection 3.4, two tests were conducted at an ambient temperature of -3°C. The final fluid thicknesses are displayed in Figure 4.16.

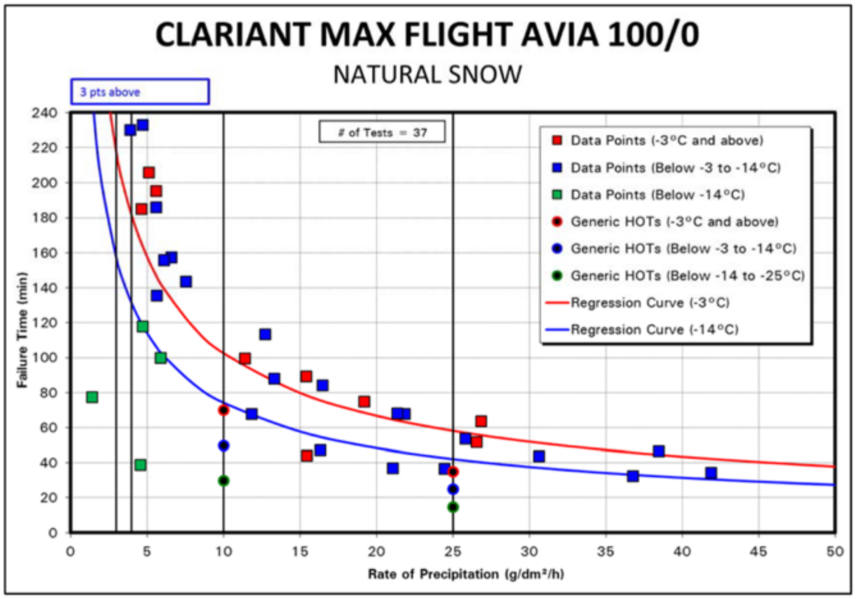

Figure 4.1: Type IV Neat – Natural Snow

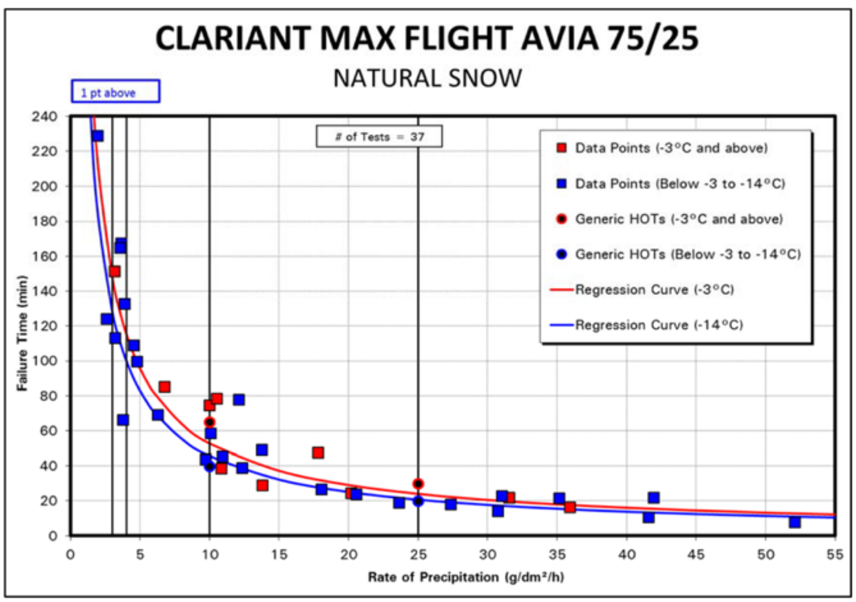

Figure 4.2: Type IV 75/25 – Natural Snow

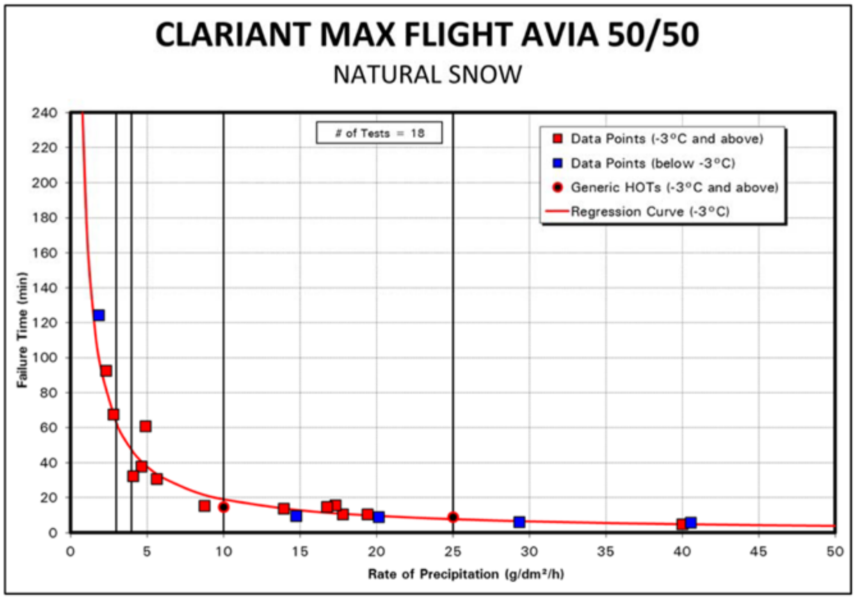

Figure 4.3: Type IV 50/50 – Natural Snow

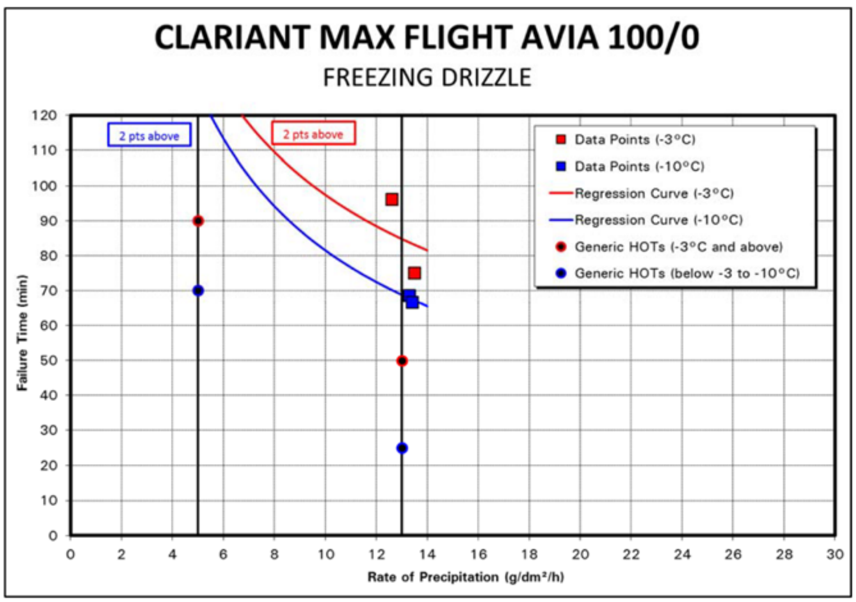

Figure 4.4: Type IV Neat – Freezing Drizzle

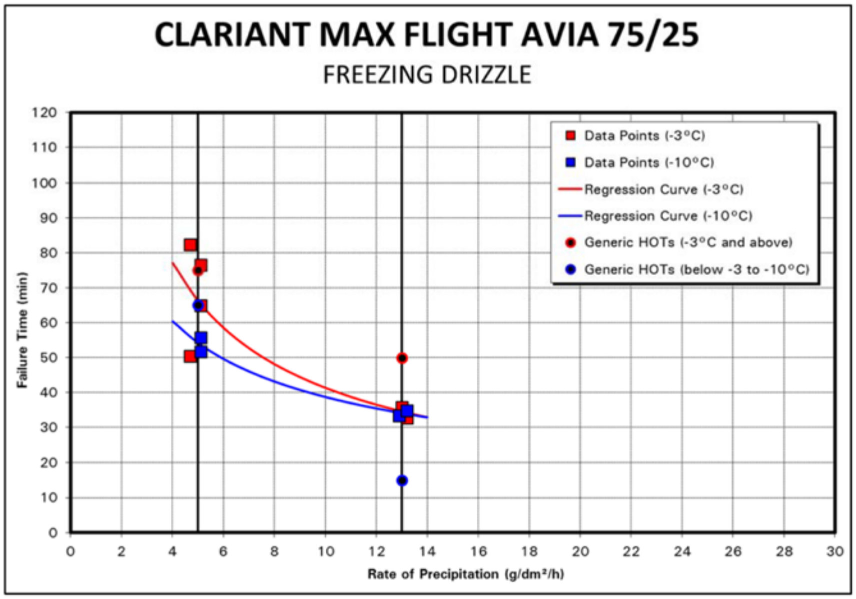

Figure 4.5: Type IV 75/25 – Freezing Drizzle

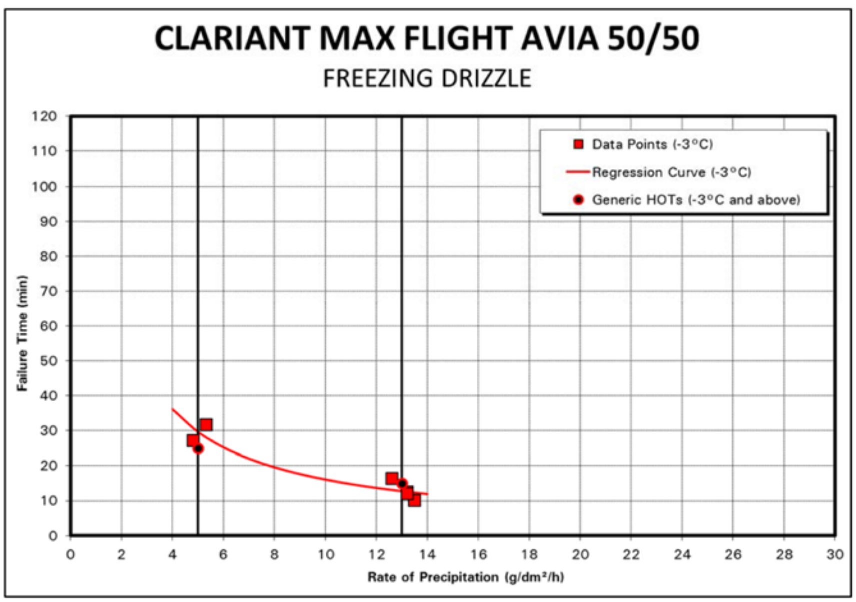

Figure 4.6: Type IV 50/50 – Freezing Drizzle

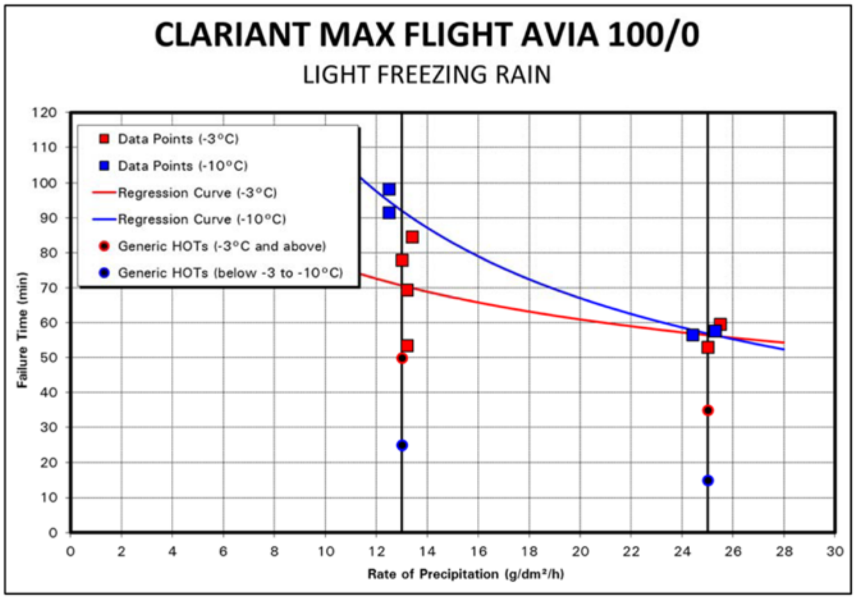

Figure 4.7: Type IV Neat – Light Freezing Rain

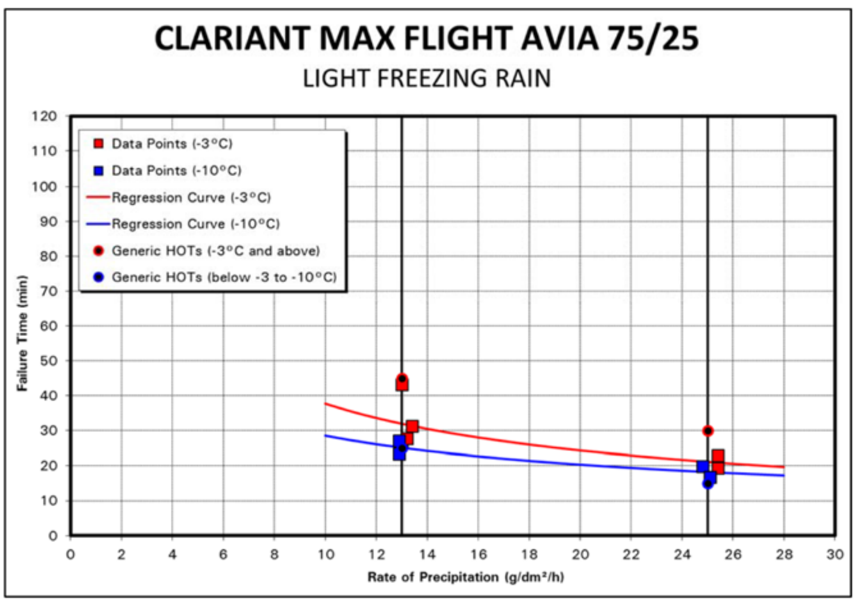

Figure 4.8: Type IV 75/25 – Light Freezing Rain

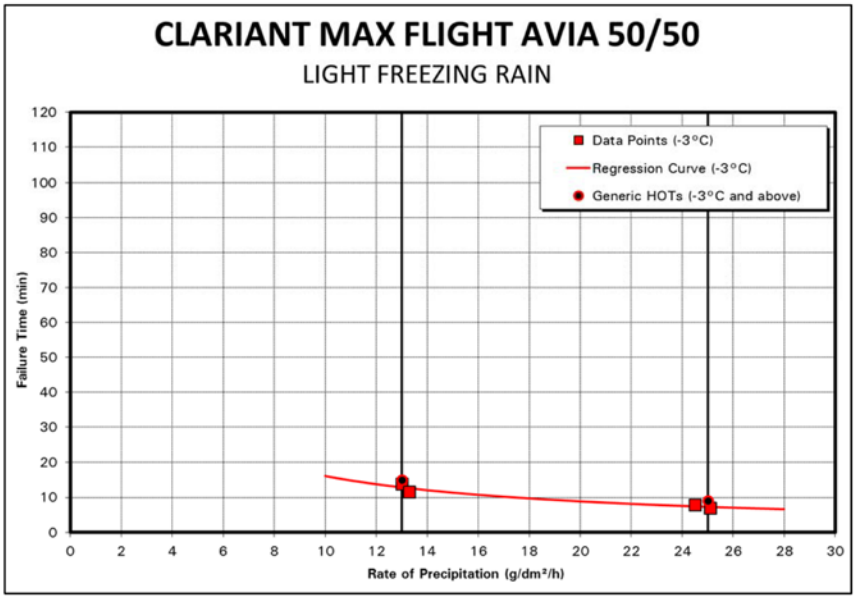

Figure 4.9: Type IV 50/50 – Light Freezing Rain

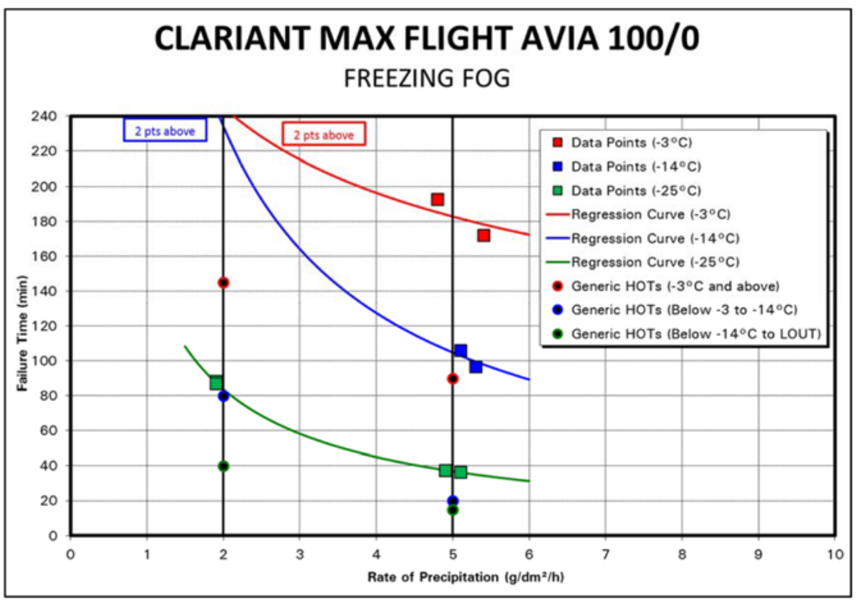

Figure 4.10: Type IV Neat – Freezing Fog

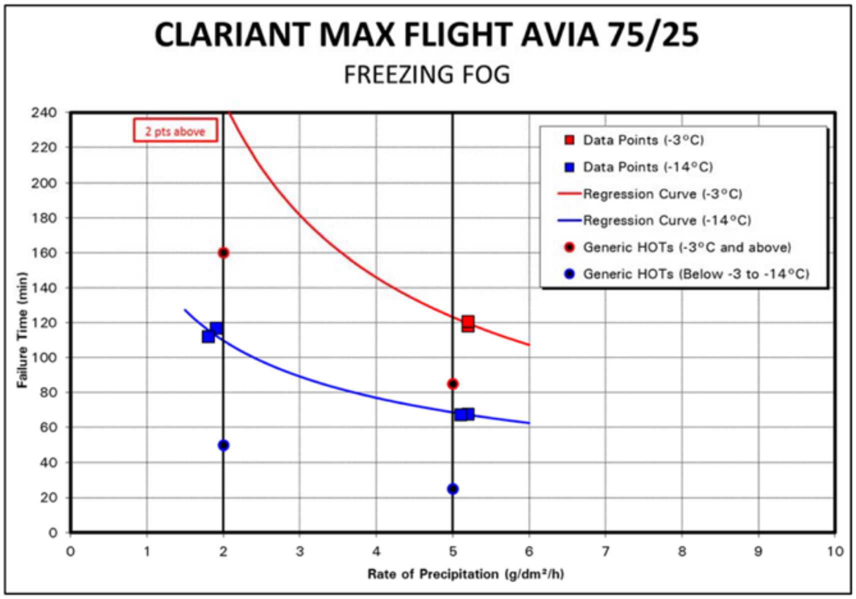

Figure 4.11: Type IV 75/25 – Freezing Fog

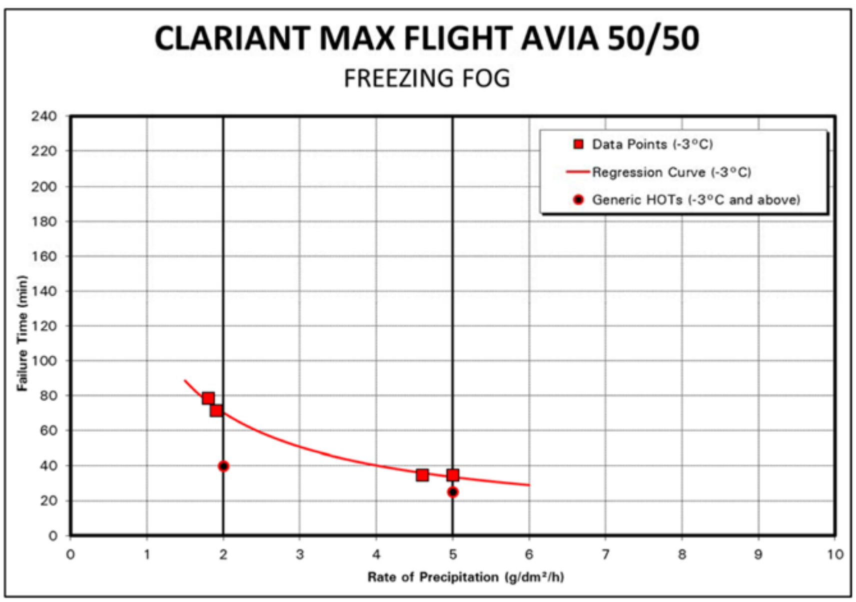

Figure 4.12: Type IV 50/50 – Freezing Fog

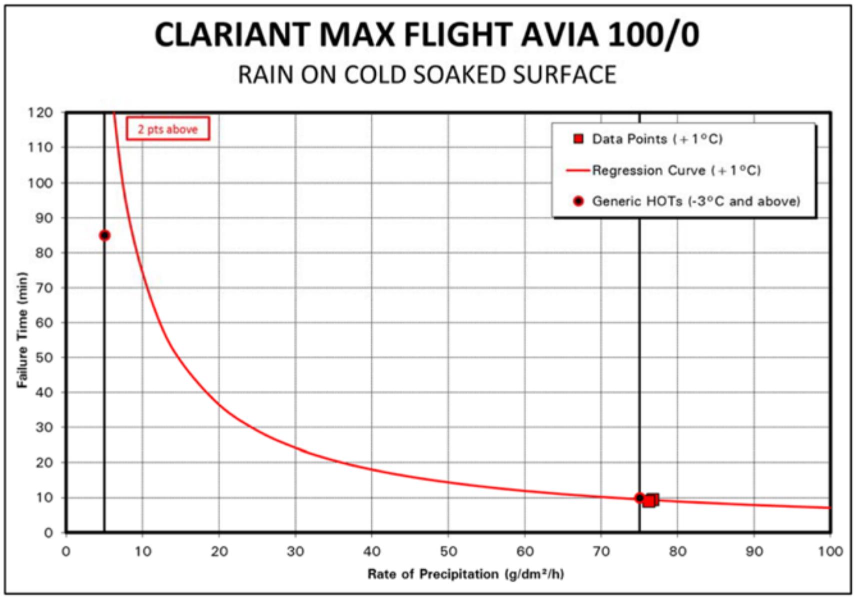

Figure 4.13: Type IV Neat – Rain on Cold-Soaked Surface

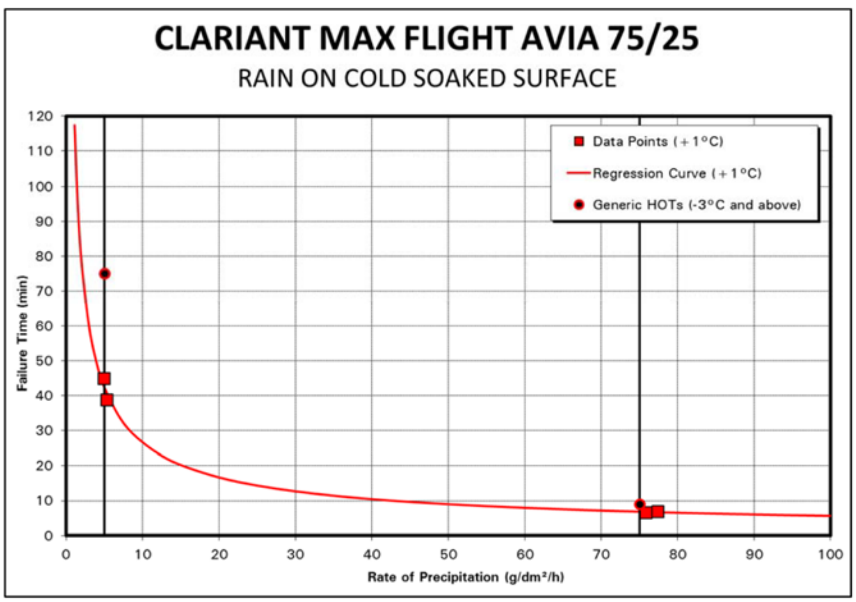

Figure 4.14: Type IV 75/25 – Rain on Cold-Soaked Surface

Table 4.1: Regression Equation Coefficients for Clariant Max Flight AVIA

Natural Snow

Fluid	Dil	R^2	Intercept (I)	Coeff. Rate (A)	Coeff. Tem (B)	Total Pts.
Clariant Max Flight AVIA	Neat	72%	2.8243	-0.6182	-0.2788	37
Clariant Max Flight AVIA	75%	91%	2.6650	-0.8573	-0.1222	37
Clariant Max Flight AVIA	50%	95%	2.2952	-0.9787	-0.0488	18

General Equation $t = 10^I R^A (2\text{-}T)^B$

Simulated Freezing Fog

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Clariant Max Flight AVIA	Neat	-3°C	97%	2.4864	-0.3214	4
Clariant Max Flight AVIA	75/25	-3°C	100%	2.6210	-0.7584	4
Clariant Max Flight AVIA	50/50	-3°C	99%	2.0887	-0.8031	4
Clariant Max Flight AVIA	Neat	-14°C	100%	2.6347	-0.8798	4
Clariant Max Flight AVIA	75/25	-14°C	99%	2.1955	-0.5133	4
Clariant Max Flight AVIA	Neat	-25°C	100%	2.1916	-0.8933	4

General Equation $t = 10^I R^A$

Simulated Freezing Drizzle

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Clariant Max Flight AVIA	Neat	-3°C	91%	2.5168	-0.5284	4
Clariant Max Flight AVIA	75/25	-3°C	79%	2.2969	-0.6805	6
Clariant Max Flight AVIA	50/50	-3°C	89%	2.0910	-0.8849	6
Clariant Max Flight AVIA	Neat	-10°C	99%	2.5583	-0.6474	4
Clariant Max Flight AVIA	75/25	-10°C	98%	2.0721	-0.4842	4

General Equation $t = 10^I R^A$

Simulated Light Freezing Rain

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Clariant Max Flight AVIA	Neat	-3°C	34%	2.2295	-0.3416	6
Clariant Max Flight AVIA	75/25	-3°C	60%	2.2052	-0.6295	6
Clariant Max Flight AVIA	50/50	-3°C	94%	2.0561	-0.8505	4
Clariant Max Flight AVIA	Neat	-10°C	99%	2.7838	-0.7360	4
Clariant Max Flight AVIA	75/25	-10°C	81%	1.9424	-0.4877	4

General Equation $t = 10^I R^A$

Simulated Rain on Cold Soaked Wing

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Clariant Max Flight AVIA	Neat	+1°C	100%	2.8870	-1.0183	4
Clariant Max Flight AVIA	75%	+1°C	100%	2.0976	-0.6736	4

General Equation $t = 10^I R^A$

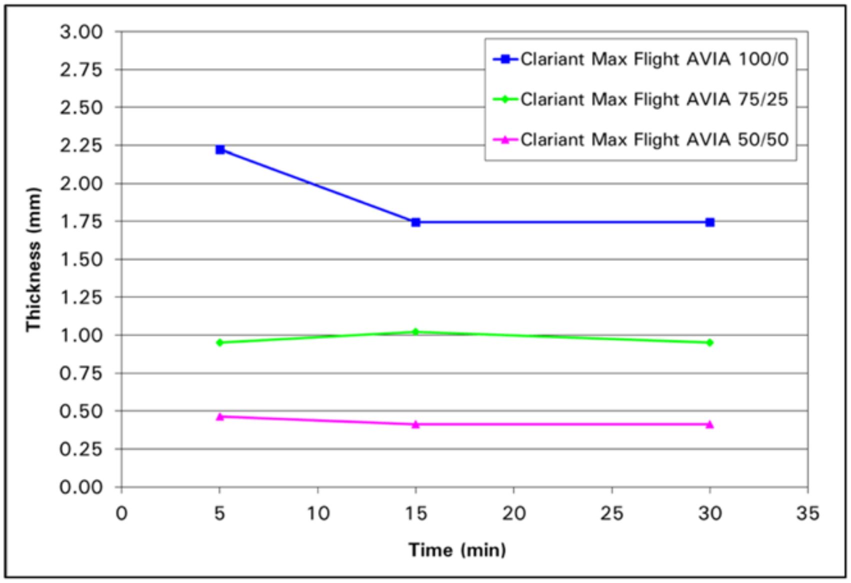

Figure 4.15: Fluid Thickness Profiles of Clariant Max Flight AVIA

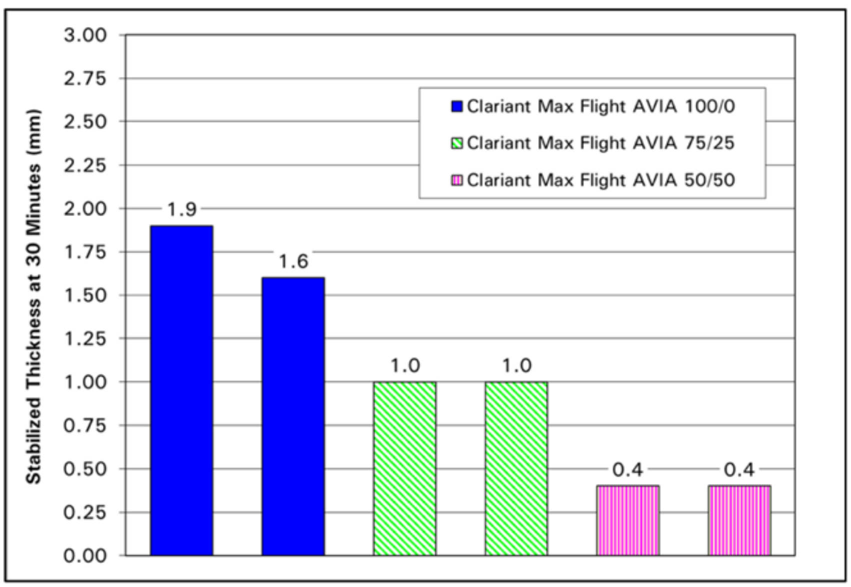

Figure 4.16: Final Fluid Thickness of Clariant Max Flight AVIA

4.2 Discussion

4.2.1 Holdover Time Table

The holdover times described in Subsection 4.1 were used to populate a fluid-specific HOT table for Clariant Max Flight AVIA. At the request of the manufacturer, the HOT table includes values for 100/0 fluid only. The HOT table is shown in both the TC format (Table 4.2) and FAA format (Table 4.3) at the end of this chapter.

4.2.2 Holdover Times in Snow, Below -14°C to LOUT

Very little endurance time data has been collected in natural snow at temperatures below -14°C. In the winter of 2003-04, testing was conducted with artificial snowmakers to collect additional data below -14°C. As a result of this testing, it was decided all Type II/IV fluids would be given generic values in the "Below -14 to LOUT" snow cells. Further testing in the winters of 2014-15 and 2015-16 in both natural and artificial snow determined the current Type II/IV generic HOTs for the "Below -14 to LOUT" snow cells. Accordingly, Clariant Max Flight AVIA has been given generic values in the "Below -14°C to LOUT" snow cells.

4.2.3 Holdover Times in Frost

It should be noted that frost holdover times are not included in the fluid-specific HOT tables. This is due to a decision made by TC and the FAA in May 2009 to move frost holdover times from the generic and fluid-specific HOT tables to a separate frost HOT table. Accordingly, frost holdover times have not been included in the Clariant Max Flight AVIA fluid-specific HOT table.

4.2.4 Fluid Viscosity

The viscosities of the fluid samples used in this testing were measured using both the AS9968 method and the manufacturer's designated method. The APS measured viscosities appear at the beginning of this document and will be published as the lowest on-wing viscosity (LOWV) values for the fluid. In order for the fluid-specific holdover times provided in this document to be valid, operators must ensure that the viscosity of the fluid being used is equal or greater than the published LOWV.

It should be noted that stable, consistent results could not be obtained for the diluted fluids (75/25 and 50/50) using the manufacturer's recommended method, which was also the AS 9968 method. APS recommended using an alternate measurement method; however, this was not done as the manufacturer elected not to have the diluted fluids included in the TC and FAA Holdover Time Guidelines.

4.2.5 Lowest Operational Use Temperatures (LOUTs)

The LOUT for Type II/III/IV fluids is determined by the higher of:

a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type;

b) The actual freezing point of the fluid plus its freezing point buffer of 7°C (13°F); and

c) For fluid dilutions, the LOUT may also be limited by the coldest temperature for which holdover times are published (-3°C for 50/50; -14°C for 75/25).

The aerodynamic acceptance and freezing point information for this fluid is provided at the beginning of this document. The LOUTs for Clariant Max Flight AVIA are:

- 100/0: -28.5°C (-19.3°F)
- 75/25: -14°C (7°F)
- 50/50: -3°C (27°F)

4.2.6 Lowest Usable Precipitation Rates in Snow

The LUPRs for Clariant Max Flight AVIA were determined by analysing the natural snow data sets using the analysis methodology described in the report "*Methodology for Endurance Time Testing of Type II, III and IV Fluids – Winter 2015-16*," which is provided as an annex to this report. The resulting statistics are shown in Table 4.4. The analysis determined the LUPRs for Clariant Max Flight AVIA are:

- 100/0 = 2 g/dm²/h;
- 75/25 = 2 g/dm²/h; and
- 50/50 = 2 g/dm²/h.

4.2.7 Publication of Holdover Times

As Clariant intends to commercialize Max Flight AVIA, TC and FAA will publish its fluid-specific HOT table in their 2016-17 Holdover Time Guidelines. The guidelines will also include the LOWV and LOUT information; the regression and LUPR data will be published in the related TC and FAA Regression Information documents.

Table 4.2: Fluid Specific Holdover Time Guidelines – Clariant Max Flight AVIA (TC Format)

TABLE 4-C-MF-AVIA

TYPE IV FLUID HOLDOVER TIME GUIDELINES
CLARIANT MAX FLIGHT AVIA

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	3:05 – 4:00	2:00	1:45 – 2:00	1:00 – 1:45	1:25 – 2:00	0:55 – 1:10	0:09 – 2:00	
		75/25								
		50/50								
below -3 to -14	below 27 to 7	100/0	1:45 – 3:55	2:00	1:15 – 2:00	0:40 – 1:15	1:10 – 2:00[7]	0:55 – 1:30[7]	CAUTION: No holdover time guidelines exist	
		75/25								
below -14 to -28.5	below 7 to -19.3	100/0	0:35 – 1:25	0:20	0:10 – 0:20	0:08 – 0:10				

NOTES
1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Table 4.3: Fluid Specific Holdover Time Guidelines – Clariant Max Flight AVIA (FAA Format)

TABLE 4C. TYPE IV HOLDOVER TIME GUIDELINES FOR
CLARIANT MAX FLIGHT AVIA

Outside Air Temperature[1] Degrees Celsius	Outside Air Temperature[1] Degrees Fahrenheit	Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Snow, Snow Grains or Snow Pellets[2] Light[3]	Snow, Snow Grains or Snow Pellets[2] Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	3:05-4:00	3:00-3:00	1:45-3:00	1:00-1:45	1:25-2:00	0:55-1:10	0:09-2:00	CAUTION: No holdover time guidelines exist
		75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		50/50	N/A	N/A	N/A	N/A	N/A	N/A	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	1:45-3:55	2:10-2:35	1:15-2:10	0:40-1:15	1:10-2:00[7]	0:55-1:30[7]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -28.5	below 7 to -19.3	100/0	0:35-1:25	0:20-0:25	0:10-0:20	0:08-0:10	CAUTION: No holdover time guidelines exist			

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

Table 4.4: LUPR Statistics – Clariant Max Flight AVIA

Data Measure	100/0		75/25		50/50	
	Stat	Rating	Stat	Rating	Stat	Rating
Total Data Points	37	40	37	40	18	30
Data Points -3 to -14°C	28	40	27	40	n/a	0
Data Points <10.0	17	40	14	40	8	30
Data Points <=9.5	17	40	13	40	8	40
Data Points <=8.5	17	40	13	40	7	40
Data Points <=7.5	17	40	13	40	7	40
Data Points <=6.5	15	40	12	40	7	40
Data Points <=5.5	10	40	11	40	6	40
Data Points <=4.5	6	40	10	40	4	40
Data Points <=3.5	4	40	5	40	3	40
Data Points <=2.5	4	40	2	30	2	30
Scatter 0-10 g	29%	20	17%	30	21%	20

Rate	100/0		75/25		50/50	
	Score	Pass/Fail	Score	Pass/Fail	Score	Pass/Fail
9 g/dm²/h	37	pass	39	pass	27	pass
8 g/dm²/h	37	pass	39	pass	27	pass
7 g/dm²/h	37	pass	39	pass	27	pass
6 g/dm²/h	37	pass	39	pass	27	pass
5 g/dm²/h	37	pass	39	pass	27	pass
4 g/dm²/h	37	pass	39	pass	27	pass
3 g/dm²/h	37	pass	39	pass	27	pass
2 g/dm²/h	37	pass	35	pass	23	pass

LUPR	100/0	75/25	50/50
	2 g/dm²/h	2 g/dm²/h	2 g/dm²/h

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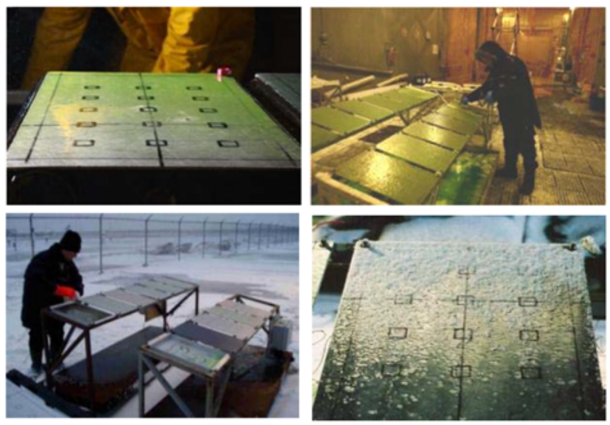
APPENDIX G

FLUID MANUFACTURER REPORT: CLARIANT SAFEWING EG IV NORTH (TYPE IV)

AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

Clariant Safewing EG IV NORTH (Type IV)



Prepared for

Clariant Produkte Deutschland GmbH

by

APS Aviation Inc.

These tests were made possible with the guidance, participation and contribution of the Transportation Development Centre of Transport Canada and the Federal Aviation Administration.

August 2016
Version 1.0
Report No. C-S4N 2015-16

AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

Clariant Safewing EG IV NORTH (Type IV)

Prepared for

Clariant Produkte Deutschland GmbH

Prepared by:

Benjamin Bernier
Project Analyst

August 29, 2016
Date

Reviewed by:

Stephanie Bendickson
Senior Project Leader

August 29, 2016
Date

These tests were made possible with the guidance, participation and contribution of the Transportation Development Centre of Transport Canada and the Federal Aviation Administration.

August 2016
Version 1.0
Report No. C-S4N 2015-16

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FLUID IDENTIFICATION AND CHARACTERISTICS

Manufacturer:	Clariant Produkte Deutschland GmbH		
Fluid Test Name:	Safewing EG IV NORTH		
Fluid Commercial Name:	Safewing EG IV NORTH		
Fluid Type / Base / Colour:	Type IV / Ethylene Glycol / Green		
Batch #:	TV 549		
Date of Receipt:	December 22, 2015		
Brix (Measured):	Neat fluid:	31.5°	
	75/25 dilution:	24.5°	
	50/50 dilution:	17.0°	
Freeze Point (Stated):	Neat fluid:	-39.5°C	
	75/25 dilution:	-23.6°C	
	50/50 dilution:	-11.8°C	
Aerodynamic LOUT (AMIL):	Neat fluid:	-30°C	
	75/25 dilution:	-20°C	
	50/50 dilution:	-9.5°C	
Viscosity:	**Manufacturer Method**	**Stated**	**Measured**
	Neat fluid[1]:	810 cP	830 cP
	75/25 dilution[1]:	496 cP	N/A[2]
	50/50 dilution[1]:	70 cP	N/A[2]
	AS 9968 Method	**Stated**	**Measured**
	Neat fluid[1]:	810 cP	830 cP
	75/25 dilution[1]:	496 cP	N/A[2]
	50/50 dilution[1]:	70 cP	N/A[2]
WSET (from AMIL):	Neat fluid:	117 minutes	

[1] Spindle LV0, UL adapter, 16 mL of fluid, 20°C, 0.3 rpm, for 10.0 minutes
[2] Viscosity measurements for the 75/25 and 50/50 dilutions were not confirmed. Obtained results were not repeatable.

SUMMARY

The primary objective of this project was to measure the endurance time performance of **Clariant Safewing EG IV NORTH** over the entire range of conditions encompassed by the Holdover Time (HOT) tables. This report contains the results of these measurements and was completed with the support of the fluid manufacturer, the Transport Development Centre (TDC) of Transport Canada (TC) and the Federal Aviation Administration (FAA).

Tests were carried out according to the protocol provided in Aerospace Recommended Practice (ARP) 5485. The test procedure consisted of pouring fluids onto clean aluminum test surfaces inclined at 10°; the onset of failure was recorded as a function of time in natural and simulated precipitation.

Tests were performed at the APS Aviation Inc. (APS) test facility at Montréal-Pierre-Elliott-Trudeau International Airport and the National Research Council Canada (NRC) Climatic Engineering Facility (CEF) in Ottawa.

De/anti-icing fluid endurance times were derived from the data collected using multi-variable regression analysis. This resulted in the generation of the fluid-specific holdover times. At the request of the manufacturer, only the 100/0 holdover times will be published by regulators. These holdover times, shown below, will be published by regulators for use in the winter 2016-17 operating season.

Clariant Safewing EG IV NORTH Type IV Fluid Holdover Times

Outside Air Temperature (°C)	Type IV Fluid Concentration Neat Fluid/ Water (Vol %/Vol %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets*			Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
			Very Light	Light	Moderate				
-3 and above	100/0	2:20-3:55	3:00-3:00	1:40-3:00	0:50-1:40	1:30-2:00	0:50-0:55	0:08-2:00	
	75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	50/50	N/A	N/A	N/A	N/A	N/A	N/A	CAUTION: No holdover time guidelines exist	
below -3 to -14	100/0	1:45-4:00	2:45-3:00	1:30-2:45	0:50-1:30	1:05-1:50	0:55-1:25		
	75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -30	100/0	0:40-1:20	0:20-0:25	0:10-0:20	0:08-0:10				

**FAA values shown, Transport Canada will publish only the lower values for very light snow and caps all snow HOTs at two hours*

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GLOSSARY

APS	APS Aviation Inc.
ARP	Aerospace Recommended Practice
CEF	Climatic Engineering Facility
FAA	Federal Aviation Administration
HOT	Holdover Time
LOUT	Lowest Operational Use Temperature
LOWV	Lowest On-Wing Viscosity
LUPR	Lowest Usable Precipitation Rate
NRC	National Research Council Canada
TC	Transport Canada
TDC	Transportation Development Centre

1. INTRODUCTION

This report has been created with the support of the fluid manufacturer, the Transport Development Centre (TDC) of Transport Canada (TC) and the Federal Aviation Administration (FAA).

Aircraft ground de/anti-icing has been the subject of concentrated industry attention in recent years due to the occurrence of several fatal icing-related aircraft accidents. Notably, attention has been placed on the enhancement of anti-icing fluids in order to provide an extended period of protection against further contamination following initial deicing. This emphasis has led to the development of fluid-specific de/anti-icing fluid holdover time (HOT) tables for Type II, Type III and Type IV fluids. These tables, accepted by regulatory authorities, are used by aircraft operators for departure planning in adverse winter conditions. Specifically, they provide the duration of time that qualified fluids provide protection against ice formation under specific weather conditions.

New anti-icing formulations continue to be developed by leading manufacturers with the specific objective of prolonging fluid holdover times without compromising the aerodynamic features of the airfoil. The purpose of the endurance time testing program is to measure the endurance times of these new fluids and develop fluid-specific HOT tables that provide guidance for their use.

Flat plate tests, conducted in natural and simulated precipitation, are used to develop HOT values for new fluids. These tests are carried out according to SAE Aerospace Recommended Practice (ARP) ARP5485, which provides the test protocols for measuring endurance times of Type II, III and IV fluids. Along with its counterpart for measuring endurance times of Type I fluids ARP5945, ARP5485 has evolved into a refined procedure for measuring the duration of de/anti-icing fluid protection against ice formation.

The current data analysis protocol for developing HOT values from endurance time data was developed in 1996-97 and uses multi-variable regression to obtain HOT values. HOT values are derived for the majority of cells in Type II/III/IV HOT tables using this protocol and are used to create a fluid-specific HOT table for each Type II/III/IV fluid tested.

This report provides a detailed account of the endurance time testing conducted by APS Aviation Inc. (APS) with **Clariant Safewing EG IV NORTH**, a new Type IV fluid. It describes the test methodology used, endurance time data collected, and analysis completed to derive fluid-specific holdover times for the fluid.

2. METHODOLOGY

Tests were carried out according to SAE Aerospace Recommended Practice (ARP) 5485, which provides the procedure and requirements for endurance time testing with Type II, III, and IV fluids under natural and simulated conditions.

The test methodology for endurance time testing carried out in the winter of 2015-16 is documented in detail in the report "*Methodology for Endurance Time Testing of Type II, III and IV Fluids – Winter 2015-16.*" A copy of this report is provided as an annex to this document.

The methodology report summarizes the key aspects of the test methodology, including some aspects included in ARP5485 and some aspects which are not included in ARP54855. It includes sections on:

a) Test Sites;

b) Test Equipment;

c) Test Procedures;

d) Precipitation Rates used in Type I, II, III and IV Endurance Time Testing;

e) Ambient Temperatures used in Type I, II, III and IV Endurance Time Testing;

f) Freezing Precipitation Droplet Sizes; and

g) Analysis Methodologies.

The data, analysis and results provided in this report are a function of the test and analysis methodologies described in the methodology report. They should only be used in conjunction with the methodologies described therein.

3. DESCRIPTION OF DATA

This section provides a summary of the number of tests conducted. Breakdowns are provided for the number of tests performed by test type, precipitation type, fluid dilution and test temperature.

3.1 Natural and Artificial Snow Tests

Tests were conducted in natural snow conditions at the APS test site and at several mobile test sites (refer to the report annex for details). No artificial snow tests were conducted. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

Fluid Dilution	Natural Snow			Artificial Snow		
	≥ -3°C	-3 to -14°C	<-14°C	-3°C	-14°C	-25°C
Neat	9	23	3	0	0	0
75/25	11	25	0	0	0	0
50/50	14	5	0	0	0	0

3.2 Freezing Precipitation Tests

Tests were conducted in freezing drizzle, light freezing rain, freezing fog and rain on cold-soaked surface conditions at the NRC CEF. The number of tests conducted is summarized below by precipitation type, fluid dilution and test temperature.

Fluid Dilution	Freezing Drizzle		Light Freezing Rain		Freezing Fog			Cold Soak
	-3°C	-10°C	-3°C	-10°C	-3°C	-14°C	-25°C	+1°C
Neat	4	4	4	4	4	4	4	4
75/25	6	4	4	4	4	4	0	4
50/50	4	0	4	0	6	0	0	0

3.3 Natural Frost Tests

Tests were conducted in natural frost at the APS test site. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

Fluid Dilution	Natural Frost			
	≥-1°C	<-1 to -3°C	<-3 to -10°C	<-10°C
Neat	0	0	1	2
75/25	0	0	1	1
50/50	1	0	0	0

3.4 Fluid Thickness Tests

Fluid thickness tests were conducted to measure the film thickness profiles of the fluid under dry conditions. Two tests were performed for each dilution. For each test, 1 litre of fluid was poured onto a flat plate mounted on a test stand inclined by 10°. Thickness measurements were taken at the 15-cm (6") line at select time intervals over a 30-minute period. Tests were conducted at -3°C.

3.5 Test Logs

Details of each test conducted are provided in the test logs included as Table 3.1 (snow) Table 3.2 (freezing precipitation), and Table 3.3 (frost).

3. DESCRIPTION OF DATA

Table 3.1: Summary of Tests Performed (Snow)

Test No.	Date	Snow Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
3	27-Dec-15	Natural Snow	EG IV NORTH	75%	0.5	14.4	29.6
4	27-Dec-15	Natural Snow	EG IV NORTH	100%	0.4	16.1	45.4
10	27-Dec-15	Natural Snow	EG IV NORTH	50%	0.5	14.2	14.3
15	27-Dec-15	Natural Snow	EG IV NORTH	50%	0.4	18.0	10.8
20	27-Dec-15	Natural Snow	EG IV NORTH	75%	-0.1	20.4	23.5
23	27-Dec-15	Natural Snow	EG IV NORTH	100%	-0.3	28.3	45.4
33	27-Dec-15	Natural Snow	EG IV NORTH	100%	-0.4	26.6	51.2
35	27-Dec-15	Natural Snow	EG IV NORTH	75%	-0.4	35.7	16.6
39	27-Dec-15	Natural Snow	EG IV NORTH	50%	-0.4	19.7	11.1
42	29-Dec-15	Natural Snow	EG IV NORTH	100%	-11.4	16.4	50.2
43	29-Dec-15	Natural Snow	EG IV NORTH	75%	-11.3	18.3	25.7
51	29-Dec-15	Natural Snow	EG IV NORTH	100%	-11.7	35.4	36.8
52	29-Dec-15	Natural Snow	EG IV NORTH	75%	-11.7	39.4	12.9
62	29-Dec-15	Natural Snow	EG IV NORTH	100%	-11.9	22.3	42.8
63	29-Dec-15	Natural Snow	EG IV NORTH	75%	-11.9	32.1	15.0
71	29-Dec-15	Natural Snow	EG IV NORTH	100%	-10.3	26.0	60.1
72	29-Dec-15	Natural Snow	EG IV NORTH	75%	-10.6	31.3	24.2
81	29-Dec-15	Natural Snow	EG IV NORTH	100%	-8.8	32.9	38.5
82	29-Dec-15	Natural Snow	EG IV NORTH	75%	-8.8	53.5	5.9
87	29-Dec-15	Natural Snow	EG IV NORTH	100%	-7.8	22.1	72.5
93	29-Dec-15	Natural Snow	EG IV NORTH	75%	-7.8	20.9	27.0
96	29-Dec-15	Natural Snow	EG IV NORTH	100%	-8.1	21.5	70.7
102	29-Dec-15	Natural Snow	EG IV NORTH	75%	-8.1	26.7	22.5
106	29-Dec-15	Natural Snow	EG IV NORTH	100%	-8.5	25.0	40.4
112	29-Dec-15	Natural Snow	EG IV NORTH	75%	-8.5	23.6	20.2
118	29-Dec-15	Natural Snow	EG IV NORTH	75%	-8.3	3.9	58.9
124	30-Dec-15	Natural Snow	EG IV NORTH	100%	-5.4	7.7	125.2
125	30-Dec-15	Natural Snow	EG IV NORTH	75%	-5.4	9.6	43.0
133	30-Dec-15	Natural Snow	EG IV NORTH	75%	-5.4	5.9	64.1
142	2-Jan-16	Natural Snow	EG IV NORTH	100%	-1.1	6.1	146.5
143	2-Jan-16	Natural Snow	EG IV NORTH	75%	-1.1	10.3	61.4
149	2-Jan-16	Natural Snow	EG IV NORTH	50%	-0.6	8.7	17.1
160	3-Jan-16	Natural Snow	EG IV NORTH	50%	-1.1	2.8	74.0
161	3-Jan-16	Natural Snow	EG IV NORTH	75%	-0.8	3.8	165.0
165	3-Jan-16	Natural Snow	EG IV NORTH	100%	-0.7	5.2	119.1
168	3-Jan-16	Natural Snow	EG IV NORTH	100%	-0.3	4.4	178.8
169	3-Jan-16	Natural Snow	EG IV NORTH	75%	-0.3	4.3	176.8

Table 3.1 (cont'd): Summary of Tests Performed (Snow)

Test No.	Date	Snow Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
176	3-Jan-16	Natural Snow	EG IV NORTH	50%	-0.4	4.5	35.5
181	3-Jan-16	Natural Snow	EG IV NORTH	50%	-0.3	2.3	92.2
186	12-Jan-16	Natural Snow	EG IV NORTH	100%	-4.7	1.9	332.9
187	12-Jan-16	Natural Snow	EG IV NORTH	75%	-4.9	1.6	196.4
199	12-Jan-16	Natural Snow	EG IV NORTH	75%	-4.3	2.7	134.9
207	12-Jan-16	Natural Snow	EG IV NORTH	100%	-4.2	7.4	132.5
214	12-Jan-16	Natural Snow	EG IV NORTH	75%	-4.2	10.4	43.5
221	16-Jan-16	Natural Snow	EG IV NORTH	100%	-4.2	2.5	236.3
222	16-Jan-16	Natural Snow	EG IV NORTH	75%	-4.2	2.6	160.8
246	17-Jan-16	Natural Snow	EG IV NORTH	100%	-8.8	4.0	174.8
247	17-Jan-16	Natural Snow	EG IV NORTH	75%	-8.7	3.2	105.1
254	18-Jan-16	Natural Snow	EG IV NORTH	75%	-8.8	4.8	77.7
259	18-Jan-16	Natural Snow	EG IV NORTH	100%	-8.6	5.1	128.3
268	3-Feb-16	Natural Snow	EG IV NORTH	100%	-4.7	5.3	183.7
269	3-Feb-16	Natural Snow	EG IV NORTH	75%	-4.8	3.3	160.7
275	3-Feb-16	Natural Snow	EG IV NORTH	50%	-4.3	15.9	12.5
285	3-Feb-16	Natural Snow	EG IV NORTH	50%	-4.5	16.2	10.8
288	3-Feb-16	Natural Snow	EG IV NORTH	100%	-4.6	35.8	48.6
289	3-Feb-16	Natural Snow	EG IV NORTH	75%	-4.5	28.2	22.9
299	9-Feb-16	Natural Snow	EG IV NORTH	75%	-7.6	1.0	311.3
309	12-Feb-16	Natural Snow	EG IV NORTH	100%	-6.7	6.1	155.1
310	12-Feb-16	Natural Snow	EG IV NORTH	75%	-7.0	6.2	68.5
323	12-Feb-16	Natural Snow	EG IV NORTH	100%	-8.8	11.8	67.3
324	12-Feb-16	Natural Snow	EG IV NORTH	75%	-8.3	10.8	43.9
335	16-Feb-16	Natural Snow	EG IV NORTH	100%	-7.3	13.3	91.4
336	16-Feb-16	Natural Snow	EG IV NORTH	75%	-7.2	13.7	49.2
355	19-Feb-16	Natural Snow	EG IV NORTH	100%	0.1	15.6	88.8
356	19-Feb-16	Natural Snow	EG IV NORTH	75%	0.3	10.0	73.5
365	19-Feb-16	Natural Snow	EG IV NORTH	50%	0.4	4.2	59.8
369	19-Feb-16	Natural Snow	EG IV NORTH	50%	-0.2	40.8	4.9
373	19-Feb-16	Natural Snow	EG IV NORTH	75%	-0.9	32.6	19.6
376	19-Feb-16	Natural Snow	EG IV NORTH	100%	-0.7	11.1	98.5
381	19-Feb-16	Natural Snow	EG IV NORTH	50%	-0.8	15.2	14.2
384	19-Feb-16	Natural Snow	EG IV NORTH	75%	0.1	2.2	205.1
391	19-Feb-16	Natural Snow	EG IV NORTH	50%	-0.6	4.0	29.0
396	19-Feb-16	Natural Snow	EG IV NORTH	50%	0.3	1.0	157.3
404	24-Feb-16	Natural Snow	EG IV NORTH	100%	-3.4	4.8	232.8

Table 3.1 (cont'd): Summary of Tests Performed (Snow)

Test No.	Date	Snow Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
405	24-Feb-16	Natural Snow	EG IV NORTH	75%	-3.7	3.6	165.5
406	24-Feb-16	Natural Snow	EG IV NORTH	50%	-3.8	1.9	123.7
420	24-Feb-16	Natural Snow	EG IV NORTH	75%	-2.4	10.4	71.1
421	24-Feb-16	Natural Snow	EG IV NORTH	50%	-2.6	5.6	29.2
429	24-Feb-16	Natural Snow	EG IV NORTH	100%	-1.4	19.4	77.9
430	24-Feb-16	Natural Snow	EG IV NORTH	75%	-1.6	17.0	32.6
431	24-Feb-16	Natural Snow	EG IV NORTH	50%	-1.6	16.9	15.0
466	24-Mar-16	Natural Snow	EG IV NORTH	100%	-5.1	16.1	66.5
467	24-Mar-16	Natural Snow	EG IV NORTH	75%	-5.2	12.9	42.0
475	24-Mar-16	Natural Snow	EG IV NORTH	50%	-6.6	29.1	6.2
479	24-Mar-16	Natural Snow	EG IV NORTH	100%	-6.6	11.7	98.5
481	24-Mar-16	Natural Snow	EG IV NORTH	100%	-6.4	42.1	28.4
482	24-Mar-16	Natural Snow	EG IV NORTH	50%	-6.4	42.6	5.8
C52	26-Feb-16	Natural Snow	EG IV NORTH	100%	-24.0	1.3	269.0
C74	27-Feb-16	Natural Snow	EG IV NORTH	100%	-22.9	5.9	99.1
C102	27-Feb-16	Natural Snow	EG IV NORTH	100%	-22.7	4.9	132.5

Table 3.2: Summary of Tests Performed (Freezing Precipitation)

Test No.	Date	Precipitation Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
21	30-Mar-16	Freezing Fog	EG IV NORTH	100%	-3.2	1.9	>240
22	30-Mar-16	Freezing Fog	EG IV NORTH	100%	-3.2	1.8	>240
23	30-Mar-16	Freezing Fog	EG IV NORTH	75%	-3.2	1.9	215.8
24	30-Mar-16	Freezing Fog	EG IV NORTH	75%	-3.2	2.1	195.7
25	30-Mar-16	Freezing Fog	EG IV NORTH	50%	-3.1	1.9	54.3
26	30-Mar-16	Freezing Fog	EG IV NORTH	50%	-3.1	1.8	71.1
49	4-Apr-16	Freezing Fog	EG IV NORTH	100%	-3.3	5.4	137.3
50	4-Apr-16	Freezing Fog	EG IV NORTH	100%	-3.3	4.8	136.2
51	4-Apr-16	Freezing Fog	EG IV NORTH	75%	-3.2	5.1	128.0
52	4-Apr-16	Freezing Fog	EG IV NORTH	75%	-3.2	5.2	124.5
53	4-Apr-16	Freezing Fog	EG IV NORTH	50%	-3.4	5.0	34.6
54	4-Apr-16	Freezing Fog	EG IV NORTH	50%	-3.4	4.6	33.1
73	31-Mar-16	Freezing Fog	EG IV NORTH	100%	-14.1	1.9	>240
74	31-Mar-16	Freezing Fog	EG IV NORTH	100%	-14.1	1.9	>240
75	31-Mar-16	Freezing Fog	EG IV NORTH	75%	-14.1	1.8	139.0
76	31-Mar-16	Freezing Fog	EG IV NORTH	75%	-14.1	1.8	124.4
91	31-Mar-16	Freezing Fog	EG IV NORTH	100%	-14.1	5.3	95.3
92	31-Mar-16	Freezing Fog	EG IV NORTH	100%	-14.1	5.1	104.3
93	31-Mar-16	Freezing Fog	EG IV NORTH	75%	-14.2	5.1	66.8
94	31-Mar-16	Freezing Fog	EG IV NORTH	75%	-14.2	5.2	66.8
105	1-Apr-16	Freezing Fog	EG IV NORTH	100%	-25.2	1.9	89.4
106	1-Apr-16	Freezing Fog	EG IV NORTH	100%	-25.2	1.7	88.5
117	1-Apr-16	Freezing Fog	EG IV NORTH	100%	-25.3	4.9	43.3
118	1-Apr-16	Freezing Fog	EG IV NORTH	100%	-25.3	4.6	43.4
145	4-Apr-16	Freezing Drizzle	EG IV NORTH	100%	-3.0	5.2	>120
146	4-Apr-16	Freezing Drizzle	EG IV NORTH	100%	-3.0	5.3	>120
147	4-Apr-16	Freezing Drizzle	EG IV NORTH	75%	-3.0	4.7	69.4
148	4-Apr-16	Freezing Drizzle	EG IV NORTH	75%	-3.2	4.7	96.4
149	4-Apr-16	Freezing Drizzle	EG IV NORTH	50%	-3.2	5.2	26.0
150	4-Apr-16	Freezing Drizzle	EG IV NORTH	50%	-3.2	5.3	31.7
173	7-Apr-16	Freezing Drizzle	EG IV NORTH	100%	-3.1	13.0	92.2
174	7-Apr-16	Freezing Drizzle	EG IV NORTH	100%	-3.1	13.1	88.3
175	7-Apr-16	Freezing Drizzle	EG IV NORTH	75%	-3.2	13.2	30.7
176	7-Apr-16	Freezing Drizzle	EG IV NORTH	75%	-3.2	13.0	32.4
177	7-Apr-16	Freezing Drizzle	EG IV NORTH	50%	-3.3	13.2	10.0
178	7-Apr-16	Freezing Drizzle	EG IV NORTH	50%	-3.3	13.2	8.4
195	5-Apr-16	Freezing Drizzle	EG IV NORTH	100%	-10.2	5.0	101.2
196	5-Apr-16	Freezing Drizzle	EG IV NORTH	100%	-10.2	4.9	122.6

Table 3.2 (cont'd): Summary of Tests Performed (Freezing Precipitation)

Test No.	Date	Precipitation Type	Fluid Name	Fluid Dilution	Test Temp (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
197	5-Apr-16	Freezing Drizzle	EG IV NORTH	75%	-10.2	5.1	62.7
198	5-Apr-16	Freezing Drizzle	EG IV NORTH	75%	-10.2	5.1	53.0
215	5-Apr-16	Freezing Drizzle	EG IV NORTH	100%	-10.3	13.3	66.7
216	5-Apr-16	Freezing Drizzle	EG IV NORTH	100%	-10.3	13.4	60.6
217	5-Apr-16	Freezing Drizzle	EG IV NORTH	75%	-10.4	12.9	30.0
218	5-Apr-16	Freezing Drizzle	EG IV NORTH	75%	-10.3	13.2	32.2
241	6-Apr-16	Light Freezing Rain	EG IV NORTH	100%	-3.2	13.3	51.7
242	6-Apr-16	Light Freezing Rain	EG IV NORTH	100%	-3.2	13.4	62.0
243	6-Apr-16	Light Freezing Rain	EG IV NORTH	75%	-3.2	13.1	27.0
244	6-Apr-16	Light Freezing Rain	EG IV NORTH	75%	-3.2	12.9	29.5
245	6-Apr-16	Light Freezing Rain	EG IV NORTH	50%	-3.2	13.1	11.5
246	6-Apr-16	Light Freezing Rain	EG IV NORTH	50%	-3.2	13.3	11.3
269	6-Apr-16	Light Freezing Rain	EG IV NORTH	100%	-3.3	25.0	50.6
270	6-Apr-16	Light Freezing Rain	EG IV NORTH	100%	-3.3	25.5	45.3
271	6-Apr-16	Light Freezing Rain	EG IV NORTH	75%	-3.3	24.5	21.0
272	6-Apr-16	Light Freezing Rain	EG IV NORTH	75%	-3.4	25.1	17.4
273	6-Apr-16	Light Freezing Rain	EG IV NORTH	50%	-3.1	25.0	7.8
274	6-Apr-16	Light Freezing Rain	EG IV NORTH	50%	-3.1	25.4	6.6
291	5-Apr-16	Light Freezing Rain	EG IV NORTH	100%	-10.0	12.5	90.9
292	5-Apr-16	Light Freezing Rain	EG IV NORTH	100%	-10.0	12.6	86.0
293	5-Apr-16	Light Freezing Rain	EG IV NORTH	75%	-10.0	12.8	27.0
294	5-Apr-16	Light Freezing Rain	EG IV NORTH	75%	-10.0	13.3	29.1
311	6-Apr-16	Light Freezing Rain	EG IV NORTH	100%	-10.0	25.3	54.8
312	6-Apr-16	Light Freezing Rain	EG IV NORTH	100%	-10.0	24.4	52.4
313	6-Apr-16	Light Freezing Rain	EG IV NORTH	75%	-9.8	24.8	18.2
314	6-Apr-16	Light Freezing Rain	EG IV NORTH	75%	-9.8	25.1	15.3
333	7-Apr-16	Cold Soak Box	EG IV NORTH	75%	1.1	5.4	51.3
334	7-Apr-16	Cold Soak Box	EG IV NORTH	75%	1.1	4.8	58.2
351	7-Apr-16	Cold Soak Box	EG IV NORTH	100%	1.0	76.0	8.7
352	7-Apr-16	Cold Soak Box	EG IV NORTH	100%	0.9	77.3	8.3
353	7-Apr-16	Cold Soak Box	EG IV NORTH	75%	1.0	75.9	4.8
354	7-Apr-16	Cold Soak Box	EG IV NORTH	75%	1.0	76.3	5.4
147R	4-Apr-16	Freezing Drizzle	EG IV NORTH	75%	-3.2	4.8	78.5
148R	4-Apr-16	Freezing Drizzle	EG IV NORTH	75%	-3.2	5.2	76.2
25R	30-Mar-16	Freezing Fog	EG IV NORTH	50%	-3.2	1.9	77.4
26R	30-Mar-16	Freezing Fog	EG IV NORTH	50%	-3.2	1.9	62.1
331R	7-Apr-16	Cold Soak Box	EG IV NORTH	100%	1.0	5.4	115.4
332R	7-Apr-16	Cold Soak Box	EG IV NORTH	100%	1.0	5.1	124.0

Table 3.3: Summary of Tests Performed (Natural Frost)

Test No.	Date	Precip. Type	Fluid Name	Fluid Dilution	Test Duration (min.)	Average Rate (g/dm²/h)	Temp (°C)	Wind Speed (km/h)	Average RH (%)	Comments
49	Apr-17-16	Natural Frost	EG IV NORTH	50%	389	0.02	4.8	5	66	Did Not Fail
16	Jan-07-16	Natural Frost	EG IV NORTH	100%	629	0.18	-5.2	9	89	Did Not Fail
25	Jan-07-16	Natural Frost	EG IV NORTH	75%	585	0.18	-5.4	9	90	Did Not Fail
34	Feb-18-16	Natural Frost	EG IV NORTH	75%	412	0.15	-12.4	6	84	Failed
39	Feb-18-16	Natural Frost	EG IV NORTH	100%	424	0.15	-12.5	6	85	Did Not Fail
2	Jan-04-16	Natural Frost	EG IV NORTH	100%	581	0.08	-19.1	7	80	Did Not Fail

4. RESULTS AND DISCUSSION

The methods used to evaluate the test data are provided in the report "*Methodology for Endurance Time Testing of Type II, III and IV Fluids – Winter 2015-16,*" which is provided as an annex to this report. The results of the data analyses and a discussion of the findings are presented in this section.

4.1 Results

The results of the endurance time and thickness tests are described in this section.

4.1.1 Endurance Time Tests – Natural Snow and Freezing Precipitation

Figures 4.1 to 4.14 present the endurance time data collected in natural snow and freezing precipitation (freezing drizzle, light freezing rain, freezing fog and rain on cold-soaked surface).

These figures show the effect of temperature, precipitation type and precipitation rate on fluid endurance time in the conditions encompassed by the Type IV HOT guidelines. The figures include the current Type IV generic holdover times for comparative purposes.

Multi-variable regression analysis was performed on these data sets as described in the annex. Table 4.1 provides the outputs from the multi-variable regression analyses. These outputs were used to derive fluid-specific holdover times for all conditions encompassed by Type IV fluid-specific HOT tables. One exception is the coldest temperature band snow cells (see Subsection 4.2.2).

4.1.2 Endurance Time Tests – Natural Frost

The natural frost data was presented in Table 3.3. The test durations were compared to the Type IV generic holdover times. Tests that were not completed (due to active frost ending before fluid failure could occur) surpassed the generic holdover times. This analysis indicates the Type IV generic frost holdover times can be considered substantiated for.

4.1.3 Fluid Thickness Tests

Figure 4.15 shows the fluid thickness test data. As described in Subsection 3.4, two tests were conducted at an ambient temperature of -3°C. The final fluid thicknesses are displayed in Figure 4.16.

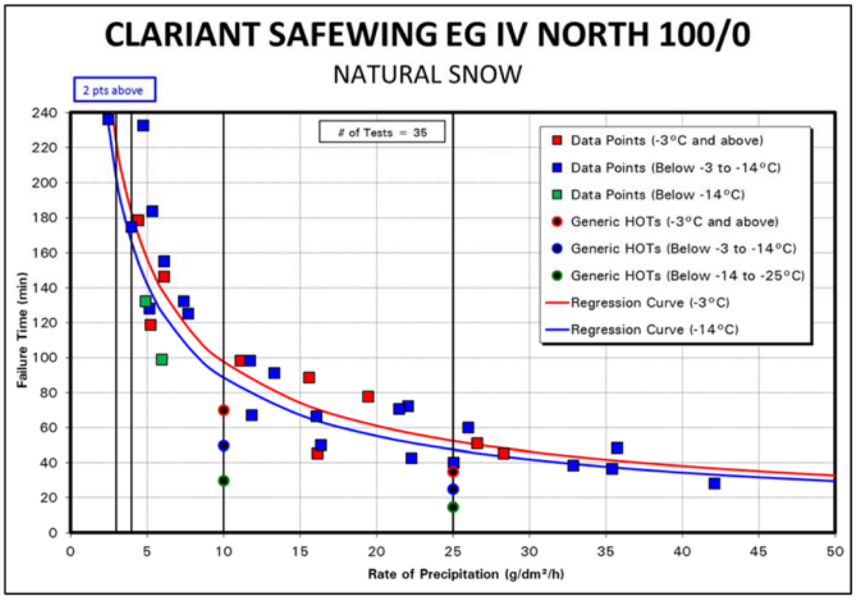


Figure 4.1: Type IV Neat – Natural Snow

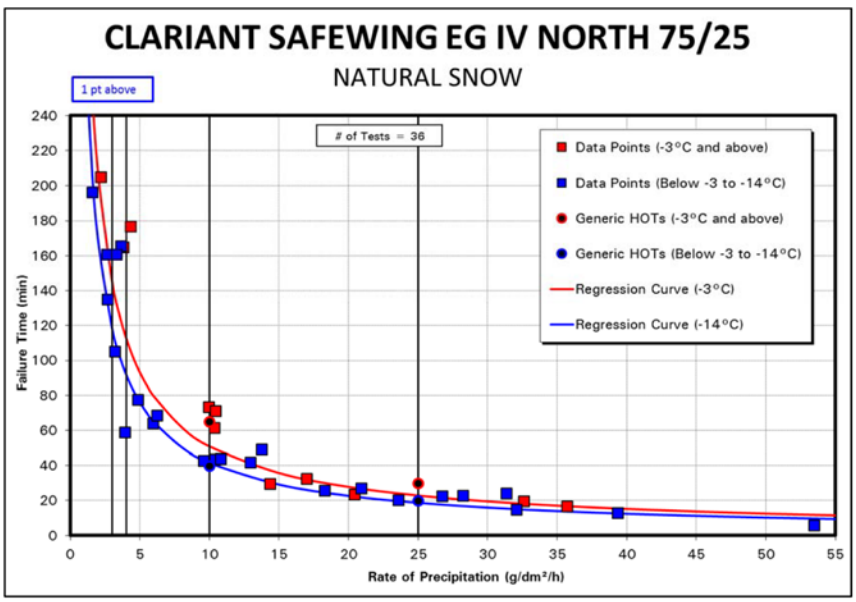


Figure 4.2: Type IV 75/25 – Natural Snow

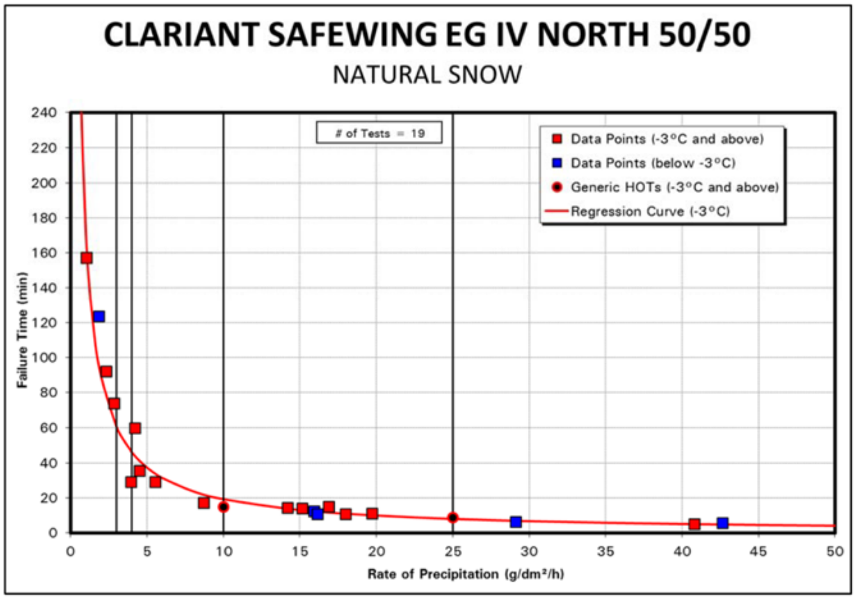


Figure 4.3: Type IV 50/50 – Natural Snow

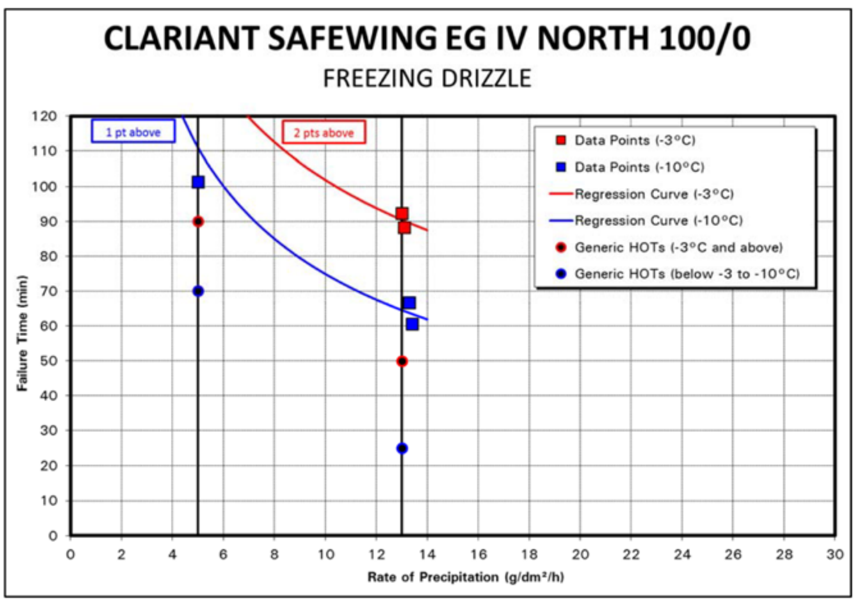


Figure 4.4: Type IV Neat – Freezing Drizzle

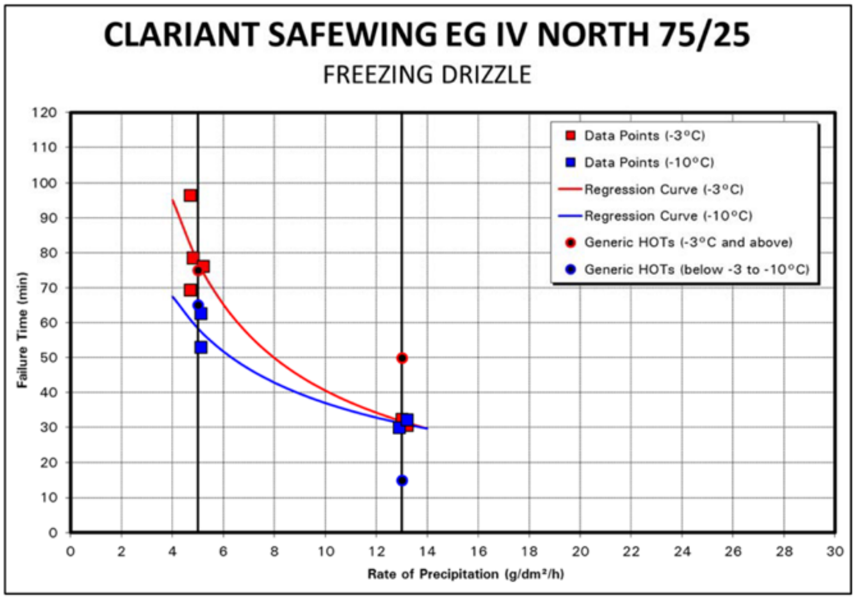


Figure 4.5: Type IV 75/25 – Freezing Drizzle

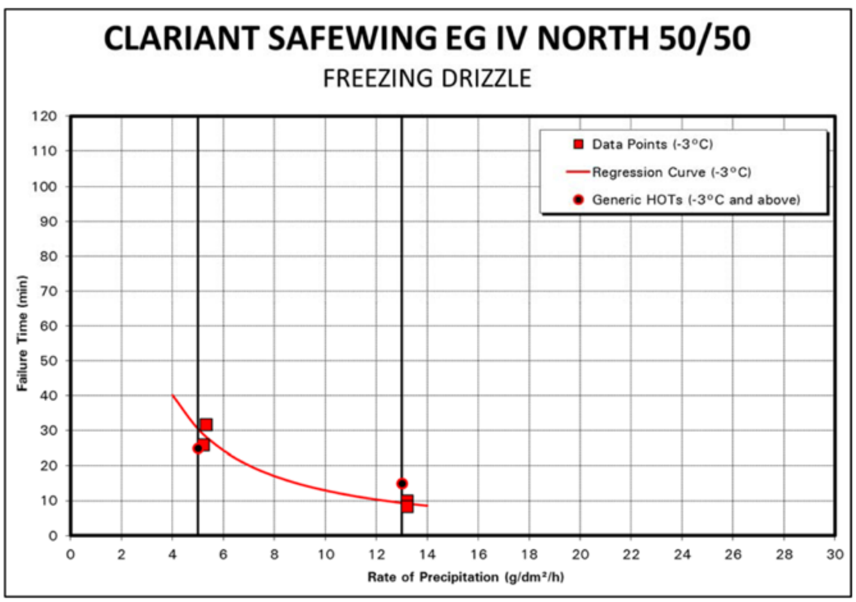


Figure 4.6: Type IV 50/50 – Freezing Drizzle

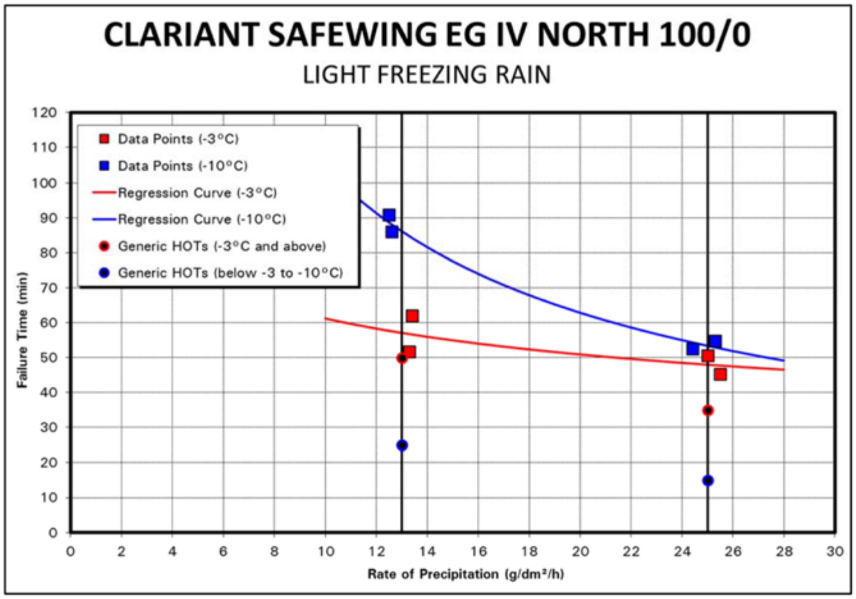


Figure 4.7: Type IV Neat – Light Freezing Rain

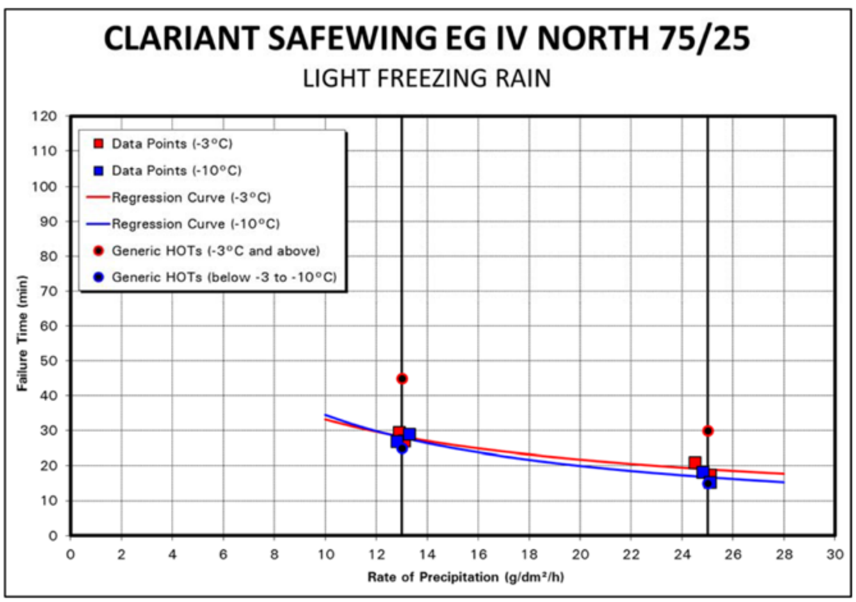


Figure 4.8: Type IV 75/25 – Light Freezing Rain

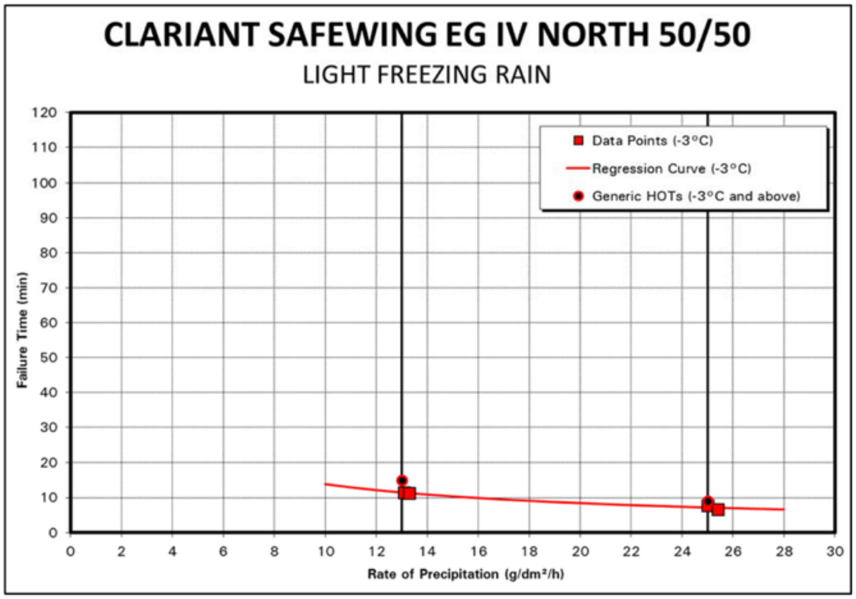


Figure 4.9: Type IV 50/50 – Light Freezing Rain

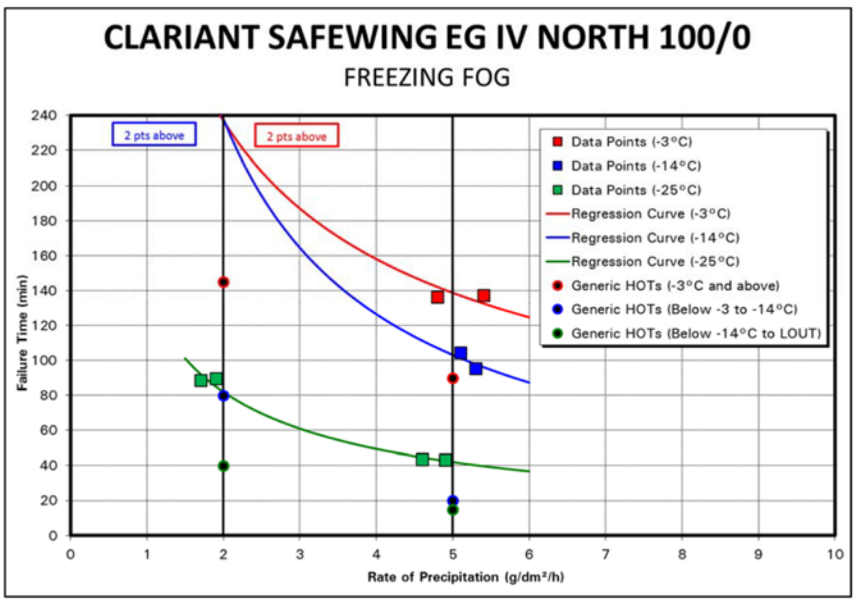


Figure 4.10: Type IV Neat – Freezing Fog

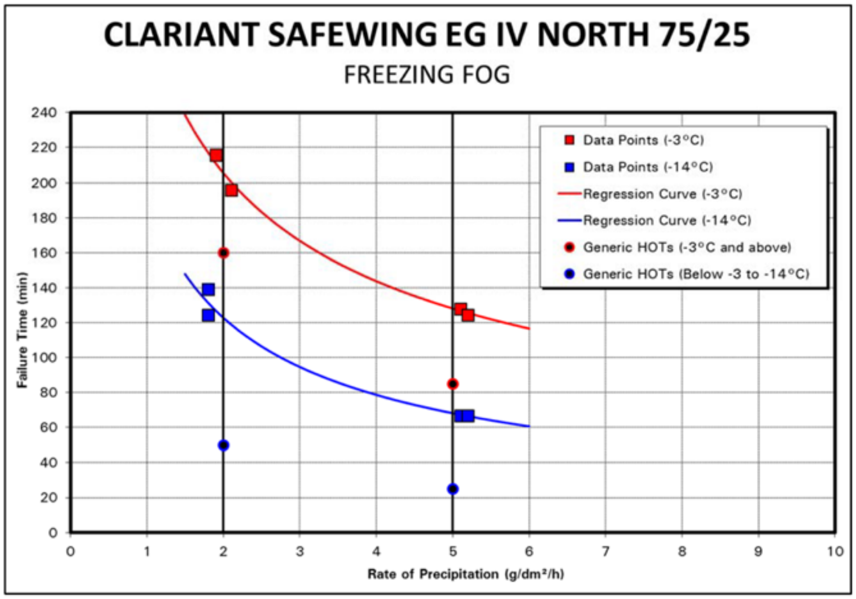


Figure 4.11: Type IV 75/25 – Freezing Fog

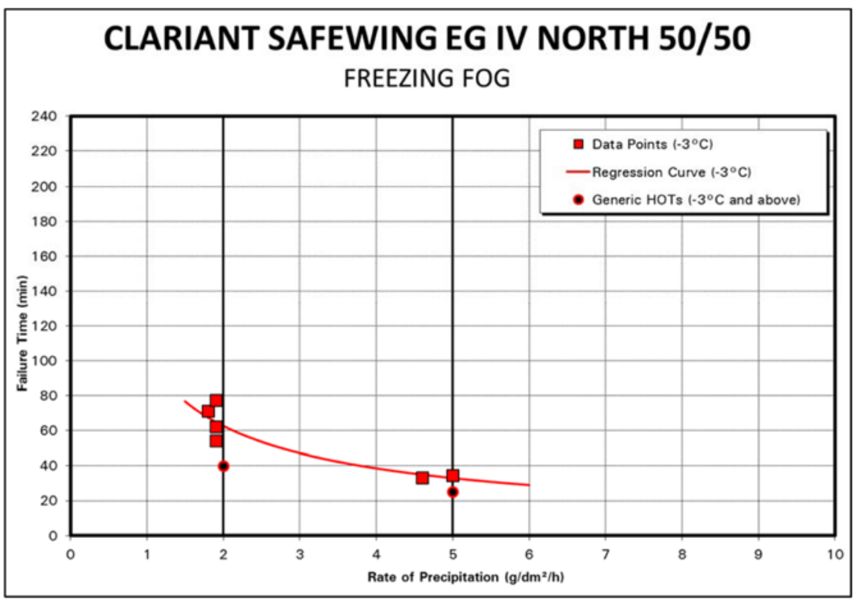


Figure 4.12: Type IV 50/50 – Freezing Fog

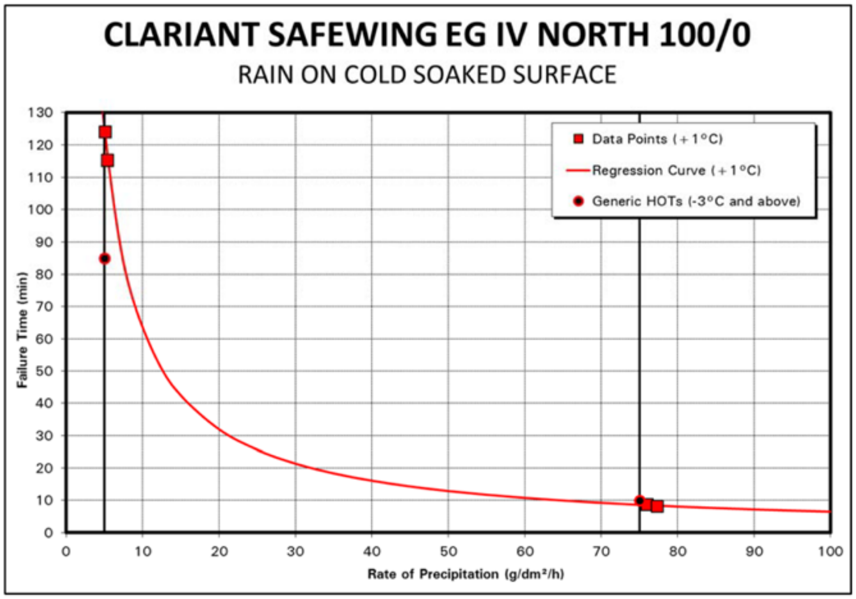


Figure 4.13: Type IV Neat – Rain on Cold-Soaked Surface

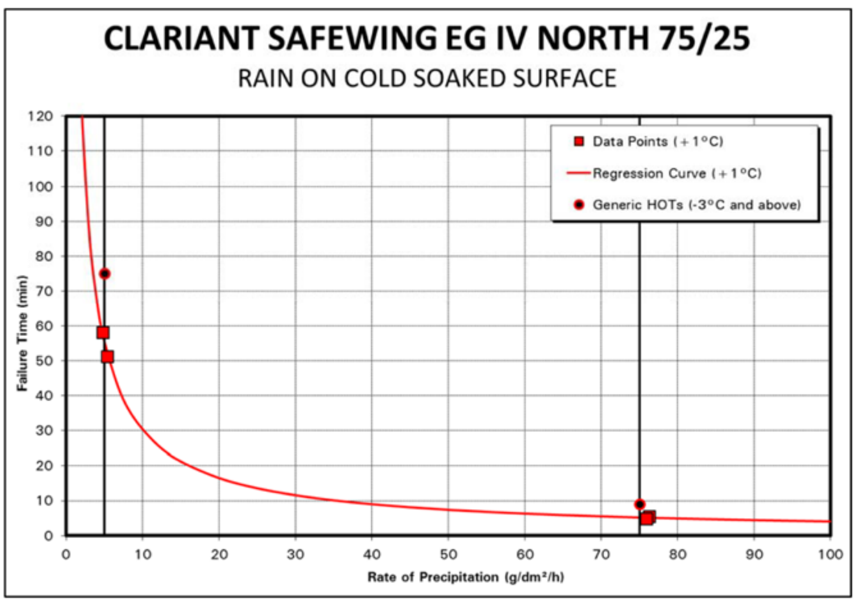


Figure 4.14: Type IV 75/25 – Rain on Cold-Soaked Surface

Table 4.1: Regression Equation Coefficients for Clariant Safewing EG IV NORTH

Natural Snow

Fluid	Dil	R^2	Intercept (I)	Coeff. Rate (A)	Coeff. Tem (B)	Total Pts.
Clariant Safewing EG IV NORTH	Neat	90%	2.7261	-0.6800	-0.0814	35
Clariant Safewing EG IV NORTH	75%	94%	2.7009	-0.8715	-0.1760	36
Clariant Safewing EG IV NORTH	50%	97%	2.2402	-0.9524	0.0000	19

General Equation $t = 10^I R^A (2\text{-}T)^B$

Simulated Freezing Fog

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Clariant Safewing EG IV NORTH	Neat	-3°C	99%	2.5514	-0.5862	4
Clariant Safewing EG IV NORTH	75/25	-3°C	99%	2.4687	-0.5172	4
Clariant Safewing EG IV NORTH	50/50	-3°C	89%	2.0092	-0.7045	6
Clariant Safewing EG IV NORTH	Neat	-14°C	100%	2.6521	-0.9130	4
Clariant Safewing EG IV NORTH	75/25	-14°C	99%	2.2833	-0.6440	4
Clariant Safewing EG IV NORTH	Neat	-25°C	99%	2.1343	-0.7329	4

General Equation $t = 10^I R^A$

Simulated Freezing Drizzle

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Clariant Safewing EG IV NORTH	Neat	-3°C	100%	2.4593	-0.4518	4
Clariant Safewing EG IV NORTH	75/25	-3°C	95%	2.5378	-0.9302	6
Clariant Safewing EG IV NORTH	50/50	-3°C	97%	2.3483	-1.2370	4
Clariant Safewing EG IV NORTH	Neat	-10°C	94%	2.4417	-0.5677	4
Clariant Safewing EG IV NORTH	75/25	-10°C	96%	2.2243	-0.6558	4

General Equation $t = 10^I R^A$

Simulated Light Freezing Rain

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Clariant Safewing EG IV NORTH	Neat	-3°C	56%	2.0514	-0.2650	4
Clariant Safewing EG IV NORTH	75/25	-3°C	90%	2.1340	-0.6127	4
Clariant Safewing EG IV NORTH	50/50	-3°C	95%	1.8574	-0.7143	4
Clariant Safewing EG IV NORTH	Neat	-10°C	99%	2.7481	-0.7299	4
Clariant Safewing EG IV NORTH	75/25	-10°C	93%	2.3327	-0.7942	4

General Equation $t = 10^I R^A$

Simulated Rain on Cold Soaked Wing

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Clariant Safewing EG IV NORTH	Neat	+1°C	100%	2.7876	-0.9859	4
Clariant Safewing EG IV NORTH	75%	+1°C	100%	2.3567	-0.8762	4

General Equation $t = 10^I R^A$

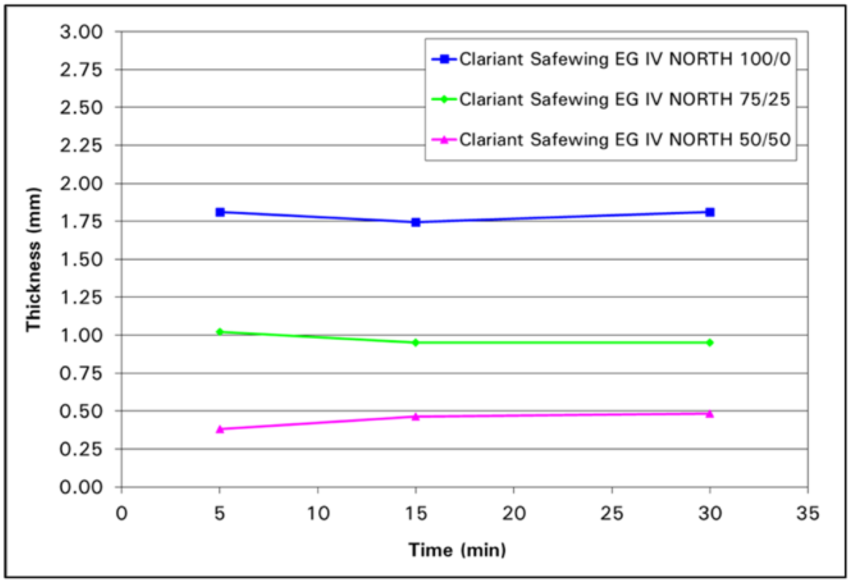


Figure 4.15: Fluid Thickness Profiles of Clariant Safewing EG IV NORTH

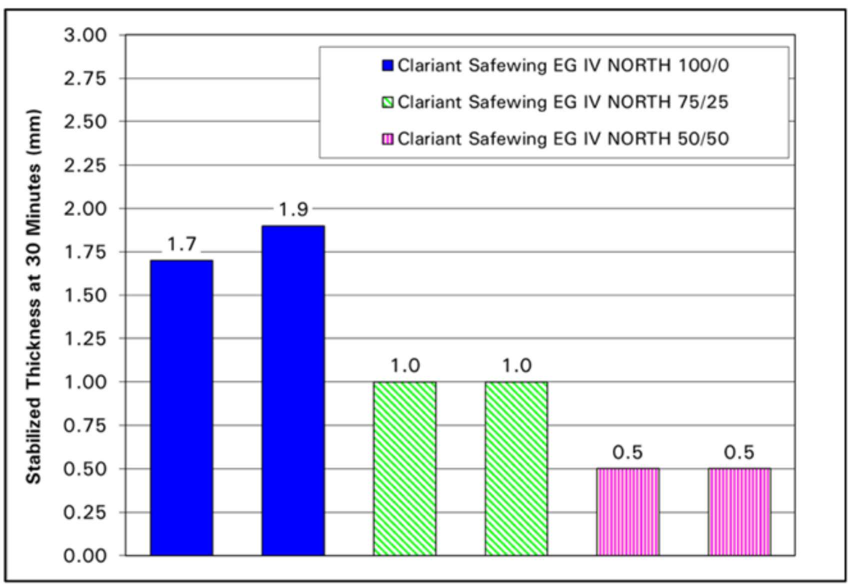


Figure 4.16: Final Fluid Thickness of Clariant Safewing EG IV NORTH

4.2 Discussion

4.2.1 Holdover Time Table

The holdover times described in Subsection 4.1 were used to populate a fluid-specific HOT table for Clariant Safewing EG IV NORTH. At the request of the manufacturer, the HOT table includes values for 100/0 fluid only. The HOT table is shown in both the TC format (Table 4.2) and FAA format (Table 4.3) at the end of this chapter.

4.2.2 Holdover Times in Snow, Below -14°C to LOUT

Very little endurance time data has been collected in natural snow at temperatures below -14°C. In the winter of 2003-04, testing was conducted with artificial snowmakers to collect additional data below -14°C. As a result of this testing, it was decided all Type II/IV fluids would be given generic values in the "Below -14 to LOUT" snow cells. Further testing in the winters of 2014-15 and 2015-16 in both natural and artificial snow determined the current Type II/IV generic HOTs for the "Below -14 to LOUT" snow cells. Accordingly, Clariant Safewing EG IV NORTH has been given generic values in the "Below -14°C to LOUT" snow cells.

4.2.3 Holdover Times in Frost

It should be noted that frost holdover times are not included in the fluid-specific HOT tables. This is due to a decision made by TC and the FAA in May 2009 to move frost holdover times from the generic and fluid-specific HOT tables to a separate frost HOT table. Accordingly, frost holdover times have not been included in the Clariant Safewing EG IV NORTH fluid-specific HOT table.

4.2.4 Fluid Viscosity

The viscosities of the fluid samples used in this testing were measured using both the AS9968 method and the manufacturer's designated method. The APS measured viscosities appear at the beginning of this document and will be published as the lowest on-wing viscosity (LOWV) values for the fluid. In order for the fluid-specific holdover times provided in this document to be valid, operators must ensure that the viscosity of the fluid being used is equal or greater than the published LOWV.

It should be noted that stable, consistent results could not be obtained for the diluted fluids (75/25 and 50/50) using the manufacturer's recommended method, which was also the AS 9968 method. APS recommended using an alternate measurement method; however, this was not done as the manufacturer elected not to have the diluted fluids included in the TC and FAA Holdover Time Guidelines.

4.2.5 Lowest Operational Use Temperatures (LOUTs)

The LOUT for Type II/III/IV fluids is determined by the higher of:

a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type;

b) The actual freezing point of the fluid plus its freezing point buffer of 7°C (13°F); and

c) For fluid dilutions, the LOUT may also be limited by the coldest temperature for which holdover times are published (-3°C for 50/50; -14°C for 75/25).

The aerodynamic acceptance and freezing point information for this fluid is provided at the beginning of this document. The LOUTs for Clariant Safewing EG IV NORTH are:

- 100/0: -30°C (-22°F)
- 75/25: -14°C (7°F)
- 50/50: -3°C (27°F)

4.2.6 Lowest Usable Precipitation Rates in Snow

The LUPRs for Clariant Safewing EG IV NORTH were determined by analysing the natural snow data sets using the analysis methodology described in the report "*Methodology for Endurance Time Testing of Type II, III and IV Fluids – Winter 2015-16*," which is provided as an annex to this report. The resulting statistics are shown in Table 4.4. The analysis determined the LUPRs for Clariant Safewing EG IV NORTH are:

- 100/0 = 2 g/dm²/h;
- 75/25 = 2 g/dm²/h; and
- 50/50 = 2 g/dm²/h.

4.2.7 Publication of Holdover Times

As Clariant intends to commercialize Safewing EG IV NORTH, TC and FAA will publish its fluid-specific HOT table in their 2016-17 Holdover Time Guidelines. The guidelines will also include the LOWV and LOUT information; the regression and LUPR data will be published in the related TC and FAA Regression Information documents.

Table 4.2: Fluid Specific Holdover Time Guidelines – Clariant Safewing EG IV NORTH (TC Format)

TABLE 4-C-NORTH

TYPE IV FLUID HOLDOVER TIME GUIDELINES
CLARIANT SAFEWING EG IV NORTH

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:20 – 3:55	2:00	1:40 – 2:00	0:50 – 1:40	1:30 – 2:00	0:50 – 0:55	0:08 – 2:00	CAUTION: No holdover time guidelines exist
		75/25								
		50/50								
below -3 to -14	below 27 to 7	100/0	1:45 – 4:00	2:00	1:30 – 2:00	0:50 – 1:30	1:05 – 1:50[7]	0:55 – 1:25[7]		
		75/25								
below -14 to -30	below 7 to -22	100/0	0:40 – 1:20	0:20	0:10 – 0:20	0:08 – 0:10				

NOTES
1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Table 4.3: Fluid Specific Holdover Time Guidelines – Clariant Safewing EG IV NORTH (FAA Format)

TABLE 4E. TYPE IV HOLDOVER TIME GUIDELINES FOR
CLARIANT SAFEWING EG IV NORTH

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:20-3:55	3:00-3:00	1:40-3:00	0:50-1:40	1:30-2:00	0:50-0:55	0:08-2:00	
		75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		50/50	N/A	N/A	N/A	N/A	N/A	N/A	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	1:45-4:00	2:45-3:00	1:30-2:45	0:50-1:30	1:05-1:50[7]	0:55-1:25[7]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -30	below 7 to -22	100/0	0:40-1:20	0:20-0:25	0:10-0:20	0:08-0:10				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

Table 4.4: LUPR Statistics – Clariant Safewing EG IV NORTH

Data Measure	100/0		75/25		50/50	
	Stat	Rating	Stat	Rating	Stat	Rating
Total Data Points	35	40	36	40	19	30
Data Points -3 to -14°C	26	40	25	40	n/a	0
Data Points <10.0	15	40	15	40	9	30
Data Points <=9.5	15	40	14	40	9	40
Data Points <=8.5	15	40	14	40	8	40
Data Points <=7.5	14	40	14	40	8	40
Data Points <=6.5	13	40	14	40	8	40
Data Points <=5.5	10	40	12	40	7	40
Data Points <=4.5	5	40	11	40	7	40
Data Points <=3.5	3	40	7	40	4	40
Data Points <=2.5	3	40	3	40	3	40
Scatter 0-10 g	15%	30	19%	30	21%	20

Rate	100/0		75/25		50/50	
	Score	Pass/Fail	Score	Pass/Fail	Score	Pass/Fail
9 g/dm²/h	39	pass	39	pass	27	pass
8 g/dm²/h	39	pass	39	pass	27	pass
7 g/dm²/h	39	pass	39	pass	27	pass
6 g/dm²/h	39	pass	39	pass	27	pass
5 g/dm²/h	39	pass	39	pass	27	pass
4 g/dm²/h	39	pass	39	pass	27	pass
3 g/dm²/h	39	pass	39	pass	27	pass
2 g/dm²/h	39	pass	39	pass	27	pass

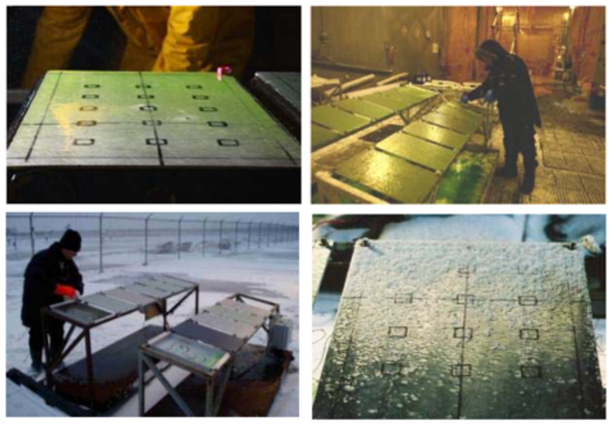
LUPR	100/0	75/25	50/50
	2 g/dm²/h	2 g/dm²/h	2 g/dm²/h

APPENDIX H

FLUID MANUFACTURER REPORT:
SHAANXI CLEANWAY AVIATION CHEMICAL CO.
CLEANSURFACE IV (TYPE IV)

AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

Shaanxi Cleanway Aviation Chemical Co. Cleansurface IV (Type IV)



Prepared for

Shaanxi Cleanway Aviation Chemical Co., Ltd

by

APS Aviation Inc.

These tests were made possible with the guidance, participation and contribution of the Transportation Development Centre of Transport Canada and the Federal Aviation Administration.

August 2016
Version 1.0
Report No. S-CS4 2015-16

AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

Shaanxi Cleanway Aviation Chemical Co. Cleansurface IV (Type IV)

Prepared for

Shaanxi Cleanway Aviation Chemical Co., Ltd.

Prepared by:

Benjamin Bernier
Project Analyst

August 29, 2016
Date

Reviewed by:

Stephanie Bendickson
Senior Project Leader

August 29, 2016
Date

These tests were made possible with the guidance, participation and contribution of the Transportation Development Centre of Transport Canada and the Federal Aviation Administration.

August 2016
Version 1.0
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FLUID IDENTIFICATION AND CHARACTERISTICS

Manufacturer:	Shaanxi Cleanway Aviation Chemical Co., Ltd.		
Fluid Test Name:	Cleansurface IV		
Fluid Commercial Name:	Cleansurface IV		
Fluid Type / Base / Colour:	Type IV / Propylene Glycol / Green		
Batch #:	15031901		
Date of Receipt:	November 23, 2015		
Brix (Measured):	Neat fluid:	38.5°	
	75/25 dilution:	31.25°	
	50/50 dilution:	21.75°	
Freeze Point (Stated):	Neat fluid:	-40.0°C	
	75/25 dilution:	-25.2°C	
	50/50 dilution:	-11.0°C	
Aerodynamic LOUT (AMIL):	Neat fluid:	-28.5°C	
	75/25 dilution:	-20°C	
	50/50 dilution:	-9.5°C	
Viscosity:	**Manufacturer Method**	**Stated**	**Measured**
	Neat fluid[1]:	16,700 cP	15,200 cP
	75/25 dilution[1]:	26,000 cP	28,500 cP
	50/50 dilution[1]:	21,120 cP	17,500 cP
	AS 9968 Method	**Stated**	**Measured**
	Neat fluid[1]:	16,700 cP	15,200 cP
	75/25 dilution[1]:	26,000 cP	28,500 cP
	50/50 dilution[1]:	21,120 cP	17,500 cP
WSET (from AMIL):	Neat fluid:	120 minutes	

[1] Spindle LV2, 600 mL low form beaker, 425 mL of fluid, 20°C, 0.3 rpm, for 10.0 minutes

SUMMARY

The primary objective of this project was to measure the endurance time performance of **Shaanxi Cleanway Aviation Chemical Co. Ltd. Cleanway Cleansurface IV** over the entire range of conditions encompassed by the Holdover Time (HOT) tables. This report contains the results of these measurements and was completed with the support of the fluid manufacturer, the Transport Development Centre (TDC) of Transport Canada (TC) and the Federal Aviation Administration (FAA).

Tests were carried out according to the protocol provided in Aerospace Recommended Practice (ARP) 5485. The test procedure consisted of pouring fluids onto clean aluminum test surfaces inclined at 10°; the onset of failure was recorded as a function of time in natural and simulated precipitation.

Tests were performed at the APS Aviation Inc. (APS) test facility at Montréal-Pierre-Elliott-Trudeau International Airport and the National Research Council Canada (NRC) Climatic Engineering Facility (CEF) in Ottawa.

De/anti-icing fluid endurance times were derived from the data collected using multi-variable regression analysis. This resulted in the generation of the fluid-specific holdover times shown below. These holdover times will be published by regulators for use in the winter 2016-17 operating season.

Shaanxi Cleanway Aviation Chemical Cleansurface IV Type IV Fluid Holdover Times

Outside Air Temperature (°C)	Type IV Fluid Concentration Neat Fluid/ Water (Vol %/Vol %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets*			Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
			Very Light	Light	Moderate				
-3 and above	100/0	2:50-4:00	3:00-3:00	1:55-3:00	1:00-1:55	2:00-2:00	1:25-1:30	0:15-2:00	
	75/25	2:35-4:00	3:00-3:00	1:55-3:00	0:45-1:35	0:50-2:00	0:35-0:45	0:09-1:15	
	50/50	1:05-2:25	1:40-2:20	0:40-1:40	0:15-0:40	0:25-0:50	0:15-0:20	CAUTION: No holdover time guidelines exist	
below -3 to -14	100/0	1:00-3:05	1:20-1:40	1:20-1:40	0:25-0:45	0:35-1:45	0:20-0:35		
	75/25	0:50-1:55	1:40-2:10	1:40-2:10	0:20-0:45	0:30-1:20	0:25-0:40		
below -14 to -28.5	100/0	0:30-0:50	0:20-0:25	0:20-0:25	0:08-0:10				

**FAA values shown, Transport Canada will publish only the lower values for very light snow and caps all snow HOTs at two hours*

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GLOSSARY

APS	APS Aviation Inc.
ARP	Aerospace Recommended Practice
CEF	Climatic Engineering Facility
FAA	Federal Aviation Administration
HOT	Holdover Time
LOUT	Lowest Operational Use Temperature
LOWV	Lowest On-Wing Viscosity
LUPR	Lowest Usable Precipitation Rate
NRC	National Research Council Canada
TC	Transport Canada
TDC	Transportation Development Centre

1. INTRODUCTION

This report has been created with the support of the fluid manufacturer, the Transport Development Centre (TDC) of Transport Canada (TC) and the Federal Aviation Administration (FAA).

Aircraft ground de/anti-icing has been the subject of concentrated industry attention in recent years due to the occurrence of several fatal icing-related aircraft accidents. Notably, attention has been placed on the enhancement of anti-icing fluids in order to provide an extended period of protection against further contamination following initial deicing. This emphasis has led to the development of fluid-specific de/anti-icing fluid holdover time (HOT) tables for Type II, Type III and Type IV fluids. These tables, accepted by regulatory authorities, are used by aircraft operators for departure planning in adverse winter conditions. Specifically, they provide the duration of time that qualified fluids provide protection against ice formation under specific weather conditions.

New anti-icing formulations continue to be developed by leading manufacturers with the specific objective of prolonging fluid holdover times without compromising the aerodynamic features of the airfoil. The purpose of the endurance time testing program is to measure the endurance times of these new fluids and develop fluid-specific HOT tables that provide guidance for their use.

Flat plate tests, conducted in natural and simulated precipitation, are used to develop HOT values for new fluids. These tests are carried out according to SAE Aerospace Recommended Practice (ARP) ARP5485, which provides the test protocols for measuring endurance times of Type II, III and IV fluids. Along with its counterpart for measuring endurance times of Type I fluids ARP5945, ARP5485 has evolved into a refined procedure for measuring the duration of de/anti-icing fluid protection against ice formation.

The current data analysis protocol for developing HOT values from endurance time data was developed in 1996-97 and uses multi-variable regression to obtain HOT values. HOT values are derived for the majority of cells in Type II/III/IV HOT tables using this protocol and are used to create a fluid-specific HOT table for each Type II/III/IV fluid tested.

This report provides a detailed account of the endurance time testing conducted by APS Aviation Inc. (APS) with **Shaanxi Cleanway Aviation Chemical Co. (Shaanxi Cleanway) Cleansurface IV**, a new Type IV fluid. It describes the test methodology used, endurance time data collected, and analysis completed to derive fluid-specific holdover times for the fluid.

2. METHODOLOGY

Tests were carried out according to SAE Aerospace Recommended Practice (ARP) 5485, which provides the procedure and requirements for endurance time testing with Type II, III, and IV fluids under natural and simulated conditions.

The test methodology for endurance time testing carried out in the winter of 2015-16 is documented in detail in the report "*Methodology for Endurance Time Testing of Type II, III and IV Fluids – Winter 2015-16.*" A copy of this report is provided as an annex to this document.

The methodology report summarizes the key aspects of the test methodology, including some aspects included in ARP5485 and some aspects which are not included in ARP54855. It includes sections on:

a) Test Sites;

b) Test Equipment;

c) Test Procedures;

d) Precipitation Rates used in Type I, II, III and IV Endurance Time Testing;

e) Ambient Temperatures used in Type I, II, III and IV Endurance Time Testing;

f) Freezing Precipitation Droplet Sizes; and

g) Analysis Methodologies.

The data, analysis and results provided in this report are a function of the test and analysis methodologies described in the methodology report. They should only be used in conjunction with the methodologies described therein.

3. DESCRIPTION OF DATA

This section provides a summary of the number of tests conducted. Breakdowns are provided for the number of tests performed by test type, precipitation type, fluid dilution and test temperature.

3.1 Natural and Artificial Snow Tests

Tests were conducted in natural snow conditions at the APS test site and at several mobile test sites (refer to the report annex for details). No artificial snow tests were conducted. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

Fluid Dilution	Natural Snow			Artificial Snow		
	≥ -3°C	-3 to -14°C	<-14°C	-3°C	-14°C	-25°C
Neat	7	21	3	0	0	0
75/25	9	24	0	0	0	0
50/50	13	5	0	0	0	0

3.2 Freezing Precipitation Tests

Tests were conducted in freezing drizzle, light freezing rain, freezing fog and rain on cold-soaked surface conditions at the NRC CEF. The number of tests conducted is summarized below by precipitation type, fluid dilution and test temperature.

Fluid Dilution	Freezing Drizzle		Light Freezing Rain		Freezing Fog			Cold Soak
	-3°C	-10°C	-3°C	-10°C	-3°C	-14°C	-25°C	+1°C
Neat	4	4	4	4	4	4	4	4
75/25	4	4	4	6	4	4	0	4
50/50	4	0	4	0	4	0	0	0

3.3 Natural Frost Tests

Tests were conducted in natural frost at the APS test site. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

Fluid Dilution	Natural Frost			
	≥-1°C	<-1 to -3°C	<-3 to -10°C	<-10°C
Neat	0	0	1	2
75/25	0	0	1	1
50/50	1	0	0	0

3.4 Fluid Thickness Tests

Fluid thickness tests were conducted to measure the film thickness profiles of the fluid under dry conditions. Two tests were performed for each dilution. For each test, 1 litre of fluid was poured onto a flat plate mounted on a test stand inclined by 10°. Thickness measurements were taken at the 15-cm (6") line at select time intervals over a 30-minute period. Tests were conducted at -3°C.

3.5 Test Logs

Details of each test conducted are provided in the test logs included as Table 3.1 (snow) Table 3.2 (freezing precipitation), and Table 3.3 (frost).

Table 3.1: Summary of Tests Performed (Snow)

Test No.	Date	Snow Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
5	27-Dec-15	Natural Snow	Cleansurface IV	100%	-0.1	21.5	187.3
6	27-Dec-15	Natural Snow	Cleansurface IV	75%	0.0	23.4	90.3
11	27-Dec-15	Natural Snow	Cleansurface IV	50%	0.5	15.8	28.0
21	27-Dec-15	Natural Snow	Cleansurface IV	50%	-0.2	21.1	23.3
24	27-Dec-15	Natural Snow	Cleansurface IV	100%	-0.3	21.2	193.2
25	27-Dec-15	Natural Snow	Cleansurface IV	75%	-0.3	26.9	72.3
28	27-Dec-15	Natural Snow	Cleansurface IV	75%	-0.4	25.8	62.4
37	27-Dec-15	Natural Snow	Cleansurface IV	50%	-0.4	22.3	16.7
46	29-Dec-15	Natural Snow	Cleansurface IV	100%	-11.3	17.2	34.7
47	29-Dec-15	Natural Snow	Cleansurface IV	75%	-11.3	17.9	27.0
55	29-Dec-15	Natural Snow	Cleansurface IV	100%	-11.7	35.3	19.8
56	29-Dec-15	Natural Snow	Cleansurface IV	75%	-11.7	32.8	13.3
66	29-Dec-15	Natural Snow	Cleansurface IV	100%	-11.9	20.6	27.4
67	29-Dec-15	Natural Snow	Cleansurface IV	75%	-11.9	21.6	21.7
75	29-Dec-15	Natural Snow	Cleansurface IV	100%	-10.6	30.2	24.6
76	29-Dec-15	Natural Snow	Cleansurface IV	75%	-10.6	29.4	27.2
85	29-Dec-15	Natural Snow	Cleansurface IV	100%	-8.8	46.8	11.4
86	29-Dec-15	Natural Snow	Cleansurface IV	75%	-8.8	48.8	9.5
89	29-Dec-15	Natural Snow	Cleansurface IV	100%	-7.8	21.5	38.3
95	29-Dec-15	Natural Snow	Cleansurface IV	75%	-7.8	21.0	39.2
98	29-Dec-15	Natural Snow	Cleansurface IV	100%	-8.1	25.6	33.1
104	29-Dec-15	Natural Snow	Cleansurface IV	75%	-8.1	25.3	30.0
105	29-Dec-15	Natural Snow	Cleansurface IV	100%	-8.1	18.1	39.8
108	29-Dec-15	Natural Snow	Cleansurface IV	100%	-8.5	23.1	31.2
114	29-Dec-15	Natural Snow	Cleansurface IV	75%	-8.5	23.4	29.2
131	30-Dec-15	Natural Snow	Cleansurface IV	75%	-5.4	6.6	159.7
144	2-Jan-16	Natural Snow	Cleansurface IV	100%	-0.8	5.8	281.2
145	2-Jan-16	Natural Snow	Cleansurface IV	75%	-0.9	5.4	222.8
150	2-Jan-16	Natural Snow	Cleansurface IV	50%	-1.1	10.7	47.5
153	3-Jan-16	Natural Snow	Cleansurface IV	50%	-0.9	3.2	152.3
162	3-Jan-16	Natural Snow	Cleansurface IV	100%	-0.5	4.9	312.6
163	3-Jan-16	Natural Snow	Cleansurface IV	75%	-0.6	5.8	206.1
172	3-Jan-16	Natural Snow	Cleansurface IV	100%	-0.3	5.4	234.8
173	3-Jan-16	Natural Snow	Cleansurface IV	75%	-0.3	5.1	226.8
174	3-Jan-16	Natural Snow	Cleansurface IV	50%	-0.3	6.6	89.9
182	3-Jan-16	Natural Snow	Cleansurface IV	50%	-0.3	3.7	124.4
192	12-Jan-16	Natural Snow	Cleansurface IV	100%	-4.7	1.9	324.9

Table 3.1 (cont'd): Summary of Tests Performed (Snow)

Test No.	Date	Snow Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
193	12-Jan-16	Natural Snow	Cleansurface IV	75%	-4.8	2.0	265.0
208	12-Jan-16	Natural Snow	Cleansurface IV	100%	-4.2	7.4	127.9
210	12-Jan-16	Natural Snow	Cleansurface IV	75%	-4.2	7.7	141.0
212	12-Jan-16	Natural Snow	Cleansurface IV	75%	-4.1	10.5	91.1
223	16-Jan-16	Natural Snow	Cleansurface IV	100%	-4.2	2.5	234.9
224	16-Jan-16	Natural Snow	Cleansurface IV	75%	-4.1	2.1	302.0
242	17-Jan-16	Natural Snow	Cleansurface IV	100%	-8.7	3.5	133.6
243	17-Jan-16	Natural Snow	Cleansurface IV	75%	-8.7	3.1	107.3
260	18-Jan-16	Natural Snow	Cleansurface IV	100%	-8.6	4.7	112.1
261	18-Jan-16	Natural Snow	Cleansurface IV	75%	-8.7	4.5	101.1
270	3-Feb-16	Natural Snow	Cleansurface IV	100%	-4.7	5.8	187.5
271	3-Feb-16	Natural Snow	Cleansurface IV	75%	-4.7	5.7	186.8
276	3-Feb-16	Natural Snow	Cleansurface IV	50%	-4.8	2.4	142.7
280	3-Feb-16	Natural Snow	Cleansurface IV	100%	-4.5	20.7	49.7
281	3-Feb-16	Natural Snow	Cleansurface IV	75%	-4.5	20.9	49.5
282	3-Feb-16	Natural Snow	Cleansurface IV	50%	-4.5	16.5	29.1
311	12-Feb-16	Natural Snow	Cleansurface IV	100%	-6.7	6.2	141.2
312	12-Feb-16	Natural Snow	Cleansurface IV	75%	-6.7	6.2	130.3
325	12-Feb-16	Natural Snow	Cleansurface IV	100%	-8.4	10.9	44.6
326	12-Feb-16	Natural Snow	Cleansurface IV	75%	-8.4	10.8	44.3
337	16-Feb-16	Natural Snow	Cleansurface IV	100%	-7.3	13.1	79.7
338	16-Feb-16	Natural Snow	Cleansurface IV	75%	-7.3	13.0	69.7
361	19-Feb-16	Natural Snow	Cleansurface IV	100%	0.1	14.4	82.3
362	19-Feb-16	Natural Snow	Cleansurface IV	75%	0.1	15.5	84.4
363	19-Feb-16	Natural Snow	Cleansurface IV	50%	0.2	11.7	74.0
378	19-Feb-16	Natural Snow	Cleansurface IV	75%	-0.1	4.8	258.5
379	19-Feb-16	Natural Snow	Cleansurface IV	50%	-0.8	12.1	46.8
407	24-Feb-16	Natural Snow	Cleansurface IV	100%	-3.5	4.5	226.9
408	24-Feb-16	Natural Snow	Cleansurface IV	75%	-3.5	4.1	213.6
409	24-Feb-16	Natural Snow	Cleansurface IV	50%	-3.8	3.0	145.6
415	24-Feb-16	Natural Snow	Cleansurface IV	50%	-3.0	6.1	59.1
432	24-Feb-16	Natural Snow	Cleansurface IV	100%	-1.4	21.1	113.6
433	24-Feb-16	Natural Snow	Cleansurface IV	75%	-1.4	19.5	77.2
434	24-Feb-16	Natural Snow	Cleansurface IV	50%	-1.6	17.0	24.3
436	24-Feb-16	Natural Snow	Cleansurface IV	50%	-1.3	20.7	21.6
440	24-Feb-16	Natural Snow	Cleansurface IV	50%	-1.1	17.9	38.9

Table 3.1 (cont'd): Summary of Tests Performed (Snow)

Test No.	Date	Snow Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
468	24-Mar-16	Natural Snow	Cleansurface IV	100%	-5.1	16.3	57.0
469	24-Mar-16	Natural Snow	Cleansurface IV	75%	-5.1	16.3	54.5
472	24-Mar-16	Natural Snow	Cleansurface IV	50%	-6.6	28.6	6.8
474	24-Mar-16	Natural Snow	Cleansurface IV	75%	-6.6	13.8	55.2
484	24-Mar-16	Natural Snow	Cleansurface IV	50%	-6.4	41.2	6.3
488	24-Mar-16	Natural Snow	Cleansurface IV	75%	-6.4	41.9	20.1
C70	26-Feb-16	Natural Snow	Cleansurface IV	100%	-23.7	0.7	105.8
C87	27-Feb-16	Natural Snow	Cleansurface IV	100%	-23.3	5.2	55.8
C124	27-Feb-16	Natural Snow	Cleansurface IV	100%	-22.0	7.8	44.0

Table 3.2: Summary of Tests Performed (Freezing Precipitation)

Test No.	Date	Precipitation Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
9	30-Mar-16	Freezing Fog	Cleansurface IV	100%	-3.2	1.9	>240
10	30-Mar-16	Freezing Fog	Cleansurface IV	100%	-3.2	1.8	>240
11	30-Mar-16	Freezing Fog	Cleansurface IV	75%	-3.2	1.9	>240
12	30-Mar-16	Freezing Fog	Cleansurface IV	75%	-3.2	1.8	>240
13	30-Mar-16	Freezing Fog	Cleansurface IV	50%	-3.2	1.9	145.8
14	30-Mar-16	Freezing Fog	Cleansurface IV	50%	-3.2	1.9	153.8
37	4-Apr-16	Freezing Fog	Cleansurface IV	100%	-3.3	5.4	165.8
38	4-Apr-16	Freezing Fog	Cleansurface IV	100%	-3.3	5.4	164.4
39	4-Apr-16	Freezing Fog	Cleansurface IV	75%	-3.3	5.2	157.3
40	4-Apr-16	Freezing Fog	Cleansurface IV	75%	-3.3	5.1	145.2
41	4-Apr-16	Freezing Fog	Cleansurface IV	50%	-3.0	5.1	67.7
42	4-Apr-16	Freezing Fog	Cleansurface IV	50%	-3.0	4.9	59.7
65	31-Mar-16	Freezing Fog	Cleansurface IV	100%	-14.1	1.7	219.1
66	31-Mar-16	Freezing Fog	Cleansurface IV	100%	-14.1	1.9	204.8
67	31-Mar-16	Freezing Fog	Cleansurface IV	75%	-14.2	1.9	125.7
68	31-Mar-16	Freezing Fog	Cleansurface IV	75%	-14.2	1.8	125.3
83	31-Mar-16	Freezing Fog	Cleansurface IV	100%	-14.1	5.4	53.1
84	31-Mar-16	Freezing Fog	Cleansurface IV	100%	-14.1	5.3	52.6
85	31-Mar-16	Freezing Fog	Cleansurface IV	75%	-14.2	4.8	48.0
86	31-Mar-16	Freezing Fog	Cleansurface IV	75%	-14.2	5.3	49.2
101	1-Apr-16	Freezing Fog	Cleansurface IV	100%	-25.2	1.9	54.2
102	1-Apr-16	Freezing Fog	Cleansurface IV	100%	-25.2	1.9	53.7
113	1-Apr-16	Freezing Fog	Cleansurface IV	100%	-25.2	4.8	28.7
114	1-Apr-16	Freezing Fog	Cleansurface IV	100%	-25.2	4.8	28.1
133	4-Apr-16	Freezing Drizzle	Cleansurface IV	100%	-3.0	5.2	>120
134	4-Apr-16	Freezing Drizzle	Cleansurface IV	100%	-3.0	5.3	>120
135	4-Apr-16	Freezing Drizzle	Cleansurface IV	75%	-3.0	5.2	112.8
136	4-Apr-16	Freezing Drizzle	Cleansurface IV	75%	-3.0	5.3	113.3
137	4-Apr-16	Freezing Drizzle	Cleansurface IV	50%	-3.2	4.7	50.0
138	4-Apr-16	Freezing Drizzle	Cleansurface IV	50%	-3.2	4.7	57.8
161	7-Apr-16	Freezing Drizzle	Cleansurface IV	100%	-3.1	12.6	125.7
162	7-Apr-16	Freezing Drizzle	Cleansurface IV	100%	-3.1	13.5	114.4
163	7-Apr-16	Freezing Drizzle	Cleansurface IV	75%	-3.2	13.0	50.5
164	7-Apr-16	Freezing Drizzle	Cleansurface IV	75%	-3.2	13.1	47.1
165	7-Apr-16	Freezing Drizzle	Cleansurface IV	50%	-3.1	13.0	24.3
166	7-Apr-16	Freezing Drizzle	Cleansurface IV	50%	-3.1	13.1	23.4
187	5-Apr-16	Freezing Drizzle	Cleansurface IV	100%	-10.1	4.8	108.4

Table 3.2 (cont'd): Summary of Tests Performed (Freezing Precipitation)

Test No.	Date	Precipitation Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
188	5-Apr-16	Freezing Drizzle	Cleansurface IV	100%	-10.1	4.8	107.5
189	5-Apr-16	Freezing Drizzle	Cleansurface IV	75%	-10.2	5.0	84.9
190	5-Apr-16	Freezing Drizzle	Cleansurface IV	75%	-10.2	4.9	75.7
207	5-Apr-16	Freezing Drizzle	Cleansurface IV	100%	-10.3	13.1	36.9
208	5-Apr-16	Freezing Drizzle	Cleansurface IV	100%	-10.3	12.5	36.2
209	5-Apr-16	Freezing Drizzle	Cleansurface IV	75%	-10.3	12.5	31.5
210	5-Apr-16	Freezing Drizzle	Cleansurface IV	75%	-10.3	13.4	30.8
229	6-Apr-16	Light Freezing Rain	Cleansurface IV	100%	-3.2	13.2	88.6
230	6-Apr-16	Light Freezing Rain	Cleansurface IV	100%	-3.2	13.0	87.2
231	6-Apr-16	Light Freezing Rain	Cleansurface IV	75%	-3.2	13.3	41.3
232	6-Apr-16	Light Freezing Rain	Cleansurface IV	75%	-3.2	13.4	43.2
233	6-Apr-16	Light Freezing Rain	Cleansurface IV	50%	-3.2	13.0	18.5
234	6-Apr-16	Light Freezing Rain	Cleansurface IV	50%	-3.2	13.1	18.6
257	6-Apr-16	Light Freezing Rain	Cleansurface IV	100%	-3.3	25.0	92.5
258	6-Apr-16	Light Freezing Rain	Cleansurface IV	100%	-3.3	25.4	82.2
259	6-Apr-16	Light Freezing Rain	Cleansurface IV	75%	-3.4	25.0	37.8
260	6-Apr-16	Light Freezing Rain	Cleansurface IV	75%	-3.4	25.4	34.2
261	6-Apr-16	Light Freezing Rain	Cleansurface IV	50%	-3.2	25.0	13.7
262	6-Apr-16	Light Freezing Rain	Cleansurface IV	50%	-3.2	25.4	13.8
283	5-Apr-16	Light Freezing Rain	Cleansurface IV	100%	-10.0	13.0	35.3
284	5-Apr-16	Light Freezing Rain	Cleansurface IV	100%	-10.1	12.8	33.0
285	5-Apr-16	Light Freezing Rain	Cleansurface IV	75%	-10.0	12.8	38.0
286	5-Apr-16	Light Freezing Rain	Cleansurface IV	75%	-10.0	12.9	41.3
303	6-Apr-16	Light Freezing Rain	Cleansurface IV	100%	-9.9	24.8	20.4
304	6-Apr-16	Light Freezing Rain	Cleansurface IV	100%	-9.9	24.8	19.5
305	6-Apr-16	Light Freezing Rain	Cleansurface IV	75%	-9.9	25.1	19.8
306	6-Apr-16	Light Freezing Rain	Cleansurface IV	75%	-9.9	25.5	24.4
323	7-Apr-16	Cold Soak Box	Cleansurface IV	100%	1.1	5.0	>120
324	7-Apr-16	Cold Soak Box	Cleansurface IV	100%	1.1	5.2	>120
325	7-Apr-16	Cold Soak Box	Cleansurface IV	75%	1.0	5.3	62.8
326	7-Apr-16	Cold Soak Box	Cleansurface IV	75%	1.1	5.4	77.5
343	7-Apr-16	Cold Soak Box	Cleansurface IV	100%	1.0	76.7	16.2
344	7-Apr-16	Cold Soak Box	Cleansurface IV	100%	1.0	75.7	14.9
345	7-Apr-16	Cold Soak Box	Cleansurface IV	75%	1.0	76.0	8.7
346	7-Apr-16	Cold Soak Box	Cleansurface IV	75%	1.0	77.3	8.9
305R	6-Apr-16	Light Freezing Rain	Cleansurface IV	75%	-10.1	24.8	28.6
306R	6-Apr-16	Light Freezing Rain	Cleansurface IV	75%	-10.1	24.8	28.3

Table 3.3: Summary of Tests Performed (Natural Frost)

Test No.	Date	Precip. Type	Fluid Name	Fluid Dilution	Test Duration (min.)	Average Rate (g/dm²/h)	Temp (°C)	Wind Speed (km/h)	Average RH (%)	Comments
4	Jan-04-16	Natural Frost	Cleansurface IV	100%	579	0.08	-19.1	7	80	Did Not Fail
17	Jan-07-16	Natural Frost	Cleansurface IV	100%	628	0.18	-5.2	9	89	Did Not Fail
27	Jan-07-16	Natural Frost	Cleansurface IV	75%	582	0.18	-5.4	9	90	Did Not Fail
35	Feb-18-16	Natural Frost	Cleansurface IV	75%	435	0.15	-12.5	6	85	Did Not Fail
38	Feb-18-16	Natural Frost	Cleansurface IV	100%	425	0.15	-12.5	6	85	Did Not Fail
48	Apr-17-16	Natural Frost	Cleansurface IV	50%	389	0.02	4.8	5	66	Did Not Fail

4. RESULTS AND DISCUSSION

The methods used to evaluate the test data are provided in the report "*Methodology for Endurance Time Testing of Type II, III and IV Fluids – Winter 2015-16,*" which is provided as an annex to this report. The results of the data analyses and a discussion of the findings are presented in this section.

4.1 Results

The results of the endurance time and thickness tests are described in this section.

4.1.1 Endurance Time Tests – Natural Snow and Freezing Precipitation

Figures 4.1 to 4.14 present the endurance time data collected in natural snow and freezing precipitation (freezing drizzle, light freezing rain, freezing fog and rain on cold-soaked surface).

These figures show the effect of temperature, precipitation type and precipitation rate on fluid endurance time in the conditions encompassed by the Type IV HOT guidelines. The figures include the current Type IV generic holdover times for comparative purposes.

Multi-variable regression analysis was performed on these data sets as described in the annex. Table 4.1 provides the outputs from the multi-variable regression analyses. These outputs were used to derive fluid-specific holdover times for all conditions encompassed by Type IV fluid-specific HOT tables. One exception is the coldest temperature band snow cells (see Subsection 4.2.2).

4.1.2 Endurance Time Tests – Natural Frost

The natural frost data was presented in Table 3.3. The test durations were compared to the Type IV generic holdover times. Tests that were not completed (due to active frost ending before fluid failure could occur) surpassed the generic holdover times. This analysis indicates the Type IV generic frost holdover times can be considered substantiated for Shaanxi Cleanway Cleansurface IV.

4.1.3 Fluid Thickness Tests

Figure 4.15 shows the fluid thickness test data. As described in Subsection 3.4, two tests were conducted at an ambient temperature of -3°C. The final fluid thicknesses are displayed in Figure 4.16.

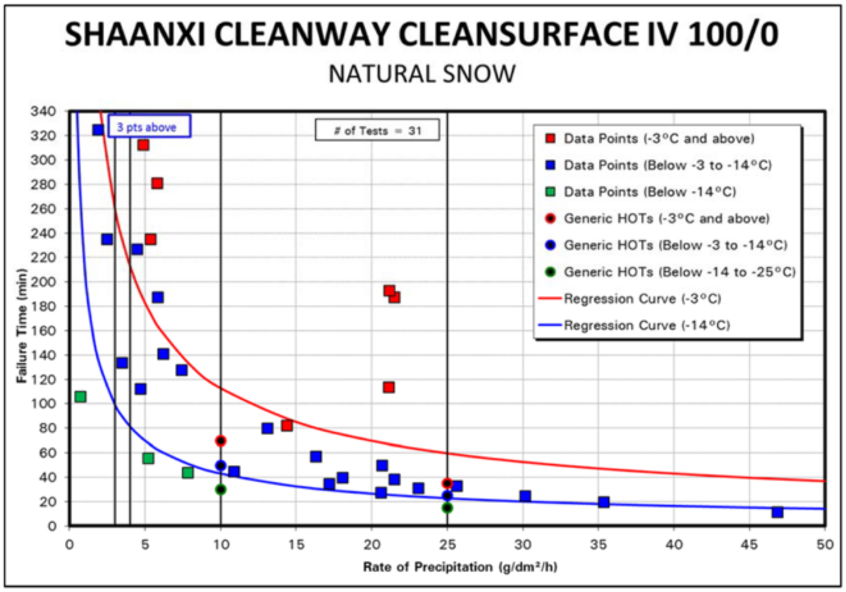


Figure 4.1: Type IV Neat – Natural Snow

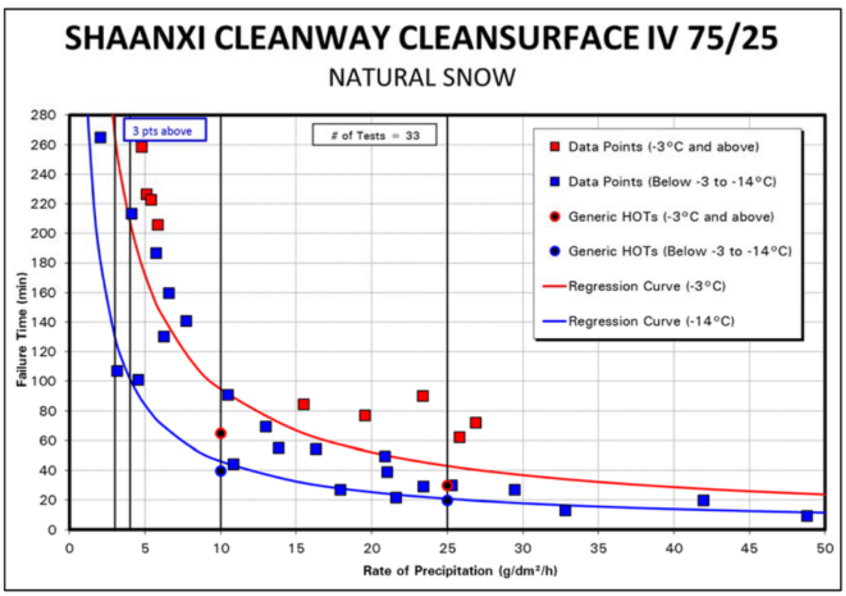


Figure 4.2: Type IV 75/25 – Natural Snow

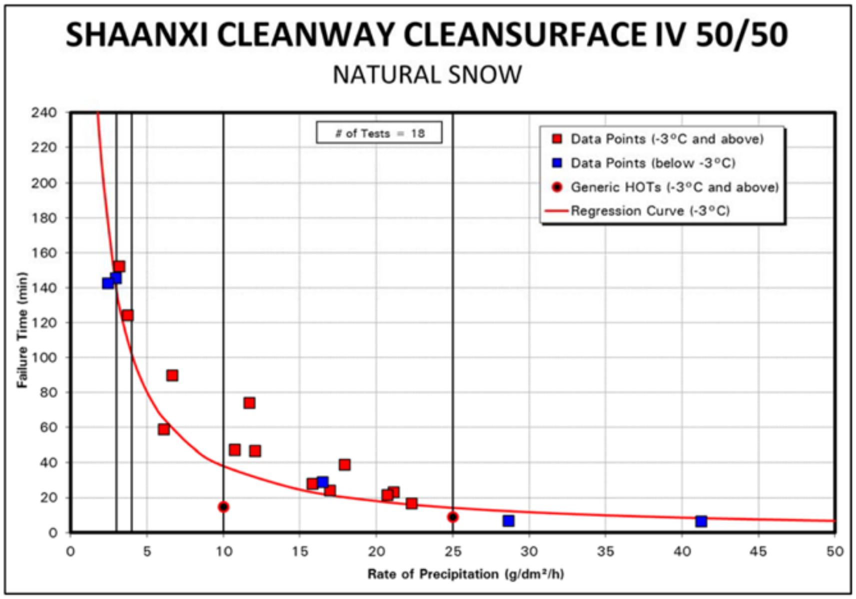


Figure 4.3: Type IV 50/50 – Natural Snow

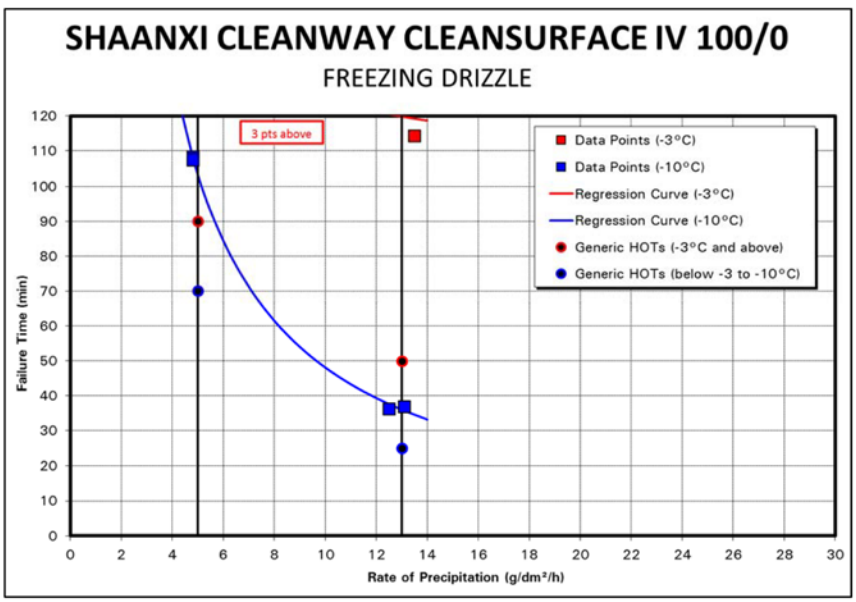


Figure 4.4: Type IV Neat – Freezing Drizzle

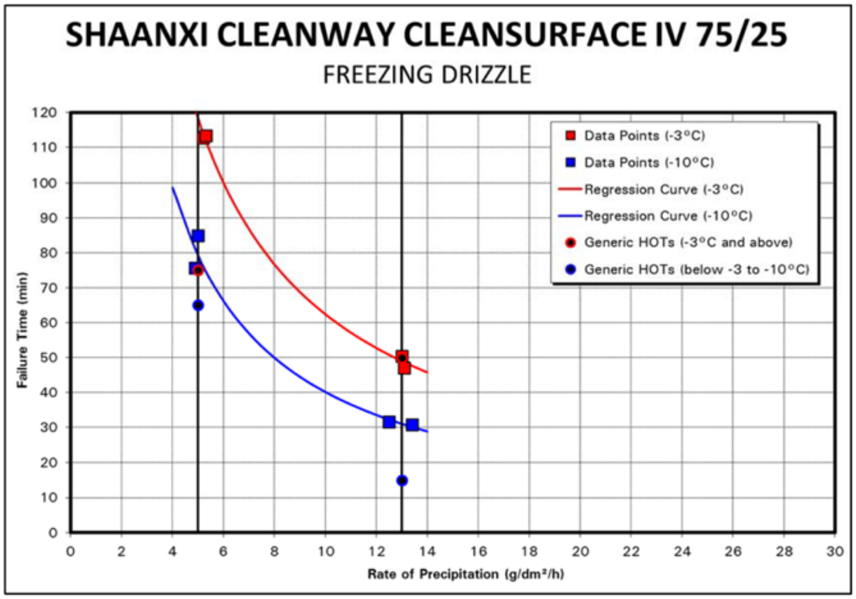


Figure 4.5: Type IV 75/25 – Freezing Drizzle

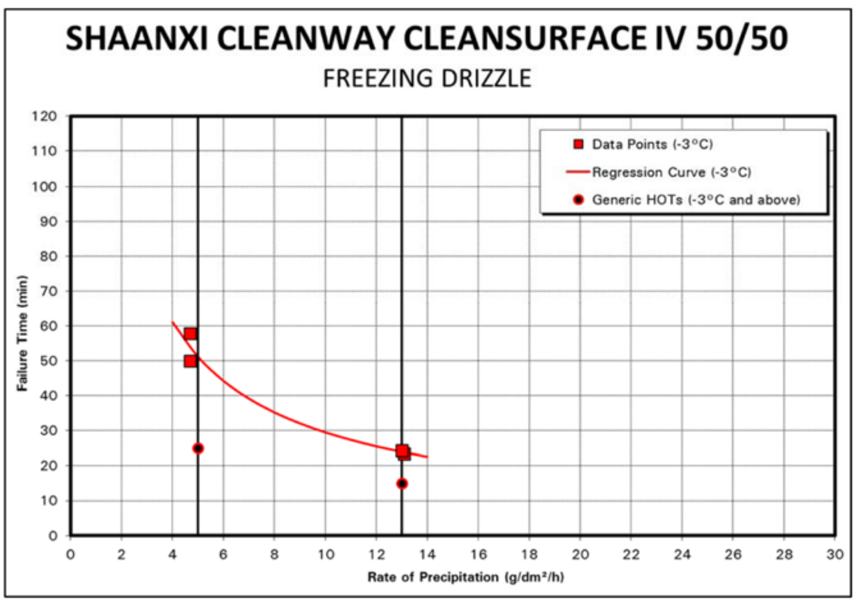


Figure 4.6: Type IV 50/50 – Freezing Drizzle

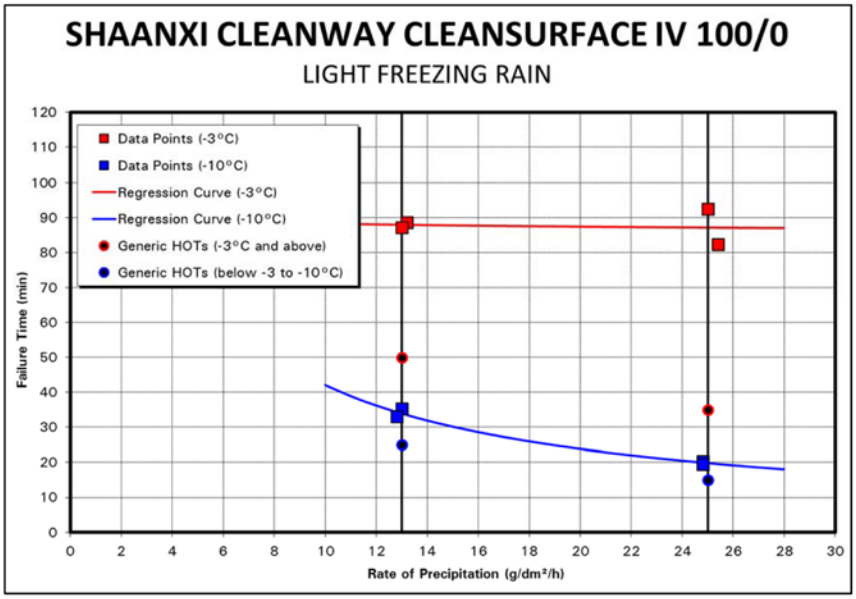


Figure 4.7: Type IV Neat – Light Freezing Rain

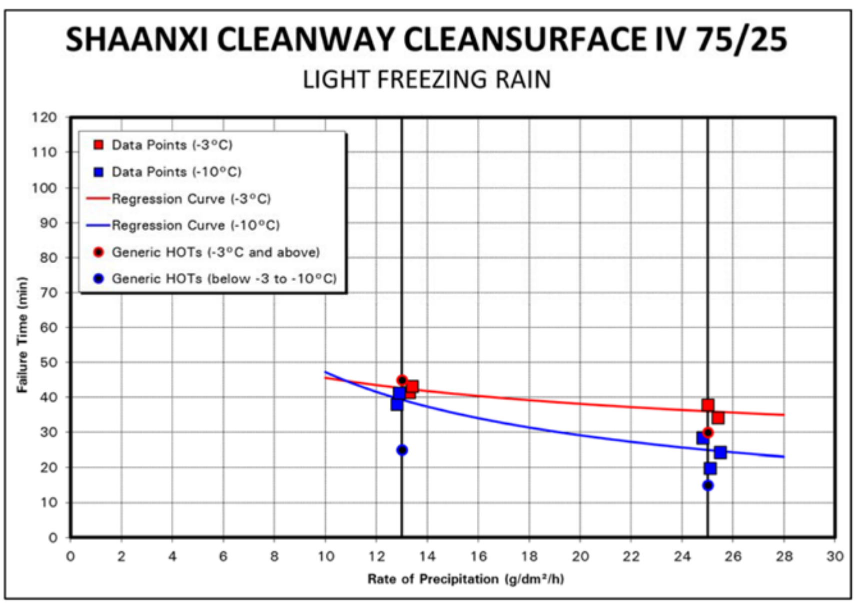


Figure 4.8: Type IV 75/25 – Light Freezing Rain

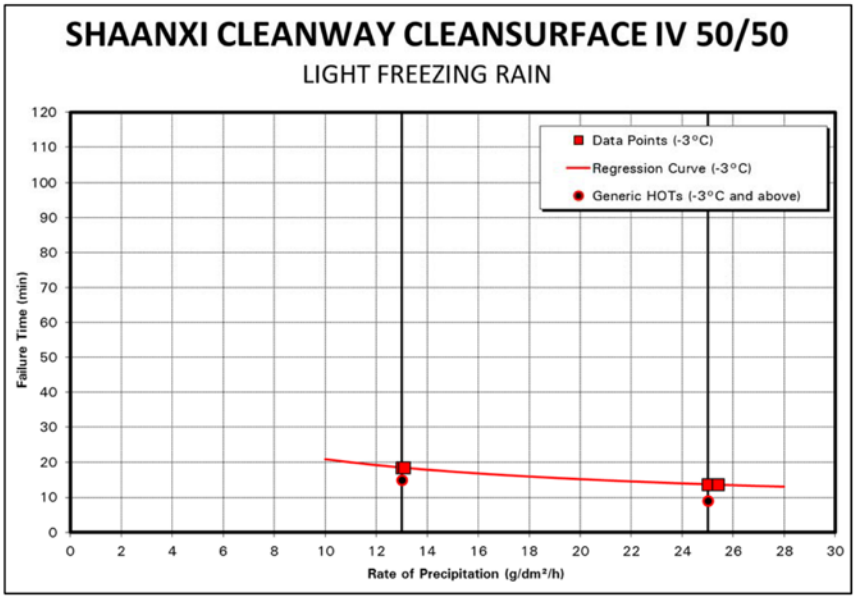


Figure 4.9: Type IV 50/50 – Light Freezing Rain

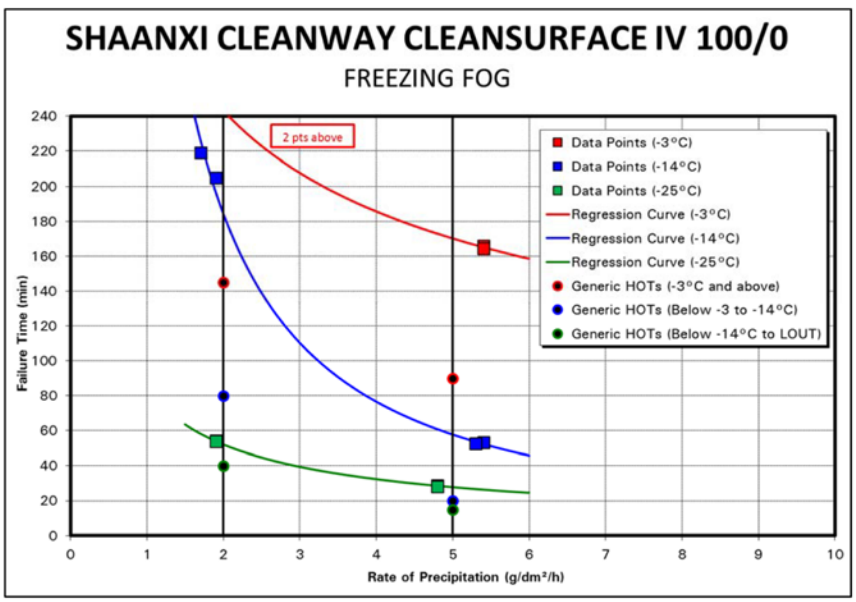


Figure 4.10: Type IV Neat – Freezing Fog

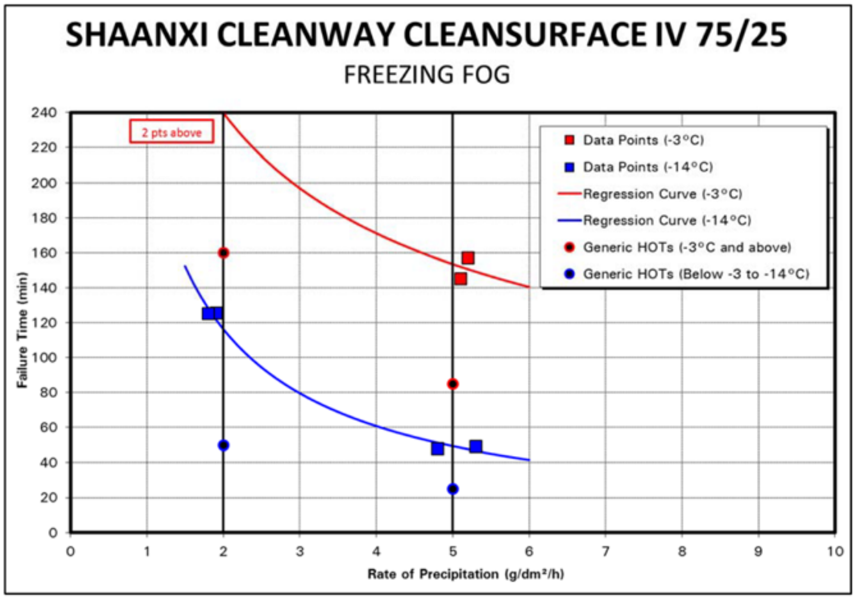


Figure 4.11: Type IV 75/25 – Freezing Fog

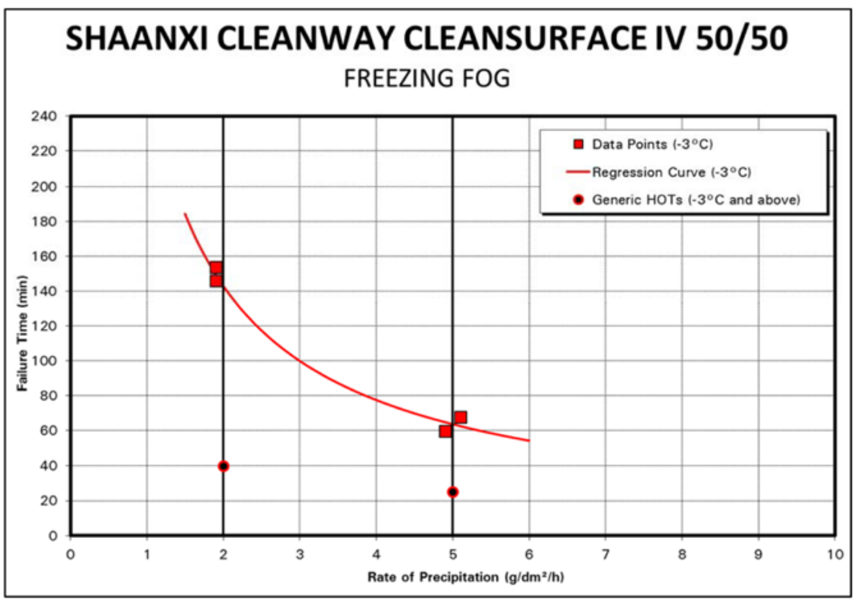


Figure 4.12: Type IV 50/50 – Freezing Fog

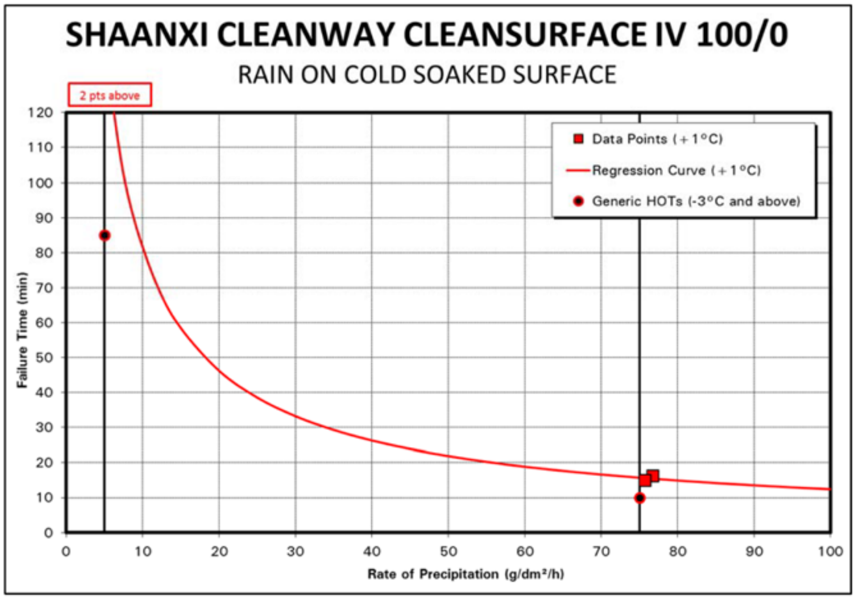


Figure 4.13: Type IV Neat – Rain on Cold-Soaked Surface

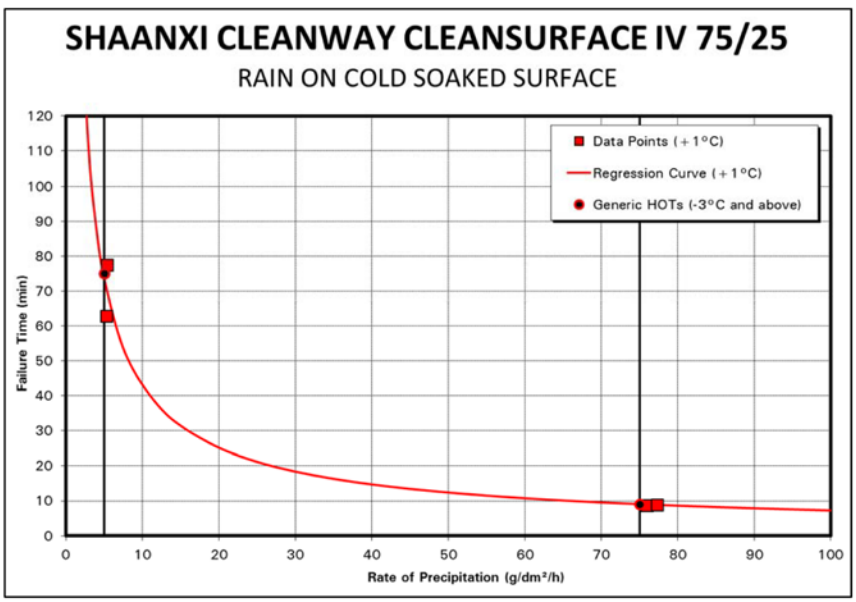


Figure 4.14: Type II 75/25 – Rain on Cold-Soaked Surface

Table 4.1: Regression Equation Coefficients for Shaanxi Cleanway Cleansurface IV

Natural Snow

Fluid	Dil	R^2	Intercept (I)	Coeff. Rate (A)	Coeff. Tem (B)	Total Pts.
Shaanxi Cleanway Cleansurface IV	Neat	90%	3.3279	-0.6974	-0.8278	31
Shaanxi Cleanway Cleansurface IV	75%	94%	3.2662	-0.8594	-0.6150	33
Shaanxi Cleanway Cleansurface IV	50%	94%	2.9686	-1.0764	-0.4446	18

General Equation $t = 10^I R^A (2-T)^B$

Simulated Freezing Fog

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Shaanxi Cleanway Cleansurface IV	Neat	-3°C	100%	2.5037	-0.3903	4
Shaanxi Cleanway Cleansurface IV	75/25	-3°C	98%	2.5266	-0.4875	4
Shaanxi Cleanway Cleansurface IV	50/50	-3°C	98%	2.4207	-0.8825	4
Shaanxi Cleanway Cleansurface IV	Neat	-14°C	100%	2.6480	-1.2687	4
Shaanxi Cleanway Cleansurface IV	75/25	-14°C	99%	2.3477	-0.9386	4
Shaanxi Cleanway Cleansurface IV	Neat	-25°C	100%	1.9241	-0.6900	4

General Equation $t = 10^I R^A$

Simulated Freezing Drizzle

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Shaanxi Cleanway Cleansurface IV	Neat	-3°C	79%	2.2230	-0.1299	4
Shaanxi Cleanway Cleansurface IV	75/25	-3°C	100%	2.7184	-0.9235	4
Shaanxi Cleanway Cleansurface IV	50/50	-3°C	98%	2.2650	-0.7956	4
Shaanxi Cleanway Cleansurface IV	Neat	-10°C	100%	2.7839	-1.1024	4
Shaanxi Cleanway Cleansurface IV	75/25	-10°C	99%	2.5842	-0.9804	4

General Equation $t = 10^I R^A$

Simulated Light Freezing Rain

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Shaanxi Cleanway Cleansurface IV	Neat	-3°C	1%	1.9595	-0.0138	4
Shaanxi Cleanway Cleansurface IV	75/25	-3°C	82%	1.9155	-0.2570	4
Shaanxi Cleanway Cleansurface IV	50/50	-3°C	100%	1.7827	-0.4609	4
Shaanxi Cleanway Cleansurface IV	Neat	-10°C	99%	2.4424	-0.8195	4
Shaanxi Cleanway Cleansurface IV	75/25	-10°C	77%	2.3692	-0.6948	6

General Equation $t = 10^I R^A$

Simulated Rain on Cold Soaked Wing

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Shaanxi Cleanway Cleansurface IV	Neat	+1°C	100%	2.7249	-0.8143	4
Shaanxi Cleanway Cleansurface IV	75%	+1°C	99%	2.4087	-0.7760	4

General Equation $t = 10^I R^A$

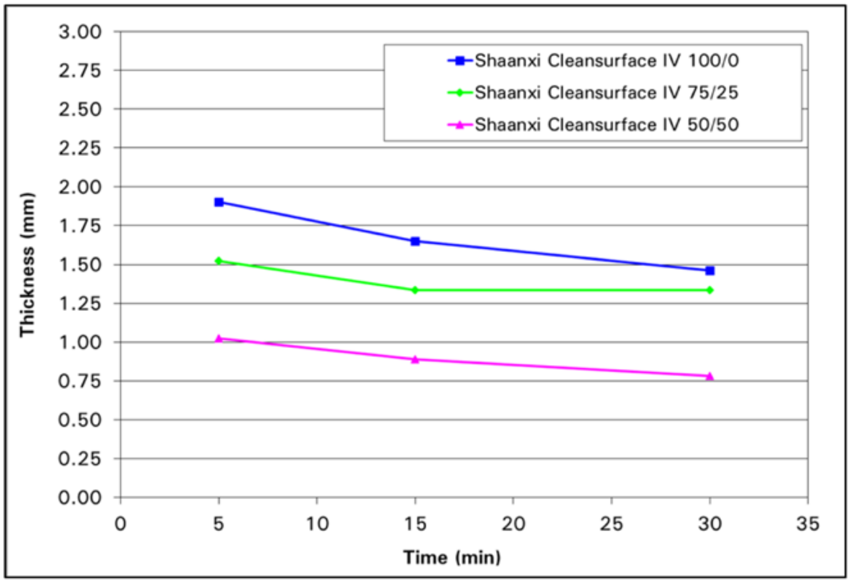


Figure 4.15: Fluid Thickness Profiles of Shaanxi Cleanway Cleansurface IV

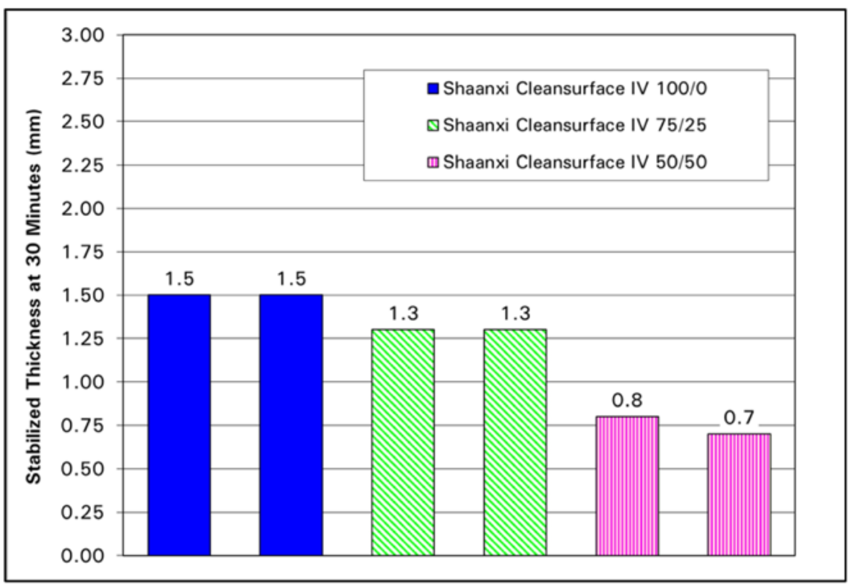


Figure 4.16: Final Fluid Thickness of Shaanxi Cleanway Cleansurface IV

4.2 Discussion

4.2.1 Holdover Time Table

The holdover times described in Subsection 4.1 were used to populate a fluid-specific HOT table for Shaanxi Cleanway Cleansurface IV. The HOT table is shown in both the TC format (Table 4.2) and FAA format (Table 4.3) at the end of this chapter.

4.2.2 Holdover Times in Snow, Below -14°C to LOUT

Very little endurance time data has been collected in natural snow at temperatures below -14°C. In the winter of 2003-04, testing was conducted with artificial snowmakers to collect additional data below -14°C. As a result of this testing, it was decided all Type II/IV fluids would be given generic values in the "Below -14 to LOUT" snow cells. Further testing in the winters of 2014-15 and 2015-16 in both natural and artificial snow determined the current Type II/IV generic HOTs for the "Below -14 to LOUT" snow cells. Accordingly, Shaanxi Cleanway Cleansurface IV has been given generic values in the "Below -14°C to LOUT" snow cells.

4.2.3 Holdover Times in Frost

It should be noted that frost holdover times are not included in the fluid-specific HOT tables. This is due to a decision made by TC and the FAA in May 2009 to move frost holdover times from the generic and fluid-specific HOT tables to a separate frost HOT table. Accordingly, frost holdover times have not been included in the Shaanxi Cleanway Cleansurface IV fluid-specific HOT table.

4.2.4 Fluid Viscosity

The viscosities of the fluid samples used in this testing were measured using both the AS9968 method and the manufacturer's designated method. The APS measured viscosities appear at the beginning of this document and will be published as the lowest on-wing viscosity (LOWV) values for the fluid. In order for the fluid-specific holdover times provided in this document to be valid, operators must ensure that the viscosity of the fluid being used is equal or greater than the published LOWV.

4.2.5 Lowest Operational Use Temperatures (LOUTs)

The LOUT for Type II/III/IV fluids is determined by the higher of:

a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type;

b) The actual freezing point of the fluid plus its freezing point buffer of 7°C (13°F); and

c) For fluid dilutions, the LOUT may also be limited by the coldest temperature for which holdover times are published (-3°C for 50/50; -14°C for 75/25).

The aerodynamic acceptance and freezing point information for this fluid is provided at the beginning of this document. The LOUTs for Shaanxi Cleanway Cleansurface IV are:

- 100/0: -28.5°C (-19.3°F)
- 75/25: -14°C (7°F)
- 50/50: -3°C (27°F)

4.2.6 Lowest Usable Precipitation Rates in Snow

The LUPRs for Shaanxi Cleanway Cleansurface IV were determined by analysing the natural snow data sets using the analysis methodology described in the report "*Methodology for Endurance Time Testing of Type II, III and IV Fluids – Winter 2015-16*," which is provided as an annex to this report. The resulting statistics are shown in Table 4.4. The analysis determined the LUPRs for Shaanxi Cleanway Cleansurface IV are:

- 100/0 = 2 g/dm²/h;
- 75/25 = 2 g/dm²/h; and
- 50/50 = 3 g/dm²/h.

4.2.7 Publication of Holdover Times

As Shaanxi Cleanway intends to commercialize Cleansurface IV, TC and FAA will publish its fluid-specific HOT table in their 2016-17 Holdover Time Guidelines. The guidelines will also include the LOWV and LOUT information; the regression and LUPR data will be published in the related TC and FAA Regression Information documents.

Table 4.2: Fluid Specific Holdover Time Guidelines – Shaanxi Cleanway Cleansurface IV (TC Format)

TABLE 4-SC-CS-IV

TYPE IV FLUID HOLDOVER TIME GUIDELINES
SHAANXI CLEANWAY AVIATION CLEANSURFACE IV

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:50 – 4:00	2:00	1:55 – 2:00	1:00 – 1:55	2:00 – 2:00	1:25 – 1:30	0:15 – 2:00	
		75/25	2:35 –4:00	2:00	1:35 – 2:00	0:45 – 1:35	0:50 – 2:00	0:35 – 0:45	0:09 – 1:15	
		50/50	1:05 – 2:25	1:40	0:40 – 1:40	0:15 – 0:40	0:25 – 0:50	0:15 – 0:20	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	1:00 – 3:05	1:20	0:45 – 1:20	0:25 – 0:45	0:35 – 1:45[7]	0:20 – 0:35[7]		
		75/25	0:50 – 1:55	1:40	0:45 – 1:40	0:20 – 0:45	0:30 – 1:20[7]	0:25 – 0:40[7]		
below -14 to -28.5	below 7 to -19.3	100/0	0:30 – 0:50	0:20	0:10 – 0:20	0:08 – 0:10				

NOTES
1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Table 4.3: Fluid Specific Holdover Time Guidelines – Shaanxi Cleanway Cleansurface IV (FAA Format)

TABLE 4O. TYPE IV HOLDOVER TIME GUIDELINES FOR SHAANXI CLEANWAY AVIATION CLEANSURFACE IV

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	2:50-4:00	3:00-3:00	1:55-3:00	1:00-1:55	2:00-2:00	1:25-1:30	0:15-2:00	
		75/25	2:35-4:00	3:00-3:00	1:35-3:00	0:45-1:35	0:50-2:00	0:35-0:45	0:09-1:15	
		50/50	1:05-2:25	1:40-2:20	0:40-1:40	0:15-0:40	0:25-0:50	0:15-0:20	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	1:00-3:05	1:20-1:40	0:45-1:20	0:25-0:45	0:35-1:45[7]	0:20-0:35[7]		
		75/25	0:50-1:55	1:40-2:10	0:45-1:40	0:20-0:45	0:30-1:20[7]	0:25-0:40[7]		
below -14 to -28.5	below 7 to -19.3	100/0	0:30-0:50	0:20-0:25	0:10-0:20	0:08-0:10				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

Table 4.4: LUPR Statistics – Shaanxi Cleanway Cleansurface IV

Data Measure	100/0		75/25		50/50	
	Stat	Rating	Stat	Rating	Stat	Rating
Total Data Points	31	40	33	40	18	30
Data Points -3 to -14°C	24	40	24	40	n/a	0
Data Points <10.0	14	40	13	40	6	20
Data Points <=9.5	14	40	13	40	6	40
Data Points <=8.5	14	40	13	40	6	40
Data Points <=7.5	13	40	12	40	6	40
Data Points <=6.5	12	40	11	40	5	40
Data Points <=5.5	9	40	8	40	4	40
Data Points <=4.5	5	40	5	40	4	40
Data Points <=3.5	4	40	3	40	3	40
Data Points <=2.5	3	40	2	30	1	20
Scatter 0-10 g	20%	20	22%	20	10%	30

Rate	100/0		75/25		50/50	
	Score	Pass/Fail	Score	Pass/Fail	Score	Pass/Fail
9 g/dm²/h	37	pass	37	pass	26	pass
8 g/dm²/h	37	pass	37	pass	26	pass
7 g/dm²/h	37	pass	37	pass	26	pass
6 g/dm²/h	37	pass	37	pass	26	pass
5 g/dm²/h	37	pass	37	pass	26	pass
4 g/dm²/h	37	pass	37	pass	26	pass
3 g/dm²/h	37	pass	37	pass	26	pass
2 g/dm²/h	37	pass	33	pass	18	fail

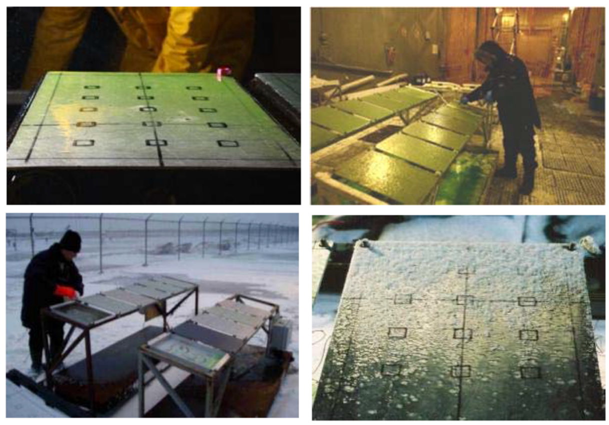
LUPR	100/0	75/25	50/50
	2 g/dm²/h	2 g/dm²/h	3 g/dm²/h

APPENDIX I

FLUID MANUFACTURER REPORT: DEICING SOLUTIONS ECO-SHIELD (TYPE IV)

AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

Deicing Solutions ECO-SHIELD (Type IV)



Prepared for

Deicing Solutions LLC

by

APS Aviation Inc.

These tests were made possible with the guidance, participation and contribution of the Transportation Development Centre of Transport Canada and the Federal Aviation Administration.

August 2016
Version 1.0
Report No. DS-ES 2015-16

AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

Deicing Solutions ECO-SHIELD (Type IV)

Prepared for

Deicing Solutions LLC

Prepared by:

Benjamin Bernier
Project Analyst

August 29, 2016
Date

Reviewed by:

Stephanie Bendickson
Senior Project Leader

August 29, 2016
Date

These tests were made possible with the guidance, participation and contribution of the Transportation Development Centre of Transport Canada and the Federal Aviation Administration.

August 2016
Version 1.0
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FLUID IDENTIFICATION AND CHARACTERISTICS

Manufacturer:	Deicing Solutions LLC
Fluid Test Name:	ECO-SHIELD
Fluid Commercial Name:	ECO-SHIELD®
Fluid Type / Base / Colour:	Type IV / Propylene Glycol / Green
Batch #:	160108D-CC
Dilutions Submitted:	100/0
Date of Receipt:	February 4, 2016
Brix (Measured):	37.75°
Freeze Point (Stated):	-34.0°C
Aerodynamic LOUT (AMIL):	-25.5°C

Viscosity:	**Stated**	**Measured**
Manufacturer Method[1]	11,400 cP	11,050 cP
AS 9968 Method[1]	11,400 cP	11,050 cP

WSET (from AMIL): 110 minutes

[1] Spindle LV1 (with guard leg), 600 mL low form (Griffin) beaker, 575 mL of fluid, 20°C, 0.3 rpm, for 10.0 minutes

SUMMARY

The primary objective of this project was to measure the endurance time performance of a new, higher viscosity sample of **Deicing Solutions ECO-SHIELD** over the entire range of conditions encompassed by the Holdover Time (HOT) tables. ECO-SHIELD was previously tested in the winter of 2014-15 and included in the 2015-16 HOT guidelines.

This report contains the results of these measurements and was completed with the support of the fluid manufacturer, the Transport Development Centre (TDC) of Transport Canada (TC) and the Federal Aviation Administration (FAA).

Tests were carried out according to the protocol provided in Aerospace Recommended Practice (ARP) 5485. The test procedure consisted of pouring fluids onto clean aluminum test surfaces inclined at 10°; the onset of failure was recorded as a function of time in natural and simulated precipitation.

Tests were performed at the APS Aviation Inc. (APS) test facility at Montréal-Pierre-Elliott-Trudeau International Airport and the National Research Council Canada (NRC) Climatic Engineering Facility (CEF) in Ottawa.

De/anti-icing fluid endurance times were derived from the data collected using multi-variable regression analysis. This resulted in the generation of the fluid-specific holdover times shown below. SAE ARP5718 provides the protocol for determining HOTs when multiple samples of a fluid undergo endurance time testing. As per that protocol, these holdover times supersede the previously published holdover times for ECO-SHIELD and therefore will be published by regulators for use in the winter 2016-17 operating season.

Deicing Solutions ECO-SHIELD Type IV Fluid Holdover Times

Outside Air Temperature (°C)	Type IV Fluid Concentration Neat Fluid/ Water (Vol %/Vol %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets*			Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
			Very Light	Light	Moderate				
-3 and above	100/0	1:15-2:40	2:25-2:50	1:20-2:25	0:45-1:20	0:40-1:30	0:35-0:40	0:15-1:35	
	75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	50/50	N/A	N/A	N/A	N/A	N/A	N/A	CAUTION: No holdover time guidelines exist	
below -3 to -14	100/0	1:10-2:35	1:55-2:15	1:05-1:55	0:35-1:05	0:50-1:25	0:30-0:40		
	75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -25.5	100/0	0:30-1:00	0:20-0:25	0:10-0:20	0:08-0:10				

**FAA values shown, Transport Canada will publish only the lower values for very light snow and caps all snow HOTs at two hours*

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GLOSSARY

APS	APS Aviation Inc.
ARP	Aerospace Recommended Practice
CEF	Climatic Engineering Facility
FAA	Federal Aviation Administration
HOT	Holdover Time
LOUT	Lowest Operational Use Temperature
LOWV	Lowest On-Wing Viscosity
LUPR	Lowest Usable Precipitation Rate
NRC	National Research Council Canada
TC	Transport Canada
TDC	Transportation Development Centre

1. INTRODUCTION

This report has been created with the support of the fluid manufacturer, the Transport Development Centre (TDC) of Transport Canada (TC) and the Federal Aviation Administration (FAA).

Aircraft ground de/anti-icing has been the subject of concentrated industry attention in recent years due to the occurrence of several fatal icing-related aircraft accidents. Notably, attention has been placed on the enhancement of anti-icing fluids in order to provide an extended period of protection against further contamination following initial deicing. This emphasis has led to the development of fluid-specific de/anti-icing fluid holdover time (HOT) tables for Type II, Type III and Type IV fluids. These tables, accepted by regulatory authorities, are used by aircraft operators for departure planning in adverse winter conditions. Specifically, they provide the duration of time that qualified fluids provide protection against ice formation under specific weather conditions.

New anti-icing formulations continue to be developed by leading manufacturers with the specific objective of prolonging fluid holdover times without compromising the aerodynamic features of the airfoil. The purpose of the endurance time testing program is to measure the endurance times of these new fluids and develop fluid-specific HOT tables that provide guidance for their use.

Flat plate tests, conducted in natural and simulated precipitation, are used to develop HOT values for new fluids. These tests are carried out according to SAE Aerospace Recommended Practice (ARP) ARP5485, which provides the test protocols for measuring endurance times of Type II, III and IV fluids. Along with its counterpart for measuring endurance times of Type I fluids ARP5945, ARP5485 has evolved into a refined procedure for measuring the duration of de/anti-icing fluid protection against ice formation.

The current data analysis protocol for developing HOT values from endurance time data was developed in 1996-97 and uses multi-variable regression to obtain HOT values. HOT values are derived for the majority of cells in Type II/III/IV HOT tables using this protocol and are used to create a fluid-specific HOT table for each Type II/III/IV fluid tested.

This report provides a detailed account of the endurance time testing conducted by APS Aviation Inc. (APS) with a new, higher viscosity sample of the Type IV fluid **Deicing Solutions ECO-SHIELD**, which was previously tested in the winter of 2014-15 and included in the 2015-16 HOT guidelines. It describes the test methodology used, endurance time data collected, and analysis completed to derive fluid-specific holdover times for the fluid.

2. METHODOLOGY

Tests were carried out according to SAE Aerospace Recommended Practice (ARP) 5485, which provides the procedure and requirements for endurance time testing with Type II, III, and IV fluids under natural and simulated conditions.

The test methodology for endurance time testing carried out in the winter of 2015-16 is documented in detail in the report "*Methodology for Endurance Time Testing of Type II, III and IV Fluids – Winter 2015-16.*" A copy of this report is provided as an annex to this document.

The methodology report summarizes the key aspects of the test methodology, including some aspects included in ARP5485 and some aspects which are not included in ARP54855. It includes sections on:

a) Test Sites;

b) Test Equipment;

c) Test Procedures;

d) Precipitation Rates used in Type I, II, III and IV Endurance Time Testing;

e) Ambient Temperatures used in Type I, II, III and IV Endurance Time Testing;

f) Freezing Precipitation Droplet Sizes; and

g) Analysis Methodologies.

The data, analysis and results provided in this report are a function of the test and analysis methodologies described in the methodology report. They should only be used in conjunction with the methodologies described therein.

3. DESCRIPTION OF DATA

This section provides a summary of the number of tests conducted. Breakdowns are provided for the number of tests performed by test type, precipitation type, fluid dilution and test temperature.

3.1 Natural and Artificial Snow Tests

Tests were conducted in natural snow conditions at the APS test site and at several mobile test sites (refer to the report annex for details). No artificial snow tests were conducted. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

Fluid Dilution	Natural Snow			Artificial Snow		
	≥ -3°C	-3 to -14°C	< -14°C	-3°C	-14°C	-25°C
Neat	9	17	3	0	0	0
75/25	0	0	0	0	0	0
50/50	0	0	0	0	0	0

3.2 Freezing Precipitation Tests

Tests were conducted in freezing drizzle, light freezing rain, freezing fog and rain on cold-soaked surface conditions at the NRC CEF. The number of tests conducted is summarized below by precipitation type, fluid dilution and test temperature.

Fluid Dilution	Freezing Drizzle		Light Freezing Rain		Freezing Fog			Cold Soak
	-3°C	-10°C	-3°C	-10°C	-3°C	-14°C	-25°C	+1°C
Neat	4	4	4	4	6	4	4	4
75/25	0	0	0	0	0	0	0	0
50/50	0	0	0	0	0	0	0	0

3.3 Natural Frost Tests

Tests were conducted in natural frost at the APS test site. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

Fluid Dilution	Natural Frost			
	≥-1°C	<-1 to -3°C	<-3 to -10°C	<-10°C
Neat	0	0	0	1
75/25	0	0	0	0
50/50	0	0	0	0

3.4 Fluid Thickness Tests

Fluid thickness tests were conducted to measure the film thickness profiles of the fluid under dry conditions. Two tests were performed for each dilution. For each test, 1 litre of fluid was poured onto a flat plate mounted on a test stand inclined by 10°. Thickness measurements were taken at the 15-cm (6") line at select time intervals over a 30-minute period. Tests were conducted at -3°C.

3.5 Test Logs

Details of each test conducted are provided in the test logs included as Table 3.1 (snow) Table 3.2 (freezing precipitation), and Table 3.3 (frost).

Table 3.1: Summary of Tests Performed (Snow)

Test No.	Date	Snow Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
300	9-Feb-16	Natural Snow	ECO-SHIELD	100%	-7.8	0.9	463.0
302	9-Feb-16	Natural Snow	ECO-SHIELD	100%	-8.0	1.3	354.0
303	12-Feb-16	Natural Snow	ECO-SHIELD	100%	-6.7	6.3	133.6
315	12-Feb-16	Natural Snow	ECO-SHIELD	100%	-6.6	4.5	144.9
316	12-Feb-16	Natural Snow	ECO-SHIELD	100%	-6.9	5.0	171.7
319	12-Feb-16	Natural Snow	ECO-SHIELD	100%	-8.4	11.3	50.5
340	16-Feb-16	Natural Snow	ECO-SHIELD	100%	-7.3	13.0	75.1
343	16-Feb-16	Natural Snow	ECO-SHIELD	100%	-7.4	10.9	82.4
346	16-Feb-16	Natural Snow	ECO-SHIELD	100%	-7.2	12.5	83.3
349	16-Feb-16	Natural Snow	ECO-SHIELD	100%	-6.8	21.1	48.5
352	16-Feb-16	Natural Snow	ECO-SHIELD	100%	-6.3	31.2	45.1
359	19-Feb-16	Natural Snow	ECO-SHIELD	100%	0.2	12.6	79.3
374	19-Feb-16	Natural Snow	ECO-SHIELD	100%	-0.8	16.5	56.4
410	24-Feb-16	Natural Snow	ECO-SHIELD	100%	-3.5	4.1	211.5
413	24-Feb-16	Natural Snow	ECO-SHIELD	100%	-3.1	7.2	86.7
425	24-Feb-16	Natural Snow	ECO-SHIELD	100%	-1.5	18.5	54.2
435	24-Feb-16	Natural Snow	ECO-SHIELD	100%	-1.2	22.1	44.0
438	24-Feb-16	Natural Snow	ECO-SHIELD	100%	-1.1	17.6	60.8
444	22-Mar-16	Natural Snow	ECO-SHIELD	100%	0.2	10.2	72.7
446	22-Mar-16	Natural Snow	ECO-SHIELD	100%	0.2	9.2	78.7
450	23-Mar-16	Natural Snow	ECO-SHIELD	100%	0.1	8.1	85.2
451	23-Mar-16	Natural Snow	ECO-SHIELD	100%	0.1	7.9	84.7
456	24-Mar-16	Natural Snow	ECO-SHIELD	100%	-5.4	8.8	119.8
460	24-Mar-16	Natural Snow	ECO-SHIELD	100%	-5.1	16.4	84.2
471	24-Mar-16	Natural Snow	ECO-SHIELD	100%	-6.6	12.4	82.6
485	24-Mar-16	Natural Snow	ECO-SHIELD	100%	-6.3	42.2	27.4
C50	26-Feb-16	Natural Snow	ECO-SHIELD	100%	-24.3	1.5	106.8
C84	27-Feb-16	Natural Snow	ECO-SHIELD	100%	-23.2	5.6	43.2
C115	27-Feb-16	Natural Snow	ECO-SHIELD	100%	-22.4	4.2	43.0

Table 3.2: Summary of Tests Performed (Freezing Precipitation)

Test No.	Date	Precipitation Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
27	30-Mar-16	Freezing Fog	ECO-SHIELD	100%	-3.2	1.9	169.4
28	30-Mar-16	Freezing Fog	ECO-SHIELD	100%	-3.2	1.9	169.5
55	4-Apr-16	Freezing Fog	ECO-SHIELD	100%	-3.0	5.1	76.5
55R	4-Apr-16	Freezing Fog	ECO-SHIELD	100%	-3.3	4.6	77.0
56	4-Apr-16	Freezing Fog	ECO-SHIELD	100%	-3.0	4.9	77.4
56R	4-Apr-16	Freezing Fog	ECO-SHIELD	100%	-3.3	4.8	75.8
77	31-Mar-16	Freezing Fog	ECO-SHIELD	100%	-14.1	1.7	176.7
78	31-Mar-16	Freezing Fog	ECO-SHIELD	100%	-14.1	1.9	164.9
95	31-Mar-16	Freezing Fog	ECO-SHIELD	100%	-14.1	5.4	68.0
96	31-Mar-16	Freezing Fog	ECO-SHIELD	100%	-14.1	5.3	66.3
107	1-Apr-16	Freezing Fog	ECO-SHIELD	100%	-25.2	1.8	64.1
108	1-Apr-16	Freezing Fog	ECO-SHIELD	100%	-25.2	1.9	63.6
119	1-Apr-16	Freezing Fog	ECO-SHIELD	100%	-25.3	4.6	34.1
120	1-Apr-16	Freezing Fog	ECO-SHIELD	100%	-25.3	4.8	32.8
151	4-Apr-16	Freezing Drizzle	ECO-SHIELD	100%	-2.9	4.7	89.9
152	4-Apr-16	Freezing Drizzle	ECO-SHIELD	100%	-2.9	5.1	88.9
179	7-Apr-16	Freezing Drizzle	ECO-SHIELD	100%	-3.2	13.4	36.6
180	7-Apr-16	Freezing Drizzle	ECO-SHIELD	100%	-3.2	13.0	40.9
199	5-Apr-16	Freezing Drizzle	ECO-SHIELD	100%	-10.2	4.8	83.5
200	5-Apr-16	Freezing Drizzle	ECO-SHIELD	100%	-10.2	4.8	93.7
219	5-Apr-16	Freezing Drizzle	ECO-SHIELD	100%	-10.3	13.1	50.1
220	5-Apr-16	Freezing Drizzle	ECO-SHIELD	100%	-10.3	13.4	52.0
247	6-Apr-16	Light Freezing Rain	ECO-SHIELD	100%	-3.2	13.0	40.6
248	6-Apr-16	Light Freezing Rain	ECO-SHIELD	100%	-3.2	13.4	43.6
275	6-Apr-16	Light Freezing Rain	ECO-SHIELD	100%	-3.3	25.4	36.7
276	6-Apr-16	Light Freezing Rain	ECO-SHIELD	100%	-3.3	25.4	37.9
295	5-Apr-16	Light Freezing Rain	ECO-SHIELD	100%	-10.1	13.0	38.3
296	5-Apr-16	Light Freezing Rain	ECO-SHIELD	100%	-10.1	12.7	41.2
315	6-Apr-16	Light Freezing Rain	ECO-SHIELD	100%	-9.9	24.8	30.3
316	6-Apr-16	Light Freezing Rain	ECO-SHIELD	100%	-9.9	24.8	33.3
335	7-Apr-16	Cold Soak Box	ECO-SHIELD	100%	1.1	5.1	92.3
336	7-Apr-16	Cold Soak Box	ECO-SHIELD	100%	1.0	5.4	87.2
355	7-Apr-16	Cold Soak Box	ECO-SHIELD	100%	1.0	76.7	12.8
356	7-Apr-16	Cold Soak Box	ECO-SHIELD	100%	1.0	76.2	13.0

Table 3.3: Summary of Tests Performed (Natural Frost)

Test No.	Date	Precip. Type	Fluid Name	Fluid Dilution	Test Duration (min.)	Average Rate (g/dm²/h)	Temp (°C)	Wind Speed (km/h)	Average RH (%)	Comments
36	Feb-18-16	Natural Frost	ECO-SHIELD	100%	427	0.15	-12.5	6	85	Did Not Fail

4. RESULTS AND DISCUSSION

The methods used to evaluate the test data are provided in the report "*Methodology for Endurance Time Testing of Type II, III and IV Fluids – Winter 2015-16,*" which is provided as an annex to this report. The results of the data analyses and a discussion of the findings are presented in this section.

4.1 Results

The results of the endurance time and thickness tests are described in this section.

4.1.1 Endurance Time Tests – Natural Snow and Freezing Precipitation

Figures 4.1 to 4.5 present the endurance time data collected in natural snow and freezing precipitation (freezing drizzle, light freezing rain, freezing fog and rain on cold-soaked surface).

These figures show the effect of temperature, precipitation type and precipitation rate on fluid endurance time in the conditions encompassed by the Type IV HOT guidelines. The figures include the current Type IV generic holdover times for comparative purposes.

Multi-variable regression analysis was performed on these data sets as described in the annex. Table 4.1 provides the outputs from the multi-variable regression analyses. These outputs were used to derive fluid-specific holdover times for all conditions encompassed by Type IV fluid-specific HOT tables. One exception is the coldest temperature band snow cells (see Subsection 4.2.2).

4.1.2 Endurance Time Tests – Natural Frost

The natural frost data was presented in Table 3.3. The test durations were compared to the Type IV generic holdover times. Tests that were not completed (due to active frost ending before fluid failure could occur) surpassed the generic holdover times. This analysis indicates the Type IV generic frost holdover times can be considered substantiated for Deicing Solutions ECO-SHIELD.

4.1.3 Fluid Thickness Tests

Figure 4.6 shows the fluid thickness test data. As described in Subsection 3.4, two tests were conducted at an ambient temperature of -3°C. The final fluid thicknesses are displayed in Figure 4.7.

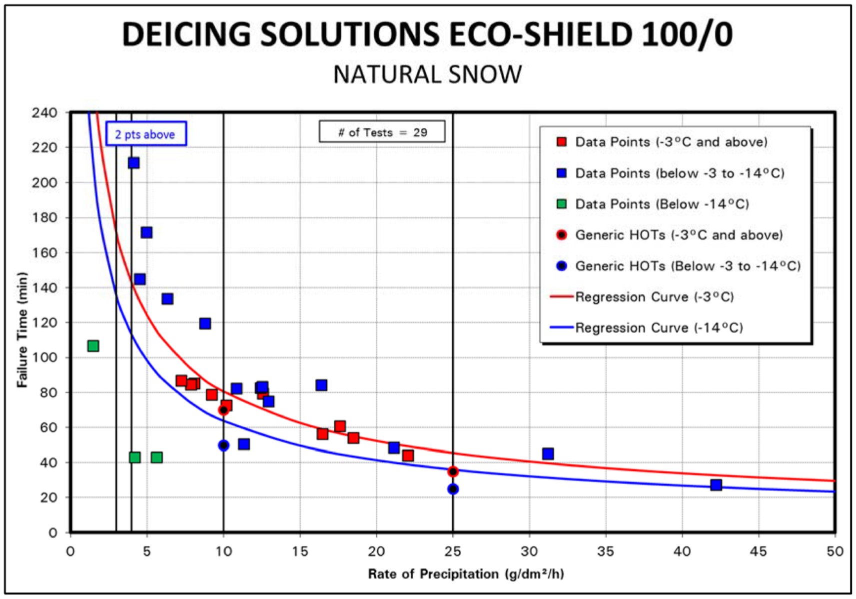

Figure 4.1: Type IV Neat – Natural Snow

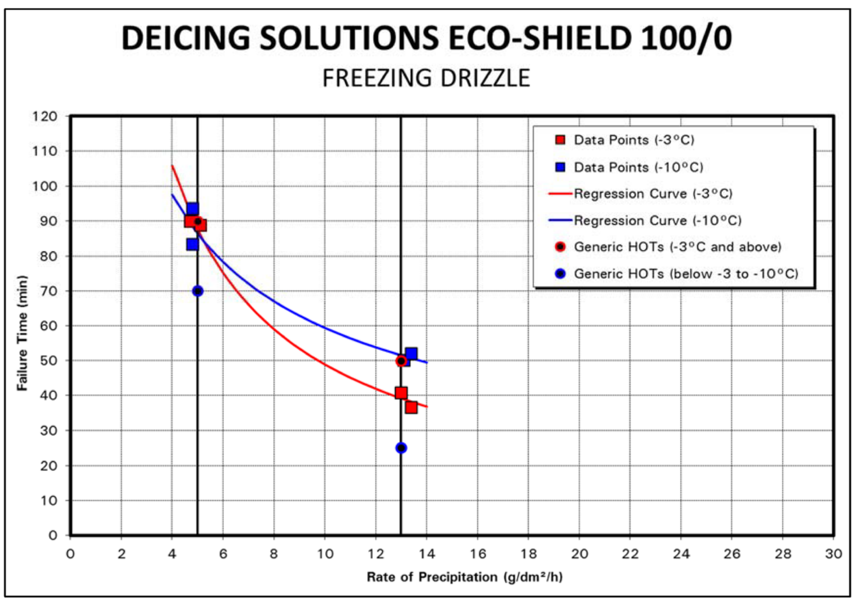

Figure 4.2: Type IV Neat – Freezing Drizzle

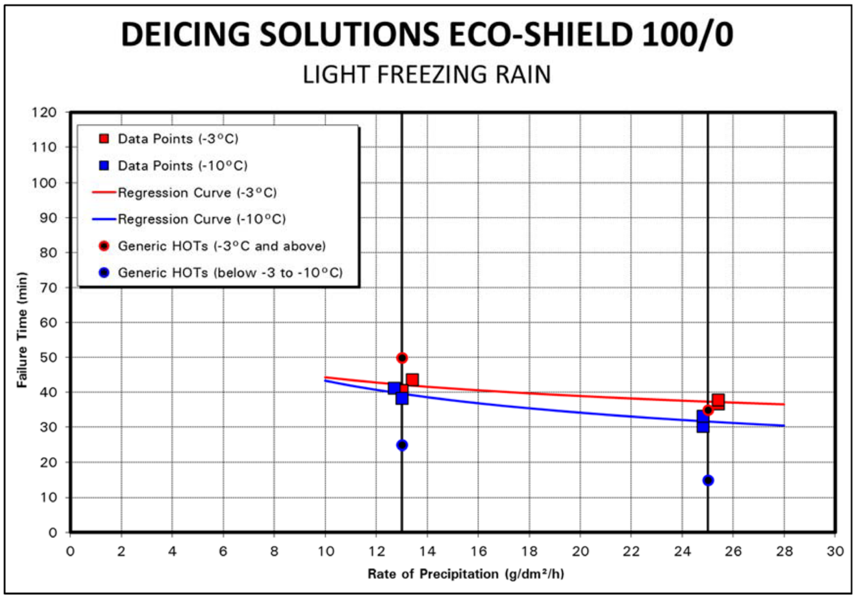

Figure 4.3: Type IV Neat – Light Freezing Rain

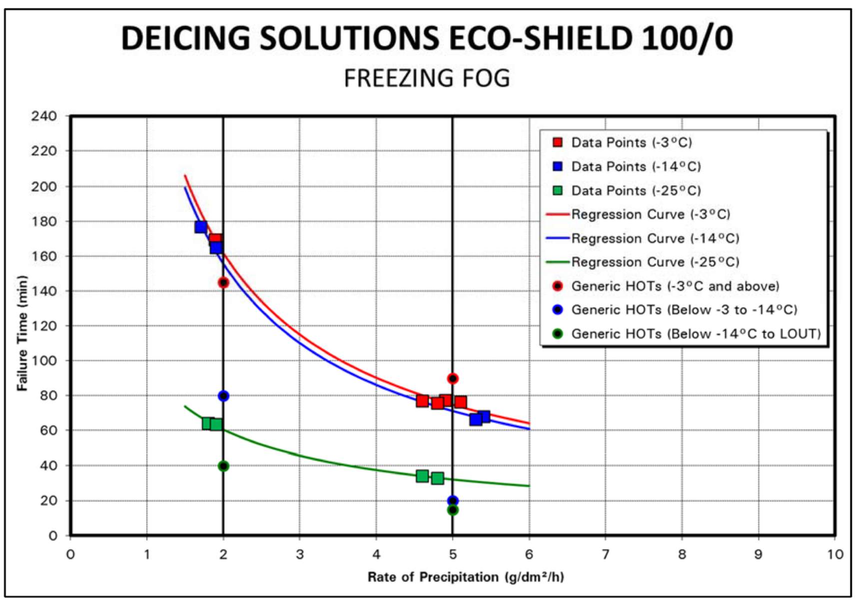

Figure 4.4: Type IV Neat – Freezing Fog

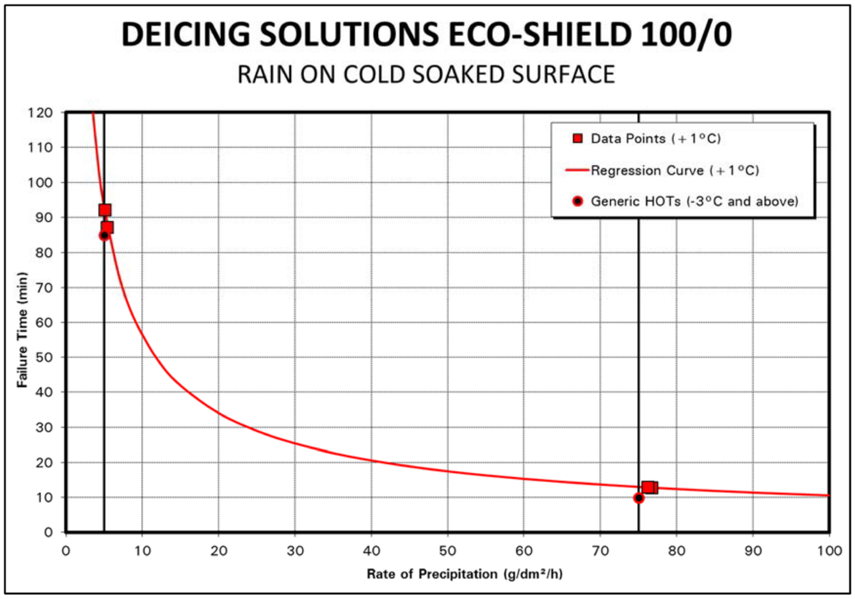

Figure 4.5: Type IV Neat – Rain on Cold-Soaked Surface

Table 4.1: Regression Equation Coefficients for Deicing Solutions ECO-SHIELD

Natural Snow

Fluid	Dil	R^2	Intercept (I)	Coeff. Rate (A)	Coeff. Tem (B)	Total Pts.
Deicing Solutions ECO-SHIELD	Neat	69%	2.6693	-0.6224	-0.2015	29

General Equation $t = 10^{I}\, R^{A}\, (2\text{-}T)^{B}$

Simulated Freezing Fog

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Deicing Solutions ECO-SHIELD	Neat	-3°C	100%	2.4628	-0.8425	6
Deicing Solutions ECO-SHIELD	Neat	-14°C	100%	2.4493	-0.8541	4
Deicing Solutions ECO-SHIELD	Neat	-25°C	100%	1.9894	-0.6913	4

General Equation $t = 10^{I}\, R^{A}$

Simulated Freezing Drizzle

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Deicing Solutions ECO-SHIELD	Neat	-3°C	99%	2.5329	-0.8434	4
Deicing Solutions ECO-SHIELD	Neat	-10°C	97%	2.3150	-0.5411	4

General Equation $t = 10^{I}\, R^{A}$

Simulated Light Freezing Rain

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Deicing Solutions ECO-SHIELD	Neat	-3°C	80%	1.8305	-0.1843	4
Deicing Solutions ECO-SHIELD	Neat	-10°C	89%	1.9809	-0.3441	4

General Equation $t = 10^{I}\, R^{A}$

Simulated Rain on Cold Soaked Wing

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Deicing Solutions ECO-SHIELD	Neat	+1°C	100%	2.4740	-0.7236	4

General Equation $t = 10^{I}\, R^{A}$

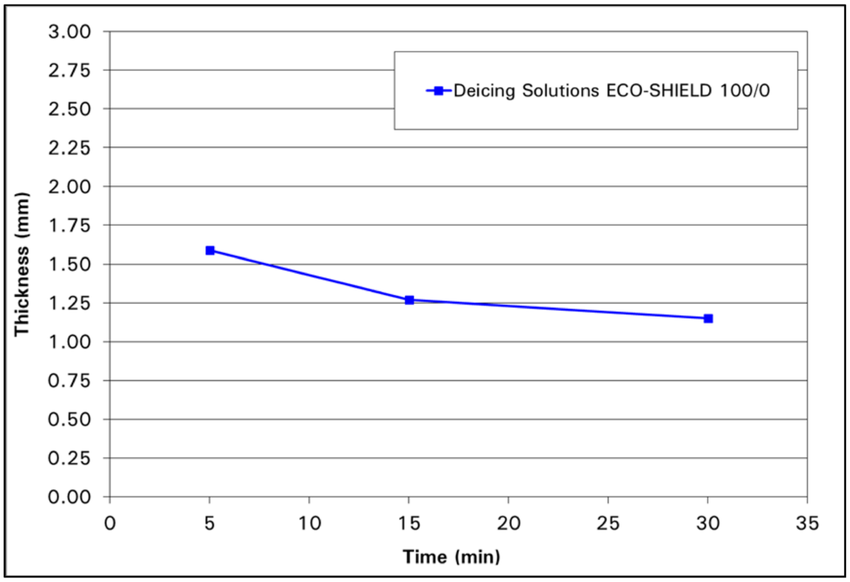

Figure 4.6: Fluid Thickness Profiles of Deicing Solutions ECO-SHIELD

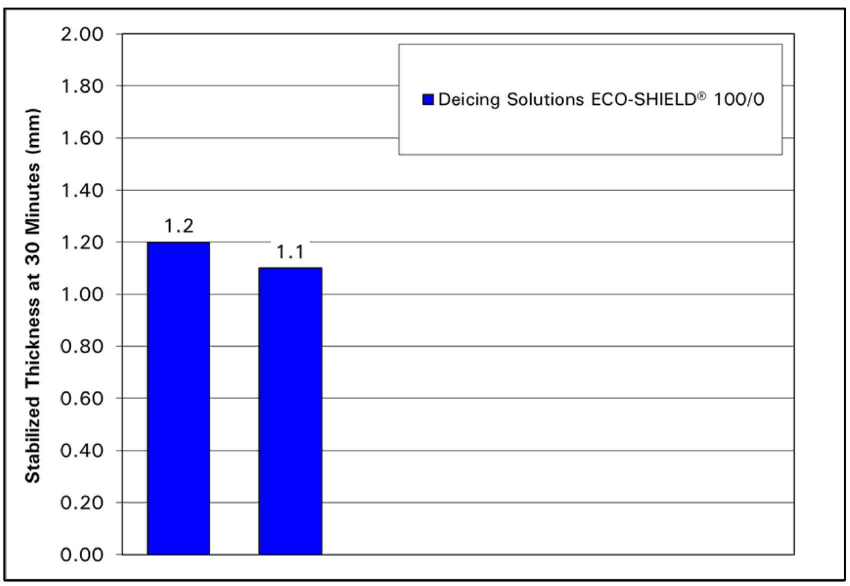

Figure 4.7: Final Fluid Thickness of Deicing Solutions ECO-SHIELD

4.2 Discussion

4.2.1 Holdover Time Table

The holdover times described in Subsection 4.1 were used to populate a fluid-specific HOT table for Deicing Solutions ECO-SHIELD. The HOT table is shown in both the TC format (Table 4.2) and FAA format (Table 4.3) at the end of this chapter.

4.2.2 Holdover Times in Snow, Below -14°C to LOUT

Very little endurance time data has been collected in natural snow at temperatures below -14°C. In the winter of 2003-04, testing was conducted with artificial snowmakers to collect additional data below -14°C. As a result of this testing, it was decided all Type II/IV fluids would be given generic values in the "Below -14 to LOUT" snow cells. Further testing in the winters of 2014-15 and 2015-16 in both natural and artificial snow determined the current Type II/IV generic HOTs for the "Below -14 to LOUT" snow cells. Accordingly, Deicing Solutions ECO-SHIELD has been given generic values in the "Below -14°C to LOUT" snow cells.

4.2.3 Holdover Times in Frost

It should be noted that frost holdover times are not included in the fluid-specific HOT tables. This is due to a decision made by TC and the FAA in May 2009 to move frost holdover times from the generic and fluid-specific HOT tables to a separate frost HOT table. Accordingly, frost holdover times have not been included in the Deicing Solutions ECO-SHIELD fluid-specific HOT table.

4.2.4 Fluid Viscosity

The viscosities of the fluid samples used in this testing were measured using both the AS9968 method and the manufacturer's designated method. The APS measured viscosities appear at the beginning of this document and will be published as the lowest on-wing viscosity (LOWV) values for the fluid. In order for the fluid-specific holdover times provided in this document to be valid, operators must ensure that the viscosity of the fluid being used is equal or greater than the published LOWV.

4.2.5 Lowest Operational Use Temperatures (LOUTs)

The LOUT for Type II/III/IV fluids is determined by the higher of:

a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type;

b) The actual freezing point of the fluid plus its freezing point buffer of 7°C (13°F); and

c) For fluid dilutions, the LOUT may also be limited by the coldest temperature for which holdover times are published (-3°C for 50/50; -14°C for 75/25).

The aerodynamic acceptance and freezing point information for this fluid is provided at the beginning of this document. The LOUT for Deicing Solutions ECO-SHIELD 100/0 is -25.5°C (-13.9°F)

4.2.6 Lowest Usable Precipitation Rates in Snow

The LUPRs for Deicing Solutions ECO-SHIELD were determined by analysing the natural snow data sets using the analysis methodology described in the report "*Methodology for Endurance Time Testing of Type II, III and IV Fluids – Winter 2015-16*," which is provided as an annex to this report. The resulting statistics are shown in Table 4.4. The analysis determined the LUPR for Deicing Solutions ECO-SHIELD 100/0 is 2 g/dm²/h;

4.2.7 Publication of Holdover Times

SAE ARP5718 provides the protocol for determining HOTs when multiple samples of a fluid undergo endurance time testing. The pertinent parts of Subsection 5.5.4 (Fluid Retesting) are excerpted below.

> *If a new sample of a fluid with the same name is submitted for ARP5485 testing, even if it is submitted years after the earlier submission, the HOT guidelines will be readjusted as follows:*
>
> *b. If the LOWV of the new sample is above the original sample, the fluid manufacturer shall have the choice of:*
>
> *2. selecting the new higher LOWV in which case the data from the earlier sample shall be eliminated and the new sample shall be used to calculate revised fluid-specific and generic holdover time guidelines.*

Deicing Solutions elected to use the new higher LOWV. Therefore, the data in this report will be used to populate the ECO-SHIELD fluid-specific holdover time tables published by TC and FAA in their 2016-17 Holdover Time Guidelines. The guidelines will also be updated to include the new LOWV and LOUT information; the updated regression and LUPR data will be published in the related TC and FAA Regression Information documents.

Table 4.2: Fluid Specific Holdover Time Guidelines – Deicing Solutions ECO-SHIELD (TC Format)

TABLE 4-DS-ES

TYPE IV FLUID HOLDOVER TIME GUIDELINES
DEICING SOLUTIONS ECO-SHIELD®

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:15 – 2:40	2:00	1:20 – 2:00	0:45 – 1:20	0:40 – 1:30	0:35 – 0:40	0:15 – 1:35	
		75/25								
		50/50								
below -3 to -14	below 27 to 7	100/0	1:10 – 2:35	1:55	1:05 – 1:55	0:35 – 1:05	0:50 – 1:25[7]	0:30 – 0:40[7]	CAUTION: No holdover time guidelines exist	
		75/25								
below -14 to -25.5	below 7 to -13.9	100/0	0:30 – 1:00	0:20	0:10 – 0:20	0:08 – 0:10				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Table 4.3: Fluid Specific Holdover Time Guidelines – Deicing Solutions ECO-SHIELD (FAA Format)

TABLE 4I. TYPE IV HOLDOVER TIME GUIDELINES FOR
DEICING SOLUTIONS ECO-SHIELD®

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:15-2:40	2:25-2:50	1:20-2:25	0:45-1:20	0:40-1:30	0:35-0:40	0:15-1:35	
		75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		50/50	N/A	N/A	N/A	N/A	N/A	N/A	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	1:10-2:35	1:55-2:15	1:05-1:55	0:35-1:05	0:50-1:25[7]	0:30-0:40[7]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -25.5	below 7 to -13.9	100/0	0:30-1:00	0:20-0:25	0:10-0:20	0:08-0:10				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

Table 4.4: LUPR Statistics – Deicing Solutions ECO-SHIELD

Data Measure	100/0	
	Stat	Rating
Total Data Points	29	40
Data Points -3 to -14°C	20	40
Data Points <10.0	14	40
Data Points <=9.5	14	40
Data Points <=8.5	12	40
Data Points <=7.5	10	40
Data Points <=6.5	9	40
Data Points <=5.5	7	40
Data Points <=4.5	6	40
Data Points <=3.5	3	40
Data Points <=2.5	3	40
Scatter 0-10 g	39%	10

Rate	100/0	
	Score	Pass/Fail
9 g/dm²/h	36	pass
8 g/dm²/h	36	pass
7 g/dm²/h	36	pass
6 g/dm²/h	36	pass
5 g/dm²/h	36	pass
4 g/dm²/h	36	pass
3 g/dm²/h	36	pass
2 g/dm²/h	36	pass

LUPR	100/0
	2 g/dm²/h

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APPENDIX J

TRANSPORT CANADA AND FEDERAL AVIATION ADMINISTRATION HOLDOVER TIME GUIDELINES, WINTER 2016-2017

TRANSPORT CANADA
HOLDOVER TIME (HOT) GUIDELINES
WINTER 2016-2017

Transport Canada
Holdover Time (HOT) Guidelines
Winter 2016-2017

Original Issue: Aug. 5, 2016

This document should be used in conjunction with *Guidelines for Aircraft Ground-Icing Operations* (TP 14052E, second edition, April 2005).

The two documents complement each other and should be used together for a thorough understanding of the subject matter.

Questions or comments on the content of the holdover time guidelines should be addressed to
Transport Canada Civil Aviation Communication Centre
Telephone 1-800-305-2059 Facsimile 613-957-4208 E-mail services@tc.gc.ca

To receive notification of HOT Guideline updates, subscribe to or update your e-news subscription at the following Transport Canada Web site:
http://wwwapps.tc.gc.ca/Comm/5/ListServ/menu.aspx
Subscribing to e-news will require an email address and selecting Holdover Time (HOT) Guidelines under Publications / Air Transportation / Aviation Safety - Safety Information.

CHANGE CONTROL RECORDS

This page indicates any changes made to individual pages within the document. Changed pages have the appropriate revision date in the footer. Sidebars are shown to assist in identifying where significant changes have been made on these pages.

It is the responsibility of the end user to periodically check the following website for updates on Holdover Time Guidelines: http://www.tc.gc.ca/eng/civilaviation/standards/commerce-holdovertime-menu-1877.htm.

REVISION	*DATE*	*DESCRIPTION OF CHANGES*	*AFFECTED PAGES*	*AUTHOR*

SUMMARY OF CHANGES FROM PREVIOUS YEAR

The principal changes from the previous year are briefly indicated herein.

Active Frost

- A note has been added to the active frost holdover time (HOT) table to provide guidance on the appropriate outside air temperature to select in changing conditions.

Type I Fluid

- The Type I HOT guidelines are unchanged.

Type II Fluid

- Fluid-specific HOT guidelines have been created for the new Type II fluid Beijing Yadilite Aviation YD-102 Type II.
- LNT Solutions P250 has been removed from the Type II guidelines.
- Significant changes (both increases and decreases) have been made to the Type II generic holdover times as a result of the new and removed Type II fluids.
- The holdover times for snow in the "below -14°C to LOUT" row have been reduced for all Type II and Type IV fluids. This is the result of a two-year research program showing the new holdover times are more appropriate.

Type III Fluid

- Supplemental testing with AllClear AeroClear MAX resulted in changes to most of its holdover times for winter 2016-2017.

Type IV Fluid

- Fluid-specific HOT guidelines have been created for three new Type IV fluids: Clariant Max Flight AVIA, Clariant Safewing EG IV NORTH and Shaanxi Cleanway Aviation Cleansurface IV.
- Cryotech Polar Guard and Dow Chemical UCAR™ FlightGuard AD-480 have been removed from the Type IV guidelines as per the protocol for removing obsolete fluids.
- Supplemental testing with Deicing Solutions ECO-SHIELD® resulted in changes to most of its holdover times for winter 2016-2017. Its lowest operational use temperature (LOUT) and lowest on-wing viscosity (LOWV) have also changed.
- Significant changes (both increases and decreases) have been made to the Type IV generic holdover times as a result of the new and removed Type IV fluids. In addition, the Type IV generic HOT table has been expanded to include holdover times for three snowfall intensities: very light, light and moderate. This was possible as, for the first time, all fluid-specific Type IV holdover time tables include light, very light and moderate snow holdover times.
- The holdover times for snow in the "below -14°C to LOUT" row have been reduced for all Type II and Type IV fluids. This is the result of a two-year research program showing the new holdover times are more appropriate.

Ice Pellet and Small Hail Allowance Times

- The rows in both the Type III and Type IV allowance time tables, each containing a specific precipitation condition, have been reordered for ease of use.
- A note has been added to both the Type III and Type IV allowance time tables indicating they are for use with aircraft with rotation speeds of 100 knots or greater only.

- A review of existing data resulted in a change to the Type III allowance time for “Light Ice Pellets Mixed with Moderate Snow” in the “Below -5 to -10°C” cell (from 10 to 5 minutes).
- Allowance times have been added to the Type IV table for “Light Ice Pellets Mixed with Light Snow” and “Light Ice Pellets Mixed with Moderate Snow” in the “Below -10 to -16°C” temperature band.
- New rows / allowance times have been added to the Type IV table for two new precipitation conditions: “Moderate Ice Pellets (or Small Hail) Mixed with Moderate Freezing Drizzle” and “Moderate Ice Pellets (or Small Hail) Mixed with Moderate Rain”.
- The coldest temperature band in the Type IV table has been divided into two temperature bands: “Below -10 to -16°C” and “Below -16 to -22°C”.

Fluid Application Tables

- Guidance for the application of Type III fluid was previously provided in the same table as the guidance provided for the application of Type II/IV fluid. For the winter of 2016-1207, this guidance is provided in two separate Type III fluid application tables. Table 11-H provides guidance for the application of heated Type III fluid and Table 11-U provides guidance for the application of unheated Type III fluid.
- Changes have been made to the Type I and Type II/IV fluid application tables to improve harmonization with the FAA and SAE fluid application tables.

Changes to TP14052 Guidelines for Aircraft Ground-Icing Operations

- Guidance has been added, as Section 10.11.1, on applying anti-icing fluid in a hangar with t-tail aircraft.
- The guidance on wingtip devices identified as critical surfaces, provided in Section 11.2.3.5, has been modified.
- The guidance on determining appropriate allowance times for small hail, provided in Section 12.1.10 c), has been expanded.
- Guidance has been added, as Section 12.9, on freezing or thickening of residual fluid in flight.
- A note has been added to the section on holdover times for active frost conditions (Section 12.1.7.7) to provide guidance on selecting an appropriate outside air temperature in changing conditions.

Adjusted Holdover Times for Flaps/Slats Deployed Prior to De/Anti-Icing

- Research into holdover times on deployed flaps/slats has been ongoing for several years. There is a substantive amount of evidence that demonstrates extended flaps and slats accelerate anti-icing fluid degradation off aircraft wings and so exists a potential safety risk. To mitigate this safety risk, Transport Canada is publishing adjusted sets of holdover time and allowance time tables with values adjusted for aircraft with flaps/slats deployed when anti-icing. These adjusted tables will have values which have been decreased by 10%. This is an interim measure which will be in place until data collection and analysis have been completed.
- The 90% adjusted tables appear at the end of this document. These tables provide the holdover / allowance times that must be used when flaps and slats are deployed prior to de/anti-icing. Standard holdover / allowance times can be used if flaps and slats are deployed as close to departure as safety allows.

CHANGES TO *Guidelines for Aircraft Ground-Icing Operations* (TP 14052E, SECOND ED., APRIL 2005)

The following changes will be incorporated into TP 14052E at its next revision. They are recorded here in advance due to the longer life cycle time associated with the updating and publication of TP 14052E and are for immediate use.

Replace Sub-Paragraph 8.1.2 (2nd paragraph), "Fluid Description", with the following:

Anti-icing fluids are similar in composition except that they also contain polymeric thickeners. They are formulated to prevent formation of unabsorbed frozen contamination for a longer period of time than deicing fluids; however, the protection is still for a limited period of time. Although Type I fluids may be used for anti-icing, Type II, III and IV fluids are typically used in the anti-icing role because they can last for a significantly longer period of time than the Type I fluids.

Replace entire contents of Sub-Paragraph 8.1.4, "Certification Applicable to Qualified Fluids", with the following:

8.1.4 Acceptable Fluids

Transport Canada does not approve or qualify de/anti-icing fluids.

The aircraft manufacturer will generally indicate in the Aircraft Maintenance Manual the applicable industry specification for aircraft consumable materials. The industry fluid specifications for de/anti-icing fluids was discussed in Section 8.1.3.

The SAE specifications require numerous chemical and physical tests at a specialized laboratory. These tests are principally for measuring the compatibility of materials used in aircraft construction and the physical properties of the fluid against the appropriate SAE specification.

Also, the SAE specifications require a series of anti-icing and aerodynamic performance tests. The aerodynamic performance tests are conducted in a calibrated wind tunnel, in a specialized laboratory, for the purpose of measuring the aerodynamic and "flow off" characteristics of the fluid against the appropriate SAE specification.

Further, fluids undergo HOT evaluation to assess their HOT characteristics and establish the values for the HOT guidelines for that particular fluid.

Add the following Paragraph to 10.6.2.4, "Areas to be Sprayed", between item (e) and paragraph beginning "Care must be taken…":

Wingtip devices have various names including winglets, strakes, sharklets, or raked wingtips; these devices are considered critical surfaces given they are part of the wing surface. A new wingtip device element, the strake has been introduced and is part of the split scimitar. The strake is installed outboard of the vertical component of the wingtip device and extends downward and therefore cannot be observed from inside the aircraft.

Replace Sub-Paragraph 10.4 (6th paragraph), "Procedure Selection", with the following:

The temperature of cold soaked wings can be considerably below the ambient temperature; therefore frost can build up in localized areas. When active frost is anticipated, the holdover times will be shortened when the wings are cold soaked, particularly when using Type I fluids. Consider applying SAE Type II or IV fluid to the surfaces as these will provide greater holdover times than Type I, along with better safety margins to prevent frost accumulation. Both wings should receive a symmetrical treatment for aerodynamic reasons.

Replace Sub-Paragraph 10.4.2 (2nd paragraph), "Two Step De/Anti-Icing", with the following:

If a two-step procedure is used, the first step is typically performed using a deicing fluid; however, alternate deicing technology or mechanical methods may be used depending on the circumstances. The selection of fluid type and concentration depends on the ambient temperature, the weather conditions and the desired holdover time. When performing a two-step process, the freezing point of a fluid used for the first step must not be more than 3°C above ambient temperature. The freezing point of an SAE Type I fluid used for a one-step process, or as the second step of a two-step operation, must be at least 10°C below the ambient temperature. The second step is to be performed before the first step freezes, typically within 3 minutes. This time may be higher than 3 minutes in some conditions, but potentially lower in heavy precipitation, colder temperatures, or for critical surfaces constructed of composite materials. If necessary, the second step shall be applied area by area. When deicing fluid is used in step 1, the application of the second step fluid will flush away the first step fluid and leave a film of anti-icing fluid, which is designed to be of adequate thickness. If freezing of the deicing fluid has occurred, step 1 must be repeated. Refer to the SAE ARP 4737 document for additional details.

Add Sub-Paragraph 10.8.1, “De/Anti-icing Fluid Compatibility with Runway Deicer”, as follows:

Recent research showed that when thickened aircraft anti-icing fluid came in contact with minimal amounts of runway deicing fluids (formate or acetate based), anti-icing protection provided by the aircraft anti-icing fluid could be diminished. The separation of the thickening agents in this fluid consequently reduce holdover time.

This can occur when fluids from the runway are splashed onto the wing by the nose gear wheels or from the use of engine thrust reversers at landing prior to when the aircraft is anti-iced using a one-step process as protection for the next flight. Additional tests also showed that when using a two-step de/anti-icing process, the application of the first step cleans off the contamination from the runway deicing fluid so that the anti-ice protection provided with the second step is not affected by the runway deicing fluids. Therefore, it is recommended that de/anti-icing applications be performed using a two-step process.

Replace Sub-Paragraph 10.11, “Applying Anti-Icing Fluid in a Hangar”, with the following:

There are operational conditions when air operators may choose to anti-ice their aircraft while the aircraft is in a heated hangar. This is one way to reduce the consumption of deicing fluid and to minimize the environmental impact of deicing.

The period of time after fluid application and the air temperature in the hangar both have an effect on the ability of the fluid to protect the aircraft when it is pulled out of the hangar and into freezing/frozen precipitation. The HOT for a fluid is based largely on the fluid’s thickness on the surface. The fluid thickness varies with time and temperature. Unless otherwise approved in an air operator’s program, the holdover time clock must be started at the time of the first application of anti-icing fluid onto a clean wing. It may not be started when the aircraft is first exposed to freezing/frozen precipitation.

Add Sub-Paragraph 10.11.1, “Applying Anti-Icing Fluid in a Hangar – T-tail Aircraft”, as follows:

When anti-icing T-tail aircraft in a hangar, care must be taken to ensure that the horizontal stabilizer/elevator of the aircraft is not in close proximity to the ceiling heating system. Excessive heating of these critical surfaces during and after anti-icing can reduce applied anti-icing fluid thickness below what is required to achieve the holdover time.

If it is impossible to position the aircraft in such a way that the tail section is not below a heating element, consider disabling the heating element during and after anti-icing. Alternately, consider opening the hangar doors to cool all surfaces if this can be done without exposing the aircraft to additional contamination.

Replace Sub-Paragraph 10.12.1 (5th paragraph), “Brooms”, with the following:

Using the wing broom to remove contamination does not always mean that the wing surface is clean and safe for flight. Every time a broom is used to remove contamination, a tactile inspection must be performed.

Replace Sub-Paragraph 10.13.3, "Hot Water", with the following:

Hot water may be used to remove large amounts of contamination (such as ice) from an aircraft, provided that the Outside Air Temperature is -3°C and above as per the application procedures for SAE Type I, II, III and IV fluids described in tables 9, 10, 11-H and 11-U of the Transport Canada HOT Guidelines document.

Delete Sub-Paragraph 10.13.3.1 Item g) only.

Replace entire contents of 10.13.5 to 10.13.5.4 with the following:

10.13.5 Ground Ice Detection Systems (GIDS)

The development of ground ice detection sensors has been stimulated by the difficulty in determining whether an aircraft is free of frozen contaminants prior to takeoff. Humans have a limited ability to accurately evaluate the condition of an aircraft's critical surface during ground icing operations. Impediments to ensuring the aircraft is free of frozen contaminants include poor lighting conditions, visibility restrictions due to blowing snow, and the difficulty in determining whether clear ice is present.

For the purposes of this document, these sensors are referred to as Remote on Ground Ice Detection Systems (ROGIDS). A Minimum Operational Performance Specification (MOPS) for these systems is identified in the SAE document AS 5681.

Air operators or service providers seeking authorization to incorporate ROGIDS into their operations should consult Transport Canada Advisory Circular AC 602-001, "Operational Use of Remote on Ground Ice Detection Systems (ROGIDS) for Post De-icing Applications". This document is available at the following website:

https://www.tc.gc.ca/eng/civilaviation/opssvs/managementservices-referencecentre-acs-600-602-001-492.htm

Add the following paragraph to the end of Sub-Paragraph 11.1.1:

The values in the Type II and Type IV generic holdover time guidelines (Table 2-Generic, Table 4-Generic) are the shortest (worst case) holdover times of all Type II or all Type IV fluids included on the Transport Canada List of Fluids. These values are specific to precipitation condition, temperature range, fluid concentration, and precipitation rate. An analysis of all available Type II and Type IV fluids is done annually to determine these values. The generic holdover times must be used if the specific Type II or Type IV fluid being used cannot be positively determined. Note: The lowest on-wing viscosity (LOWV) of the fluid being used must always be respected, even when the generic Type II or Type IV holdover times are used.

Replace Sub-Paragraph 11.1.2, "Current Holdover Time Guidelines", with the following:

Current HOT Guidelines can be found at the following website:
http://www.tc.gc.ca/eng/civilaviation/standards/commerce-holdovertime-menu-1877.htm

The following information can be found at the above website:

a) Active Frost HOT Guidelines;
b) Type I Fluid Generic HOT Guidelines;
c) Type II Fluid HOT Guidelines;
d) Type III Fluid HOT Guidelines;
e) Type IV Fluid HOT Guidelines;
f) Ice Pellet and Small Hail Allowance Times;
g) Snowfall Intensities as a Function of Prevailing Visibility;
h) List of Fluids Tested for Anti-Icing Performance and Aerodynamic Acceptance; and
i) De/Anti-Icing Fluid Application Procedures.

Replace Sub-Paragraph 11.1.4.1 a) "Estimating the Precipitation Rate" with the following:

The METAR/SPECI reported snowfall intensity is based only on observed visibility in accordance with the Environment Canada MANOBS. Scientific research has demonstrated that the use of observed visibility in snow as the sole criteria in the MANOBS, for establishing snow intensity is not accurate enough for use with the holdover time guidelines. The evidence indicates that a visibility and temperature pair needs to be used for establishing the more accurate snowfall intensity required for use with the holdover time guidelines.

The highest snowfall intensities occur near 0°C. It has also been determined that during night time snowfall conditions, for the same snowfall intensity, visibility is about twice as good as it is during the day (i.e. one can see further at night than during the day for the same snowfall intensity). This factor must be considered in estimating the snowfall intensity.

The relationship between visibility and snowfall intensity was analyzed and is documented in TP14151E. The relevant information from TP14151E is contained in the Transport Canada "Snowfall Intensities as a Function of Prevailing Visibility" table contained in the holdover time guidelines.

The METAR/SPECI reported visibility or flight crew observed visibility will be used with the "Snowfall Intensities as a Function of Prevailing Visibility" table to establish snowfall intensity for Type I, II, III and IV holdover time guidelines, during snow, snow grain, or snow pellet precipitation conditions.

The "Snowfall Intensities as a Function of Prevailing Visibility" table, should also be used when snow, snow grains or snow pellets are accompanied by blowing or drifting snow in the METAR/SPECI.

Examples:

CYUY 161300Z 26005KT 1SM -SN OVC015 M01/M05 A2964

In the above METAR the snowfall intensity is reported as light. However, based upon the Transport Canada "Snowfall Intensities as a Function of Prevailing Visibility" table, with a visibility of 1 statute mile, in daylight and a temperature of -1°C, the snowfall intensity is classified as moderate. The snowfall intensity of moderate – not the METAR reported intensity of light – will be used to determine which HOT Guideline value is appropriate for the fluid in use.

CYVO 160200Z 15011G17KT 1SM -SN DRSN OVC009 M06/M08 A2948

In the above METAR the snowfall intensity is reported as light. However, based upon the Transport Canada "Snowfall Intensities as a Function of Prevailing Visibility" table, with a visibility of 1 statute mile, in darkness and a temperature of -6°C, the snowfall intensity is classified as moderate. The snowfall intensity of moderate – not the METAR reported intensity of light – will be used to determine which HOT Guideline value is appropriate for the fluid in use.

Rarely, there may be circumstances where the METAR/SPECI reported visibility or flight crew observed visibility is substantially reduced due to obscuration conditions such as fog, mist, freezing fog, dust, haze, or smoke. These obscuration conditions contribute very little to the overall catch rate at the wing surface and using the "Snowfall Intensities as a Function of Prevailing Visibility" table, would likely over estimate the snow fall intensity.

Under these conditions and with a careful assessment by the flight crew to ensure that the obscuration conditions are not concealing significant snowfall intensities, the METAR/SPECI reported snowfall intensity can be used.

Example:

CYTS 231000Z 21003KT ½ SM SN FZFG OVC003 M03/M03 A2969

In the above METAR, the snowfall intensity is reported as moderate. Based on the Transport Canada "Snowfall Intensities as a Function of Prevailing Visibility" table, with a visibility of ½ statute mile, in darkness and a temperature of -3°C, the snowfall intensity is classified as heavy. However, since freezing fog is present as an obscuring condition, a moderate snowfall intensity (as reported in the METAR) can be used to determine which HOT Guideline value is appropriate for the fluid in use, provided the crew can ensure that the obscuration is not concealing significant snowfall intensities.

Note: The Transport Canada "Snowfall Intensities as a Function of Prevailing Visibility" table can be found along with the current HOT Guidelines through the Transport Canada website: www.tc.gc.ca.

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Use of Runway Visual Range (RVR) with the Snowfall Intensities as a Function of Prevailing Visibility Table

There has been some confusion regarding the values indicated below the visibility (in parentheses) in the Snowfall Intensity table. The values indicated in parentheses refer to the visibility in metres and not an RVR.

RVR should not be used to determine visibility for the following reasons:

a) RVR transmissometers were never intended to measure visibility with respect to snowfall intensity for use with holdover time guidelines.

b) The RVR equipment is designed to provide pilots with an expected visual range along the runway, based on an associated runway edge and centerline lighting intensity. For a given obscuration phenomenon and precipitation intensity (fog, snow, etc.) the RVR will vary based on the selected runway lighting level. Therefore multiple RVR are possible for a given condition even though the meteorological conditions remain the same.

c) Furthermore RVR's in excess of 6000 ft are simply reported as 6000+. This level of resolution, only allows limited use of the Snowfall Intensity table (for example in darkness and at a temperature of -1°C and an RVR of 6000+, the only conclusion that can be drawn from the Snowfall Intensity table is that we are not in heavy snow, and that we could be in Moderate, Light or Very Light Snow conditions).

Varying Weather Conditions After Completion of Anti-Icing Procedure

During periods when the weather conditions are varying after completion of the anti-icing procedure, crews should reassess the previously selected holdover time. When doing so crews need to consider the following:

1) Improving weather conditions – if the snowfall intensity decreases, the original HOT should be retained;

2) Worsening weather conditions – if the snowfall intensity increases, a new lower HOT should be established and used.

Replace Sub-Paragraph 11.1.5, "Elapsed time is less than the lowest time in the HOT cell", with the following:

Transport Canada has previously considered that, under an approved ground icing program, if the lowest time in a cell has NOT been exceeded for conditions covered by the Guidelines, there is no requirement to inspect the aircraft's critical surfaces prior to commencing a takeoff.

This position was based on evidence gained during fluids testing. The HOT values are conservative for the lowest number in the cell, if:

a) The conditions present are NOT in excess of those conditions represented by the table (e.g. for snow, it would be a moderate snow condition); and

b) The impact of other factors (e.g. jet blast) has been considered and deemed not to affect the HOT.

If there is doubt surrounding the conditions associated with using the lowest time as a decision-making criterion, an inspection prior to takeoff would be prudent. This inspection should be conducted in accordance with the procedures described in the Air Operator's Approved Ground Icing Program.

Replace Sub-Paragraph 11.1.8, "Meteorological Conditions for which the HOT Guidelines are not applicable", with the following:

The HOT Guidelines do not include guidelines for all meteorological conditions. Holdover time guidelines have not been assessed for the following conditions: a) Hail; b) Moderate and Heavy Freezing Rain; and c) Heavy Snow.

Note: Operators need to assess whether operations can be safely conducted under these conditions.

Additionally, holdover time guidelines have not been assessed for Ice Pellets or Small Hail, since a formal protocol for this testing has not yet been developed and included in standard SAE testing methodologies and no visual failure criteria have yet been identified for these conditions. Instead, allowance times have been developed for operations during ice pellet conditions as a result of research carried out by Transport Canada and the FAA. As it has been determined small hail is equivalent to ice pellets, allowance times are also provided for small hail conditions.

Replace entire contents of Sub-Paragraph 11.1.9, "Use of approved fluids", with the following:

11.1.9 Use of De/Anti-icing Fluids

The operator is ultimately responsible for ensuring that only fluids tested to SAE AMS1424 or SAE AMS1428 are applied when the HOT Guidelines will be utilized operationally.

The Transport Canada Holdover Time Guidelines document, published on an annual basis, contains lists of fluids that have been tested with respect to anti-icing performance (SAE AMS1424 or SAE AMS1428) and aerodynamic acceptance (SAE AMS1424 or SAE AMS1428) only.

Therefore, the end user is cautioned that they must confirm that other SAE AMS1424 or SAE AMS1428 technical requirement tests such as fluid stability, toxicity, materials compatibility, etc. have been conducted. The fluid manufacturer will supply all samples for testing and, is responsible for obtaining independent laboratory confirmation of conformance to these requirements of AMS1424 or AMS1428. The fluid manufacturer should provide certificates of conformance upon request.

Add Sub-Paragraph 11.1.12, "Type I HOT Guidelines for Aircraft with Critical Surfaces Constructed Using Composite Materials", as follows:

The recent introduction of new aircraft constructed primarily with composite materials required a review of Type I fluid holdover time performance when used on these aircraft. This review has shown that the holdover time performance of Type I fluids on composite surfaces is reduced when compared to aluminum surfaces. Type I fluid holdover time evaluations were conducted and holdover times have been developed for use with aircraft critical surfaces constructed primarily with composite materials.

It is not the intent that the composite holdover times be used on aircraft where previous experience has shown the acceptable use of aluminum holdover times (unless those aircraft have predominately or entirely composite critical surfaces). If there is any doubt, consult with the aircraft manufacturer to determine whether to use aluminum or composite holdover times.

Add Sub-Paragraph 11.1.13, "Longer Holdover Times for 75/25 Dilutions", as follows:

For some brand-specific fluids, protection is increased in some cells when fluid concentration is reduced. The addition of certain quantities of water to some neat fluids can enhance their performance up to a certain point. Without knowing about this particular fluid mix phenomenon, an operator may think that the data presented in the tables are in error.

Add Sub-Paragraph 11.1.14, "Holdover Times for Non-Standard Dilutions of Type II, III and IV fluids", as follows:

When a Type II, III, or IV fluid is diluted to other than the published 100/0, 75/25 or 50/50 dilutions, the more conservative holdover time and LOUT associated with either the dilution above or below the selected dilution are applicable.

For example:

1) The holdover time and LOUT of a 80/20 dilution would be the more conservative holdover time and LOUT of either the 100/0 or 75/25 dilutions;
2) The holdover time and LOUT of a 60/40 dilution would be the more conservative holdover time and LOUT of either the 75/25 or 50/50 dilutions.

Add Subparagraph 11.2.3.5, "Wingtip Devices Identified as Critical Surfaces", as follows:

Wingtip devices have various names, including winglets, strakes, sharklets, or raked wingtips. The guidance below applies for these devices.

a) Without Split Scimitars or Strakes (Winglets, Sharklets, etc.): These devices must be confirmed to be free of frozen contamination as part of the pre-takeoff inspection. Current practices include a visual scan or the use of an approved representative surface, as specified in the operator's TC-approved ground deicing program.

b) With Split Scimitars, Strakes, or Similar Devices: A new wingtip device element, the strake, has been introduced and is part of the split scimitar. The strake is installed outboard of the vertical component of the wingtip device and extends downward and therefore cannot be observed from inside the aircraft. Manufacturers may designate the upper inboard surface of the vertical element of the wingtip device as a representative surface to assure no frozen contamination is present. The anti-icing procedures specified require this inboard surface to be anti-iced first starting at the top and working downward. The strake is anti-iced after the inboard surface application is completed. A visual scan of the designated representative surface (upper inboard surface of the vertical element of both wingtips) is required prior to takeoff as part of the pre-takeoff inspection. This paragraph applies only to aircraft with split scimitar wingtip devices. This guidance will be revised when new wingtip types become available.

c) Boeing Wingtip Devices Currently in Use on the B737 (Including Wingtip Devices with Split Scimitar Elements), B747, B757, B767, and MD11: Boeing has demonstrated that these wingtip devices do not require a visual inspection as part of the pre-takeoff inspection if a complete deicing of these wingtip device surfaces is accomplished during the aircraft deicing procedure. Following the accomplishment of the wingtip device deicing procedure no further action concerning the wingtip device is required as long as the determined HOT does not expire before departure. Upon expiration of the determined HOT prior to departure, a pre-takeoff contamination inspection must be accomplished. This inspection must include a visual inspection of the wingtip devices, and if adhering frozen contamination is detected, the aircraft must return for appropriate ground deicing/anti-icing retreatment prior to departure.

Replace Sub-Paragraph 12.1.2, "Ice Pellet Conditions", with the following:

Holdover time guidelines have not been assessed for ice pellets, since a formal protocol for ice pellet testing has not yet been developed and included in standard SAE testing methodologies and no visual failure criteria have been identified for ice pellet conditions.

However, comprehensive ice pellet research was conducted jointly by the research teams of the FAA and Transport Canada. This research consisted of extensive climatic chamber, wind tunnel, and live aircraft testing with ice pellets (light and moderate) and light ice pellets mixed with other forms of precipitation. Results of this research provide the basis for allowance times for operations in light and moderate ice pellets, as well as allowance times for operations in light ice pellets mixed with other forms of precipitation.

Replace Sub-Paragraph 12.1.6, "Cold Dry Snow Falling on a Cold Dry Wing", with the following:

12.1.6 Cold Dry Snow (or Ice Crystals) Falling on a Cold Dry Wing

Conditions are encountered whereby cold dry snow (or ice crystals) is falling onto the cold wing of an aircraft. The wind often causes the snow (or ice crystals) to swirl and move across the surface of the wing and it is evident that the snow (or ice crystals) is not adhering to the wing surface. Under these circumstances the application of deicing/anti-icing fluid to the wing of the aircraft would likely result in the snow (or ice crystals) sticking to the fluid. Under such operational conditions it may not be prudent to apply fluids to the wing.

However, if snow or ice crystals have accumulated at any location on the wing surface it must be removed prior to takeoff. It cannot be assumed that snow or ice crystals on a wing will "blow off" during the takeoff. For example, refueling with fuel warmer than the wing skin temperature may create a condition whereby previously non adhering contaminants may adhere to the wing surfaces.

Replace entire contents of Sub-Paragraph 12.1.7 "Frost", with the following:

12.1.7 Frost

Frost occurs frequently during winter operating conditions. Frost due to radiation cooling is a uniform thin white deposit of fine crystalline texture, which forms on exposed surfaces that are below freezing, generally on calm cloudless nights where the air at the surface is close to saturation. When the deposit is thin enough for surface features underneath the frost, such as paint lines, markings and lettering, to be distinguished it is often referred to as hoarfrost. Frost can also form on the upper or lower surfaces of the wing due to cold soaked fuel. Frost has the appearance of being a minor contaminant and therefore does not offer the same obvious signal of danger as do other types of contamination such as snow or ice. However, frost is an insidious threat to the safety of aircraft operations because it always adheres to the aircraft surface, is rough and causes significant lift degradation and increased drag.

12.1.7.1 Active Frost

Active frost is a condition when frost is forming. During active frost conditions, frost will form on an unprotected surface or re-form on a surface protected with de/anti-icing fluid where the holdover time has expired.

Frost forms whenever the exposed surface temperature cools below OAT to, or below, the frost point (not dew point). The mechanisms for cooling include:

1) radiation cooling; or
2) conductive cooling (due to cold soaked fuel).

If the exposed surface temperature is equal to or below the frost point, frost will begin to accrete on the surface. Once formed, residual accreted frost may remain after the active frost phase if the exposed surface temperature remains below freezing.

12.1.7.2 Dew Point and Frost Point

The dew point is the temperature at a given pressure to which air must be cooled to cause saturation. The dew point can occur below or above 0°C.

The frost point is the temperature, at or below 0°C (32°F), at which moisture in the air will condense as a layer of frost on an exposed surface. The frost point occurs between the OAT and dew point.

METAR does not report frost point; however, it does report dew point. The frost point is higher (warmer) than the dew point for a given humidity in the air. The frost point and the dew point are the same at 0°C; at a dew point of -40°C, the frost point is 3.2°C warmer (-36.8°C). The following table provides further examples of the correlation between dew point and frost point.

Dew Point Temperature (°C)	Frost Point Temperature (°C)
0	0.0
-5	-4.4
-10	-8.9
-15	-13.5
-20	-18.0
-25	-22.7
-30	-27.3
-35	-32.1
-40	-36.8

12.1.7.3 Radiation Cooling

Radiation cooling will generally occur during clear sky (e.g. SKC, high FEW or high SCT), low wind (e.g. less than 10 knots), and low light (e.g. shade, at night or in low angle / obscured sun) conditions. These conditions will cause the exposed surface temperature to cool below the OAT. Once the exposed surface temperature cools to the frost point or below, active frost occurs.

Certain surface finishes and material compositions may be more susceptible to radiation cooling, and as a result, different areas of an aircraft may begin to accrete frost at different times. Radiation cooling can cause an exposed surface to cool several degrees below the OAT; therefore, frost can form on an exposed surface at an OAT several degrees above 0°C.

Depending on conditions, time to frost formation may range from minutes to hours. As a result, a surface that appears free of frost during an early inspection may become contaminated later. When conditions are favorable for active frost formation, a direct inspection of critical surfaces conducted as close as possible to the departure time is recommended.

12.1.7.4 Cold Soaked Fuel Cooling

Cold soaked fuel cooling results from conductive cooling due to very cold fuel on board at destination or from refueling with fuel that may be cooler than the OAT. Cold soaked fuel conditions are highly variable and therefore, only direct surface temperature readings are accurate, but not available at most stations. Fuel temperature does not accurately predict cold soaked fuel conditions but may provide an initial indication, particularly in the period after landing and prior to fuelling. The presence of frost under the wing is a good indication of cold soaked fuel conditions.

In extreme cases, cold soaking may reduce the surface temperature below the fluid LOUT and cause aerodynamic performance degradation due to fluid freezing or the inability of the fluid to adequately flow off the treated surface.

12.1.7.5 Combined Radiation and Cold Soaked Fuel Cooling Effects

Cold soaked fuel cooling combined with radiation cooling effects can cause reductions in active frost holdover times. This is particularly true for Type I fluid holdover times as these are shorter in duration, and therefore use of a thickened anti-icing fluid should be considered.

12.1.7.6 De/Anti-Icing in Active Frost Conditions

Frost reforming after removal is an indication of active frost. During active frost, anti-icing protection is required and operations should be conducted in accordance with holdover time guidelines and minimum fluid quantity and temperature application procedures therein. Applications such as misting or mopping of Type I fluid may not provide adequate heat or fluid quantity to use the holdover times in active frost conditions.

In active frost conditions, deicing alone is insufficient, therefore, once the frost has been removed, a preventative anti-icing coating is required.

12.1.7.7 Fluid Holdover Times for Active Frost Conditions

Fluid holdover times in active frost conditions differ from holdover times in other conditions as they incorporate an allowance for the temperature differential (typically 6 to 8°C) between the OAT and the exposed surface temperature due to radiation cooling. As a result of this allowance, the OAT should be used to determine the appropriate active frost holdover time.

Note: Changes in OAT over the course of longer frost HOT can be significant; the appropriate HOT to use is the HOT provided for the coldest OAT that has occurred in the time between the de/anti-icing fluid application and takeoff.

Note: Active frost holdover times may be reduced in the presence of combined cooling effects or extreme surface cooling. In extreme cases, the surface temperature may be below the fluid LOUT and cause aerodynamic performance degradation due to fluid freezing or the inability of the fluid to adequately flow off the treated surface.

12.1.7.8 Frost on the Underside of the Wing

CAR 602.11(3) states: Notwithstanding subsection (12.1.7.9), a person may conduct a takeoff in an aircraft that has frost adhering to the underside of its wings that is caused by cold-soaked fuel, if the takeoff is conducted in accordance with the aircraft manufacturer's instructions for takeoff under those conditions.

12.1.7.9 Frost on the Fuselage

Despite the requirement to clean contamination from critical surfaces, it is acceptable for aircraft, including those with aft fuselage mounted engines, to take off when hoarfrost is adhering to the upper surface of the fuselage if it is the only remaining contaminant, provided all vents and ports are clear. Contact the aircraft manufacturer for further details.

Add Sub-Paragraph 12.1.9, "Hail and Small Hail", as follows:

The meteorological conditions "Hail" and "Small Hail" are different. Hail is a more intense condition for which holdover times do not exist. Small hail is a lighter condition, meteorologically equivalent to ice pellets, for which allowance times are provided.

Add Sub-Paragraph 12.1.10, "Small Hail / Snow Pellets (METAR Codes GS/SHGS)", as follows:

The World Meteorological Organization (WMO) states METAR code GS is used for two meteorological conditions: "snow pellets" and "small hail." Different holdover times/allowance times apply in these two weather conditions. If the weather condition is snow pellets, the snow holdover times are applicable. If the weather condition is small hail, the ice pellet and small hail allowance times are applicable. Furthermore, the ice pellet and small hail allowance times are applicable if the prevailing weather condition between "snow pellets" and "small hail" cannot be determined given that these are more restrictive than the snow holdover times.

It has been determined that Canada does not follow the WMO standard for reporting these two weather conditions. In Canada, METAR code GS is used exclusively for snow pellets; METAR code SHGS with remarks is used to report small hail (METAR code SHGS without remarks is snow pellet showers). Therefore, different holdover times / allowance times apply when these METAR codes are reported in Canada as compared to other countries including the United States.

In addition, there are differences between countries in whether or not intensity is reported with small hail. in Canada, the United States and most other countries, no intensity is reported with small hail. In some other countries, e.g. Japan, intensity is reported with small hail.

Based on this information and Canadian air operator feedback, the following guidance must be followed.

a) When operating in Canada:

   i. When METAR code GS is reported: the condition is snow pellets and the snow holdover times should be used.

   ii. When METAR code SHGS (with or without remarks) is reported: the condition is either snow pellet showers or small hail and the appropriate ice pellet and small hail allowance times should be used.

b) When operating in the United States / International: When METAR code GS or SHGS is reported: the condition could be snow pellets or small hail; the ice pellet/small hail allowance times should be used.

c) Determining appropriate allowance times for Small Hail: If no intensity is reported with small hail, the moderate ice pellet allowance times must be used. If an intensity is reported with small hail, the allowance times for the ice pellet condition with the equivalent intensity should be used, e.g. light small hail = light ice pellets, moderate small hail = moderate ice pellets. This also applies in mixed conditions, e.g. if light small hail mixed with light snow is reported, use the "light ice pellets mixed with light snow" allowance times. The following examples illustrate the application of this guidance:

   i. If you get a report of "Small Hail" but no intensity is reported with it, you must use the "Moderate Ice Pellets" allowance times. This is shown in the row "Moderate Ice Pellets or Small Hail"

ii. If you get a report of “Small Hail” and its intensity is reported as “moderate”, you must also use the “Moderate Ice Pellets or Small Hail” allowance times.

iii. If you get a report of “Small Hail” and its intensity is reported as “light”, you can use the “Light Ice Pellets” allowance times.

iv. If you get a report of “Small Hail” and its intensity is reported as “light” and it is mixed with another condition (snow, rain, freezing rain), you can use the equivalent light ice pellets allowance times. For example, if you have Light Small Hail mixed with Light Rain, you can use the “Light Ice Pellets mixed with Light Rain” allowance times.

Replace Sub-Paragraph 12.3 (5th paragraph), “Configuration During Deicing Procedures”, with the following:

Two possible options are: delaying slat/flap deployment until just prior to takeoff; or deploying the devices prior to de/anti-icing so that the surfaces under these devices are treated. With the second option, the holdover time and allowance time will be reduced due to the steeper angles of the slat/flap in the deployed configuration.

Delaying the slat/flap deployment may be the preferred option for optimum protection from ice buildup. If it is necessary to remove contamination from the slats/flaps, it may be best to deploy the slats/flaps for deicing and anti-icing and then retract them prior to taxi. Consult the Aircraft Operating Manual and/or aircraft manufacturer for more details.

Replace Sub-Paragraph 12.6.7 (e), “Recommended “Clean Aircraft Concept” Practices”, with the following:

e) The general rule for ground icing procedures is that the deicing and anti-icing processes must be done symmetrically. That is, whatever final treatment (i.e. same brand name fluid) is administered on one wing must be applied to the other wing for aerodynamic symmetry reasons.

Add Sub-Paragraph 12.9 Freezing or Thickening of Residual Fluid in Flight

It is possible for anti-icing fluid to flow back to aerodynamically quiet areas of aircraft wings after takeoff where the residual fluid can partially freeze or appear thickened. Research indicates that this can occur on a regular basis but poses no risk to safety.

Anti-icing fluids are designed in such a way that most of the fluid will flow off aircraft wings, particularly from the leading edge. The leading edge is the most aerodynamically critical section of the wing whereas its trailing edge can accrue some residual fluid and remain acceptable for safe operations.

Add the following definitions to Section 18 “Glossary”:

Lowest On-Wing Viscosity
Lowest viscosity of a fluid for which the applicable holdover time table can still be used.

Maximum On-Wing Viscosity
Maximum viscosity of a fluid which is still aerodynamically acceptable.

HOLDOVER TIME (HOT) GUIDELINES FOR WINTER 2016-2017

Standard HOT Guidelines and Allowance Times

Transport Canada Holdover Time Guidelines Winter 2016-2017

Supplemental Guidance

Table 7	Snowfall Intensities as a Function of Prevailing Visibility
Table 8	List of Fluids Tested for Anti-Icing Performance and Aerodynamic Acceptance
Table 9	Guidelines for the Application of SAE Type I Fluid
Table 10	Guidelines for the Application of SAE Type II and IV Fluid
Table 11-H	Guidelines for the Application of Heated SAE Type III Fluid
Table 11-U	Guidelines for the Application of Unheated SAE Type III Fluid

90% Adjusted HOT Guidelines and Allowance Times

Table 0-90%	SAE Type I, Type II, Type III, and Type IV Fluid Active Frost 90% Adjusted HOT Guidelines
Table 1-90%-A	SAE Type I Fluid 90% Adjusted HOT Guidelines on Critical Aircraft Surfaces Composed Predominantly of Aluminum
Table 1-90%-C	SAE Type I Fluid 90% Adjusted HOT Guidelines on Critical Aircraft Surfaces Composed Predominantly of Composite
Table 2-90%-Generic	SAE Type II Fluid 90% Adjusted HOT Guidelines
Table 2-90%-A-E26	Type II Fluid 90% Adjusted HOT Guidelines - ABAX Ecowing 26
Table 2-90%-AS-CWII	Type II Fluid 90% Adjusted HOT Guidelines - Aviation Shaanxi Hi-Tech Cleanwing II
Table 2-90%-BY-YDII	Type II Fluid 90% Adjusted HOT Guidelines - Beijing Yadilite Aviation YD-102 Type II
Table 2-90%-C-F	Type II Fluid 90% Adjusted HOT Guidelines - Clariant Safewing MP II FLIGHT
Table 2-90%-C-F+	Type II Fluid 90% Adjusted HOT Guidelines - Clariant Safewing MP II FLIGHT PLUS
Table 2-90%-CR-PGII	Type II Fluid 90% Adjusted HOT Guidelines - Cryotech Polar Guard® II
Table 2-90%-K-ABC-IC	Type II Fluid 90% Adjusted HOT Guidelines - Kilfrost ABC-Ice Clear II
Table 2-90%-K-ABC-K+	Type II Fluid 90% Adjusted HOT Guidelines - Kilfrost ABC-K Plus
Table 2-90%-N-FCY-2	Type II Fluid 90% Adjusted HOT Guidelines - Newave Aerochemical FCY-2
Table 2-90%-N-FCY-2B+	Type II Fluid 90% Adjusted HOT Guidelines - Newave Aerochemical FCY-2 Bio+
Table 3LS-90%-A-ACM	Low Speed Type III Fluid 90% Adjusted HOT Guidelines - AllClear AeroClear MAX
Table 3HS-90%-A-ACM	High Speed Type III Fluid 90% Adjusted HOT Guidelines - AllClear AeroClear MAX
Table 3LS-90%-C-2031	Low Speed Type III Fluid 90% Adjusted HOT Guidelines - Clariant Safewing MP III 2031 ECO
Table 3HS-90%-C-2031	High Speed Type III Fluid 90% Adjusted HOT Guidelines - Clariant Safewing MP III 2031 ECO
Table 4-90%-Generic	SAE Type IV Fluid 90% Adjusted HOT Guidelines
Table 4-90%-A-E-AD49	Type IV Fluid 90% Adjusted HOT Guidelines - ABAX Ecowing AD-49
Table 4-90%-C-MF04	Type IV Fluid 90% Adjusted HOT Guidelines - Clariant Max Flight 04
Table 4-90%-C-MFA	Type IV Fluid 90% Adjusted HOT Guidelines - Clariant Max Flight AVIA
Table 4-90%-C-MFS	Type IV Fluid 90% Adjusted HOT Guidelines - Clariant Max Flight SNEG
Table 4-90%-C-N	Type IV Fluid 90% Adjusted HOT Guidelines - Clariant Safewing EG IV NORTH
Table 4-90%-C-L	Type IV Fluid 90% Adjusted HOT Guidelines - Clariant Safewing MP IV LAUNCH
Table 4-90%-C-L+	Type IV Fluid 90% Adjusted HOT Guidelines - Clariant Safewing MP IV LAUNCH PLUS
Table 4-90%-CR-PGA	Type IV Fluid 90% Adjusted HOT Guidelines - Cryotech Polar Guard® Advance

TABLE 0

SAE TYPE I, TYPE II, TYPE III, AND TYPE IV FLUID ACTIVE FROST HOLDOVER TIME GUIDELINES

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1,2,3] Degrees Celsius	Outside Air Temperature[1,2,3] Degrees Fahrenheit	Approximate Holdover Times (hours:minutes) Active Frost Type I
-1 and above	30 and above	0:45 *(0:35)*[5]
below -1 to -3	below 30 to 27	
below -3 to -10	below 27 to 14	
below -10 to -14	below 14 to 7	
below -14 to -21	below 7 to -6	
below -21 to LOUT	below -6 to LOUT	

Outside Air Temperature[2,3]		Concentration Neat Fluid/Water (Volume %/ Volume %)	Approximate Holdover Times (hours:minutes) Active Frost		
Degrees Celsius	Degrees Fahrenheit		Type II	Type III[4]	Type IV
-1 and above	30 and above	100/0	8:00	2:00	12:00
		75/25	5:00	1:00	5:00
		50/50	3:00	0:30	3:00
below -1 to -3	below 30 to 27	100/0	8:00	2:00	12:00
		75/25	5:00	1:00	5:00
		50/50	1:30	0:30	3:00
below -3 to -10	below 27 to 14	100/0	8:00	2:00	10:00
		75/25	5:00	1:00	5:00
below -10 to -14	below 14 to 7	100/0	6:00	2:00	6:00
		75/25	1:00	1:00	1:00
below -14 to -21	below 7 to -6	100/0	6:00	2:00	6:00
below -21 to -25	below -6 to -13	100/0	2:00	2:00	4:00
Below -25	below -13	100/0	No Holdover Time Guidelines Exist		

NOTES

1 Type I Fluid / Water Mixture must be selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 Changes in outside air temperature (OAT) over the course of longer frost events can be significant; the appropriate holdover time to use is the one provided for the coldest OAT that has occurred in the time between the de/anti-icing fluid application and takeoff.
4 To use the Type III fluid frost holdover times, the fluid brand being used must be known. AllClear AeroClear MAX must be applied unheated. Clariant Safewing MP III 2031 ECO must be applied heated.
5 Value in parentheses is for aircraft with critical surfaces that are predominantly or entirely constructed of composite materials.

CAUTIONS

- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2016-2017

TABLE 1-A

SAE TYPE I FLUID HOLDOVER TIME GUIDELINES ON CRITICAL AIRCRAFT SURFACES COMPOSED PREDOMINANTLY OF ALUMINUM[1]

These holdover times apply to aircraft with critical surfaces constructed predominantly or entirely of aluminum materials that have demonstrated satisfactory use of these holdover times.

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit	Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3] Very Light[4]	Light[4]	Moderate	Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
-3 and above	27 and above	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	
below -3 to -6	below 27 to 21	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6	CAUTION: No holdover time guidelines exist	
below -6 to -10	below 21 to 14	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
below -10	below 14	5 – 9	7	4 – 7	2 – 4				

NOTES

1. Type I Fluid / Water Mixture must be selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2. Ensure that the lowest operational use temperature (LOUT) is respected.
3. To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4. Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6. No holdover time guidelines exist for this condition for 0°C (32°F) and below.
7. Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2016-2017

TABLE 1-C

SAE TYPE I FLUID HOLDOVER TIME GUIDELINES ON CRITICAL AIRCRAFT SURFACES COMPOSED PREDOMINANTLY OF COMPOSITES[1]

These holdover times apply to newer aircraft with critical surfaces constructed predominantly or entirely of composite materials.
THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit	Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
			Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	9 – 16	12	6 – 12	3 – 6	8 – 13	4 – 6	1 – 5	
below -3 to -6	below 27 to 21	6 – 8	11	5 – 11	2 – 5	5 – 9	4 – 6	CAUTION: No holdover time guidelines exist	
below -6 to -10	below 21 to 14	4 – 8	9	5 – 9	2 – 5	4 – 7	2 – 5		
below -10	below 14	4 – 7	7	4 – 7	2 – 4				

NOTES

1 Type I Fluid / Water Mixture must be selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2016-2017

TABLE 2-Generic

SAE TYPE II FLUID HOLDOVER TIME GUIDELINES

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2,3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	0:35 – 1:30	0:20 – 0:45	0:30 – 1:00	0:15 – 0:30	0:07 – 0:40	CAUTION: No holdover time guidelines exist
		75/25	0:25 – 0:55	0:15 – 0:25	0:15 – 0:40	0:10 – 0:20	0:04 – 0:25	
		50/50	0:15 – 0:25	0:05 – 0:10	0:08 – 0:15	0:05 – 0:09		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:05	0:15 – 0:30	0:20 – 0:45[7]	0:10 – 0:20[7]		
		75/25	0:25 – 0:50	0:08 – 0:20	0:15 – 0:25[7]	0:08 – 0:15[7]		
below -14 to LOUT	below 7 to LOUT	100/0	0:20 – 0:35[8]	0:08 – 0:10[8]				

NOTES
1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10°C (14°F).
8 If the LOUT is unknown, no holdover time guidelines exist below -22.5°C (-8.5°F).

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2016-2017

TABLE 2-A-E26

TYPE II FLUID HOLDOVER TIME GUIDELINES
ABAX ECOWING 26

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:25 – 2:35	1:35	1:00 – 1:35	0:40 – 1:00	0:50 – 1:35	0:40 – 0:50	0:20 – 1:25	
		75/25	1:05 – 1:55	1:15	0:45 – 1:15	0:25 – 0:45	0:45 – 1:05	0:25 – 0:35	0:10 – 1:00	
		50/50	0:30 – 0:45	0:40	0:20 – 0:40	0:10 – 0:20	0:15 – 0:25	0:08 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:45 – 2:15	1:25	0:55 – 1:25	0:35 – 0:55	0:30 – 1:10[7]	0:15 – 0:35[7]		
		75/25	0:35 – 1:15	0:55	0:40 – 0:55	0:25 – 0:40	0:20 – 0:50[7]	0:15 – 0:25[7]		
below -14 to -25	below 7 to -13	100/0	0:25 – 0:45	0:20	0:10 – 0:20	0:08 – 0:10				

NOTES

1. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2. To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3. Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7. No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

TABLE 2-AS-CWII

TYPE II FLUID HOLDOVER TIME GUIDELINES
AVIATION SHAANXI HI-TECH CLEANWING II

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1] Degrees Celsius	Outside Air Temperature[1] Degrees Fahrenheit	Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2,3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	0:55 – 1:50	0:30 – 0:55	0:35 – 1:05	0:25 – 0:35	0:10 – 0:55	CAUTION: No holdover time guidelines exist
		75/25	0:50 – 1:20	0:25 – 0:45	0:35 – 1:00	0:20 – 0:30	0:07 – 0:50	
		50/50	0:35 – 1:00	0:15 – 0:30	0:20 – 0:40	0:10 – 0:20		
below -3 to -14	below 27 to 7	100/0	0:45 – 1:50	0:30 – 0:55	0:30 – 0:55[7]	0:20 – 0:25[7]		
		75/25	0:40 – 1:45	0:25 – 0:45	0:35 – 0:40[7]	0:20 – 0:25[7]		
below -14 to -29	below 7 to -20.2	100/0	0:20 – 0:50	0:08 – 0:10				

Approximate Holdover Times Under Various Weather Conditions (hours:minutes)

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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TABLE 2-BY-YDII

TYPE II FLUID HOLDOVER TIME GUIDELINES
BEIJING YADILITE AVIATION YD-102 TYPE II

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	1:10 – 2:00	1:40	0:50 – 1:40	0:25 – 0:50	0:40 – 1:15	0:35 – 0:40	0:10 – 1:00	CAUTION: No holdover time guidelines exist
		75/25	0:25 – 0:55	0:50	0:25 – 0:50	0:15 – 0:25	0:15 – 0:40	0:10 – 0:20	0:04 – 0:25	
		50/50	0:15 – 0:25	0:25	0:10 – 0:25	0:05 – 0:10	0:08 – 0:15	0:07 – 0:09		
below -3 to -14	below 27 to 7	100/0	0:45 – 1:30	1:00	0:30 – 1:00	0:15 – 0:30	0:35 – 0:50[7]	0:25 – 0:25[7]		
		75/25	0:30 – 0:50	0:35	0:20 – 0:35	0:08 – 0:20	0:15 – 0:25[7]	0:09 – 0:15[7]		
below -14 to -29	below 7 to -20.2	100/0	0:20 – 0:45	0:20	0:10 – 0:20	0:08 – 0:10				

NOTES
1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2016-2017

TABLE 2-C-F

TYPE II FLUID HOLDOVER TIME GUIDELINES
CLARIANT SAFEWING MP II FLIGHT

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	3:30 – 4:00	2:00	1:35 – 2:00	1:00 – 1:35	1:20 – 2:00	0:45 – 1:25	0:10 – 1:30	
		75/25	1:50 – 2:45	2:00	1:20 – 2:00	0:40 – 1:20	1:10 – 1:30	0:30 – 0:55	0:06 – 0:50	
		50/50	0:55 – 1:45	0:45	0:25 – 0:45	0:10 – 0:25	0:20 – 0:30	0:10 – 0:15	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:55 – 1:45	1:50	1:05 – 1:50	0:40 – 1:05	0:35 – 1:30[7]	0:25 – 0:45[7]		
		75/25	0:25 – 1:05	1:20	0:40 – 1:20	0:20 – 0:40	0:25 – 1:10[7]	0:20 – 0:35[7]		
below -14 to -29	below 7 to -20.2	100/0	0:30 – 0:50	0:20	0:10 – 0:20	0:08 – 0:10				

NOTES

1. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2. To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3. Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7. No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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TABLE 2-C-F+

TYPE II FLUID HOLDOVER TIME GUIDELINES
CLARIANT SAFEWING MP II FLIGHT PLUS

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2,3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:40 – 4:00	0:50 – 1:50	1:25 – 2:00	0:45 – 1:00	0:15 – 2:00	
		75/25	2:35 – 4:00	1:00 – 1:45	1:35 – 2:00	0:50 – 1:15	0:15 – 1:15	
		50/50	1:05 – 2:20	0:15 – 0:25	0:30 – 1:05	0:15 – 0:20		
below -3 to -14	below 27 to 7	100/0	0:40 – 2:20	0:35 – 1:15	0:35 – 1:25[7]	0:35 – 0:55[7]	CAUTION: No holdover time guidelines exist	
		75/25	0:30 – 1:45	0:55 – 1:40	0:25 – 1:10[7]	0:30 – 0:45[7]		
below -14 to -29	below 7 to -20.2	100/0	0:20 – 0:40	0:08 – 0:10				

NOTES
1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2016-2017

TABLE 2-CR-PGII

TYPE II FLUID HOLDOVER TIME GUIDELINES
CRYOTECH POLAR GUARD® II

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	2:50 – 4:00	2:00	1:50 – 2:00	1:20 – 1:50	1:35 – 2:00	1:15 – 1:30	0:15 – 2:00	CAUTION: No holdover time guidelines exist
		75/25	2:30 – 4:00	2:00	1:20 – 2:00	0:45 – 1:20	1:40 – 2:00	0:40 – 1:10	0:09 – 1:40	
		50/50	0:50 – 1:25	1:20	0:35 – 1:20	0:15 – 0:35	0:20 – 0:45	0:09 – 0:20		
below -3 to -14	below 27 to 7	100/0	0:55 – 2:30	1:45	1:15 – 1:45	0:55 – 1:15	0:35 – 1:35[7]	0:35 – 0:45[7]		
		75/25	0:40 – 1:30	1:45	1:00 – 1:45	0:35 – 1:00	0:25 – 1:05[7]	0:35 – 0:45[7]		
below -14 to -30.5	below 7 to -22.9	100/0	0:25 – 0:50	0:20	0:10 – 0:20	0:08– 0:10				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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TABLE 2-K-ABC-IC

TYPE II FLUID HOLDOVER TIME GUIDELINES
KILFROST ABC-ICE CLEAR II

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:00 – 1:45	1:45	0:50 – 1:45	0:25 – 0:50	0:40 – 1:05	0:25 – 0:35	0:07 – 0:45	CAUTION: No holdover time guidelines exist
		75/25	0:50 – 1:10	1:20	0:40 – 1:20	0:20 – 0:40	0:30 – 0:45	0:20 – 0:30	0:05 – 0:35	
		50/50	0:15 – 0:30	0:20	0:15 – 0:20	0:08 – 0:15	0:10 – 0:20	0:07 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:40 – 1:35	1:15	0:35 – 1:15	0:20 – 0:35	0:25 – 1:00[7]	0:15 – 0:30[7]		
		75/25	0:40 – 1:20	0:55	0:25 – 0:55	0:15 – 0:25	0:25 – 0:45[7]	0:15 – 0:20[7]		
below -14 to -29.5	below 7 to -21.1	100/0	0:20 – 0:40	0:20	0:10 – 0:20	0:08 – 0:10				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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Transport Canada Holdover Time Guidelines — Winter 2016-2017

TABLE 2-K-ABC-K+

TYPE II FLUID HOLDOVER TIME GUIDELINES
KILFROST ABC-K PLUS

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[2,3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	2:15 – 3:45	1:00 – 1:40	1:50 – 2:00	1:00 – 1:25	0:20 – 2:00	CAUTION: No holdover time guidelines exist
		75/25	1:40 – 2:30	0:35 – 1:10	1:25 – 2:00	0:50 – 1:10	0:15 – 2:00	
		50/50	0:35 – 1:05	0:07 – 0:15	0:20 – 0:30	0:10 – 0:15		
below -3 to -14	below 27 to 7	100/0	0:30 – 1:05	0:50 – 1:25	0:25 – 1:00[7]	0:15 – 0:35[7]		
		75/25	0:25 – 1:25	0:35 – 1:05	0:20 – 0:55[7]	0:09 – 0:30[7]		
below -14 to -29	below 7 to -20.2	100/0	0:30 – 0:55	0:08 – 0:10				

NOTES
1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2016-2017

TABLE 2-N-FCY-2

TYPE II FLUID HOLDOVER TIME GUIDELINES
NEWAVE AEROCHEMICAL FCY-2

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2,3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:15 – 2:25	0:30 – 0:55	0:35 – 1:05	0:25 – 0:35	0:08 – 0:45	
		75/25	0:50 – 1:30	0:20 – 0:40	0:25 – 0:45	0:15 – 0:25	0:05 – 0:25	
		50/50	0:25 – 0:35	0:15 – 0:25	0:10 – 0:20	0:07 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:45 – 1:30	0:15 – 0:30	0:20 – 0:45[7]	0:15 – 0:20[7]		CAUTION: No holdover time guidelines exist
		75/25	0:30 – 1:05	0:10 – 0:20	0:15 – 0:30[7]	0:08 – 0:15[7]		
below -14 to -28	below 7 to -18.4	100/0	0:25 – 0:35	0:08 – 0:10				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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TABLE 2-N-FCY-2B+

TYPE II FLUID HOLDOVER TIME GUIDELINES
NEWAVE AEROCHEMICAL FCY-2 BIO+

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:25 – 2:30	2:00	1:05 – 2:00	0:30 – 1:05	0:50 – 1:20	0:25 – 0:45	0:08 – 1:15	
		75/25	0:45 – 1:20	1:20	0:40 – 1:20	0:20 – 0:40	0:25 – 0:50	0:15 – 0:25	0:06 – 0:35	
		50/50	0:15 – 0:30	0:25	0:15 – 0:25	0:08 – 0:15	0:10 – 0:20	0:08 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:40 – 1:30	1:00	0:30 – 1:00	0:15 – 0:30	0:35 – 1:05[7]	0:15 – 0:30[7]		
		75/25	0:30 – 1:05	0:35	0:20 – 0:35	0:08 – 0:20	0:20 – 0:35[7]	0:15 – 0:20[7]		
below -14 to -28.5	below 7 to -19.3	100/0	0:20 – 1:00	0:20	0:10 – 0:20	0:08 – 0:10				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines **Winter 2016-2017**

TABLE 3LS-A-ACM

LOW SPEED TYPE III FLUID HOLDOVER TIME GUIDELINES
ALLCLEAR AEROCLEAR MAX, APPLIED UNHEATED[1]

FOR AIRCRAFT CONFORMING TO THE SAE AS5900 LOW SPEED AERODYNAMIC TEST CRITERION

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	100/0	0:45 – 1:10	1:00	0:30 – 1:00	0:14 – 0:30	0:20 – 0:45	0:14 – 0:20	0:06 – 0:40	
		75/25								
		50/50							CAUTION: No holdover time guidelines exist	
below -3 to -10	below 27 to 14	100/0	0:45 – 1:25	1:00	0:30 – 1:00	0:14 – 0:30	0:20 – 0:40	0:15 – 0:25		
		75/25								
below -10 to -16	below 14 to 3.2	100/0	0:30 – 1:05	1:00	0:30 – 1:00	0:14 – 0:30				

NOTES
1 Fluid must be applied unheated to use these holdover times. No holdover times exist for this fluid applied heated.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type III fluid cannot be used.
3 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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Transport Canada Holdover Time Guidelines — Winter 2016-2017

TABLE 3HS-A-ACM

HIGH SPEED TYPE III FLUID HOLDOVER TIME GUIDELINES
ALLCLEAR AEROCLEAR MAX, APPLIED UNHEATED[1]

FOR AIRCRAFT CONFORMING TO THE SAE AS5900 HIGH SPEED AERODYNAMIC TEST CRITERION

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	100/0	0:45 – 1:10	1:00	0:30 – 1:00	0:14 – 0:30	0:20 – 0:45	0:14 – 0:20	0:06 – 0:40	
		75/25								
		50/50								
below -3 to -10	below 27 to 14	100/0	0:45 –1:25	1:00	0:30 – 1:00	0:14 – 0:30	0:20 – 0:40	0:15 – 0:25		
		75/25							CAUTION: No holdover time guidelines exist	
below -10 to -25	below 14 to -13	100/0	0:30 – 1:05	1:00	0:30 – 1:00	0:14 – 0:30				
below -25 to -35	below -13 to -31	100/0	0:15 – 0:40	0:40	0:19 – 0:40	0:09 – 0:19				

NOTES

1. Fluid must be applied unheated to use these holdover times. No holdover times exist for this fluid applied heated.
2. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type III fluid cannot be used.
3. To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4. Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6. No holdover time guidelines exist for this condition for 0°C (32°F) and below.
7. Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 5 provides allowance times for ice pellets and small hail).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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Transport Canada Holdover Time Guidelines — Winter 2016-2017

TABLE 3LS-C-2031

LOW SPEED TYPE III FLUID HOLDOVER TIME GUIDELINES
CLARIANT SAFEWING MP III 2031 ECO, APPLIED HEATED[1]

FOR AIRCRAFT CONFORMING TO THE SAE AS5900 LOW SPEED AERODYNAMIC TEST CRITERION

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	100/0	0:25 – 0:50	0:40	0:20 – 0:40	0:10 – 0:20	0:17 – 0:30	0:10 – 0:14	0:05 – 0:30	
		75/25	0:19 – 0:40	0:35	0:16 – 0:35	0:07 – 0:16	0:13 – 0:20	0:08 – 0:09	0:03 – 0:18	
		50/50	0:13 – 0:18	0:25	0:13 – 0:25	0:07 – 0:13	0:13 – 0:14	0:07 – 0:07	CAUTION: No holdover time guidelines exist	
below -3 to -10	below 27 to 14	100/0	0:35 – 1:15	0:40	0:20 – 0:40	0:10 – 0:20	0:14 – 0:30	0:09 – 0:13		
		75/25	0:19 – 0:45[8]	0:25[8]	0:12 – 0:25[8]	0:05 – 0:12[8]	0:09 – 0:16[8]	0:06 – 0:08[8]		
below -10 to -16.5	below 14 to 2.3	100/0	0:25 – 0:45	0:40	0:19 – 0:40	0:09 – 0:19				

NOTES

1. Fluid must be applied heated to use these holdover times. No holdover times exist for this fluid applied unheated.
2. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type III fluid cannot be used.
3. To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4. Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6. No holdover time guidelines exist for this condition for 0°C (32°F) and below.
7. Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
8. No holdover time guidelines exist for 75/25 fluid below -9°C (15.8°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2016-2017

TABLE 3HS-C-2031

HIGH SPEED TYPE III FLUID HOLDOVER TIME GUIDELINES
CLARIANT SAFEWING MP III 2031 ECO, APPLIED HEATED[1]

FOR AIRCRAFT CONFORMING TO THE SAE AS5900 HIGH SPEED AERODYNAMIC TEST CRITERION

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	100/0	0:25 – 0:50	0:40	0:20 – 0:40	0:10 – 0:20	0:17 – 0:30	0:10 – 0:14	0:05 – 0:30	CAUTION: No holdover time guidelines exist
		75/25	0:19 – 0:40	0:35	0:16 – 0:35	0:07 – 0:16	0:13 – 0:20	0:08 – 0:09	0:03 – 0:18	
		50/50	0:13 – 0:18	0:25	0:13 – 0:25	0:07 – 0:13	0:13 – 0:14	0:07 – 0:07		
below -3 to -10	below 27 to 14	100/0	0:35 – 1:15	0:40	0:20 – 0:40	0:10 – 0:20	0:14 – 0:30	0:09 – 0:13		
		75/25	0:19 – 0:45	0:25	0:12 – 0:25	0:05 – 0:12	0:09 – 0:16	0:06 – 0:08		
below -10 to -25	below 14 to -13	100/0	0:25 – 0:45	0:40	0:19 – 0:40	0:09 – 0:19				
below -25 to -29	below -13 to -20.2	100/0	0:25 – 0:45	0:40	0:19 – 0:40	0:09 – 0:19				

NOTES

1 Fluid must be applied heated to use these holdover times. No holdover times exist for this fluid applied unheated.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type III fluid cannot be used.
3 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 5 provides allowance times for ice pellets and small hail).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2016-2017

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER TIME GUIDELINES

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	1:15 – 2:40	2:00	1:10 – 2:00	0:35 – 1:10	0:40 – 1:30	0:35 – 0:40	0:08 – 1:25	
		75/25	1:25 – 2:40	2:00	1:15 – 2:00	0:45 – 1:15	0:50 – 1:20	0:30 – 0:45	0:09 – 1:15	
		50/50	0:25 – 0:50	0:40	0:25 – 0:40	0:15 – 0:25	0:15 – 0:30	0:09 – 0:15	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 1:35	1:20	0:45 – 1:20	0:25 – 0:45	0:25 – 1:20[7]	0:20 – 0:25[7]		
		75/25	0:30 – 1:10	1:40	0:45 – 1:40	0:20 – 0:45	0:15 – 1:05[7]	0:15 – 0:25[7]		
below -14 to LOUT	below 7 to LOUT	100/0	0:20 – 0:40[8]	0:20[8]	0:10 – 0:20[8]	0:08 – 0:10[8]				

NOTES

1. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2. To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3. Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7. No holdover time guidelines exist for this condition below -10°C (14°F).
8. If the LOUT is unknown, no holdover time guidelines exist below -22.5°C (-8.5°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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TABLE 4-A-E-AD49

TYPE IV FLUID HOLDOVER TIME GUIDELINES
ABAX ECOWING AD-49

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Snow, Snow Grains or Snow Pellets[2] Light[3]	Snow, Snow Grains or Snow Pellets[2] Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	3:20 – 4:00	2:00	1:50 – 2:00	1:10 – 1:50	1:25 – 2:00	1:00 – 1:25	0:10 – 1:55	
		75/25	2:25 – 4:00	2:00	1:40 – 2:00	1:20 – 1:40	1:55 – 2:00	0:50 – 1:30	0:10 – 1:40	
		50/50	0:25 – 0:50	0:40	0:25 – 0:40	0:15 – 0:25	0:15 – 0:30	0:10 – 0:15	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 1:35	2:00	1:50 – 2:00	1:10 – 1:50	0:25 – 1:25[7]	0:20 – 0:25[7]		
		75/25	0:30 – 1:10	2:00	1:40 – 2:00	1:20 – 1:40	0:15 – 1:05[7]	0:15 – 0:25[7]		
below -14 to -26	below 7 to -14.8	100/0	0:25 – 0:40	0:20	0:10 – 0:20	0:08 – 0:10				

NOTES

1. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2. To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3. Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7. No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2016-2017

TABLE 4-C-MF04

TYPE IV FLUID HOLDOVER TIME GUIDELINES
CLARIANT MAX FLIGHT 04

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:40 – 4:00	2:00	2:00 – 2:00	1:25 – 2:00	2:00 – 2:00	1:10 – 1:30	0:20 – 2:00	
		75/25								
		50/50							CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:50 – 2:30	2:00	1:10 – 2:00	0:35 – 1:10	0:25 – 1:30[7]	0:20 – 0:40[7]		
		75/25								
below -14 to -23.5	below 7 to -10.3	100/0	0:20 – 0:45	0:20	0:10 – 0:20	0:08 – 0:10				

NOTES

1. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2. To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3. Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7. No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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TABLE 4-C-MFA

TYPE IV FLUID HOLDOVER TIME GUIDELINES
CLARIANT MAX FLIGHT AVIA

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	3:05 – 4:00	2:00	1:45 – 2:00	1:00 – 1:45	1:25 – 2:00	0:55 – 1:10	0:09 – 2:00	
		75/25								
		50/50							CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	1:45 – 3:55	2:00	1:15 – 2:00	0:40 – 1:15	1:10 – 2:00[7]	0:55 – 1:30[7]		
		75/25								
below -14 to -28.5	below 7 to -19.3	100/0	0:35 – 1:25	0:20	0:10 – 0:20	0:08 – 0:10				

NOTES

1. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2. To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3. Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7. No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

TABLE 4-C-MFS

TYPE IV FLUID HOLDOVER TIME GUIDELINES
CLARIANT MAX FLIGHT SNEG

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Snow, Snow Grains or Snow Pellets[2] Light[3]	Snow, Snow Grains or Snow Pellets[2] Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:25 – 4:00	2:00	1:40 – 2:00	1:05 – 1:40	2:00 – 2:00	0:50 – 1:40	0:20 – 1:30	
		75/25	4:00 – 4:00	2:00	1:30 – 2:00	0:55 – 1:30	1:30 – 2:00	1:05 – 1:20	0:15 – 1:45	
		50/50	1:30 – 3:30	1:45	0:45 – 1:45	0:20 – 0:45	0:35 – 1:10	0:15 – 0:30		
below -3 to -14	below 27 to 7	100/0	0:45 – 2:20	2:00	1:15 – 2:00	0:45 – 1:15	0:30 – 1:25[7]	0:25 – 0:40[7]	CAUTION: No holdover time guidelines exist	
		75/25	0:30 – 1:25	1:40	1:00 – 1:40	0:40 – 1:00	0:20 – 1:05[7]	0:20 – 0:40[7]		
below -14 to -29	below 7 to -20.2	100/0	0:20 – 0:50	0:20	0:10 – 0:20	0:08 – 0:10				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines Winter 2016-2017

TABLE 4-C-N

TYPE IV FLUID HOLDOVER TIME GUIDELINES
CLARIANT SAFEWING EG IV NORTH

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:20 – 3:55	2:00	1:40 – 2:00	0:50 – 1:40	1:30 – 2:00	0:50 – 0:55	0:08 – 2:00	
		75/25								
		50/50								
below -3 to -14	below 27 to 7	100/0	1:45 – 4:00	2:00	1:30 – 2:00	0:50 – 1:30	1:05 – 1:50[7]	0:55 – 1:25[7]	CAUTION: No holdover time guidelines exist	
		75/25								
below -14 to -30	below 7 to -22	100/0	0:40 – 1:20	0:20	0:10 – 0:20	0:08 – 0:10				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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TABLE 4-C-L

TYPE IV FLUID HOLDOVER TIME GUIDELINES
CLARIANT SAFEWING MP IV LAUNCH

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	4:00 – 4:00	2:00	1:45 – 2:00	1:05 – 1:45	1:30 – 2:00	1:00 – 1:40	0:15 – 1:40	
		75/25	3:40 – 4:00	2:00	1:45 – 2:00	1:00 – 1:45	1:40 – 2:00	0:45 – 1:15	0:10 – 1:45	
		50/50	1:25 – 2:45	1:25	0:45 – 1:25	0:25 – 0:45	0:30 – 0:50	0:20 – 0:25	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	1:00 – 1:55	2:00	1:20 – 2:00	0:50 – 1:20	0:35 – 1:40[7]	0:25 – 0:45[7]		
		75/25	0:40 – 1:20	2:00	1:25 – 2:00	0:45 – 1:25	0:25 – 1:10[7]	0:25 – 0:45[7]		
below -14 to -28.5	below 7 to -19.3	100/0	0:30 – 0:50	0:20	0:10 – 0:20	0:08 – 0:10				

NOTES

1. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2. To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3. Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7. No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2016-2017

TABLE 4-C-L+

TYPE IV FLUID HOLDOVER TIME GUIDELINES
CLARIANT SAFEWING MP IV LAUNCH PLUS

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	3:55 – 4:00	2:00	2:00 – 2:00	0:55 – 2:00	2:00 – 2:00	1:00 – 2:00	0:20 – 2:00	CAUTION: No holdover time guidelines exist
		75/25	3:55 – 4:00	2:00	1:55 – 2:00	0:50 – 1:55	2:00 – 2:00	1:20 – 1:25	0:20 – 1:50	
		50/50	1:15 – 1:50	1:35	0:45 – 1:35	0:20 – 0:45	0:25 – 1:00	0:15 – 0:20		
below -3 to -14	below 27 to 7	100/0	0:55 – 2:15	2:00	1:25 – 2:00	0:40 – 1:25	0:25 – 1:35[7]	0:25 – 0:40[7]		
		75/25	0:40 – 2:00	2:00	1:15 – 2:00	0:30 – 1:15	0:20 – 1:05[7]	0:20 – 0:30[7]		
below -14 to -29	below 7 to -20.2	100/0	0:25 – 0:50	0:20	0:10 – 0:20	0:08 – 0:10				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

TABLE 4-CR-PGA

TYPE IV FLUID HOLDOVER TIME GUIDELINES
CRYOTECH POLAR GUARD® ADVANCE

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:50 – 4:00	2:00	1:50 – 2:00	1:20 – 1:50	1:35 – 2:00	1:15 – 1:30	0:15 – 2:00	CAUTION: No holdover time guidelines exist
		75/25	2:30 – 4:00	2:00	1:20 – 2:00	0:45 – 1:20	1:40 – 2:00	0:40 – 1:10	0:09 – 1:40	
		50/50	0:50 – 1:25	1:20	0:35 – 1:20	0:15 – 0:35	0:20 – 0:45	0:09 – 0:20		
below -3 to -14	below 27 to 7	100/0	0:55 – 2:30	1:45	1:15 – 1:45	0:55 – 1:15	0:35 – 1:35[7]	0:35 – 0:45[7]		
		75/25	0:40 – 1:30	1:45	1:00 – 1:45	0:35 – 1:00	0:25 – 1:05[7]	0:35 – 0:45[7]		
below -14 to -30.5	below 7 to -22.9	100/0	0:25 – 0:50	0:20	0:10 – 0:20	0:08 – 0:10				

NOTES

1. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2. To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3. Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7. No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

TABLE 4-DS-ES

TYPE IV FLUID HOLDOVER TIME GUIDELINES
DEICING SOLUTIONS ECO-SHIELD®

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	1:15 – 2:40	2:00	1:20 – 2:00	0:45 – 1:20	0:40 – 1:30	0:35 – 0:40	0:15 – 1:35	
		75/25								
		50/50							CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	1:10 – 2:35	1:55	1:05 – 1:55	0:35 – 1:05	0:50 – 1:25[7]	0:30 – 0:40[7]		
		75/25								
below -14 to -25.5	below 7 to -13.9	100/0	0:30 – 1:00	0:20	0:10 – 0:20	0:08 – 0:10				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

TABLE 4-D-E106

TYPE IV FLUID HOLDOVER TIME GUIDELINES
DOW CHEMICAL UCAR™ ENDURANCE EG106

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:05 – 3:10	2:00	1:20 – 2:00	0:40 – 1:20	1:10 – 2:00	0:50 – 1:15	0:20 – 2:00	
		75/25								
		50/50								
below -3 to -14	below 27 to 7	100/0	1:50 – 3:20	2:00	1:05 – 2:00	0:30 – 1:05	0:55 – 1:50[7]	0:45 – 1:10[7]	CAUTION: No holdover time guidelines exist	
		75/25								
below -14 to -27	below 7 to -16.6	100/0	0:30 – 1:05	0:20	0:10 – 0:20	0:08 – 0:10				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2016-2017

TABLE 4-D-AD49

TYPE IV FLUID HOLDOVER TIME GUIDELINES
DOW CHEMICAL UCAR™ FLIGHTGUARD AD-49

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	3:20 – 4:00	2:00	1:50 – 2:00	1:10 – 1:50	1:25 – 2:00	1:00 – 1:25	0:10 – 1:55	CAUTION: No holdover time guidelines exist
		75/25	2:25 – 4:00	2:00	1:40 – 2:00	1:20 – 1:40	1:55 – 2:00	0:50 – 1:30	0:10 – 1:40	
		50/50	0:25 – 0:50	0:40	0:25 – 0:40	0:15 – 0:25	0:15 – 0:30	0:10 – 0:15		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:35	2:00	1:50 – 2:00	1:10 – 1:50	0:25 – 1:25[7]	0:20 – 0:25[7]		
		75/25	0:30 – 1:10	2:00	1:40 – 2:00	1:20 – 1:40	0:15 – 1:05[7]	0:15 – 0:25[7]		
below -14 to -26	below 7 to -14.8	100/0	0:25 – 0:40	0:20	0:10 – 0:20	0:08 – 0:10				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2016-2017

TABLE 4-K-ABC-S+

TYPE IV FLUID HOLDOVER TIME GUIDELINES
KILFROST ABC-S PLUS

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	2:10 – 4:00	2:00	2:00 – 2:00	1:15 – 2:00	1:50 – 2:00	1:05 – 2:00	0:25 – 2:00	
		75/25	1:25 – 2:40	2:00	1:15 – 2:00	0:45 – 1:15	1:00 – 1:20	0:30 – 0:50	0:10 – 1:20	
		50/50	0:30 – 0:55	1:00	0:30 – 1:00	0:15 – 0:30	0:15 – 0:40	0:15 – 0:20	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:55 – 3:30	2:00	1:45 – 2:00	1:00 – 1:45	0:25 – 1:35[7]	0:20 – 0:30[7]		
		75/25	0:45 – 1:50	1:45	1:00 – 1:45	0:35 – 1:00	0:20 – 1:10[7]	0:15 – 0:25[7]		
below -14 to -28	below 7 to -18.4	100/0	0:40 – 1:00	0:20	0:10 – 0:20	0:08 – 0:10				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

TABLE 4-L-E450

TYPE IV FLUID HOLDOVER TIME GUIDELINES
LNT SOLUTIONS E450

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:50 – 2:55	2:00	1:35 – 2:00	1:00 – 1:35	1:35 – 2:00	0:55 – 1:20	0:25 – 2:00	CAUTION: No holdover time guidelines exist
		75/25								
		50/50								
below -3 to -14	below 27 to 7	100/0	1:30 – 3:55	1:50	1:10 – 1:50	0:45 – 1:10	1:45 – 2:00[7]	1:05 – 1:40[7]		
		75/25								
below -14 to -22.5	below 7 to -8.5	100/0	0:35 – 1:05	0:20	0:10 – 0:20	0:08 – 0:10				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

TABLE 4-N-F-9311

TYPE IV FLUID HOLDOVER TIME GUIDELINES
NEWAVE AEROCHEMICAL FCY 9311

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:55 – 4:00	2:00	1:10 – 2:00	0:35 – 1:10	1:10 – 2:00	0:40 – 1:05	0:15 – 1:25	CAUTION: No holdover time guidelines exist
		75/25								
		50/50								
below -3 to -14	below 27 to 7	100/0	0:35 – 2:05	1:35	0:50 – 1:35	0:25 – 0:50	0:35 – 1:20[7]	0:20 – 0:35[7]		
		75/25								
below -14 to -29.5	below 7 to -21.1	100/0	0:30 – 0:55	0:20	0:10 – 0:20	0:08 – 0:10				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines **Winter 2016-2017**

TABLE 4-SC-CSIV

TYPE IV FLUID HOLDOVER TIME GUIDELINES
SHAANXI CLEANWAY AVIATION CLEANSURFACE IV

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	2:50 – 4:00	2:00	1:55 – 2:00	1:00 – 1:55	2:00 – 2:00	1:25 – 1:30	0:15 – 2:00	CAUTION: No holdover time guidelines exist
		75/25	2:35 – 4:00	2:00	1:35 – 2:00	0:45 – 1:35	0:50 – 2:00	0:35 – 0:45	0:09 – 1:15	
		50/50	1:05 – 2:25	1:40	0:40 – 1:40	0:15 – 0:40	0:25 – 0:50	0:15 – 0:20		
below -3 to -14	below 27 to 7	100/0	1:00 – 3:05	1:20	0:45 – 1:20	0:25 – 0:45	0:35 – 1:45[7]	0:20 – 0:35[7]		
		75/25	0:50 – 1:55	1:40	0:45 – 1:40	0:20 – 0:45	0:30 – 1:20[7]	0:25 – 0:40[7]		
below -14 to -28.5	below 7 to -19.3	100/0	0:30 – 0:50	0:20	0:10 – 0:20	0:08 – 0:10				

NOTES

1. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2. To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3. Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7. No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

ICE PELLET AND SMALL HAIL ALLOWANCE TIMES

1. Background

During the winter of 2006-2007, operations in ice pellets were approved by the FAA (Transport Canada opted not to publish guidance that winter) for “light ice pellets” with an allowance time of 25 minutes. That time was based on limited research conducted late in the winter of 2005-2006 at the request of various industry groups. Additional and more comprehensive ice pellet research was conducted jointly by the research teams of the FAA and Transport Canada the following winter.

This research consisted of extensive climatic chamber, wind tunnel, and live aircraft testing with ice pellets (light and moderate) and light ice pellets mixed with other forms of precipitation. Results of this research provide the basis for more comprehensive allowance times for operations in light ice pellets, as well as allowance times for operations in moderate ice pellets and light ice pellets mixed with other forms of precipitation.

Additional ice pellet research was conducted during the winter season of 2008-2009 which further expanded the ice pellet allowance times under specified conditions. Guidance was also provided for Type IV anti-icing fluid with embedded ice pellets “aged” beyond its allowance time when the precipitation stops at or prior to the expiration of the allowance time. This research demonstrated that provided the precipitation has stopped within the respective allowance time, the fluid remains effective up to 90 minutes after the start of the application time of the anti-icing fluid.

During the winter of 2009-2010, wind tunnel research conducted with a newer generation type airfoil showed that Type IV Propylene Glycol (PG) and Type IV Ethylene Glycol (EG) fluids behave differently under certain temperature and ice pellet conditions. Specifically, higher aircraft rotation speeds are required to effectively remove Type IV PG fluid contaminated with light or moderate ice pellets at temperatures less than -10°C. Therefore, there are no allowance times associated with the use of Type IV PG fluids on aircraft with rotation speeds of less than 115 knots in conditions of light or moderate ice pellets at temperatures below -10°C.

Furthermore, research with this newer generation type airfoil has shown that the allowance times are shorter when using Type IV PG fluids under certain conditions for all aircraft regardless of the rotation speed. This research resulted in the allowance time when using Type IV PG fluids at temperatures of 5°C and above being limited to 15 minutes in moderate ice pellets.

Research has also indicated that Type IV PG fluids are removed less effectively when contaminated with moderate ice pellets at temperatures below -16°C; operations in these conditions are not recommended. Therefore, there are no allowance times associated with the use of PG fluids in conditions of moderate ice pellets at temperatures below -16°C, irrespective of aircraft rotation speed.

Type IV allowance times do not currently exist below -22°C as existing cold temperature data is limited or not available below -22°C and therefore allowance times cannot be provided.

Allowance times are also published for undiluted (100/0) Type III fluid applied unheated in select conditions. Further testing is required to expand Type III allowance times in other conditions, such as temperatures below -10°C.

Allowance times for small hail are also published, as it was determined small hail is meteorologically equivalent to ice pellets.

The current allowance times, which were developed based on the aerodynamic testing described above, are provided in the Type III (Table 5) and Type IV (Table 6) allowance time tables.

2. Operational Guidance

(a) Tests have shown that ice pellets generally remain in the frozen state imbedded in Type III and Type IV anti-icing fluid, and are not absorbed and dissolved by the fluid in the same manner as other forms of precipitation.

Using current guidelines for determining anti-icing fluid failure, the presence of a contaminant not absorbed by the fluid (remaining imbedded) would be an indication that the fluid has failed. These imbedded ice pellets are generally not readily detectable by the human eye during pre-takeoff contamination inspection procedures. Therefore, a visual pre-takeoff contamination inspection in ice pellet conditions may not be of value and is not required.

(b) The research data have also shown that after proper deicing and anti-icing, the accumulation of light ice pellets, moderate ice pellets, and ice pellets mixed with other forms of precipitation in Type III and Type IV fluid will not prevent the fluid from flowing off the aerodynamic surfaces during takeoff. This flow-off, due to the shearing forces, occurs with rotation speeds consistent with Type III or Type IV anti-icing fluid recommended applications, and up to the applicable allowance time listed in the allowance time tables. These allowance times are from the start of the anti-icing fluid application. Additionally, if the ice pellet condition stops, and the allowance time has not been exceeded, the operator is permitted to consider the anti-icing fluid effective without any further action up to 90 minutes after the start of the application time of the anti-icing fluid. To use this guidance in the following conditions, the outside air temperature (OAT) must remain constant or increase during the 90-minute period:

- 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; and
- light ice pellets mixed with moderate rain.

Examples:

1) Type IV anti-icing fluid is applied with a start of application time of 10:00, OAT is 0°C, light ice pellets fall until 10:20 and stop and do not restart. The allowance time stops at 10:50; however, provided that no precipitation restarts after the allowance time of 10:50 the aircraft may takeoff without any further action up to 11:30.

2) Type IV anti-icing fluid is applied with a start of application time of 10:00, OAT is 0°C, light ice pellets mixed with freezing drizzle falls until 10:10 and stops and restarts at 10:15 and stops at 10:20. The allowance time stops at 10:25, however provided that the OAT remains constant or increases and that no precipitation restarts after the allowance time of 10:25, the aircraft may takeoff without any further action up to 11:30.

3) On the other hand, if Type IV anti-icing fluid is applied with a start of application time of 10:00, OAT is 0°C, light ice pellets mixed with freezing drizzle falls until 10:10 and stops and restarts at 10:30 with the allowance time stopping at 10:25 the aircraft may not takeoff, no matter how short the time or type of precipitation after 10:25, without being deiced and anti-iced if precipitation is present.

(c) Operators with a deicing program updated to include the allowance time information contained herein will be allowed, in the specified ice pellet and small hail conditions listed in Tables 5 and 6, up to the specific allowance time, to commence the takeoff with the following restrictions:

1) The aircraft critical surfaces must be free of contaminants before applying anti icing fluid. If not, the aircraft must be properly deiced and checked to be free of contaminants before the application of anti-icing fluid.

2) The allowance time is valid only if the aircraft is anti-iced with undiluted Type III or Type IV fluid.

3) The Type III allowance times are only applicable for unheated anti-icing fluid applications.

4) Due to the shearing qualities of Type III and Type IV fluids with imbedded ice pellets, allowance times are limited to aircraft with a rotation speed of 100 knots or greater, or 115 knots or greater as indicated in the allowance time tables.

5) If the takeoff is not accomplished within the applicable allowance time, the aircraft must be completely deiced, and if precipitation is still present, anti-iced again prior to a subsequent takeoff. If the precipitation stops at or before the time limits of the applicable allowance time and does not restart, the aircraft may takeoff up to 90 minutes after the start of the application of the Type III or Type IV anti-icing fluid, subject to the restrictions in 2(b) above.

6) A pre-takeoff contamination inspection is not required. The allowance time cannot be extended by an internal or external inspection of the aircraft critical surfaces.
7) If ice pellet precipitation becomes heavier than moderate or if the light ice pellets mixed with other forms of allowable precipitation exceeds the listed intensities or temperature range, the allowance time cannot be used.
8) If the temperature decreases below the temperature on which the allowance time was based,
   a) and the new lower temperature has an associated allowance time for the precipitation condition and the present time is within the new allowance time, then that new time must be used as the allowance time limit.
   b) and the allowance time has expired (within the 90 minute post anti-icing window if the precipitation has stopped within the allowance time), the aircraft may not takeoff and must be completely deiced and, if applicable, anti-iced before a subsequent takeoff.
9) If an intensity is reported with small hail, the ice pellet condition with the equivalent intensity can be used, e.g. if light small hail is reported, the "light ice pellets" allowance times can be used. This also applies in mixed conditions, e.g. if light small hail mixed with light snow is reported, use the "light ice pellets mixed with light snow" allowance times.

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TABLE 5

SAE TYPE III FLUID ICE PELLET AND SMALL HAIL ALLOWANCE TIMES[1]

This table is for use with SAE Type III undiluted (100/0) fluids applied unheated only

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Precipitation Type	Outside Air Temperature		
	-5°C and above	Below -5 to -10°C	Below -10°C[2]
Light Ice Pellets	10 minutes	10 minutes	Caution: No allowance times currently exist
Light Ice Pellets Mixed with Light Snow	10 minutes	10 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes	5 minutes	
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	7 minutes	5 minutes	
Light Ice Pellets Mixed with Light Freezing Rain	7 minutes	5 minutes	
Light Ice Pellets Mixed with Light Rain	7 minutes[3]		
Light Ice Pellets Mixed with Moderate Rain			
Moderate Ice Pellets (or Small Hail)[4]	5 minutes	5 minutes	

NOTES
1 These allowance times are for use with aircraft with rotation speeds of 100 knots or greater.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 No allowance times exist in this condition for temperatures below 0°C; consider use of light ice pellets mixed with light freezing rain.
4 If no intensity is reported with small hail, use the "moderate ice pellets or small hail" allowance times. If an intensity is reported with small hail, the ice pellet condition with the equivalent intensity can be used, e.g. if light small hail is reported, the "light ice pellets" allowance times can be used. This also applies in mixed conditions, e.g. if light small hail mixed with light snow is reported, use the "light ice pellets mixed with light snow" allowance times.

CAUTIONS
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **Allowance time cannot be extended by an inspection of the aircraft critical surfaces.**
- **Takeoff is allowed up to 90 minutes after start of fluid application if the precipitation stops at or before the allowance time expires and does not restart. The OAT must not decrease during the 90 minutes to use this guidance in conditions of light ice pellets mixed with either: light or moderate freezing drizzle, light freezing rain, or light rain.**

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TABLE 6

SAE TYPE IV FLUID ICE PELLET AND SMALL HAIL ALLOWANCE TIMES[1]

This table is for use with SAE Type IV undiluted (100/0) fluids only. All Type IV fluids are propylene glycol based with the exception of Clariant Max Flight AVIA, Clariant Safewing EG IV NORTH, Dow EG106 and LNT Solutions E450 which are ethylene glycol based.

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Precipitation Type	Outside Air Temperature			
	-5°C and above	Below -5 to -10°C	Below -10 to -16°C	Below -16 to -22°C[2]
Light Ice Pellets	50 minutes	30 minutes	30 minutes[3]	30 minutes[3]
Light Ice Pellets Mixed with Light Snow	40 minutes	15 minutes	15 minutes[3]	
Light Ice Pellets Mixed with Moderate Snow	20 minutes	7 minutes	5 minutes[3]	
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 minutes	10 minutes		
Light Ice Pellets Mixed with Light Freezing Rain	25 minutes	10 minutes	**Caution: No allowance times currently exist**	
Light Ice Pellets Mixed with Light Rain	25 minutes[4]			
Light Ice Pellets Mixed with Moderate Rain	25 minutes[5]			
Moderate Ice Pellets (or Small Hail)[6]	25 minutes[7]	10 minutes	10 minutes[3]	10 minutes[8]
Moderate Ice Pellets (or Small Hail)[6] Mixed with Moderate Freezing Drizzle	10 minutes	7 minutes	**Caution: No allowance times currently exist**	
Moderate Ice Pellets (or Small Hail)[6] Mixed with Moderate Rain	10 minutes[5]			

NOTES

1. These allowance times are for use with aircraft with rotation speeds of 100 knots or greater.
2. Ensure that the lowest operational use temperature (LOUT) is respected.
3. No allowance times exist for propylene glycol (PG) fluids when used on aircraft with rotation speeds less than 115 knots. (For these aircraft, if the fluid type is not known, assume zero allowance time.)
4. No allowance times exist in this condition for temperatures below 0°C; consider use of light ice pellets mixed with light freezing rain.
5. No allowance times exist in this condition for temperatures below 0°C.
6. If no intensity is reported with small hail, use the "moderate ice pellets or small hail" allowance times. If an intensity is reported with small hail, the ice pellet condition with the equivalent intensity can be used, e.g. if light small hail is reported, the "light ice pellets" allowance times can be used. This also applies in mixed conditions, e.g. if light small hail mixed with light snow is reported, use the "light ice pellets mixed with light snow" allowance times.
7. Allowance time is 15 minutes for propylene glycol (PG) fluids or when the fluid type is unknown.
8. No allowance times exist for propylene glycol (PG) fluids in this condition for temperatures below -16°C.

CAUTIONS

- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **Allowance time cannot be extended by an inspection of the aircraft critical surfaces.**
- **Takeoff is allowed up to 90 minutes after start of fluid application if the precipitation stops at or before the allowance time expires and does not restart. The OAT must not decrease during the 90 minutes to use this guidance in conditions of light ice pellets mixed with either: light or moderate freezing drizzle, light freezing rain, light rain, or moderate rain.**

TABLE 7

SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY[1]

Lighting	Temperature Range		Visibility in Snow in Statute Miles (Metres)			
	°C	°F	Heavy	Moderate	Light	Very Light
Darkness	-1 and above	30 and above	≤1 (≤1600)	>1 to 2½ (>1600 to 4000)	>2½ to 4 (>4000 to 6400)	>4 (>6400)
Darkness	Below -1	Below 30	≤3/4 (≤1200)	>3/4 to 1½ (>1200 to 2400)	>1½ to 3 (>2400 to 4800)	>3 (>4800)
Daylight	-1 and above	30 and above	≤½ (≤800)	>½ to 1½ (>800 to 2400)	>1½ to 3 (>2400 to 4800)	>3 (>4800)
Daylight	Below -1	Below 30	≤3/8 (≤600)	>3/8 to 7/8 (>600 to 1400)	>7/8 to 2 (>1400 to 3200)	>2 (>3200)

1 Based on: *Relationship between Visibility and Snowfall Intensity* (TP 14151E), Transportation Development Centre, Transport Canada, November 2003; and *Theoretical Considerations in the Estimation of Snowfall Rate Using Visibility* (TP 12893E), Transportation Development Centre, Transport Canada, November 1998.

HOW TO READ AND USE THE TABLE

The METAR/SPECI reported visibility or flight crew observed visibility will be used with this visibility table to establish snowfall intensity for Type I, II, III and IV holdover time guidelines, during snow, snow grain, or snow pellet precipitation conditions.

This visibility table will also be used when snow, snow grains or snow pellets are accompanied by blowing or drifting snow in the METAR/SPECI.

RVR values should not be used with this table.

Example: *CYVO 160200Z 15011G17KT 1SM -SN DRSN OVC009 M06/M08 A2948*

In the above METAR the snowfall intensity is reported as light. However, based upon the Transport Canada "Snowfall Intensities as a Function of Prevailing Visibility" table, with a visibility of 1 statute mile, in darkness and a temperature of -6°C, the snowfall intensity is classified as moderate. The snowfall intensity of moderate - not the METAR reported intensity of light - will be used to determine which holdover time guideline value is appropriate for the fluid in use.

TABLE 8-1

LIST OF TYPE I FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE

(see cautions and notes on page 67)

COMPANY NAME	FLUID NAME	TYPE OF GLYCOL[1]	EXPIRY[2] (Y-M-D)	LOWEST OPERATIONAL USE TEMPERATURE[3]				
				DILUTION[4,5] (FLUID/WATER)	LOW SPEED AERODYNAMIC TEST[6]		HIGH SPEED AERODYNAMIC TEST[6]	
					°C	°F	°C	°F
ABAX Industries	DE-950	PG	18-05-01	71/29	-26	-14.8	-31	-23.8
ADDCON EUROPE GmbH	IceFree I.80	PG	17-05-20	70/30	-26	-14.8	-32	-25.6
ALAB Industries	WDF 1	EG	18-04-25	70/30	-40	-40	-45	-49
AllClear Systems LLC	Lift-Off E-188	EG	18-07-15	70/30	-40	-40	-41.5	-42.7
AllClear Systems LLC	Lift-Off P-88	PG	18-06-11	70/30	-24.5	-12.1	-29.5	-21.1
Arcton Ltd.	Arctica DG ready-to-use	DEG	18-06-02	as supplied	-26	-14.8	-26	-14.8
Arcton Ltd.	Arctica DG 91 Concentrate	DEG	17-07-16	75/25	*-25[14]*	*-13[14]*	-25	-13
AVIAFLUID International Ltd.[11]	AVIAFLO EG	EG	16-11-28	70/30	-40.5	-40.9	-44	-47.2
Aviation Shaanxi Hi-Tech Physical Chemical Co. Ltd.	Cleanwing I	PG	19-09-30	75/25	Not tested[10]	Not tested[10]	-39.5	-39.1
Aviation Xi'an High-Tech Physical Chemical Co. Ltd.	KHF-1	PG	19-05-22	75/25	Not tested[10]	Not tested[10]	-38.5	-37.3
Baltic Ground Services[11]	*DEFROSOL ADF*	*NCG*	*15-03-18[9]*	*65/35*	*-25*	*-13*	*-30*	*-22*
Beijing Wangye Aviation Chemical Product Co Ltd.	KLA-1	EG	19-09-08	60/40	Not tested[10]	Not tested[10]	-30.5	-22.9
Beijing Yadilite Aviation Advanced Materials Corporation	YD-101 Type I	PG	17-05-27	60/40	Not tested[10]	Not tested[10]	-30	-22
Beijing Yadilite Aviation Advanced Materials Corporation	YD-101A Type I	EG	17-11-01	70/30	Not tested[10]	Not tested[10]	-38	-36.4
Boryszew S.A.	Borygo Plane I	PG	17-12-04	75/25	-25	-13	-30	-22
CHEMCO Inc.	CHEMR EG I	EG	20-04-01	70/30	-37	-34.6	-43	-45.4
CHEMCO Inc.	*CHEMR REG I*	*EG*	*16-07-08[9]*	*75/25*	*-36*	*-32.8*	*-40.5*	*-40.9*
Clariant Produkte (Deutschland) GmbH	*EcoFlo Concentrate*	*NCG*	*13-07-06[9]*	*65/35*	*Not tested[10]*	*Not tested[10]*	*-30.5*	*-22.9*
Clariant Produkte (Deutschland) GmbH	*EcoFlo 2 Concentrate*	*NCG*	*13-07-25[9]*	*65/35*	*Not tested[10]*	*Not tested[10]*	*-29*	*-20.2*
Clariant Produkte (Deutschland) GmbH	Octaflo EF Concentrate	PG	18-03-20	65/35	-25	-13	-33	-27.4
Clariant Produkte (Deutschland) GmbH	*Octaflo EF-80*	*PG*	*13-12-21[9]*	*70/30*	*-25*	*-13*	*-33*	*-27.4*
Clariant Produkte (Deutschland) GmbH	Octaflo EG Concentrate	EG	17-07-23	70/30	-40.5	-40.9	-44	-47.2
Clariant Produkte (Deutschland) GmbH	Octaflo LYOD	EG	20-03-16	70/30	-40	-40	-45.5	-49.9
Clariant Produkte (Deutschland) GmbH	Safewing EG I 1996 (88)	EG	19-10-15	70/30	-39.5	-39.1	-41.5	-42.7

TABLE 8-1 (cont'd)

LIST OF TYPE I FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE

(see cautions and notes on page 67)

Company Name	Fluid Name	Type of Glycol[1]	Expiry[2] (Y-M-D)	Lowest Operational Use Temperature[3]				
				Dilution[4,5] (Fluid/Water)	Low Speed Aerodynamic Test[6]		High Speed Aerodynamic Test[6]	
					°C	°F	°C	°F
Clariant Produkte (Deutschland) GmbH	Safewing MP I 1938 ECO	PG	20-05-11	65/35	-25.5	-13.9	-32	-25.6
Clariant Produkte (Deutschland) GmbH	Safewing MP I 1938 ECO (80)	PG	20-05-20	71/29	-25	-13	-32.5	-26.5
Clariant Produkte (Deutschland) GmbH	Safewing MP I 1938 ECO (80) Premix 55% i.g. ready-to-use	PG	17-03-13	as supplied	Not tested[10]	Not tested[10]	-19	-2.2
Clariant Produkte (Deutschland) GmbH	Safewing MP I ECO PLUS (80)	PG	19-03-13	71/29	-25	-13	-33	-27.4
Cryotech Deicing Technology	Polar Plus®	PG	20-01-13	63/37	-27	-16.6	-32	-25.6
Cryotech Deicing Technology	Polar Plus® LT	PG	20-01-26	63/37	-27	-16.6	-33	-27.4
Cryotech Deicing Technology	Polar Plus® LT (80)	PG	20-04-12	70/30	-27	-16.6	-33	-27.4
Cryotech Deicing Technology	Polar Plus® (80)	PG	17-09-12	70/30	-24.5	-12.1	-32.5	-26.5
Deicing Solutions LLC	Safetemp® ES Plus (Multiple Location)	PG	18-08-29	65/35	-25.5	-13.9	-31	-23.8
Dow Chemical Company	UCAR™ ADF Concentrate	EG	19-05-11	75/25	-36	-32.8	-45	-49
Dow Chemical Company	UCAR™ ADF XL54[17]	EG	19-05-11	as supplied	-33	-27.4	-33	-27.4
Dow Chemical Company	UCAR™ PG ADF Concentrate	PG	19-05-11	65/35	-25	-13	-32	-25.6
Dow Chemical Company	UCAR™ PG ADF Dilute 55/45[18]	PG	19-05-11	as supplied	-24	-11.2	-25	-13
DR Energy Group LTD.	Northern Guard I	EG	17-06-16	65/35	Not tested[10]	Not tested[10]	-39.5	-39.1
Heilongjiang Hangjie Aero-chemical Technology Co. Ltd.	HJF-1	EG	17-10-02	65/35	Not tested[10]	Not tested[10]	-42	-43.6
Heilongjiang Hangjie Aero-chemical Technology Co. Ltd.	HJF-1A	EG	16-09-02	75/25	Not tested[10]	Not tested[10]	-40.5	-40.9
HOC Industries	SafeTemp® ES Plus	PG	20-04-12	65/35	-25.5	-13.9	-29	-20.2
Inland Technologies CANADA Inc.	DuraGly-E Type I ADF Concentrate	EG	19-01-13	60/40	-33	-27.4	-33	-27.4
Inland Technologies CANADA Inc.	*DuraGly-P Type I ADF Concentrate*	*PG*	*15-02-04[9]*	*60/40*	*-25*	*-13*	*-25*	*-13*
Inland Technologies CANADA Inc.	Inland ADF Concentrate[12] (Multiple Location)	EG	Y-M-D[12]	75/25	-36	-32.8	-42.5	-44.5
Kilfrost Limited	Kilfrost DF Plus	PG	19-07-16	69/31	-25.5	-13.9	-32	-25.6
Kilfrost Limited	Kilfrost DF Plus (80)	PG	20-05-02	69/31	-26	-14.8	-31.5	-24.7
Kilfrost Limited	Kilfrost DF Plus (88)	PG	19-07-16	63/37	-25.5	-13.9	-32	-25.6
Kilfrost Limited	Kilfrost DF^{Sustain}	NCG	19-08-06	68/32	-34	-29.2	-41	-41.8

TABLE 8-1 (cont'd)

LIST OF TYPE I FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE

(see cautions and notes on page 67)

Company Name	Fluid Name	Type of Glycol[1]	Expiry[2] (Y-M-D)	Lowest Operational Use Temperature[3]					
				Dilution[4,5] (Fluid/Water)	Low Speed Aerodynamic Test[6]		High Speed Aerodynamic Test[6]		
					°C	°F	°C	°F	
LNT Solutions	LNT E188	EG	17-10-01	70/30	-30.5	-22.9	-41	-41.8	
LNT Solutions	LNT P180	PG	17-10-04	69/31	-26	-14.8	-32	-25.6	
LNT Solutions	LNT P188	PG	18-11-28	70/30	-24.5	-12.1	-31.5	-24.7	
Newave Aerochemical Co. Ltd.	FCY-1A	EG	19-02-20	75/25	-40	-40	-40	-40	
Newave Aerochemical Co. Ltd.	*FCY-1Bio+*	*EG*	*16-07-08[13]*	*75/25*	*Not tested[10]*	*Not tested[10]*	*-40.5*	*-40.9*	
Oksayd Co. Ltd.	DEFROST EG 88.1	EG	17-09-02	70/30	Not tested[10]	Not tested[10]	-44.5	-48.1	
Shaanxi Cleanway Aviation Chemical Co., Ltd	Cleansurface I	EG	17-09-12	75/25	*-32.5[14]*	*-26.5[14]*	-40.5	-40.9	
Shaanxi Cleanway Aviation Chemical Co., Ltd	Cleansurface I-BIO	EG	18-07-11	75/25	Not tested[10]	Not tested[10]	-37	-34.6	
Velvana a.s.	AIRVEL OK 1	PG	17-01-28	70/30	-26	-14.8	-30	-22	

TABLE 8-2

LIST OF TYPE II FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE

(see cautions and notes on page 67)

Company Name	Fluid Name	Type of Glycol[1]	Expiry[2] (Y-M-D)	Dilution (Fluid/Water)	Lowest Operational Use Temperature[3] High Speed Aerodynamic Test[6] °C	°F	Lowest On-Wing Viscosity[7,8] (mPa.s) Manufacturer Method	AS 9968 Method
ABAX Industries	Ecowing 26	PG	17-04-28	100/0	-25	-13	4 900 (f)	4 600 (a)
				75/25	-14	7	2 200 (a)	2 200 (a)
				50/50	-3	27	50 (a)	50 (a)
Aviation Shaanxi Hi-Tech Physical Chemical Co. Ltd.	Cleanwing II	PG	17-05-20	100/0	-29	-20.2	4 650 (d)	4 500 (a)
				75/25	-14	7	9 450 (d)	10 000 (a)
				50/50	-3	27	10 150 (d)	10 200 (a)
Beijing Yadilite Aviation Advanced Materials Corporation	YD-102 Type II	PG	18-02-26	100/0	-29	-20.2	4 500 (a)	4 500 (a)
				75/25	-14	7	12 850 (a)	12 850 (a)
				50/50	-3	27	820 (a)	300 (k)
Clariant Produkte (Deutschland) GmbH	Safewing MP II FLIGHT	PG	18-05-11	100/0	-29	-20.2	3 340 (a)	3 340 (a)
				75/25	-14	7	12 900 (c)	12 900 (c)
				50/50	-3	27	11 500 (a)	11 500 (a)
Clariant Produkte (Deutschland) GmbH	Safewing MP II FLIGHT PLUS	PG	18-04-06	100/0	-29	-20.2	3 650 (l)	3 100 (a)
				75/25	-14	7	12 400 (l)	10 450 (a)
				50/50	-3	27	7 800 (l)	7 050 (a)
Cryotech Deicing Technology	Polar Guard® II	PG	17-03-11	100/0	-30.5	-22.9	4 400 (e)	4 050 (a)
				75/25	-14	7	11 600 (e)	9 750 (a)
				50/50	-3	27	80 (a)	80 (a)
Kilfrost Limited	ABC-3	PG	16-10-08	100/0	-27	-16.6	2 500 (d)	2 500 (a)
				75/25	-14	7	2 000 (d)	2 000 (a)
				50/50	-3	27	400 (d)	400 (a)
Kilfrost Limited	ABC-Ice Clear II	PG	17-05-13	100/0	-29.5	-21.1	7 720 (a)	7 720 (a)
				75/25	-14	7	5 660 (a)	5 660 (a)
				50/50	-3	27	580 (a)	558 (k)
Kilfrost Limited	ABC-K Plus	PG	16-11-24	100/0	-29	-20.2	2 850 (d)	2 640 (a)
				75/25	-14	7	12 650 (d)	12 650 (c)
				50/50	-3	27	4 200 (d)	5 260 (a)
Newave Aerochemical Co. Ltd.	FCY-2	PG	17-02-20	100/0	-28	-18.4	7 000 (d)	8 920 (a)
				75/25	-14	7	18 550 (d)	18 550 (c)
				50/50	-3	27	6 750 (d)	7 030 (a)

TABLE 8-2 (cont'd)

LIST OF TYPE II FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE

(see cautions and notes on page 67)

Company Name	Fluid Name	Type of Glycol[1]	Expiry[2] (Y-M-D)	Dilution (Fluid/Water)	Lowest Operational Use Temperature[3] High Speed Aerodynamic Test[6] °C	Lowest Operational Use Temperature[3] High Speed Aerodynamic Test[6] °F	Lowest On-Wing Viscosity[7,8] (mPa.s) Manufacturer Method	Lowest On-Wing Viscosity[7,8] (mPa.s) AS 9968 Method
Newave Aerochemical Co. Ltd.	FCY-2 Bio+	PG	17-05-06	100/0	-28.5	-19.3	7 210 (a)	7 210 (a)
				75/25	-14	7	21 400 (c)	21 400 (c)
				50/50	-3	27	1 900 (a)	1 900 (a)

TABLE 8-3

LIST OF TYPE III FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE

(see cautions and notes on page 67)

Company Name	Fluid Name	Type of Glycol[1]	Expiry[2] (Y-M-D)	Dilution (Fluid/Water)	Lowest Operational Use Temperature[3]				Lowest On-Wing Viscosity[7,8] (mPa.s)	
					Low Speed Aerodynamic Test[6]		High Speed Aerodynamic Test[6]		Manufacturer Method	AS 9968 Method
					°C	°F	°C	°F		
AllClear Systems LLC	AeroClear MAX	EG	16-12-22[15]	100/0	-16	3.2	-35	-31	7 300 (j)	Not Available[16]
				75/25	Dilution Not Applicable		Dilution Not Applicable		Dilution Not Applicable	
				50/50	Dilution Not Applicable		Dilution Not Applicable		Dilution Not Applicable	
Clariant Produkte (Deutschland) GmbH	*Safewing MP III 2031 ECO*	*PG*	*15-08-15*[9]	*100/0*	*-16.5*	*2.3*	*-29*	*-20.2*	*120 (k)*	*120 (k)*
				75/25	*-9*	*15.8*	*-10*	*14*	*86 (k)*	*86 (k)*
				50/50	*-3*	*27*	*-3*	*27*	*16 (k)*	*16 (k)*

TABLE 8-4

LIST OF TYPE IV FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE

(see cautions and notes on page 67)

COMPANY NAME	FLUID NAME	TYPE OF GLYCOL[1]	EXPIRY[2] (Y-M-D)	DILUTION (FLUID/WATER)	LOWEST OPERATIONAL USE TEMPERATURE[3]		LOWEST ON-WING VISCOSITY[7,8] (mPa.s)	
					HIGH SPEED AERODYNAMIC TEST[6]		MANUFACTURER METHOD	AS 9968 METHOD
					°C	°F		
ABAX Industries	Ecowing AD-49	PG	18-04-22	100/0	-26	-14.8	12 150 (g)	11 000 (a)
				75/25	-14	7	30 700 (g)	32 350 (c)
				50/50	-3	27	19 450 (g)	21 150 (c)
Clariant Produkte (Deutschland) GmbH	*Max Flight 04*	*PG*	*16-07-23[9]*	*100/0*	*-23.5*	*-10.3*	*5 540 (b)*	*5 540 (a)*
				75/25	*Dilution Not Applicable*		*Dilution Not Applicable*	
				50/50	*Dilution Not Applicable*		*Dilution Not Applicable*	
Clariant Produkte (Deutschland) GmbH	Max Flight AVIA	EG	18-04-25	100/0	-28.5	-19.3	1 000 (k)	1 000 (k)
				75/25	Dilution Not Applicable		Dilution Not Applicable	
				50/50	Dilution Not Applicable		Dilution Not Applicable	
Clariant Produkte (Deutschland) GmbH	Max Flight SNEG	PG	18-03-09	100/0	-29	-20.2	8 700 (m)	8 050 (a)
				75/25	-14	7	20 200 (n)	21 800 (c)
				50/50	-3	27	13 600(n)	15 000 (c)
Clariant Produkte (Deutschland) GmbH	Safewing EG IV NORTH	EG	18-04-06	100/0	-30	-22	830 (k)	830 (k)
				75/25	Dilution Not Applicable		Dilution Not Applicable	
				50/50	Dilution Not Applicable		Dilution Not Applicable	
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH	PG	18-05-05	100/0	-28.5	-19.3	7 550 (a)	7 550 (a)
				75/25	-14	7	18 000 (a)	18 000 (a)
				50/50	-3	27	17 800 (a)	17 800 (a)
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH PLUS	PG	17-03-24	100/0	-29	-20.2	8 700 (m)	8 450 (a)
				75/25	-14	7	18 800 (n)	17 200 (c)
				50/50	-3	27	9 700 (m)	12 150 (a)
Cryotech Deicing Technology	Polar Guard® Advance	PG	17-03-11	100/0	-30.5	-22.9	4 400 (e)	4 050 (a)
				75/25	-14	7	11 600 (e)	9 750 (a)
				50/50	-3	27	80 (a)	80 (a)
Deicing Solutions LLC	ECO-SHIELD®	PG	18-02-22	100/0	-25.5	-13.9	11 050 (a)	11 050 (a)
				75/25	Dilution Not Applicable		Dilution Not Applicable	
				50/50	Dilution Not Applicable		Dilution Not Applicable	
Dow Chemical Company	UCAR™ Endurance EG106 De/Anti-Icing Fluid	EG	17-05-20	100/0	-27	-16.6	24 850 (h)	2 230 (a)
				75/25	Dilution Not Applicable		Dilution Not Applicable	
				50/50	Dilution Not Applicable		Dilution Not Applicable	

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TABLE 8-4 (cont'd)

LIST OF TYPE IV FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE

(see cautions and notes on page 67)

COMPANY NAME	FLUID NAME	TYPE OF GLYCOL[1]	EXPIRY[2] (Y-M-D)	DILUTION (FLUID/WATER)	LOWEST OPERATIONAL USE TEMPERATURE[3] HIGH SPEED AERODYNAMIC TEST[6] °C	°F	LOWEST ON-WING VISCOSITY[7,8] (mPa.s) MANUFACTURER METHOD	AS 9968 METHOD
Dow Chemical Company	UCAR™ FlightGuard AD-49	PG	17-05-20	100/0	-26	-14.8	12 150 (g)	11 000 (a)
				75/25	-14	7	30 700 (g)	32 350 (c)
				50/50	-3	27	19 450 (g)	21 150 (c)
Kilfrost Limited	ABC-S Plus	PG	17-06-16	100/0	-28	-18.4	17 900 (d)	17 900 (c)
				75/25	-14	7	18 300 (d)	18 300 (c)
				50/50	-3	27	7 500 (d)	7 500 (a)
LNT Solutions	LNT E450	EG	17-07-29	100/0	-22.5	-8.5	45 300 (i)	Not Available[16]
				75/25	Dilution Not Applicable		Dilution Not Applicable	
				50/50	Dilution Not Applicable		Dilution Not Applicable	
Newave Aerochemical Co. Ltd.	FCY 9311	PG	18-01-18	100/0	-29.5	-21.1	14 100 (c)	14 100 (c)
				75/25	Dilution Not Applicable		Dilution Not Applicable	
				50/50	Dilution Not Applicable		Dilution Not Applicable	
Shaanxi Cleanway Aviation Chemical Co., Ltd	Cleansurface IV	PG	17-05-25	100/0	-28.5	-19.3	15 200 (c)	15 200 (c)
				75/25	-14	7	28 500 (c)	28 500 (c)
				50/50	-3	27	17 500 (c)	17 500 (c)

CAUTIONS AND NOTES FOR TABLES 8-1, 8-2, 8-3, 8-4

CAUTIONS

- This table lists fluids that have been tested with respect to anti-icing performance and aerodynamic acceptance (Type I: SAE AMS1424 §3.5.2 and §3.5.3; Type II/ III/ IV: SAE AMS1428 §3.2.4 and §3.2.5) only. These tests were conducted by Anti-icing Materials International Laboratory: www.uqac.ca/amil. The end user is responsible for contacting the fluid manufacturer to confirm all other SAE AMS1424/1428 technical requirement tests, such as fluid stability, toxicity, materials compatibility, etc. have been conducted.
- LOUT data provided in these tables is based strictly on the manufacturer's data; the end user is responsible for verifying the validity of this data.
- Type I fluids supplied in concentrated form must not be used in that form and must be diluted.

NOTES

1 PG = conventional glycol (propylene glycol); EG = conventional glycol (ethylene glycol); DEG = conventional glycol (diethylene glycol); NCG = non-conventional glycol (organic non-ionic diols and triols, e.g. 1,3-propanediol, glycerine) and mixtures of non-conventional glycol and conventional glycol; NG = non-glycol (e.g. organic salts) and mixtures of non-glycol and glycol.

2 Expiry date is the earlier expiry date of the Aerodynamic Test(s) or Water Spray Endurance Test. Fluids that are tested after the issuance of this list will appear in a later update.

3 The values in this table were determined using test results from pre-production fluid samples when available. In some cases, the fluid manufacturer requested the publication of a more conservative value than the pre-production test value. The lowest operational use temperature (LOUT) for a given fluid is the higher (warmer) of:

a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type;

b) The actual freezing point of the fluid plus its freezing point buffer (Type I = 10°C/18°F; Type II/III/IV = 7°C/13°F); or

c) For diluted Type II/III/IV fluids, the coldest temperature for which holdover times are published.

4 The LOUT for Type I fluids that are intended to be diluted is derived from a dilution that provides the lowest operational use temperature. For other Type I dilutions, determine the freezing point of the fluid and add a 10°C freezing point buffer, as a dilution will usually yield a higher and more restrictive operational use temperature. Consult the fluid manufacturer or fluid documentation for further clarification and guidance on establishing the appropriate operational use temperature of a diluted fluid.

5 Type I concentrate fluids have also been tested at 50/50 (glycol/water) dilution.

6 If uncertain whether the aircraft to be treated conforms to the low speed or the high speed aerodynamic test, consult the aircraft manufacturer. The aerodynamic test is defined in SAE AS5900 (latest version).

7 The viscosity values in this table are those of the fluids provided by the manufacturers for holdover time testing. For the holdover times to be valid, the viscosity of the fluid on the wing shall not be lower than that in this table. The user should periodically ensure that the viscosity of a fluid sample taken from the wing surface is not lower than that listed.

8 The SAE AS9968 viscosity method should only be used for field verification and auditing purposes; when in doubt as to which method is appropriate, use the manufacturer method. Viscosity measurement methods are indicated as letters (in parentheses) beside each viscosity value. Details of each measurement method are shown in the table below. The exact measurement method (spindle, container, fluid volume, temperature, speed, duration) must be used to compare the viscosity of a sample to a viscosity given in this table.

Method	Brookfield Spindle*	Container	Fluid Volume	Temp.**	Speed	Duration
a	LV1 (with guard leg)	600 mL low form (Griffin) beaker	575 mL***	20°C	0.3 rpm	10.0 minutes
b	LV1 (with guard leg)	600 mL low form (Griffin) beaker	575 mL***	20°C	0.3 rpm	33.3 minutes
c	LV2-disc (with guard leg)	600 mL low form (Griffin) beaker	425 mL***	20°C	0.3 rpm	10.0 minutes
d	LV2-disc (with guard leg)	150 mL tall form (Berzelius) beaker	135 mL***	20°C	0.3 rpm	10.0 minutes
e	SC4-34/13R	small sample adapter	10 mL	20°C	0.3 rpm	10.0 minutes
f	SC4-34/13R	small sample adapter	10 mL	20°C	0.3 rpm	30.0 minutes
g	SC4-31/13R	small sample adapter	10 mL	20°C	0.3 rpm	10.0 minutes
h	SC4-31/13R	small sample adapter	10 mL	0°C	0.3 rpm	10.0 minutes
i	SC4-31/13R	small sample adapter	9 mL	0°C	0.3 rpm	10.0 minutes
j	SC4-31/13R	small sample adapter	9 mL	0°C	0.3 rpm	30.0 minutes
k	LV0	ultra low adapter	16 mL	20°C	0.3 rpm	10.0 minutes
l	LV1	big sample adapter	50 mL	20°C	0.3 rpm	10.0 minutes
m	LV1	big sample adapter	55 mL	20°C	0.3 rpm	10.0 minutes
n	LV2-disc	big sample adapter	60 mL	20°C	0.3 rpm	10.0 minutes

* Spindle must be attached to a Brookfield viscometer model equipped with an LV spring.
** Sample temperature will affect readings; ensure sufficient time is allowed for sample to reach thermal equilibrium before starting test. Use of a cooling bath strongly recommended.
*** If necessary, adjust fluid volume to ensure fluid is level with notch on the spindle shaft.

9 Fluids listed in italics have expired and will be removed from this listing four years after expiry.

10 Manufacturer has indicated fluid was not tested.

11 Manufacturer has not provided fluid information as required in SAE ARP5718A; fluid may be removed from this listing in subsequent revisions.

12 Dow UCAR™ ADF Concentrate, sold under the product name Inland ADF Concentrate, qualified from 2015-09-04.

13 Currently in the test/re-test process.

14 Fluid was not retested for low speed aerodynamics. This data will be removed four years after the expiry of the last low speed test.

15 Fluid did not meet the minimum Water Spray Endurance Test requirement for a Type III fluid in AMS1428G; Transport Canada and the FAA have proposed a change to the SAE G-12 for this requirement.

16 Measurements using the SAE AS9968 method do not provide stable, reliable results. Use the manufacturer method to evaluate viscosity.

17 For UCAR™ ADF XL54, refer to primary site qualification of UCAR™ ADF Concentrate.

18 For UCAR™ PG ADF Dilute 55/45, refer to primary site qualification of UCAR™ PG ADF Concentrate.

Transport Canada Holdover Time Guidelines — Winter 2016-2017

TABLE 9

GUIDELINES FOR THE APPLICATION OF SAE TYPE I FLUID

Outside Air Temperature (OAT)[1]	One-Step Procedure De/Anti-icing	Two-Step Procedure	
		First Step: Deicing	Second Step: Anti-icing[2]
0°C (32°F) and above	Heated mix of fluid and water with a freezing point of at least 10°C (18°F) below OAT	Heated water or a heated fluid/water mixture	Heated mix of fluid and water with a freezing point of at least 10°C (18°F) below OAT
Below 0°C (32°F) to LOUT		Heated fluid/water mixture with a freezing point at OAT or below	

1 Fluids must not be used at temperatures below their lowest operational use temperature (LOUT).

2 To be applied before first step fluid freezes, typically within 3 minutes. (This time may be higher than 3 minutes in some conditions, but potentially lower in heavy precipitation, colder temperatures, or for critical surfaces constructed of composite materials. If necessary, the second step shall be applied area by area.)

NOTES

- This table is applicable for the use of Type I holdover time guidelines in all conditions including active frost. If holdover times are not required, a temperature of 60°C (140°F) at the nozzle is desirable.
- If holdover times are required, the temperature of water or fluid/water mixtures shall be at least 60°C (140°F) at the nozzle. Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendations.
- To use Type I Holdover Times Guidelines in all conditions including active frost, an additional minimum of 1 litre/m^2 (~2 gal./100 sq. ft.) of heated Type I fluid mixture must be applied to the surfaces after all frozen contamination is removed. This application is necessary to heat the surfaces, as heat contributes significantly to the Type I fluid holdover times. The required protection can be provided using a 1-step method by applying more fluid than is strictly needed to just remove all of the frozen contamination (the same additional amount stated above is required).
- The lowest operational use temperature (LOUT) for a given Type I fluid is the higher (warmer) of:
  a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type; or
  b) The actual freezing point of the fluid plus its freezing point buffer of 10°C (18°F).

CAUTION

- **Wing skin temperatures may differ and in some cases may be lower than outside air temperatures; a stronger mix (more glycol) may be needed under these conditions.**

TABLE 10

GUIDELINES FOR THE APPLICATION OF SAE TYPE II AND IV FLUID
(FLUID CONCENTRATIONS IN % VOLUME)

Outside Air Temperature (OAT)[1]	One-Step Procedure De/Anti-icing	Two-Step Procedure	
		First Step: Deicing	Second Step: Anti-icing[2]
0°C (32°F) and above	100/0, 75/25 or 50/50 Heated[3] Type II or IV fluid/water mixture	Heated water or a heated Type I, II, III, or IV fluid/water mixture	100/0, 75/25 or 50/50 Type II or IV fluid/water mixture
Below 0°C (32°F) to -3°C (27°F)	100/0, 75/25 or 50/50 Heated[3] Type II or IV fluid/water mixture	Heated Type I, II, III, or IV fluid/water mixture with a freezing point at OAT or below	100/0, 75/25 or 50/50 Type II or IV fluid/water mixture
Below -3°C (27°F) to -14°C (7°F)	100/0 or 75/25 Heated[3] Type II or IV fluid/water mixture	Heated Type I, II, III, or IV fluid/water mixture with a freezing point at OAT or below	100/0 or 75/25 Type II or IV fluid/water mixture
Below -14°C (7°F) to LOUT	100/0 Heated[3] Type II or IV fluid/water mixture	Heated Type I, II, III, or IV fluid/water mixture with a freezing point at OAT or below	100/0 Type II or IV fluid/water mixture

1 Fluids must not be used at temperatures below their lowest operational use temperature (LOUT). Consideration should be given to the use of Type I/III fluid when Type II/IV fluid cannot be used due to LOUT limitations (see Table 9, 11-U, 11-H). The LOUT for a given Type II/IV fluid is the higher (warmer) of:
   a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type;
   b) The actual freezing point of the fluid plus its freezing point buffer of 7°C (13°F); or
   c) For diluted Type II/IV fluids, the coldest temperature for which holdover times are published.

2 To be applied before first step fluid freezes, typically within 3 minutes. (This time may be longer than 3 minutes in some conditions, but potentially shorter in heavy precipitation, in colder temperatures, or for critical surfaces constructed of composite materials. If necessary, the second step shall be applied area by area.)

3 Clean aircraft may be anti-iced with unheated fluid.

NOTES

- For heated fluids, a fluid temperature not less than 60°C (140°F) at the nozzle is desirable.
- Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendations.

CAUTIONS

- **Wing skin temperatures may differ and in some cases may be lower than outside air temperatures; a stronger mix (more glycol) may be needed under these conditions.**
- **Whenever frost or ice occurs on the lower surface of the wing in the area of the fuel tank, indicating a cold soaked wing, the 50/50 dilutions of Type II or IV shall not be used for the anti-icing step because fluid freezing may occur.**
- **An insufficient amount of anti-icing fluid may cause a substantial loss of holdover time. This is particularly true when using a Type I fluid mixture for the first step in a two-step procedure.**

TABLE 11-H

GUIDELINES FOR THE APPLICATION OF HEATED SAE TYPE III FLUID
(FLUID CONCENTRATIONS IN % VOLUME)

Outside Air Temperature (OAT)[1]	**One-Step Procedure De/Anti-icing**	**Two-Step Procedure**	
		First Step: Deicing	**Second Step: Anti-icing[2]**
0°C (32°F) and above	100/0, 75/25 or 50/50 Heated Type III fluid/water mixture	Heated[3] water or a heated[3] Type I, II, III, or IV fluid/water mixture	100/0, 75/25 or 50/50 Heated Type III fluid/water mixture
Below 0°C (32°F) to -3°C (27°F)	100/0, 75/25 or 50/50 Heated Type III fluid/water mixture	Heated[3] Type I, II, III, or IV fluid/water mixture with a freezing point at OAT or below	100/0, 75/25 or 50/50 Heated Type III fluid/water mixture
Below -3°C (27°F) to -10°C (14°F)	100/0 or 75/25 Heated Type III fluid/water mixture	Heated[3] Type I, II, III, or IV fluid/water mixture with a freezing point at OAT or below	100/0 or 75/25 Heated Type III fluid/water mixture
Below -10°C (14°F) to LOUT	100/0 Heated Type III fluid/water mixture	Heated[3] Type I, II, III, or IV fluid/water mixture with a freezing point at OAT or below	100/0 Heated Type III fluid/water mixture

1 Fluids must not be used at temperatures below their lowest operational use temperature (LOUT). Consider the use of Type I when Type III fluid cannot be used (see Table 9). The LOUT for a given Type III fluid is the higher (warmer) of:
 a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type;
 b) The actual freezing point of the fluid plus its freezing point buffer of 7°C (13°F); or
 c) For diluted Type III fluid, the coldest temperature for which holdover times are published.

2 To be applied before first step fluid freezes, typically within 3 minutes. (This time may be longer than 3 minutes in some conditions, but potentially shorter in heavy precipitation, in colder temperatures, or for critical surfaces constructed of composite materials. If necessary, the second step shall be applied area by area.)

3 For heated fluids, a fluid temperature not less than 60°C (140°F) at the nozzle is desirable.

NOTES

- To use Type III Holdover Times Guidelines in all conditions including active frost, an additional minimum of 1 litre/m^2 (~2 gal./100 sq. ft.) of heated Type III fluid mixture must be applied to the surfaces after all frozen contamination is removed. This application is necessary to heat the surfaces, as heat contributes significantly to the Type III fluid holdover times. The required protection can be provided using a 1-step method by applying more fluid than is strictly needed to just remove all of the frozen contamination (the same additional amount stated above is required).
- If holdover times are required, the temperature of fluid/water mixtures shall be at least 60°C (140°F) at the nozzle. Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendations.

CAUTIONS

- **Wing skin temperatures may differ and in some cases may be lower than outside air temperatures; a stronger mix (more glycol) may be needed under these conditions.**
- **Whenever frost or ice occurs on the lower surface of the wing in the area of the fuel tank, indicating a cold soaked wing, the 50/50 dilutions of Type III shall not be used for the anti-icing step because fluid freezing may occur.**
- **An insufficient amount of anti-icing fluid may cause a substantial loss of holdover time. This is particularly true when using a Type I fluid mixture for the first step in a two-step procedure.**

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TABLE 11-U

GUIDELINES FOR THE APPLICATION OF UNHEATED SAE TYPE III FLUID
(FLUID CONCENTRATIONS IN % VOLUME)

Outside Air Temperature (OAT)[1]	One-Step Procedure Anti-icing Only[4]	Two-Step Procedure	
		First Step: Deicing	Second Step: Anti-icing[2]
0°C (32°F) and above	100/0, 75/25 or 50/50 Unheated Type III fluid/water mixture	Heated[3] water or a heated[3] Type I, II, III, or IV fluid/water mixture	100/0, 75/25 or 50/50 Unheated Type III fluid/water mixture
Below 0°C (32°F) to -3°C (27°F)	100/0, 75/25 or 50/50 Unheated Type III fluid/water mixture	Heated[3] Type I, II, III, or IV fluid/water mixture with a freezing point at OAT or below	100/0, 75/25 or 50/50 Unheated Type III fluid/water mixture
Below -3°C (27°F) to -10°C (14°F)	100/0 or 75/25 Unheated Type III fluid/water mixture	Heated[3] Type I, II, III, or IV fluid/water mixture with a freezing point at OAT or below	100/0 or 75/25 Unheated Type III fluid/water mixture
Below -10°C (14°F) to LOUT	100/0 Unheated Type III fluid/water mixture	Heated[3] Type I, II, III, or IV fluid/water mixture with a freezing point at OAT or below	100/0 Unheated Type III fluid/water mixture

1 Fluids must not be used at temperatures below their lowest operational use temperature (LOUT). Consider the use of Type I when Type III fluid cannot be used (see Table 9). The LOUT for a given Type III fluid is the higher (warmer) of:
   a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type;
   b) The actual freezing point of the fluid plus its freezing point buffer of 7°C (13°F); or
   c) For diluted Type III fluid, the coldest temperature for which holdover times are published.

2 To be applied before first step fluid freezes, typically within 3 minutes. (This time may be longer than 3 minutes in some conditions, but potentially shorter in heavy precipitation, in colder temperatures, or for critical surfaces constructed of composite materials. If necessary, the second step shall be applied area by area.)

3 For heated fluids, a fluid temperature not less than 60°C (140°F) at the nozzle is desirable.

4 One-step procedure with unheated Type III fluid is only possible on a clean aircraft. If deicing is required, a two-step procedure must be used.

NOTES

- Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendations.

CAUTIONS

- **Wing skin temperatures may differ and in some cases may be lower than outside air temperatures; a stronger mix (more glycol) may be needed under these conditions.**
- **Whenever frost or ice occurs on the lower surface of the wing in the area of the fuel tank, indicating a cold soaked wing, the 50/50 dilutions of Type III shall not be used for the anti-icing step because fluid freezing may occur.**
- **An insufficient amount of anti-icing fluid may cause a substantial loss of holdover time. This is particularly true when using a Type I fluid mixture for the first step in a two-step procedure.**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 0-90%

SAE TYPE I, TYPE II, TYPE III, AND TYPE IV FLUID ACTIVE FROST
90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1,2]		Approximate Holdover Times (hours:minutes)
Degrees Celsius	Degrees Fahrenheit	Active Frost Type I
-1 and above	30 and above	0:40 *(0:31)*[4]
below -1 to -3	below 30 to 27	
below -3 to -10	below 27 to 14	
below -10 to -14	below 14 to 7	
below -14 to -21	below 7 to -6	
below -21 to LOUT	below -6 to LOUT	

Outside Air Temperature[2]		Concentration Neat Fluid/Water (Volume %/ Volume %)	Approximate Holdover Times (hours:minutes) Active Frost		
Degrees Celsius	Degrees Fahrenheit		Type II	Type III[3]	Type IV
-1 and above	30 and above	100/0	7:12	1:48	10:48
		75/25	4:30	0:54	4:30
		50/50	2:42	0:27	2:42
below -1 to -3	below 30 to 27	100/0	7:12	1:48	10:48
		75/25	4:30	0:54	4:30
		50/50	1:21	0:27	2:42
below -3 to -10	below 27 to 14	100/0	7:12	1:48	9:00
		75/25	4:30	0:54	4:30
below -10 to -14	below 14 to 7	100/0	5:24	1:48	5:24
		75/25	0:54	0:54	0:54
below -14 to -21	below 7 to -6	100/0	5:24	1:48	5:24
below -21 to -25	below -6 to -13	100/0	1:48	1:48	3:36
Below -25	below -13	100/0	No Holdover Time Guidelines Exist		

NOTES

1 Type I Fluid / Water Mixture must be selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 To use the Type III fluid frost holdover times, the fluid brand being used must be known. AllClear AeroClear MAX must be applied unheated. Clariant Safewing MP III 2031 ECO must be applied heated.
4 Value in parentheses is for aircraft with critical surfaces that are predominantly or entirely constructed of composite materials.

CAUTIONS

- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2016-2017

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 1-90%-A

SAE TYPE I FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES ON CRITICAL AIRCRAFT SURFACES COMPOSED PREDOMINANTLY OF ALUMINUM[1]

These holdover times apply to aircraft with critical surfaces constructed predominantly or entirely of aluminum materials that have demonstrated satisfactory use of these holdover times.

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit	Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3] Very Light[4]	Light[4]	Moderate	Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
-3 and above	27 and above	10 – 15	16	10 – 16	5 – 10	8 – 12	4 – 5	2 – 5	CAUTION: No holdover time guidelines exist
below -3 to -6	below 27 to 21	7 – 12	13	7 – 13	5 – 7	5 – 8	4 – 5	CAUTION: No holdover time guidelines exist	CAUTION: No holdover time guidelines exist
below -6 to -10	below 21 to 14	5 – 9	10	5 – 10	4 – 5	4 – 6	2 – 5	CAUTION: No holdover time guidelines exist	CAUTION: No holdover time guidelines exist
below -10	below 14	5 – 8	6	4 – 6	2 – 4	CAUTION: No holdover time guidelines exist	CAUTION: No holdover time guidelines exist	CAUTION: No holdover time guidelines exist	CAUTION: No holdover time guidelines exist

NOTES

1. Type I Fluid / Water Mixture must be selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2. Ensure that the lowest operational use temperature (LOUT) is respected.
3. To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4. Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6. No holdover time guidelines exist for this condition for 0°C (32°F) and below.
7. Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 1-90%-C

SAE TYPE I FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES ON CRITICAL AIRCRAFT SURFACES COMPOSED PREDOMINANTLY OF COMPOSITES[1]

These holdover times apply to newer aircraft with critical surfaces constructed predominantly or entirely of composite materials.
THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit	Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
			Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	8 – 14	11	5 – 11	3 – 5	7 – 12	4 – 5	1 – 5	
below -3 to -6	below 27 to 21	5 –7	10	5 – 10	2 – 5	5 – 8	4 – 5	CAUTION: No holdover time guidelines exist	
below -6 to -10	below 21 to 14	4 – 7	8	5 – 8	2 – 5	4 – 6	2 – 5		
below -10	below 14	4 – 6	6	4 – 6	2 – 4				

NOTES

1 Type I Fluid / Water Mixture must be selected so that the freezing point of the mixture is at least 10°C (18°F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2-90%-Generic

SAE TYPE II FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2,3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	0:32 – 1:21	0:18 – 0:41	0:27 – 0:54	0:14 – 0:27	0:06 – 0:36	
		75/25	0:23 – 0:50	0:14 – 0:23	0:14 – 0:36	0:09 – 0:18	0:04 – 0:23	
		50/50	0:14 – 0:23	0:05 – 0:09	0:07 – 0:14	0:05 – 0:08	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:18 – 0:59	0:14 – 0:27	0:18 – 0:41[7]	0:09 – 0:18[7]		
		75/25	0:23 – 0:45	0:07 – 0:18	0:14 – 0:23[7]	0:07 – 0:14[7]		
below -14 to LOUT	below 7 to LOUT	100/0	0:18 – 0:32[8]	0:07 – 0:09[8]				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10°C (14°F).
8 If the LOUT is unknown, no holdover time guidelines exist below -22.5°C (-8.5°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2-90%-A-E26

TYPE II FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES
ABAX ECOWING 26

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	1:17 – 2:20	1:26	0:54 – 1:26	0:36 – 0:54	0:45 – 1:26	0:36 – 0:45	0:18 – 1:17	CAUTION: No holdover time guidelines exist
		75/25	0:59 – 1:44	1:08	0:41 – 1:08	0:23 – 0:41	0:41 – 0:59	0:23 – 0:32	0:09 – 0:54	
		50/50	0:27 – 0:41	0:36	0:18 – 0:36	0:09 – 0:18	0:14 – 0:23	0:07 – 0:09	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:41 – 2:02	1:17	0:50 – 1:17	0:32 – 0:50	0:27 – 1:03[7]	0:14 – 0:32[7]		
		75/25	0:32 – 1:08	0:50	0:36 – 0:50	0:23 – 0:36	0:18 – 0:45[7]	0:14 – 0:23[7]		
below -14 to -25	below 7 to -13	100/0	0:23 – 0:41	0:18	0:09 – 0:18	0:07 – 0:09				

NOTES

1. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2. To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3. Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7. No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2-90%-AS-CWII

TYPE II FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES
AVIATION SHAANXI HI-TECH CLEANWING II

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2,3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	0:50 – 1:39	0:27 – 0:50	0:32 – 0:59	0:23 – 0:32	0:09 – 0:50	CAUTION: No holdover time guidelines exist
		75/25	0:45 – 1:12	0:23 – 0:41	0:32 – 0:54	0:18 – 0:27	0:06 – 0:45	
		50/50	0:32 – 0:54	0:14 – 0:27	0:18 – 0:36	0:09 – 0:18		
below -3 to -14	below 27 to 7	100/0	0:41 – 1:39	0:27 – 0:50	0:27 – 0:50[7]	0:18 – 0:23[7]		
		75/25	0:36 – 1:35	0:23 – 0:41	0:32 – 0:36[7]	0:18 – 0:23[7]		
below -14 to -29	below 7 to -20.2	100/0	0:18 – 0:45	0:07 – 0:09				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines **Winter 2016-2017**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2-90%-BY-YDII

TYPE II FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES
BEIJING YADILITE AVIATION YD-102 TYPE II

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:03 – 1:48	1:30	0:45 – 1:30	0:23 – 0:45	0:36 – 1:08	0:32 – 0:36	0:09 – 0:54	CAUTION: No holdover time guidelines exist
		75/25	0:23 – 0:50	0:45	0:23 – 0:45	0:14 – 0:23	0:14 – 0:36	0:09 – 0:18	0:04 – 0:23	
		50/50	0:14 – 0:23	0:23	0:09 – 0:23	0:05 – 0:09	0:07 – 0:14	0:06 – 0:08		
below -3 to -14	below 27 to 7	100/0	0:41 – 1:21	0:54	0:27 – 0:54	0:14 – 0:27	0:32 – 0:45[7]	0:23 – 0:23[7]		
		75/25	0:27 – 0:45	0:32	0:18 – 0:32	0:07 – 0:18	0:14 – 0:23[7]	0:08 – 0:14[7]		
below -14 to -29	below 7 to -20.2	100/0	0:18 – 0:41	0:18	0:09 – 0:18	0:07 – 0:09				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2-90%-C-F

TYPE II FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES CLARIANT SAFEWING MP II FLIGHT

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	3:09 – 3:36	2:00	1:26 – 2:00	0:54 – 1:26	1:12 – 1:48	0:41 – 1:17	0:09 – 1:21	CAUTION: No holdover time guidelines exist
		75/25	1:39 – 2:29	2:00	1:12 – 2:00	0:36 – 1:12	1:03 – 1:21	0:27 – 0:50	0:05 – 0:45	
		50/50	0:50 – 1:35	0:41	0:23 – 0:41	0:09 – 0:23	0:18 – 0:27	0:09 – 0:14		
below -3 to -14	below 27 to 7	100/0	0:50 – 1:35	1:39	0:59 – 1:39	0:36 – 0:59	0:32 – 1:21[7]	0:23 – 0:41[7]		
		75/25	0:23 – 0:59	1:12	0:36 – 1:12	0:18 – 0:36	0:23 – 1:03[7]	0:18 – 0:32[7]		
below -14 to -29	below 7 to -20.2	100/0	0:27 – 0:45	0:18	0:09 – 0:18	0:07 – 0:09				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2016-2017

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2-90%-C-F+

TYPE II FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES
CLARIANT SAFEWING MP II FLIGHT PLUS

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[2,3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	2:24 – 3:36	0:45 – 1:39	1:17 – 1:48	0:41 – 0:54	0:14 – 1:48	CAUTION: No holdover time guidelines exist
		75/25	2:20 – 3:36	0:54 – 1:35	1:26 – 1:48	0:45 – 1:08	0:14 – 1:08	
		50/50	0:59 – 2:06	0:14 – 0:23	0:27 – 0:59	0:14 – 0:18		
below -3 to -14	below 27 to 7	100/0	0:36 – 2:06	0:32 – 1:08	0:32 – 1:17[7]	0:32 – 0:50[7]		
		75/25	0:27 – 1:35	0:50 – 1:30	0:23 – 1:03[7]	0:27 – 0:41[7]		
below -14 to -29	below 7 to -20.2	100/0	0:18 – 0:36	0:07 – 0:09				

NOTES
1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2016-2017

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2-90%-CR-PGII

TYPE II FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES CRYOTECH POLAR GUARD® II

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	2:33 – 3:36	2:00	1:39 – 2:00	1:12 – 1:39	1:26 – 1:48	1:08 – 1:21	0:14 – 1:48	CAUTION: No holdover time guidelines exist
		75/25	2:15 – 3:36	2:00	1:12 – 2:00	0:41 – 1:12	1:30 – 1:48	0:36 – 1:03	0:08 – 1:30	
		50/50	0:45 – 1:17	1:12	0:32 – 1:12	0:14 – 0:32	0:18 – 0:41	0:08 – 0:18		
below -3 to -14	below 27 to 7	100/0	0:50 – 2:15	1:35	1:08 – 1:35	0:50 – 1:08	0:32 – 1:26[7]	0:32 – 0:41[7]		
		75/25	0:36 – 1:21	1:35	0:54 – 1:35	0:32 – 0:54	0:23 – 0:59[7]	0:32 – 0:41[7]		
below -14 to -30.5	below 7 to -22.9	100/0	0:23 – 0:45	0:18	0:09 – 0:18	0:07 – 0:09				

NOTES

1. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2. To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3. Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7. No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2-90%-K-ABC-IC

TYPE II FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES
KILFROST ABC-ICE CLEAR II

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	0:54 – 1:35	1:35	0:45 – 1:35	0:23 – 0:45	0:36 – 0:59	0:23 – 0:32	0:06 – 0:41	CAUTION: No holdover time guidelines exist
		75/25	0:45 – 1:03	1:12	0:36 – 1:12	0:18 – 0:36	0:27 – 0:41	0:18 – 0:27	0:05 – 0:32	
		50/50	0:14 – 0:27	0:18	0:14 – 0:18	0:07 – 0:14	0:09 – 0:18	0:06 – 0:09	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:36 – 1:26	1:08	0:32 – 1:08	0:18 – 0:32	0:23 – 0:54[7]	0:14 – 0:27[7]		
		75/25	0:36 – 1:12	0:50	0:23 – 0:50	0:14 – 0:23	0:23 – 0:41[7]	0:14 – 0:18[7]		
below -14 to -29.5	below 7 to -21.1	100/0	0:18 – 0:36	0:18	0:09 – 0:18	0:07 – 0:09				

NOTES

1. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2. To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3. Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7. No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2-90%-K-ABC-K+

TYPE II FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES
KILFROST ABC-K PLUS

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2,3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:02 – 3:23	0:54 – 1:30	1:39 – 1:48	0:54 – 1:17	0:18 – 1:48	CAUTION: No holdover time guidelines exist
		75/25	1:30 – 2:15	0:32 – 1:03	1:17 – 1:48	0:45 – 1:03	0:14 – 1:48	
		50/50	0:32 – 0:59	0:06 – 0:14	0:18 – 0:27	0:09 – 0:14		
below -3 to -14	below 27 to 7	100/0	0:27 – 0:59	0:45 – 1:17	0:23 – 0:54[7]	0:14 – 0:32[7]		
		75/25	0:23 – 1:17	0:32 – 0:59	0:18 – 0:50[7]	0:08 – 0:27[7]		
below -14 to -29	below 7 to -20.2	100/0	0:27 – 0:50	0:07 – 0:09				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2-90%-N-FCY-2

TYPE II FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES NEWAVE AEROCHEMICAL FCY-2

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2,3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:08 – 2:11	0:27 – 0:50	0:32 – 0:59	0:23 – 0:32	0:07 – 0:41	CAUTION: No holdover time guidelines exist
		75/25	0:45 – 1:21	0:18 – 0:36	0:23 – 0:41	0:14 – 0:23	0:05 – 0:23	
		50/50	0:23 – 0:32	0:14 – 0:23	0:09 – 0:18	0:06 – 0:09		
below -3 to -14	below 27 to 7	100/0	0:41 – 1:21	0:14 – 0:27	0:18 – 0:41[7]	0:14 – 0:18[7]		
		75/25	0:27 – 0:59	0:09 – 0:18	0:14 – 0:27[7]	0:07 – 0:14[7]		
below -14 to -28	below 7 to -18.4	100/0	0:23 – 0:32	0:07 – 0:09				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2-90%-N-FCY-2B+

TYPE II FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES
NEWAVE AEROCHEMICAL FCY-2 BIO+

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	1:17 – 2:15	2:00	0:59 – 2:00	0:27 – 0:59	0:45 – 1:12	0:23 – 0:41	0:07 – 1:08	
		75/25	0:41 – 1:12	1:12	0:36 – 1:12	0:18 – 0:36	0:23 – 0:45	0:14 – 0:23	0:05 – 0:32	
		50/50	0:14 – 0:27	0:23	0:14 – 0:23	0:07 – 0:14	0:09 – 0:18	0:07 – 0:09	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:36 – 1:21	0:54	0:27 – 0:54	0:14 – 0:27	0:32 – 0:59[7]	0:14 – 0:27[7]		
		75/25	0:27 – 0:59	0:32	0:18 – 0:32	0:07 – 0:18	0:18 – 0:32[7]	0:14 – 0:18[7]		
below -14 to -28.5	below 7 to -19.3	100/0	0:18 – 0:54	0:18	0:09 – 0:18	0:07 – 0:09				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 3LS-90%-A-ACM

LOW SPEED TYPE III FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES ALLCLEAR AEROCLEAR MAX, APPLIED UNHEATED[1]

FOR AIRCRAFT CONFORMING TO THE SAE AS5900 LOW SPEED AERODYNAMIC TEST CRITERION

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	100/0	0:41 – 1:03	0:54	0:27 – 0:54	0:13 – 0:27	0:18 – 0:41	0:13 – 0:18	0:05 – 0:36	
		75/25								
		50/50							CAUTION: No holdover time guidelines exist	
below -3 to -10	below 27 to 14	100/0	0:41 – 1:17	0:54	0:27 – 0:54	0:13 – 0:27	0:18 – 0:36	0:14 – 0:23		
		75/25								
below -10 to -16	below 14 to 3.2	100/0	0:27 – 0:59	0:54	0:27 – 0:54	0:13 – 0:27				

NOTES

1 Fluid must be applied unheated to use these holdover times. No holdover times exist for this fluid applied heated.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type III fluid cannot be used.
3 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines **Winter 2016-2017**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 3HS-90%-A-ACM

HIGH SPEED TYPE III FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES ALLCLEAR AEROCLEAR MAX, APPLIED UNHEATED[1]

FOR AIRCRAFT CONFORMING TO THE SAE AS5900 HIGH SPEED AERODYNAMIC TEST CRITERION

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3] Very Light[4]	Snow, Snow Grains or Snow Pellets[3] Light[4]	Snow, Snow Grains or Snow Pellets[3] Moderate	Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
-3 and above	27 and above	100/0	0:41 – 1:03	0:54	0:27 – 0:54	0:13 – 0:27	0:18 – 0:41	0:13 – 0:18	0:05 – 0:36	CAUTION: No holdover time guidelines exist
		75/25								
		50/50							CAUTION: No holdover time guidelines exist	
below -3 to -10	below 27 to 14	100/0	0:41 – 1:17	0:54	0:27 – 0:54	0:13 – 0:27	0:18 – 0:36	0:14 – 0:23		
		75/25								
below -10 to -25	below 14 to -13	100/0	0:27 – 0:59	0:54	0:27 – 0:54	0:13 – 0:27	CAUTION: No holdover time guidelines exist			
below -25 to -35	below -13 to -31	100/0	0:14 – 0:36	0:36	0:17 – 0:36	0:08 – 0:17				

NOTES

1 Fluid must be applied unheated to use these holdover times. No holdover times exist for this fluid applied heated.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type III fluid cannot be used.
3 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 5-90% provides allowance times for ice pellets and small hail).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines **Winter 2016-2017**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 3LS-90%-C-2031

LOW SPEED TYPE III FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES CLARIANT SAFEWING MP III 2031 ECO, APPLIED HEATED[1]

FOR AIRCRAFT CONFORMING TO THE SAE AS5900 LOW SPEED AERODYNAMIC TEST CRITERION

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	100/0	0:23 – 0:45	0:36	0:18 – 0:36	0:09 – 0:18	0:15 – 0:27	0:09 – 0:13	0:05 – 0:27	
		75/25	0:17 – 0:36	0:32	0:14 – 0:32	0:06 – 0:14	0:12 – 0:18	0:07 – 0:08	0:03 – 0:16	
		50/50	0:12 – 0:16	0:23	0:12 – 0:23	0:06 – 0:12	0:12 – 0:13	0:06 – 0:06	CAUTION: No holdover time guidelines exist	
below -3 to -10	below 27 to 14	100/0	0:32 – 1:08	0:36	0:18 – 0:36	0:09 – 0:18	0:13 – 0:27	0:08 – 0:12		
		75/25	0:17 – 0:41[8]	0:23[8]	0:11 – 0:23[8]	0:05 – 0:11[8]	0:08 – 0:14[8]	0:05 – 0:07[8]		
below -10 to -16.5	below 14 to 2.3	100/0	0:23 – 0:41	0:36	0:17 – 0:36	0:08 – 0:17				

NOTES

1 Fluid must be applied heated to use these holdover times. No holdover times exist for this fluid applied unheated.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type III fluid cannot be used.
3 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
8 No holdover time guidelines exist for 75/25 fluid below -9°C (15.8°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 3HS-90%-C-2031

HIGH SPEED TYPE III FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES CLARIANT SAFEWING MP III 2031 ECO, APPLIED HEATED[1]

FOR AIRCRAFT CONFORMING TO THE SAE AS5900 HIGH SPEED AERODYNAMIC TEST CRITERION

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	100/0	0:23 – 0:45	0:36	0:18 – 0:36	0:09 – 0:18	0:15 – 0:27	0:09 – 0:13	0:05 – 0:27	
		75/25	0:17 – 0:36	0:32	0:14 – 0:32	0:06 – 0:14	0:12 – 0:18	0:07 – 0:08	0:03 – 0:16	
		50/50	0:12 – 0:16	0:23	0:12 – 0:23	0:06 – 0:12	0:12 – 0:13	0:06 – 0:06	CAUTION: No holdover time guidelines exist	
below -3 to -10	below 27 to 14	100/0	0:32 – 1:08	0:36	0:18 – 0:36	0:09 – 0:18	0:13 – 0:27	0:08 – 0:12		
		75/25	0:17 – 0:41	0:23	0:11 – 0:23	0:05 – 0:11	0:08 – 0:14	0:05 – 0:07		
below -10 to -25	below 14 to -13	100/0	0:23 – 0:41	0:36	0:17 – 0:36	0:08 – 0:17				
below -25 to -29	below -13 to -20.2	100/0	0:23 – 0:41	0:36	0:17 – 0:36	0:08 – 0:17				

NOTES

1. Fluid must be applied heated to use these holdover times. No holdover times exist for this fluid applied unheated.
2. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type III fluid cannot be used.
3. To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4. Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6. No holdover time guidelines exist for this condition for 0°C (32°F) and below.
7. Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 5-90% provides allowance times for ice pellets and small hail).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4-90%-Generic

SAE TYPE IV FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Snow, Snow Grains or Snow Pellets[2] Light[3]	Snow, Snow Grains or Snow Pellets[2] Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:08 – 2:24	2:00	1:03 – 2:00	0:32 – 1:03	0:36 – 1:21	0:32 – 0:36	0:07 – 1:17	CAUTION: No holdover time guidelines exist
		75/25	1:17 – 2:24	1:53	1:08 – 1:53	0:41 – 1:08	0:45 – 1:12	0:27 – 0:41	0:08 – 1:08	
		50/50	0:23 – 0:45	0:36	0:23 – 0:36	0:14 – 0:23	0:14 – 0:27	0:08 – 0:14		
below -3 to -14	below 27 to 7	100/0	0:18 – 1:26	1:12	0:41 – 1:12	0:23 – 0:41	0:23 – 1:12[7]	0:18 – 0:23[7]		
		75/25	0:27 – 1:03	1:30	0:41 – 1:30	0:18 – 0:41	0:14 – 0:59[7]	0:14 – 0:23[7]		
below -14 to LOUT	below 7 to LOUT	100/0	0:18 – 0:36[8]	0:18[8]	0:09 – 0:18[8]	0:07 – 0:09[8]				

NOTES
1. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2. To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3. Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7. No holdover time guidelines exist for this condition below -10°C (14°F).
8. If the LOUT is unknown, no holdover time guidelines exist below -22.5°C (-8.5°F).

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4-90%-A-E-AD49

TYPE IV FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES ABAX ECOWING AD-49

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	3:00 – 3:36	2:00	1:39 – 2:00	1:03 – 1:39	1:17 – 1:48	0:54 – 1:17	0:09 – 1:44	CAUTION: No holdover time guidelines exist
		75/25	2:11 – 3:36	1:53	1:30 – 1:53	1:12 – 1:30	1:44 – 1:48	0:45 – 1:21	0:09 – 1:30	
		50/50	0:23 – 0:45	0:36	0:23 – 0:36	0:14 – 0:23	0:14 – 0:27	0:09 – 0:14		
below -3 to -14	below 27 to 7	100/0	0:18 – 1:26	2:00	1:39 – 2:00	1:03 – 1:39	0:23 – 1:17[7]	0:18 – 0:23[7]		
		75/25	0:27 – 1:03	1:53	1:30 – 1:53	1:12 – 1:30	0:14 – 0:59[7]	0:14 – 0:23[7]		
below -14 to -26	below 7 to -14.8	100/0	0:23 – 0:36	0:18	0:09 – 0:18	0:07 – 0:09				

NOTES
1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4-90%-C-MF04

TYPE IV FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES
CLARIANT MAX FLIGHT 04

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	2:24 – 3:36	2:00	2:00 – 2:00	1:17 – 2:00	1:48 – 1:48	1:03 – 1:21	0:18 – 1:48	
		75/25								
		50/50								
below -3 to -14	below 27 to 7	100/0	0:45 – 2:15	2:00	1:03 – 2:00	0:32 – 1:03	0:23 – 1:21[7]	0:18 – 0:36[7]		CAUTION: No holdover time guidelines exist
		75/25								
below -14 to -23.5	below 7 to -10.3	100/0	0:18 – 0:41	0:18	0:09 – 0:18	0:07 – 0:09				

NOTES
1. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2. To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3. Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7. No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4-90%-C-MFA

TYPE IV FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES
CLARIANT MAX FLIGHT AVIA

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:47 – 3:36	2:00	1:35 – 2:00	0:54 – 1:35	1:17 – 1:48	0:50 – 1:03	0:08 – 1:48	CAUTION: No holdover time guidelines exist
		75/25								
		50/50							CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	1:35 – 3:32	1:57	1:08 – 1:57	0:36 – 1:08	1:03 – 1:48[7]	0:50 – 1:21[7]		
		75/25								
below -14 to -28.5	below 7 to -19.3	100/0	0:32 – 1:17	0:18	0:09 – 0:18	0:07 – 0:09	CAUTION: No holdover time guidelines exist			

NOTES
1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4-90%-C-MFS

TYPE IV FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES CLARIANT MAX FLIGHT SNEG

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	2:11 – 3:36	2:00	1:30 – 2:00	0:59 – 1:30	1:48 – 1:48	0:45 – 1:30	0:18 – 1:21	
		75/25	3:36 – 3:36	2:00	1:21 – 2:00	0:50 – 1:21	1:21 – 1:48	0:59 – 1:12	0:14 – 1:35	
		50/50	1:21 – 3:09	1:35	0:41 – 1:35	0:18 – 0:41	0:32 – 1:03	0:14 – 0:27	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:41 – 2:06	1:48	1:08 – 1:48	0:41 – 1:08	0:27 – 1:17[7]	0:23 – 0:36[7]		
		75/25	0:27 – 1:17	1:30	0:54 – 1:30	0:36 – 0:54	0:18 – 0:59[7]	0:18 – 0:36[7]		
below -14 to -29	below 7 to -20.2	100/0	0:18 – 0:45	0:18	0:09 – 0:18	0:07 – 0:09				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2016-2017

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4-90%-C-N

TYPE IV FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES CLARIANT SAFEWING EG IV NORTH

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	2:06 – 3:32	2:00	1:30 – 2:00	0:45 – 1:30	1:21 – 1:48	0:45 – 0:50	0:07 – 1:48	CAUTION: No holdover time guidelines exist
		75/25								
		50/50							CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	1:35 – 3:36	2:00	1:21 – 2:00	0:45 – 1:21	0:59 – 1:39[7]	0:50 – 1:17[7]		
		75/25								
below -14 to -30	below 7 to -22	100/0	0:36 – 1:12	0:18	0:09 – 0:18	0:07 – 0:09				

NOTES

1. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2. To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3. Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7. No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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Transport Canada Holdover Time Guidelines **Winter 2016-2017**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4-90%-C-L

TYPE IV FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES
CLARIANT SAFEWING MP IV LAUNCH

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	3:36 – 3:36	2:00	1:35 – 2:00	0:59 – 1:35	1:21 – 1:48	0:54 – 1:30	0:14 – 1:30	
		75/25	3:18 – 3:36	2:00	1:35 – 2:00	0:54 – 1:35	1:30 – 1:48	0:41 – 1:08	0:09 – 1:35	
		50/50	1:17 – 2:29	1:17	0:41 – 1:17	0:23 – 0:41	0:27 – 0:45	0:18 – 0:23	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:54 – 1:44	1:57	1:12 – 1:57	0:45 – 1:12	0:32 – 1:30[7]	0:23 – 0:41[7]		
		75/25	0:36 – 1:12	2:00	1:17 – 2:00	0:41 – 1:17	0:23 – 1:03[7]	0:23 – 0:41[7]		
below -14 to -28.5	below 7 to -19.3	100/0	0:27 – 0:45	0:18	0:09 – 0:18	0:07 – 0:09				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4-90%-C-L+

TYPE IV FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES
CLARIANT SAFEWING MP IV LAUNCH PLUS

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	3:32 – 3:36	2:00	1:53 – 2:00	0:50 – 1:53	1:48 – 1:48	0:54 – 1:48	0:18 – 1:48	
		75/25	3:32 – 3:36	2:00	1:44 – 2:00	0:45 – 1:44	1:48 – 1:48	1:12 – 1:17	0:18 – 1:39	
		50/50	1:08 – 1:39	1:26	0:41 – 1:26	0:18 – 0:41	0:23 – 0:54	0:14 – 0:18	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:50 – 2:02	2:00	1:17 – 2:00	0:36 – 1:17	0:23 – 1:26[7]	0:23 – 0:36[7]		
		75/25	0:36 – 1:48	2:00	1:08 – 2:00	0:27 – 1:08	0:18 – 0:59[7]	0:18 – 0:27[7]		
below -14 to -29	below 7 to -20.2	100/0	0:23 – 0:45	0:18	0:09 – 0:18	0:07 – 0:09				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4-90%-CR-PGA

TYPE IV FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES CRYOTECH POLAR GUARD® ADVANCE

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Snow, Snow Grains or Snow Pellets[2] Light[3]	Snow, Snow Grains or Snow Pellets[2] Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:33 – 3:36	2:00	1:39 – 2:00	1:12 – 1:39	1:26 – 1:48	1:08 – 1:21	0:14 – 1:48	CAUTION: No holdover time guidelines exist
		75/25	2:15 – 3:36	2:00	1:12 – 2:00	0:41 – 1:12	1:30 – 1:48	0:36 – 1:03	0:08 – 1:30	
		50/50	0:45 – 1:17	1:12	0:32 – 1:12	0:14 – 0:32	0:18 – 0:41	0:08 – 0:18		
below -3 to -14	below 27 to 7	100/0	0:50 – 2:15	1:35	1:08 – 1:35	0:50 – 1:08	0:32 – 1:26[7]	0:32 – 0:41[7]		
		75/25	0:36 – 1:21	1:35	0:54 – 1:35	0:32 – 0:54	0:23 – 0:59[7]	0:32 – 0:41[7]		
below -14 to -30.5	below 7 to -22.9	100/0	0:23 – 0:45	0:18	0:09 – 0:18	0:07 – 0:09				

NOTES

1. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2. To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3. Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7. No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4-90%-DS-ES

TYPE IV FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES DEICING SOLUTIONS ECO-SHIELD®

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:08 – 2:24	2:00	1:12 – 2:00	0:41 – 1:12	0:36 – 1:21	0:32 – 0:36	0:14 – 1:26	CAUTION: No holdover time guidelines exist
		75/25								
		50/50								
below -3 to -14	below 27 to 7	100/0	1:03 – 2:20	1:44	0:59 – 1:44	0:32 – 0:59	0:45 – 1:17[7]	0:27 – 0:36[7]		
		75/25								
below -14 to -25.5	below 7 to -13.9	100/0	0:27 – 0:54	0:18	0:09 – 0:18	0:07 – 0:09				

NOTES

1. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2. To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3. Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7. No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4-90%-D-E106

TYPE IV FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES
DOW CHEMICAL UCAR™ ENDURANCE EG106

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	1:53 – 2:51	2:00	1:12 – 2:00	0:36 – 1:12	1:03 – 1:48	0:45 – 1:08	0:18 – 1:48	CAUTION: No holdover time guidelines exist
		75/25								
		50/50								
below -3 to -14	below 27 to 7	100/0	1:39 – 3:00	1:57	0:59 – 1:57	0:27 – 0:59	0:50 – 1:39[7]	0:41 – 1:03[7]		
		75/25								
below -14 to -27	below 7 to -16.6	100/0	0:27 – 0:59	0:18	0:09 – 0:18	0:07 – 0:09				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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Transport Canada Holdover Time Guidelines — Winter 2016-2017

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4-90%-D-AD49

TYPE IV FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES DOW CHEMICAL UCAR™ FLIGHTGUARD AD-49

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	3:00 – 3:36	2:00	1:39 – 2:00	1:03 – 1:39	1:17 – 1:48	0:54 – 1:17	0:09 – 1:44	
		75/25	2:11 – 3:36	1:53	1:30 – 1:53	1:12 – 1:30	1:44 – 1:48	0:45 – 1:21	0:09 – 1:30	
		50/50	0:23 – 0:45	0:36	0:23 – 0:36	0:14 – 0:23	0:14 – 0:27	0:09 – 0:14		
below -3 to -14	below 27 to 7	100/0	0:18 – 1:26	2:00	1:39 – 2:00	1:03 – 1:39	0:23 – 1:17[7]	0:18 – 0:23[7]	CAUTION: No holdover time guidelines exist	
		75/25	0:27 – 1:03	1:53	1:30 – 1:53	1:12 – 1:30	0:14 – 0:59[7]	0:14 – 0:23[7]		
below -14 to -26	below 7 to -14.8	100/0	0:23 – 0:36	0:18	0:09 – 0:18	0:07 – 0:09				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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Transport Canada Holdover Time Guidelines **Winter 2016-2017**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4-90%-K-ABC-S+

TYPE IV FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES
KILFROST ABC-S PLUS

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
			Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
Degrees Celsius	Degrees Fahrenheit			Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	1:57 – 3:36	2:00	1:53 – 2:00	1:08 – 1:53	1:39 – 1:48	0:59 – 1:48	0:23 – 1:48	CAUTION: No holdover time guidelines exist
		75/25	1:17 – 2:24	1:53	1:08 – 1:53	0:41 – 1:08	0:54 – 1:12	0:27 – 0:45	0:09 – 1:12	
		50/50	0:27 – 0:50	0:54	0:27 – 0:54	0:14 – 0:27	0:14 – 0:36	0:14 – 0:18		
below -3 to -14	below 27 to 7	100/0	0:50 – 3:09	2:00	1:35 – 2:00	0:54 – 1:35	0:23 – 1:26[7]	0:18 – 0:27[7]		
		75/25	0:41 – 1:39	1:35	0:54 – 1:35	0:32 – 0:54	0:18 – 1:03[7]	0:14 – 0:23[7]		
below -14 to -28	below 7 to -18.4	100/0	0:36 – 0:54	0:18	0:09 – 0:18	0:07 – 0:09				

NOTES
1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4-90%-L-E450

TYPE IV FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES LNT SOLUTIONS E450

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Snow, Snow Grains or Snow Pellets[2] Light[3]	Snow, Snow Grains or Snow Pellets[2] Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:39 – 2:38	2:00	1:26 – 2:00	0:54 – 1:26	1:26 – 1:48	0:50 – 1:12	0:23 – 1:48	CAUTION: No holdover time guidelines exist
		75/25								
		50/50							CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	1:21 – 3:32	1:39	1:03 – 1:39	0:41 – 1:03	1:35 – 1:48[7]	0:59 – 1:30[7]		
		75/25								
below -14 to -22.5	below 7 to -8.5	100/0	0:32 – 0:59	0:18	0:09 – 0:18	0:07 – 0:09				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4-90%-N-F-9311

TYPE IV FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES
NEWAVE AEROCHEMICAL FCY 9311

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	1:44 – 3:36	2:00	1:03 – 2:00	0:32 – 1:03	1:03 – 1:48	0:36 – 0:59	0:14 – 1:17	CAUTION: No holdover time guidelines exist
		75/25								
		50/50								
below -3 to -14	below 27 to 7	100/0	0:32 – 1:53	1:26	0:45 – 1:26	0:23 – 0:45	0:32 – 1:12[7]	0:18 – 0:32[7]		
		75/25								
below -14 to -29.5	below 7 to -21.1	100/0	0:27 – 0:50	0:18	0:09 – 0:18	0:07 – 0:09				

NOTES

1. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2. To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3. Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7. No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines Winter 2016-2017

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4-90%-SC-CSIV

TYPE IV FLUID 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES
SHAANXI CLEANWAY AVIATION CLEANSURFACE IV

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	2:33 – 3:36	2:00	1:44 – 2:00	0:54 – 1:44	1:48 – 1:48	1:17 – 1:21	0:14 – 1:48	
		75/25	2:20 – 3:36	2:00	1:26 – 2:00	0:41 – 1:26	0:45 – 1:48	0:32 – 0:41	0:08 – 1:08	
		50/50	0:59 – 2:11	1:30	0:36 – 1:30	0:14 – 0:36	0:23 – 0:45	0:14 – 0:18		
below -3 to -14	below 27 to 7	100/0	0:54 – 2:47	1:12	0:41 – 1:12	0:23 – 0:41	0:32 – 1:35[7]	0:18 – 0:32[7]	CAUTION: No holdover time guidelines exist	
		75/25	0:45 – 1:44	1:30	0:41 – 1:30	0:18 – 0:41	0:27 – 1:12[7]	0:23 – 0:36[7]		
below -14 to -28.5	below 7 to -19.3	100/0	0:27 – 0:45	0:18	0:09 – 0:18	0:07 – 0:09				

NOTES
1. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2. To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3. Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7. No holdover time guidelines exist for this condition below -10°C (14°F).

CAUTIONS
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 5-90%

SAE TYPE III FLUID
90 PERCENT ADJUSTED ICE PELLET AND SMALL HAIL ALLOWANCE TIMES[1]

This table is for use with SAE Type III undiluted (100/0) fluids applied unheated only

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Precipitation Type	Outside Air Temperature		
	-5°C and above	Below -5 to -10°C	Below -10°C[2]
Light Ice Pellets	9 minutes	9 minutes	Caution: No allowance times currently exist
Light Ice Pellets Mixed with Light Snow	9 minutes	9 minutes	
Light Ice Pellets Mixed with Moderate Snow	9 minutes	5 minutes	
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	6 minutes	5 minutes	
Light Ice Pellets Mixed with Light Freezing Rain	6 minutes	5 minutes	
Light Ice Pellets Mixed with Light Rain	6 minutes[3]		
Light Ice Pellets Mixed with Moderate Rain			
Moderate Ice Pellets (or Small Hail)[4]	5 minutes	5 minutes	

NOTES

1 These allowance times are for use with aircraft with rotation speeds of 100 knots or greater.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 No allowance times exist in this condition for temperatures below 0°C; consider use of light ice pellets mixed with light freezing rain.
4 If no intensity is reported with small hail, use the "moderate ice pellets or small hail" allowance times. If an intensity is reported with small hail, the ice pellet condition with the equivalent intensity can be used, e.g. if light small hail is reported, the "light ice pellets" allowance times can be used. This also applies in mixed conditions, e.g. if light small hail mixed with light snow is reported, use the "light ice pellets mixed with light snow" allowance times.

CAUTIONS

- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **Allowance time cannot be extended by an inspection of the aircraft critical surfaces.**
- **Takeoff is allowed up to 90 minutes after start of fluid application if the precipitation stops at or before the allowance time expires and does not restart. The OAT must not decrease during the 90 minutes to use this guidance in conditions of light ice pellets mixed with either: light or moderate freezing drizzle, light freezing rain, or light rain.**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 6-90%

SAE TYPE IV FLUID
90 PERCENT ADJUSTED ICE PELLET AND SMALL HAIL ALLOWANCE TIMES[1]

This table is for use with SAE Type IV undiluted (100/0) fluids only. All Type IV fluids are propylene glycol based with the exception of Clariant Max Flight AVIA, Clariant Safewing EG IV NORTH, Dow EG106 and LNT Solutions E450 which are ethylene glycol based.

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Precipitation Type	Outside Air Temperature			
	-5°C and above	Below -5 to -10°C	Below -10 to -16°C	Below -16 to -22°C[2]
Light Ice Pellets	45 minutes	27 minutes	27 minutes[3]	27 minutes[3]
Light Ice Pellets Mixed with Light Snow	36 minutes	14 minutes	14 minutes[3]	
Light Ice Pellets Mixed with Moderate Snow	18 minutes	6 minutes	5 minutes[3]	
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	23 minutes	9 minutes		
Light Ice Pellets Mixed with Light Freezing Rain	23 minutes	9 minutes	**Caution: No allowance times currently exist**	
Light Ice Pellets Mixed with Light Rain	23 minutes[4]			
Light Ice Pellets Mixed with Moderate Rain	23 minutes[5]			
Moderate Ice Pellets (or Small Hail)[6]	23 minutes[7]	9 minutes	9 minutes[3]	9 minutes[8]
Moderate Ice Pellets (or Small Hail)[6] Mixed with Moderate Freezing Drizzle	9 minutes	6 minutes	**Caution: No allowance times currently exist**	
Moderate Ice Pellets (or Small Hail)[6] Mixed with Moderate Rain	9 minutes[5]			

NOTES

1. These allowance times are for use with aircraft with rotation speeds of 100 knots or greater.
2. Ensure that the lowest operational use temperature (LOUT) is respected.
3. No allowance times exist for propylene glycol (PG) fluids when used on aircraft with rotation speeds less than 115 knots. (For these aircraft, if the fluid type is not known, assume zero allowance time.)
4. No allowance times exist in this condition for temperatures below 0°C; consider use of light ice pellets mixed with light freezing rain.
5. No allowance times exist in this condition for temperatures below 0°C.
6. If no intensity is reported with small hail, use the "moderate ice pellets or small hail" allowance times. If an intensity is reported with small hail, the ice pellet condition with the equivalent intensity can be used, e.g. if light small hail is reported, the "light ice pellets" allowance times can be used. This also applies in mixed conditions, e.g. if light small hail mixed with light snow is reported, use the "light ice pellets mixed with light snow" allowance times.
7. Allowance time is 14 minutes for propylene glycol (PG) fluids or when the fluid type is unknown.
8. No allowance times exist for propylene glycol (PG) fluids in this condition for temperatures below -16°C.

CAUTIONS

- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **Allowance time cannot be extended by an inspection of the aircraft critical surfaces.**
- **Takeoff is allowed up to 90 minutes after start of fluid application if the precipitation stops at or before the allowance time expires and does not restart. The OAT must not decrease during the 90 minutes to use this guidance in conditions of light ice pellets mixed with either: light or moderate freezing drizzle, light freezing rain, light rain, or moderate rain.**

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FAA
HOLDOVER TIME GUIDELINES
WINTER 2016-2017

FAA
HOLDOVER TIME GUIDELINES

WINTER 2016-2017
ORIGINAL ISSUE: AUG. 5, 2016

The information contained in this document serves as the official FAA guidance, Holdover Times and Allowance Times for use during the 2016-2017 winter season. This document is designed to be used in conjunction with the FAA N 8900 series notice "Revised FAA-Approved Deicing Program Updates, Winter 2016-2017."

Questions concerning FAA aircraft ground de/anti-icing requirements or Flight Standards policies should be addressed to charles.j.enders@faa.gov or 202-267-4557.

Questions on the technical content of the holdover time tables should be addressed to warren.underwood@faa.gov or 404-305-6652.

Questions regarding editorial content or web access issues should be addressed to sung.shin@faa.gov or 202-267-8086.

CHANGE CONTROL RECORDS

This page indicates any changes made to individual pages within the document. Changed pages have the appropriate revision date in the footer. Sidebars are shown to assist in identifying where changes have been made on these pages.

It is the responsibility of the end user to periodically check the following website for updates: https://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/deicing/.

REVISION	DATE	DESCRIPTION OF CHANGES	AFFECTED PAGES	AUTHOR

SUMMARY OF CHANGES FOR WINTER 2016-2017

The principal changes from the previous year are briefly indicated herein.

ACTIVE FROST

- A note has been added to the active frost holdover time (HOT) table to provide guidance on the appropriate outside air temperature to select in changing conditions.

TYPE I FLUIDS

- The Type I HOT guidelines are unchanged.

TYPE II FLUIDS

- Fluid-specific HOT guidelines have been created for the new Type II fluid Beijing Yadilite Aviation YD-102 Type II.
- LNT Solutions P250 has been removed from the Type II guidelines.
- Significant changes (both increases and decreases) have been made to the Type II generic holdover times as a result of the new and removed Type II fluids.
- The holdover times for snow in the “below -14°C to LOUT” row have been reduced for all Type II and Type IV fluids. This is the result of a two-year research program showing the new holdover times are more appropriate.

TYPE III FLUIDS

- Supplemental testing with AllClear AeroClear MAX resulted in changes to most of its holdover times for winter 2016-2017.

TYPE IV FLUIDS

- Fluid-specific HOT guidelines have been created for three new Type IV fluids: Clariant Max Flight AVIA, Clariant Safewing EG IV NORTH and Shaanxi Cleanway Aviation Cleansurface IV.
- Cryotech Polar Guard and Dow Chemical UCAR™ FlightGuard AD-480 have been removed from the Type IV guidelines as per the protocol for removing obsolete fluids.
- Supplemental testing with Deicing Solutions ECO-SHIELD® resulted in changes to most of its holdover times for winter 2016-2017. Its lowest operational use temperature (LOUT) and lowest on-wing viscosity (LOWV) have also changed.
- Significant changes (both increases and decreases) have been made to the Type IV generic holdover times as a result of the new and removed Type IV fluids. In addition, the Type IV generic HOT table has been expanded to include holdover times for three snowfall intensities: very light, light and moderate. This was possible as, for the first time, all fluid-specific Type IV holdover time tables include light, very light and moderate snow holdover times.
- The holdover times for snow in the “below -14°C to LOUT” row have been reduced for all Type II and Type IV fluids. This is the result of a two-year research program showing the new holdover times are more appropriate.

ICE PELLET AND SMALL HAIL ALLOWANCE TIMES

- The rows in both the Type III and Type IV allowance time tables, each containing a specific precipitation condition, have been reordered for ease of use.
- A note has been added to both the Type III and Type IV allowance time tables indicating they are for use with aircraft with rotation speeds of 100 knots or greater only.

FAA Holdover Time Guidelines Winter 2016-2017

- A review of existing data resulted in a change to the Type III allowance time for “Light Ice Pellets Mixed with Moderate Snow” in the “Below -5 to -10°C” cell (from 10 to 5 minutes).
- Allowance times have been added for Type IV fluid in “Light Ice Pellets Mixed with Light Snow” and “Light Ice Pellets Mixed with Moderate Snow” in the “Below -10 to -16°C” temperature band.
- New rows / allowance times have been added to the Type IV table for two new precipitation conditions: “Moderate Ice Pellets (or Small Hail) Mixed with Moderate Freezing Drizzle” and “Moderate Ice Pellets (or Small Hail) Mixed with Moderate Rain”.
- The coldest temperature band in the Type IV table has been divided into two temperature bands: “Below -10 to -16°C” and “Below -16 to -22°C.”

FLUID APPLICATION TABLES

- Guidance for the application of Type III fluid was previously provided in the same table as the guidance for the application of Type II/IV fluid. For the winter of 2016-2017, this guidance is provided in two separate Type III fluid application tables. Table 11-H provides guidance for the application of heated Type III fluid and Table 11-U provides guidance for the application of unheated Type III fluid.
- Changes have been made to the Type I and Type II/IV fluid application tables to improve harmonization with the Transport Canada and SAE fluid application tables.

EARLY FLUID FAILURE ON EXTENDED SLATS AND FLAPS

- Research has determined that fluid degradation is accelerated by the steeper angles of the flaps/slats in the takeoff configuration. The degree of potential degradation is significantly affected by the specific aircraft design. For the winter of 2014-2015, holdover time and allowance time tables were published which include 90% adjusted holdover / allowance times. These adjusted tables will continue to be used for winter 2016-2017.
- The 90% adjusted tables provide holdover / allowance times that must be used when flaps and slats are deployed prior to de/anti-icing. Standard holdover / allowance times can be used if flaps and slats are deployed as close to departure as safety allows. Additional guidance is provided in the FAA N 8900 series notice “Revised FAA-Approved Deicing Program Updates, Winter 2016-2017.”

IMPORTANT NOTE ON HOTS FOR NON-STANDARD DILUTIONS OF TYPE II, III, AND IV FLUIDS

- When a Type II, III, or IV fluid is diluted to other than the published 100/0, 75/25 or 50/50 dilutions, the more conservative holdover time and LOUT associated with either the dilution above or below the selected dilution are applicable. For example:
  (a) The holdover time and LOUT of an 80/20 dilution would be the more conservative holdover time and LOUT of either the 100/0 or 75/25 dilutions;
  (b) The holdover time and LOUT of a 60/40 dilution would be the more conservative holdover time and LOUT of either the 75/25 or 50/50 dilutions.

RELOCATION OF KEY GUIDANCE CONTENT

- The guidance material previously contained in this document under the heading “Key Guidance” has been relocated to the related FAA N 8900 series notice “Revised FAA-Approved Deicing Program Updates, Winter 2016-2017.” This has been done so that all pertinent guidance material is provided in a single document.

HOLDOVER TIME (HOT) GUIDELINES FOR WINTER 2016-2017

Standard HOT Guidelines and Allowance Times

Supplemental Guidance

FAA Holdover Time Guidelines Winter 2016-2017

90% Adjusted HOT Guidelines and Allowance Times

FAA Holdover Time Guidelines — Winter 2016-2017

TABLE 0. HOLDOVER TIME GUIDELINES FOR SAE TYPE I, TYPE II, TYPE III, AND TYPE IV FLUIDS IN ACTIVE FROST

Outside Air Temperature[1,2,3] Degrees Celsius	Outside Air Temperature[1,2,3] Degrees Fahrenheit	Approximate Holdover Times (hours:minutes) Active Frost Type I
-1 and above	30 and above	0:45 (0:35)[5]
below -1 to -3	below 30 to 27	
below -3 to -10	below 27 to 14	
below -10 to -14	below 14 to 7	
below -14 to -21	below 7 to -6	
below -21 to LOUT	below -6 to LOUT	

Outside Air Temperature[2,3] Degrees Celsius	Outside Air Temperature[2,3] Degrees Fahrenheit	Concentration Neat Fluid/Water (Volume %/ Volume %)	Approximate Holdover Times (hours:minutes) Active Frost Type II	Type III[4]	Type IV
-1 and above	30 and above	100/0	8:00	2:00	12:00
		75/25	5:00	1:00	5:00
		50/50	3:00	0:30	3:00
below -1 to -3	below 30 to 27	100/0	8:00	2:00	12:00
		75/25	5:00	1:00	5:00
		50/50	1:30	0:30	3:00
below -3 to -10	below 27 to 14	100/0	8:00	2:00	10:00
		75/25	5:00	1:00	5:00
below -10 to -14	below 14 to 7	100/0	6:00	2:00	6:00
		75/25	1:00	1:00	1:00
below -14 to -21	below 7 to -6	100/0	6:00	2:00	6:00
below -21 to -25	below -6 to -13	100/0	2:00	2:00	4:00
Below -25	Below -13	No holdover time guidelines exist			

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

1 Type I Fluid / Water Mixture must be selected so that the freezing point of the mixture is at least 10 °C (18 °F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 Changes in outside air temperature (OAT) over the course of longer frost events can be significant; the appropriate holdover time to use is the one provided for the coldest OAT that has occurred in the time between the de/anti-icing fluid application and takeoff.
4 To use the Type III fluid frost holdover times, the fluid brand being used must be known. AllClear AeroClear MAX must be applied unheated. Clariant Safewing MP III 2031 ECO must be applied heated.
5 Value in parentheses is for aircraft with critical surfaces that are predominantly or entirely constructed of composite materials.

CAUTIONS:

- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

FAA Holdover Time Guidelines **Winter 2016-2017**

TABLE 1A. HOLDOVER TIME GUIDELINES FOR SAE TYPE I FLUID ON CRITICAL AIRCRAFT SURFACES COMPOSED PREDOMINANTLY OF ALUMINUM

Outside Air Temperature[1,2]		Wing Surface	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	Aluminum	0:11-0:17	0:18-0:22	0:11-0:18	0:06-0:11	0:09-0:13	0:02-0:05	0:02-0:05	CAUTION: No holdover time guidelines exist
below -3 to -6	below 27 to 21	Aluminum	0:08-0:13	0:14-0:17	0:08-0:14	0:05-0:08	0:05-0:09	0:02-0:05		
below -6 to -10	below 21 to 14	Aluminum	0:06-0:10	0:11-0:13	0:06-0:11	0:04-0:06	0:04-0:07	0:02-0:05		
Below -10	below 14	Aluminum	0:05-0:09	0:07-0:08	0:04-0:07	0:02-0:04				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Type I fluid / water mixture must be selected so that the freezing point of the mixture is at least 10 °C (18 °F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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TABLE 1C. HOLDOVER TIME GUIDELINES FOR SAE TYPE I FLUID ON CRITICAL AIRCRAFT SURFACES COMPOSED PREDOMINANTLY OF COMPOSITES

Outside Air Temperature[1,2]		Wing Surface	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	Composite	0:09-0:16	0:12-0:15	0:06-0:12	0:03-0:06	0:08-0:13	0:02-0:05	0:01-0:05	CAUTION: No holdover time guidelines exist
below -3 to -6	below 27 to 21	Composite	0:06-0:08	0:11-0:13	0:05-0:11	0:02-0:05	0:05-0:09	0:02-0:05	CAUTION: No holdover time guidelines exist	
below -6 to -10	below 21 to 14	Composite	0:04-0:08	0:09-0:12	0:05-0:09	0:02-0:05	0:04-0:07	0:02-0:05		
Below -10	below 14	Composite	0:04-0:07	0:07-0:08	0:04-0:07	0:02-0:04	CAUTION: No holdover time guidelines exist			

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Type I fluid / water mixture must be selected so that the freezing point of the mixture is at least 10 °C (18 °F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

TABLE 2-GENERIC. TYPE II HOLDOVER TIME GUIDELINES FOR SAE TYPE II FLUIDS

Outside Air Temperature[1]		Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2,3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	0:35-1:30	0:20-0:45	0:30-1:00	0:15-0:30	0:07-0:40	CAUTION: No holdover time guidelines exist
		75/25	0:25-0:55	0:15-0:25	0:15-0:40	0:10-0:20	0:04-0:25	
		50/50	0:15-0:25	0:05-0:10	0:08-0:15	0:05-0:09		
below -3 to -14	below 27 to 7	100/0	0:20-1:05	0:15-0:30	0:20-0:45[7]	0:10-0:20[7]		
		75/25	0:25-0:50	0:08-0:20	0:15-0:25[7]	0:08-0:15[7]		
Below -14 to LOUT	Below 7 to LOUT	100/0	0:20-0:35[8]	0:08-0:10[8]				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).
8 If the LOUT is unknown, no holdover time guidelines exist below -22.5 °C (-8.5 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

FAA Holdover Time Guidelines **Winter 2016-2017**

TABLE 2A. TYPE II HOLDOVER TIME GUIDELINES FOR
ABAX ECOWING 26

Outside Air Temperature[1] Degrees Celsius	Outside Air Temperature[1] Degrees Fahrenheit	Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Snow, Snow Grains or Snow Pellets[2] Light[3]	Snow, Snow Grains or Snow Pellets[2] Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:25-2:35	1:35-1:50	1:00-1:35	0:40-1:00	0:50-1:35	0:40-0:50	0:20-1:25	CAUTION: No holdover time guidelines exist
		75/25	1:05-1:55	1:15-1:25	0:45-1:15	0:25-0:45	0:45-1:05	0:25-0:35	0:10-1:00	
		50/50	0:30-0:45	0:40-0:50	0:20-0:40	0:10-0:20	0:15-0:25	0:08-0:10		
below -3 to -14	below 27 to 7	100/0	0:45-2:15	1:25-1:40	0:55-1:25	0:35-0:55	0:30-1:10[7]	0:15-0:35[7]		
		75/25	0:35-1:15	0:55-1:05	0:40-0:55	0:25-0:40	0:20-0:50[7]	0:15-0:25[7]		
below -14 to -25	below 7 to -13	100/0	0:25-0:45	0:20-0:25	0:10-0:20	0:08-0:10				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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FAA Holdover Time Guidelines — Winter 2016-2017

TABLE 2B. TYPE II HOLDOVER TIME GUIDELINES FOR AVIATION SHAANXI HI-TECH CLEANWING II

Outside Air Temperature[1]		Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2,3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	0:55-1:50	0:30-0:55	0:35-1:05	0:25-0:35	0:10-0:55	
		75/25	0:50-1:20	0:25-0:45	0:35-1:00	0:20-0:30	0:07-0:50	
		50/50	0:35-1:00	0:15-0:30	0:20-0:40	0:10-0:20	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:45-1:50	0:30-0:55	0:30-0:55[7]	0:20-0:25[7]		
		75/25	0:40-1:45	0:25-0:45	0:35-0:40[7]	0:20-0:25[7]		
below -14 to -29	below 7 to -20.2	100/0	0:20-0:50	0:08-0:10				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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TABLE 2C. TYPE II HOLDOVER TIME GUIDELINES FOR BEIJING YADILITE AVIATION YD-102 TYPE II

Outside Air Temperature[1] Degrees Celsius	Outside Air Temperature[1] Degrees Fahrenheit	Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Snow, Snow Grains or Snow Pellets[2] Light[3]	Snow, Snow Grains or Snow Pellets[2] Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:10-2:00	1:40-2:00	0:50-1:40	0:25-0:50	0:40-1:15	0:35-0:40	0:10-1:00	CAUTION: No holdover time guidelines exist
		75/25	0:25-0:55	0:50-1:05	0:25-0:50	0:15-0:25	0:15-0:40	0:10-0:20	0:04-0:25	
		50/50	0:15-0:25	0:25-0:30	0:10-0:25	0:05-0:10	0:08-0:15	0:07-0:09		
below -3 to -14	below 27 to 7	100/0	0:45-1:30	1:00-1:15	0:30-1:00	0:15-0:30	0:35-0:50[7]	0:25-0:25[7]		
		75/25	0:30-0:50	0:35-0:45	0:20-0:35	0:08-0:20	0:15-0:25[7]	0:09-0:15[7]		
Below -14 to -29	Below 7 to -20.2	100/0	0:20-0:45	0:20-0:25	0:10-0:20	0:08-0:10				

Approximate Holdover Times Under Various Weather Conditions (hours:minutes)

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

FAA Holdover Time Guidelines — Winter 2016-2017

TABLE 2D. TYPE II HOLDOVER TIME GUIDELINES FOR CLARIANT SAFEWING MP II FLIGHT

Outside Air Temperature[1]		Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[2]**			**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
				Very Light[3]	**Light[3]**	**Moderate**				
-3 and above	27 and above	100/0	3:30-4:00	2:35-3:00	1:35-2:35	1:00-1:35	1:20-2:00	0:45-1:25	0:10-1:30	
		75/25	1:50-2:45	2:35-3:00	1:20-2:35	0:40-1:20	1:10-1:30	0:30-0:55	0:06-0:50	
		50/50	0:55-1:45	0:45-0:55	0:25-0:45	0:10-0:25	0:20-0:30	0:10-0:15	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:55-1:45	1:50-2:10	1:05-1:50	0:40-1:05	0:35-1:30[7]	0:25-0:45[7]		
		75/25	0:25-1:05	1:20-1:40	0:40-1:20	0:20-0:40	0:25-1:10[7]	0:20-0:35[7]		
Below -14 to -29	Below 7 to -20.2	100/0	0:30-0:50	0:20-0:25	0:10-0:20	0:08-0:10				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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TABLE 2E. TYPE II HOLDOVER TIME GUIDELINES FOR CLARIANT SAFEWING MP II FLIGHT PLUS

Outside Air Temperature[1]		Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[2,3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	2:40-4:00	0:50-1:50	1:25-2:00	0:45-1:00	0:15-2:00	
		75/25	2:35-4:00	1:00-1:45	1:35-2:00	0:50-1:15	0:15-1:15	
		50/50	1:05-2:20	0:15-0:25	0:30-1:05	0:15-0:20	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:40-2:20	0:35-1:15	0:35-1:25[7]	0:35-0:55[7]		
		75/25	0:30-1:45	0:55-1:40	0:25-1:10[7]	0:30-0:45[7]		
Below -14 to -29	Below 7 to -20.2	100/0	0:20-0:40	0:08-0:10				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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TABLE 2F. TYPE II HOLDOVER TIME GUIDELINES FOR CRYOTECH POLAR GUARD® II

Outside Air Temperature[1]		Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
			Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
Degrees Celsius	Degrees Fahrenheit			Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	2:50-4:00	2:35-2:50	1:50-2:35	1:20-1:50	1:35-2:00	1:15-1:30	0:15-2:00	
		75/25	2:30-4:00	2:25-2:55	1:20-2:25	0:45-1:20	1:40-2:00	0:40-1:10	0:09-1:40	
		50/50	0:50-1:25	1:20-1:45	0:35-1:20	0:15-0:35	0:20-0:45	0:09-0:20	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:55-2:30	1:45-1:55	1:15-1:45	0:55-1:15	0:35-1:35[7]	0:35-0:45[7]		
		75/25	0:40-1:30	1:45-2:05	1:00-1:45	0:35-1:00	0:25-1:05[7]	0:35-0:45[7]		
Below -14 to -30.5	Below 7 to -22.9	100/0	0:25-0:50	0:20-0:25	0:10-0:20	0:08-0:10				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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TABLE 2G. TYPE II HOLDOVER TIME GUIDELINES FOR KILFROST ABC-ICE CLEAR II

Outside Air Temperature[1]		Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:00-1:45	1:45-2:10	0:50-1:45	0:25-0:50	0:40-1:05	0:25-0:35	0:07-0:45	
		75/25	0:50-1:10	1:20-1:45	0:40-1:20	0:20-0:40	0:30-0:45	0:20-0:30	0:05-0:35	
		50/50	0:15-0:30	0:20-0:25	0:15-0:20	0:08-0:15	0:10-0:20	0:07-0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:40-1:35	1:15-1:35	0:35-1:15	0:20-0:35	0:25-1:00[7]	0:15-0:30[7]		
		75/25	0:40-1:20	0:55-1:10	0:25-0:55	0:15-0:25	0:25-0:45[7]	0:15-0:20[7]		
Below -14 to -29.5	Below 7 to -21.1	100/0	0:20-0:40	0:20-0:25	0:10-0:20	0:08-0:10				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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TABLE 2H. TYPE II HOLDOVER TIME GUIDELINES FOR KILFROST ABC-K PLUS

Outside Air Temperature[1]		Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2,3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:15-3:45	1:00-1:40	1:50-2:00	1:00-1:25	0:20-2:00	CAUTION: No holdover time guidelines exist
		75/25	1:40-2:30	0:35-1:10	1:25-2:00	0:50-1:10	0:15-2:00	
		50/50	0:35-1:05	0:07-0:15	0:20-0:30	0:10-0:15		
below -3 to -14	below 27 to 7	100/0	0:30-1:05	0:50-1:25	0:25-1:00[7]	0:15-0:35[7]		
		75/25	0:25-1:25	0:35-1:05	0:20-0:55[7]	0:09-0:30[7]		
below -14 to -29	below 7 to -20.2	100/0	0:30-0:55	0:08-0:10				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

FAA Holdover Time Guidelines — Winter 2016-2017

TABLE 2I. TYPE II HOLDOVER TIME GUIDELINES FOR NEWAVE AEROCHEMICAL FCY-2

Outside Air Temperature[1]		Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2,3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:15-2:25	0:30-0:55	0:35-1:05	0:25-0:35	0:08-0:45	
		75/25	0:50-1:30	0:20-0:40	0:25-0:45	0:15-0:25	0:05-0:25	
		50/50	0:25-0:35	0:15-0:25	0:10-0:20	0:07-0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:45-1:30	0:15-0:30	0:20-0:45[7]	0:15-0:20[7]		
		75/25	0:30-1:05	0:10-0:20	0:15-0:30[7]	0:08-0:15[7]		
below -14 to -28	below 7 to -18.4	100/0	0:25-0:35	0:08-0:10				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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TABLE 2J. TYPE II HOLDOVER TIME GUIDELINES FOR NEWAVE AEROCHEMICAL FCY-2 BIO+

Outside Air Temperature[1]		Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	1:25-2:30	2:20-2:55	1:05-2:20	0:30-1:05	0:50-1:20	0:25-0:45	0:08-1:15	CAUTION: No holdover time guidelines exist
		75/25	0:45-1:20	1:20-1:40	0:40-1:20	0:20-0:40	0:25-0:50	0:15-0:25	0:06-0:35	
		50/50	0:15-0:30	0:25-0:30	0:15-0:25	0:08-0:15	0:10-0:20	0:08-0:10		
below -3 to -14	below 27 to 7	100/0	0:40-1:30	1:00-1:15	0:30-1:00	0:15-0:30	0:35-1:05[7]	0:15-0:30[7]		
		75/25	0:30-1:05	0:35-0:45	0:20-0:35	0:08-0:20	0:20-0:35[7]	0:15-0:20[7]		
below -14 to -28.5	below 7 to -19.3	100/0	0:20-1:00	0:20-0:25	0:10-0:20	0:08-0:10				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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TABLE 3A-LS. LOW SPEED TYPE III HOLDOVER TIME GUIDELINES FOR ALLCLEAR AEROCLEAR MAX, APPLIED UNHEATED[1]

FOR AIRCRAFT CONFORMING TO THE SAE AS5900 LOW SPEED AERODYNAMIC TEST CRITERION

Outside Air Temperature[2]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3] Very Light[4]	Light[4]	Moderate	Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
-3 and above	27 and above	100/0	0:45-1:10	1:00-1:15	0:30-1:00	0:14-0:30	0:20-0:45	0:14-0:20	0:06-0:40	CAUTION: No holdover time guidelines exist
		75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		50/50	N/A	N/A	N/A	N/A	N/A	N/A	CAUTION: No holdover time guidelines exist	
below -3 to -10	below 27 to 14	100/0	0:45-1:25	1:00-1:15	0:30-1:00	0:14-0:30	0:20-0:40	0:15-0:25		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -10 to -16	below 14 to 3.2	100/0	0:30-1:05	1:00-1:15	0:30-1:00	0:14-0:30	CAUTION: No holdover time guidelines exist			

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Fluid must be applied unheated to use these holdover times. No holdover times exist for this fluid when applied heated.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type III fluid cannot be used.
3 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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TABLE 3A-HS. HIGH SPEED TYPE III HOLDOVER TIME GUIDELINES FOR ALLCLEAR AEROCLEAR MAX, APPLIED UNHEATED[1]

FOR AIRCRAFT CONFORMING TO THE SAE AS5900 HIGH SPEED AERODYNAMIC TEST CRITERION

Outside Air Temperature[2]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3] Very Light[4]	Light[4]	Moderate	Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
-3 and above	27 and above	100/0	0:45-1:10	1:00-1:15	0:30-1:00	0:14-0:30	0:20-0:45	0:14-0:20	0:06-0:40	CAUTION: No holdover time guidelines exist
		75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		50/50	N/A	N/A	N/A	N/A	N/A	N/A		
below -3 to -10	below 27 to 14	100/0	0:45-1:25	1:00-1:15	0:30-1:00	0:14-0:30	0:20-0:40	0:15-0:25		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -10 to -25	below 14 to -13	100/0	0:30-1:05	1:00-1:15	0:30-1:00	0:14-0:30				
below -25 to -35	below -13 to -31	100/0	0:15-0:40	0:40-0:50	0:19-0:40	0:09-0:19				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Fluid must be applied unheated to use these holdover times. No holdover times exist for this fluid when applied heated.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type III fluid cannot be used.
3 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 5 provides allowance times for ice pellets and small hail).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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TABLE 3B-LS. LOW SPEED TYPE III HOLDOVER TIME GUIDELINES FOR CLARIANT SAFEWING MP III 2031 ECO, APPLIED HEATED[1]

FOR AIRCRAFT CONFORMING TO THE SAE AS5900 LOW SPEED AERODYNAMIC TEST CRITERION

Outside Air Temperature[2]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3] Very Light[4]	Snow, Snow Grains or Snow Pellets[3] Light[4]	Snow, Snow Grains or Snow Pellets[3] Moderate	Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
-3 and above	27 and above	100/0	0:25-0:50	0:40-0:55	0:20-0:40	0:10-0:20	0:17-0:30	0:10-0:14	0:05-0:30	CAUTION: No holdover time guidelines exist
		75/25	0:19-0:40	0:35-0:45	0:16-0:35	0:07-0:16	0:13-0:20	0:08-0:09	0:03-0:18	
		50/50	0:13-0:18	0:25-0:30	0:13-0:25	0:07-0:13	0:13-0:14	0:07-0:07		
below -3 to -10	below 27 to 14	100/0	0:35-1:15	0:40-0:50	0:20-0:40	0:10-0:20	0:14-0:30	0:09-0:13		
		75/25	0:19-0:45[8]	0:25-0:35[8]	0:12-0:25[8]	0:05-0:12[8]	0:09-0:16[8]	0:06-0:08[8]		
below -10 to -16.5	below 14 to 2.3	100/0	0:25-0:45	0:40-0:45	0:19-0:40	0:09-0:19				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Fluid must be applied heated to use these holdover times. No holdover times exist for this fluid applied unheated.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type III fluid cannot be used.
3 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
8 No holdover time guidelines exist for 75/25 fluid below -9 °C (15.8 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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TABLE 3B-HS. HIGH SPEED TYPE III HOLDOVER TIME GUIDELINES FOR CLARIANT SAFEWING MP III 2031 ECO, APPLIED HEATED[1]

FOR AIRCRAFT CONFORMING TO THE SAE AS5900 HIGH SPEED AERODYNAMIC TEST CRITERION

Outside Air Temperature[2]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3] Very Light[4]	Light[4]	Moderate	Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
-3 and above	27 and above	100/0	0:25-0:50	0:40-0:55	0:20-0:40	0:10-0:20	0:17-0:30	0:10-0:14	0:05-0:30	CAUTION: No holdover time guidelines exist
		75/25	0:19-0:40	0:35-0:45	0:16-0:35	0:07-0:16	0:13-0:20	0:08-0:09	0:03-0:18	
		50/50	0:13-0:18	0:25-0:30	0:13-0:25	0:07-0:13	0:13-0:14	0:07-0:07		
below -3 to -10	below 27 to 14	100/0	0:35-1:15	0:40-0:50	0:20-0:40	0:10-0:20	0:14-0:30	0:09-0:13		
		75/25	0:19-0:45	0:25-0:35	0:12-0:25	0:05-0:12	0:09-0:16	0:06-0:08		
below -10 to -25	below 14 to -13	100/0	0:25-0:45	0:40-0:45	0:19-0:40	0:09-0:19				
below -25 to -29	below -13 to -20.2	100/0	0:25-0:45	0:40-0:45	0:19-0:40	0:09-0:19				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Fluid must be applied heated to use these holdover times. No holdover times exist for this fluid applied unheated.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type III fluid cannot be used.
3 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 5 provides allowance times for ice pellets and small hail).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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TABLE 4-GENERIC. TYPE IV HOLDOVER TIME GUIDELINES FOR SAE TYPE IV FLUIDS

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:15-2:40	2:20-2:45	1:10-2:20	0:35-1:10	0:40-1:30	0:35-0:40	0:08-1:25	
		75/25	1:25-2:40	2:05-2:15	1:15-2:05	0:45-1:15	0:50-1:20	0:30-0:45	0:09-1:15	
		50/50	0:25-0:50	0:40-0:45	0:25-0:40	0:15-0:25	0:15-0:30	0:09-0:15		
below -3 to -14	below 27 to 7	100/0	0:20-1:35	1:20-1:40	0:45-1:20	0:25-0:45	0:25-1:20[7]	0:20-0:25[7]		CAUTION: No holdover time guidelines exist
		75/25	0:30-1:10	1:40-2:00	0:45-1:40	0:20-0:45	0:15-1:05[7]	0:15-0:25[7]		
below-14 to LOUT	Below 7 to LOUT	100/0	0:20-0:40[8]	0:20-0:25[8]	0:10-0:20[8]	0:08-0:10[8]				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).
8 If the LOUT is unknown, no holdover time guidelines exist below -22.5 °C (-8.5 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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TABLE 4A. TYPE IV HOLDOVER TIME GUIDELINES FOR ABAX ECOWING AD-49

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Snow, Snow Grains or Snow Pellets[2] Light[3]	Snow, Snow Grains or Snow Pellets[2] Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	3:20-4:00	2:50-3:00	1:50-2:50	1:10-1:50	1:25-2:00	1:00-1:25	0:10-1:55	
		75/25	2:25-4:00	2:05-2:15	1:40-2:05	1:20-1:40	1:55-2:00	0:50-1:30	0:10-1:40	
		50/50	0:25-0:50	0:40-0:45	0:25-0:40	0:15-0:25	0:15-0:30	0:10-0:15		
below -3 to -14	below 27 to 7	100/0	0:20-1:35	2:50-3:00	1:50-2:50	1:10-1:50	0:25-1:25[7]	0:20-0:25[7]		CAUTION: No holdover time guidelines exist
		75/25	0:30-1:10	2:05-2:15	1:40-2:05	1:20-1:40	0:15-1:05[7]	0:15-0:25[7]		
below -14 to -26	below 7 to -14.8	100/0	0:25-0:40	0:20-0:25	0:10-0:20	0:08-0:10				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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TABLE 4B. TYPE IV HOLDOVER TIME GUIDELINES FOR CLARIANT MAX FLIGHT 04

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	2:40-4:00	3:00-3:00	2:45-3:00	1:25-2:45	2:00-2:00	1:10-1:30	0:20-2:00	CAUTION: No holdover time guidelines exist
		75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		50/50	N/A	N/A	N/A	N/A	N/A	N/A		
below -3 to -14	below 27 to 7	100/0	0:50-2:30	2:20-2:50	1:10-2:20	0:35-1:10	0:25-1:30[7]	0:20-0:40[7]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -23.5	below 7 to -10.3	100/0	0:20-0:45	0:20-0:25	0:10-0:20	0:08-0:10				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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TABLE 4C. TYPE IV HOLDOVER TIME GUIDELINES FOR CLARIANT MAX FLIGHT AVIA

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Snow, Snow Grains or Snow Pellets[2] Light[3]	Snow, Snow Grains or Snow Pellets[2] Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	3:05-4:00	3:00-3:00	1:45-3:00	1:00-1:45	1:25-2:00	0:55-1:10	0:09-2:00	CAUTION: No holdover time guidelines exist
		75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		50/50	N/A	N/A	N/A	N/A	N/A	N/A	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	1:45-3:55	2:10-2:35	1:15-2:10	0:40-1:15	1:10-2:00[7]	0:55-1:30[7]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -28.5	below 7 to -19.3	100/0	0:35-1:25	0:20-0:25	0:10-0:20	0:08-0:10	CAUTION: No holdover time guidelines exist			

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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TABLE 4D. TYPE IV HOLDOVER TIME GUIDELINES FOR CLARIANT MAX FLIGHT SNEG

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:25-4:00	2:45-3:00	1:40-2:45	1:05-1:40	2:00-2:00	0:50-1:40	0:20-1:30	CAUTION: No holdover time guidelines exist
		75/25	4:00-4:00	2:25-2:50	1:30-2:25	0:55-1:30	1:30-2:00	1:05-1:20	0:15-1:45	
		50/50	1:30-3:30	1:45-2:20	0:45-1:45	0:20-0:45	0:35-1:10	0:15-0:30		
below -3 to -14	below 27 to 7	100/0	0:45-2:20	2:00-2:20	1:15-2:00	0:45-1:15	0:30-1:25[7]	0:25-0:40[7]		
		75/25	0:30-1:25	1:40-2:00	1:00-1:40	0:40-1:00	0:20-1:05[7]	0:20-0:40[7]		
below -14 to -29	below 7 to -20.2	100/0	0:20-0:50	0:20-0:25	0:10-0:20	0:08-0:10				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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TABLE 4E. TYPE IV HOLDOVER TIME GUIDELINES FOR CLARIANT SAFEWING EG IV NORTH

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:20-3:55	3:00-3:00	1:40-3:00	0:50-1:40	1:30-2:00	0:50-0:55	0:08-2:00	
		75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		50/50	N/A	N/A	N/A	N/A	N/A	N/A		
below -3 to -14	below 27 to 7	100/0	1:45-4:00	2:45-3:00	1:30-2:45	0:50-1:30	1:05-1:50[7]	0:55-1:25[7]	CAUTION: No holdover time guidelines exist	
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -30	below 7 to -22	100/0	0:40-1:20	0:20-0:25	0:10-0:20	0:08-0:10				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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TABLE 4F. TYPE IV HOLDOVER TIME GUIDELINES FOR
CLARIANT SAFEWING MP IV LAUNCH

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	4:00-4:00	2:50-3:00	1:45-2:50	1:05-1:45	1:30-2:00	1:00-1:40	0:15-1:40	
		75/25	3:40-4:00	3:00-3:00	1:45-3:00	1:00-1:45	1:40-2:00	0:45-1:15	0:10-1:45	
		50/50	1:25-2:45	1:25-1:40	0:45-1:25	0:25-0:45	0:30-0:50	0:20-0:25	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	1:00-1:55	2:10-2:30	1:20-2:10	0:50-1:20	0:35-1:40[7]	0:25-0:45[7]		
		75/25	0:40-1:20	2:25-2:55	1:25-2:25	0:45-1:25	0:25-1:10[7]	0:25-0:45[7]		
below -14 to -28.5	below 7 to -19.3	100/0	0:30-0:50	0:20-0:25	0:10-0:20	0:08-0:10				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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TABLE 4G. TYPE IV HOLDOVER TIME GUIDELINES FOR CLARIANT SAFEWING MP IV LAUNCH PLUS

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	3:55-4:00	3:00-3:00	2:05-3:00	0:55-2:05	2:00-2:00	1:00-2:00	0:20-2:00	CAUTION: No holdover time guidelines exist
		75/25	3:55-4:00	3:00-3:00	1:55-3:00	0:50-1:55	2:00-2:00	1:20-1:25	0:20-1:50	
		50/50	1:15-1:50	1:35-2:00	0:45-1:35	0:20-0:45	0:25-1:00	0:15-0:20		
below -3 to -14	below 27 to 7	100/0	0:55-2:15	3:00-3:00	1:25-3:00	0:40-1:25	0:25-1:35[7]	0:25-0:40[7]		
		75/25	0:40-2:00	2:55-3:00	1:15-2:55	0:30-1:15	0:20-1:05[7]	0:20-0:30[7]		
below -14 to -29	below 7 to -20.2	100/0	0:25-0:50	0:20-0:25	0:10-0:20	0:08-0:10				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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TABLE 4H. TYPE IV HOLDOVER TIME GUIDELINES FOR CRYOTECH POLAR GUARD® ADVANCE

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:50-4:00	2:35-2:50	1:50-2:35	1:20-1:50	1:35-2:00	1:15-1:30	0:15-2:00	
		75/25	2:30-4:00	2:25-2:55	1:20-2:25	0:45-1:20	1:40-2:00	0:40-1:10	0:09-1:40	
		50/50	0:50-1:25	1:20-1:45	0:35-1:20	0:15-0:35	0:20-0:45	0:09-0:20		
below -3 to -14	below 27 to 7	100/0	0:55-2:30	1:45-1:55	1:15-1:45	0:55-1:15	0:35-1:35[7]	0:35-0:45[7]	CAUTION: No holdover time guidelines exist	
		75/25	0:40-1:30	1:45-2:05	1:00-1:45	0:35-1:00	0:25-1:05[7]	0:35-0:45[7]		
Below -14 to -30.5	Below 7 to -22.9	100/0	0:25-0:50	0:20-0:25	0:10-0:20	0:08-0:10				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

TABLE 4I. TYPE IV HOLDOVER TIME GUIDELINES FOR DEICING SOLUTIONS ECO-SHIELD®

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	1:15-2:40	2:25-2:50	1:20-2:25	0:45-1:20	0:40-1:30	0:35-0:40	0:15-1:35	CAUTION: No holdover time guidelines exist
		75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		50/50	N/A	N/A	N/A	N/A	N/A	N/A		
below -3 to -14	below 27 to 7	100/0	1:10-2:35	1:55-2:15	1:05-1:55	0:35-1:05	0:50-1:25[7]	0:30-0:40[7]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -25.5	below 7 to -13.9	100/0	0:30-1:00	0:20-0:25	0:10-0:20	0:08-0:10				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

TABLE 4J. TYPE IV HOLDOVER TIME GUIDELINES FOR DOW CHEMICAL UCAR™ ENDURANCE EG106

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Snow, Snow Grains or Snow Pellets[2] Light[3]	Snow, Snow Grains or Snow Pellets[2] Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:05-3:10	2:45-3:00	1:20-2:45	0:40-1:20	1:10-2:00	0:50-1:15	0:20-2:00	CAUTION: No holdover time guidelines exist
		75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		50/50	N/A	N/A	N/A	N/A	N/A	N/A	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	1:50-3:20	2:10-2:45	1:05-2:10	0:30-1:05	0:55-1:50[7]	0:45-1:10[7]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -27	below 7 to -16.6	100/0	0:30-1:05	0:20-0:25	0:10-0:20	0:08-0:10	CAUTION: No holdover time guidelines exist			

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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TABLE 4K. TYPE IV HOLDOVER TIME GUIDELINES FOR DOW CHEMICAL UCAR™ FLIGHTGUARD AD-49

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	3:20-4:00	2:50-3:00	1:50-2:50	1:10-1:50	1:25-2:00	1:00-1:25	0:10-1:55	CAUTION: No holdover time guidelines exist
		75/25	2:25-4:00	2:05-2:15	1:40-2:05	1:20-1:40	1:55-2:00	0:50-1:30	0:10-1:40	
		50/50	0:25-0:50	0:40-0:45	0:25-0:40	0:15-0:25	0:15-0:30	0:10-0:15		
below -3 to -14	below 27 to 7	100/0	0:20-1:35	2:50-3:00	1:50-2:50	1:10-1:50	0:25-1:25[7]	0:20-0:25[7]		
		75/25	0:30-1:10	2:05-2:15	1:40-2:05	1:20-1:40	0:15-:1:05[7]	0:15-0:25[7]		
below -14 to -26	below 7 to -14.8	100/0	0:25-0:40	0:20-0:25	0:10-0:20	0:08-0:10				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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TABLE 4L. TYPE IV HOLDOVER TIME GUIDELINES FOR KILFROST ABC-S PLUS

Outside Air Temperature[1] Degrees Celsius	Outside Air Temperature[1] Degrees Fahrenheit	Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]: Very Light[3]	Snow, Snow Grains or Snow Pellets[2]: Light[3]	Snow, Snow Grains or Snow Pellets[2]: Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:10-4:00	3:00-3:00	2:05-3:00	1:15-2:05	1:50-2:00	1:05-2:00	0:25-2:00	
		75/25	1:25-2:40	2:05-2:25	1:15-2:05	0:45-1:15	1:00-1:20	0:30-0:50	0:10-1:20	
		50/50	0:30-0:55	1:00-1:10	0:30-1:00	0:15-0:30	0:15-0:40	0:15-0:20		
below -3 to -14	below 27 to 7	100/0	0:55-3:30	2:55-3:00	1:45-2:55	1:00-1:45	0:25-1:35[7]	0:20-0:30[7]	CAUTION: No holdover time guidelines exist	
		75/25	0:45-1:50	1:45-2:00	1:00-1:45	0:35-1:00	0:20-1:10[7]	0:15-0:25[7]		
below -14 to -28	below 7 to -18.4	100/0	0:40-1:00	0:20-0:25	0:10-0:20	0:08-0:10				

Approximate Holdover Times Under Various Weather Conditions (hours:minutes)

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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TABLE 4M. TYPE IV HOLDOVER TIME GUIDELINES FOR LNT SOLUTIONS E450

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	1:50-2:55	2:25-2:45	1:35-2:25	1:00-1:35	1:35-2:00	0:55-1:20	0:25-2:00	
		75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		50/50	N/A	N/A	N/A	N/A	N/A	N/A	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	1:30-3:55	1:50-2:05	1:10-1:50	0:45-1:10	1:45-2:00[7]	1:05-1:40[7]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -22.5	below 7 to -8.5	100/0	0:35-1:05	0:20-0:25	0:10-0:20	0:08-0:10				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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TABLE 4N. TYPE IV HOLDOVER TIME GUIDELINES FOR NEWAVE AEROCHEMICAL FCY 9311

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:55-4:00	2:20-2:55	1:10-2:20	0:35-1:10	1:10-2:00	0:40-1:05	0:15-1:25	
		75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		50/50	N/A	N/A	N/A	N/A	N/A	N/A		
below -3 to -14	below 27 to 7	100/0	0:35-2:05	1:35-2:00	0:50-1:35	0:25-0:50	0:35-1:20[7]	0:20-0:35[7]		CAUTION: No holdover time guidelines exist
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -29.5	below 7 to -21.1	100/0	0:30-0:55	0:20-0:25	0:10-0:20	0:08-0:10				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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TABLE 4O. TYPE IV HOLDOVER TIME GUIDELINES FOR SHAANXI CLEANWAY AVIATION CLEANSURFACE IV

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	2:50-4:00	3:00-3:00	1:55-3:00	1:00-1:55	2:00-2:00	1:25-1:30	0:15-2:00	
		75/25	2:35-4:00	3:00-3:00	1:35-3:00	0:45-1:35	0:50-2:00	0:35-0:45	0:09-1:15	
		50/50	1:05-2:25	1:40-2:20	0:40-1:40	0:15-0:40	0:25-0:50	0:15-0:20	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	1:00-3:05	1:20-1:40	0:45-1:20	0:25-0:45	0:35-1:45[7]	0:20-0:35[7]		
		75/25	0:50-1:55	1:40-2:10	0:45-1:40	0:20-0:45	0:30-1:20[7]	0:25-0:40[7]		
below -14 to -28.5	below 7 to -19.3	100/0	0:30-0:50	0:20-0:25	0:10-0:20	0:08-0:10				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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ICE PELLET AND SMALL HAIL ALLOWANCE TIMES

1. Background

During the winter of 2006-2007, operations in ice pellets were approved by the FAA for "light ice pellets" with an allowance time of 25 minutes. That time was based on limited research conducted late in the winter of 2005-2006 at the request of various industry groups. Additional and more comprehensive ice pellet research was conducted jointly by the research teams of the FAA and Transport Canada the following winter.

This research consisted of extensive climatic chamber, wind tunnel, and live aircraft testing with ice pellets (light and moderate) and light ice pellets mixed with other forms of precipitation. Results of this research provide the basis for more comprehensive allowance times for operations in light ice pellets, as well as allowance times for operations in moderate ice pellets and light ice pellets mixed with other forms of precipitation.

Additional ice pellet research was conducted during the winter season of 2008-2009 which further expanded the ice pellet allowance times under specified conditions. Guidance was also provided for Type IV anti-icing fluid with embedded ice pellets "aged" beyond its allowance time when the precipitation stops at or prior to the expiration of the allowance time. This research demonstrated that provided the precipitation has stopped within the respective allowance time, the fluid remains effective up to 90 minutes after the start of the application time of the anti-icing fluid.

During the winter of 2009-2010, wind tunnel research conducted with a newer generation type airfoil showed that Type IV Propylene Glycol (PG) and Type IV Ethylene Glycol (EG) fluids behave differently under certain temperature and ice pellet conditions. Specifically, higher aircraft rotation speeds are required to effectively remove Type IV PG fluid contaminated with light or moderate ice pellets at temperatures less than -10 °C. Therefore, there are no allowance times associated with the use of Type IV PG fluids on aircraft with rotation speeds of less than 115 knots in conditions of light or moderate ice pellets at temperatures below -10 °C.

Furthermore, research with this newer generation type airfoil has shown that the allowance times are shorter when using Type IV PG fluids under certain conditions for all aircraft regardless of the rotation speed. This research resulted in the allowance time when using Type IV PG fluids at temperatures of -5 °C and above being limited to 15 minutes in moderate ice pellets.

Research has also indicated that Type IV PG fluids are removed less effectively when contaminated with moderate ice pellets at temperatures below -16 °C; operations in these conditions are not recommended. Therefore, there are no allowance times associated with the use of PG fluids in conditions of moderate ice pellets at temperatures below -16 °C, irrespective of aircraft rotation speed.

Type IV allowance times do not currently exist below -22 °C as existing cold temperature data is limited or not available below -22 °C and therefore allowance times cannot be provided.

Allowance times are also published for undiluted (100/0) Type III fluid applied unheated in select conditions. Further testing is required to expand Type III allowance times in other conditions, such as temperatures below -10 °C.

Allowance times for small hail are also published, as it was determined small hail is meteorologically equivalent to ice pellets.

The current allowance times, which were developed based on the aerodynamic testing described above, are provided in the Type III (Table 5) and Type IV (Table 6) allowance time tables.

2. Operational Guidance

(a) Tests have shown that ice pellets generally remain in the frozen state imbedded in Type III and Type IV anti-icing fluid, and are not absorbed and dissolved by the fluid in the same manner as other forms of precipitation. Using current guidelines for determining anti-icing fluid failure, the presence of a contaminant not absorbed by the fluid (remaining imbedded) would be an indication that the fluid has failed. These imbedded ice pellets are generally not readily detectable by the human eye during pre-takeoff contamination check procedures. Therefore, a visual pre-takeoff contamination check in ice pellet conditions may not be of value and is not required.

(b) The research data have also shown that after proper deicing and anti-icing, the accumulation of light ice pellets, moderate ice pellets, and ice pellets mixed with other forms of precipitation in Type III and Type IV fluid will not prevent the fluid from flowing off the aerodynamic surfaces during takeoff. This flow-off, due to the shearing forces, occurs with rotation speeds consistent with Type III or Type IV anti-icing fluid recommended applications, and up to the applicable allowance time listed in the allowance time tables. These allowance times are from the start of the anti-icing fluid application. Additionally, if the ice pellet condition stops, and the allowance time has not been exceeded, the operator is permitted to consider the anti-icing fluid effective without any further action up to 90 minutes after the start of the application time of the anti-icing fluid. To use this guidance in the following conditions, the outside air temperature (OAT) must remain constant or increase during the 90-minute period:

- 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; and
- light ice pellets mixed with moderate rain.

Examples:

1) Type IV anti-icing fluid is applied with a start of application time of 10:00, OAT is 0 °C, light ice pellets fall until 10:20 and stop and do not restart. The allowance time stops at 10:50; however, provided that no precipitation restarts after the allowance time of 10:50 the aircraft may takeoff without any further action up to 11:30.

2) Type IV anti-icing fluid is applied with a start of application time of 10:00, OAT is 0 °C, light ice pellets mixed with freezing drizzle falls until 10:10 and stops and restarts at 10:15 and stops at 10:20. The allowance time stops at 10:25, however provided that the OAT remains constant or increases and that no precipitation restarts after the allowance time of 10:25, the aircraft may takeoff without any further action up to 11:30.

3) On the other hand, if Type IV anti-icing fluid is applied with a start of application time of 10:00, OAT is 0 °C, light ice pellets mixed with freezing drizzle falls until 10:10 and stops and restarts at 10:30 with the allowance time stopping at 10:25 the aircraft may not takeoff, no matter how short the time or type of precipitation after 10:25, without being deiced and anti-iced if precipitation is present.

(c) Operators with a deicing program updated to include the allowance time information contained herein , will be allowed, in the specified ice pellet and small hail conditions listed in Tables 5 and 6, up to the specific allowance time, to commence the takeoff with the following restrictions:

1) The aircraft critical surfaces must be free of contaminants before applying anti-icing fluid. If not, the aircraft must be properly deiced and checked to be free of contaminants before the application of anti-icing fluid.

2) The allowance time is valid only if the aircraft is anti-iced with undiluted Type III or Type IV fluid.

3) The Type III allowance times are only applicable for unheated anti-icing fluid applications.

4) Due to the shearing qualities of Type III and Type IV fluids with imbedded ice pellets, allowance times are limited to aircraft with a rotation speed of 100 knots or greater, or 115 knots or greater as indicated in the allowance time tables.

5) If the takeoff is not accomplished within the applicable allowance time, the aircraft must be completely deiced, and if precipitation is still present, anti-iced again prior to a subsequent takeoff. If the precipitation stops at or before the time limits of the applicable allowance time and does not restart, the aircraft may takeoff up to 90 minutes after the start of the application of the Type III or Type IV anti-icing fluid, subject to the restrictions in 2(b) above.

6) A pre-takeoff contamination check is not required. The allowance time cannot be extended by an internal or external check of the aircraft critical surfaces.

7) If ice pellet precipitation becomes heavier than moderate or if the light ice pellets mixed with other forms of allowable precipitation exceeds the listed intensities or temperature range, the allowance time cannot be used.

8) If the temperature decreases below the temperature on which the allowance time was based,

   a) and the new lower temperature has an associated allowance time for the precipitation condition and the present time is within the new allowance time, then that new time must be used as the allowance time limit.

   b) and the allowance time has expired (within the 90 minute post anti-icing window if the precipitation has stopped within the allowance time), the aircraft may not takeoff and must be completely deiced and, if applicable, anti-iced before a subsequent takeoff.

9) If an intensity is reported with small hail, the ice pellet condition with the equivalent intensity can be used, e.g. if light small hail is reported, the “light ice pellets” allowance times can be used. This also applies in mixed conditions, e.g. if light small hail mixed with light snow is reported, use the “light ice pellets mixed with light snow” allowance times.

TABLE 5. ICE PELLET AND SMALL HAIL ALLOWANCE TIMES FOR SAE TYPE III FLUIDS[1]

This table is for use with SAE Type III undiluted (100/0) fluids applied unheated only

Precipitation Type	Outside Air Temperature		
	-5°C and above	Below -5 to -10°C	Below -10°C[2]
Light Ice Pellets	10 minutes	10 minutes	Caution: No allowance times currently exist
Light Ice Pellets Mixed with Light Snow	10 minutes	10 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes	5 minutes	
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	7 minutes	5 minutes	
Light Ice Pellets Mixed with Light Freezing Rain	7 minutes	5 minutes	
Light Ice Pellets Mixed with Light Rain	7 minutes[3]		
Light Ice Pellets Mixed with Moderate Rain			
Moderate Ice Pellets (or Small Hail)[4]	5 minutes	5 minutes	

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

NOTES

1 These allowance times are for use with aircraft with rotation speeds of 100 knots or greater.

2 Ensure that the lowest operational use temperature (LOUT) is respected.

3 No allowance times exist in this condition for temperatures below 0 °C; consider use of light ice pellets mixed with light freezing rain.

4 If no intensity is reported with small hail, use the "moderate ice pellets or small hail" allowance times. If an intensity is reported with small hail, the ice pellet condition with the equivalent intensity can be used, e.g. if light small hail is reported, the "light ice pellets" allowance times can be used. This also applies in mixed conditions, e.g. if light small hail mixed with light snow is reported, use the "light ice pellets mixed with light snow" allowance times.

CAUTIONS:

- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**
- **Allowance time cannot be extended by an inspection of the aircraft critical surfaces.**
- **Takeoff is allowed up to 90 minutes after start of fluid application if the precipitation stops at or before the allowance time expires and does not restart. The OAT must not decrease during the 90 minutes to use this guidance in conditions of light ice pellets mixed with either: light or moderate freezing drizzle, light freezing rain, or light rain.**

FAA Holdover Time Guidelines Winter 2016-2017

TABLE 6. ICE PELLET AND SMALL HAIL ALLOWANCE TIMES FOR SAE TYPE IV FLUIDS[1]

This table is for use with SAE Type IV undiluted (100/0) fluids only. All Type IV fluids are propylene glycol based with the exception of Clariant Max Flight AVIA, Clariant Safewing EG IV NORTH, Dow EG106 and LNT E450 which are ethylene glycol based.

Precipitation Type	Outside Air Temperature			
	-5°C and above	Below -5 to -10°C	Below -10 to -16°C	Below -16 to -22°C[2]
Light Ice Pellets	50 minutes	30 minutes	30 minutes[3]	30 minutes[3]
Light Ice Pellets Mixed with Light Snow	40 minutes	15 minutes	15 minutes[3]	
Light Ice Pellets Mixed with Moderate Snow	20 minutes	7 minutes	5 minutes[3]	
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 minutes	10 minutes		
Light Ice Pellets Mixed with Light Freezing Rain	25 minutes	10 minutes	**Caution: No allowance times currently exist**	
Light Ice Pellets Mixed with Light Rain	25 minutes[4]			
Light Ice Pellets Mixed with Moderate Rain	25 minutes[5]			
Moderate Ice Pellets (or Small Hail)[6]	25 minutes[7]	10 minutes	10 minutes[3]	10 minutes[8]
Moderate Ice Pellets (or Small Hail)[6] Mixed with Moderate Freezing Drizzle	10 minutes	7 minutes	**Caution: No allowance times currently exist**	
Moderate Ice Pellets (or Small Hail)[6] Mixed with Moderate Rain	10 minutes[5]			

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

NOTES

1 These allowance times are for use with aircraft with rotation speeds of 100 knots or greater.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 No allowance times exist for propylene glycol (PG) fluids when used on aircraft with rotation speeds less than 115 knots. (For these aircraft, if the fluid type is not known, assume zero allowance time.)
4 No allowance times exist in this condition for temperatures below 0 °C; consider use of light ice pellets mixed with light freezing rain.
5 No allowance times exist in this condition for temperatures below 0 °C.
6 If no intensity is reported with small hail, use the "moderate ice pellets or small hail" allowance times. If an intensity is reported with small hail, the ice pellet condition with the equivalent intensity can be used, e.g. if light small hail is reported, the "light ice pellets" allowance times can be used. This also applies in mixed conditions, e.g. if light small hail mixed with light snow is reported, use the "light ice pellets mixed with light snow" allowance times.
7 Allowance time is 15 minutes for propylene glycol (PG) fluids or when the fluid type is unknown.
8 No allowance times exist for propylene glycol (PG) fluids in this condition for temperatures below -16 °C.

CAUTIONS:

- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**
- **Allowance time cannot be extended by an inspection of the aircraft critical surfaces.**
- **Takeoff is allowed up to 90 minutes after start of fluid application if the precipitation stops at or before the allowance time expires and does not restart. The OAT must not decrease during the 90 minutes to use this guidance in conditions of light ice pellets mixed with either: light or moderate freezing drizzle, light freezing rain, light rain, or moderate rain.**

TABLE 7. SNOWFALL INTENSITIES AS A FUNCTION OF PREVAILING VISIBILITY

Time of Day	Temp.		Visibility in Statute Miles (Meters)									
	Degrees Celsius	Degrees Fahrenheit	≥ 2 1/2 (≥ 4000)	2 (3200)	1 3/4 (2800)	1 1/2 (2400)	1 1/4 (2000)	1 (1600)	3/4 (1200)	1/2 (800)	≤ 1/4 (≤ 400)	
Day	colder/equal -1	colder/equal 30	Very Light	Very Light	Very Light	Light	Light	Light	Moderate	Moderate	Heavy	Snowfall Intensity
	warmer than -1	warmer than 30	Very Light	Light	Light	Light	Light	Moderate	Moderate	Heavy	Heavy	
Night	colder/equal -1	colder/equal 30	Very Light	Light	Light	Moderate	Moderate	Moderate	Moderate	Heavy	Heavy	
	warmer than -1	warmer than 30	Very Light	Light	Moderate	Moderate	Moderate	Moderate	Heavy	Heavy	Heavy	

NOTE 1: This table is for estimating snowfall intensity. It is based upon the technical report, "The Estimation of Snowfall Rate Using Visibility," Rasmussen, et al., Journal of Applied Meteorology, October 1999 and additional in situ data.

NOTE 2: This table is to be used with Type I, II, III, and IV fluid guidelines.

NOTE 3: The use of Runway Visual Range (RVR) is not permitted for determining visibility used with the holdover tables.

NOTE 4: Some METARS contain tower visibility as well as surface visibility. Whenever surface visibility is available from an official source, such as a METAR, in either the main body of the METAR or in the Remarks ("RMK") section, the preferred action is to use the surface visibility value.

NOTE 5: If visibility from a source other than the METAR is used, round to the nearest visibility in the table, rounding down if it is right in between two values. For example, .6 and .625 (5/8) would both be rounded to .5 (1/2).

HEAVY = Caution—No Holdover Time Guidelines Exist

During snow conditions alone, the use of Table 7 in determining snowfall intensities does not require pilot company coordination or company reporting procedures since this table is more conservative than the visibility table used by official weather observers in determining snowfall intensities.

Because the FAA Snowfall Intensities Table, like the FMH-1 Table, uses visibility to determine snowfall intensities, if the visibility is being reduced by snow along with other forms of obscuration such as fog, haze, smoke, etc., the FAA Snowfall Intensities Table does not need to be used to estimate the snowfall intensity for HOT determination during the presence of these obscurations. Use of the FAA Snowfall Intensities as a Function of Prevailing Visibility Table under these conditions may needlessly overestimate the actual snowfall intensity. Therefore, the snowfall intensity being reported by the weather observer or automated surface observing system (ASOS), from the FMH-1 Table, may be used.

TABLE 8-1

LIST OF TYPE I FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE

(see cautions and notes on page 55)

Company Name	Fluid Name	Type of Glycol[1]	Expiry[2] (Y-M-D)	Lowest Operational Use Temperature[3]				
				Dilution[4,5] (Fluid/Water)	Low Speed Aerodynamic Test[6]		High Speed Aerodynamic Test[6]	
					°C	°F	°C	°F
ABAX Industries	DE-950	PG	18-05-01	71/29	-26	-14.8	-31	-23.8
ADDCON EUROPE GmbH	IceFree I.80	PG	17-05-20	70/30	-26	-14.8	-32	-25.6
ALAB Industries	WDF 1	EG	18-04-25	70/30	-40	-40	-45	-49
AllClear Systems LLC	Lift-Off E-188	EG	18-07-15	70/30	-40	-40	-41.5	-42.7
AllClear Systems LLC	Lift-Off P-88	PG	18-06-11	70/30	-24.5	-12.1	-29.5	-21.1
Arcton Ltd.	Arctica DG ready-to-use	DEG	18-06-02	as supplied	-26	-14.8	-26	-14.8
Arcton Ltd.	Arctica DG 91 Concentrate	DEG	17-07-16	75/25	*-25*[14]	*-13*[14]	-25	-13
AVIAFLUID International Ltd.[11]	AVIAFLO EG	EG	16-11-28	70/30	-40.5	-40.9	-44	-47.2
Aviation Shaanxi Hi-Tech Physical Chemical Co. Ltd.	Cleanwing I	PG	19-09-30	75/25	Not tested[10]	Not tested[10]	-39.5	-39.1
Aviation Xi'an High-Tech Physical Chemical Co. Ltd.	KHF-1	PG	19-05-22	75/25	Not tested[10]	Not tested[10]	-38.5	-37.3
Baltic Ground Services[11]	*DEFROSOL ADF*	*NCG*	*15-03-18*[9]	*65/35*	*-25*	*-13*	*-30*	*-22*
Beijing Wangye Aviation Chemical Product Co Ltd.	KLA-1	EG	19-09-08	60/40	Not tested[10]	Not tested[10]	-30.5	-22.9
Beijing Yadilite Aviation Advanced Materials Corporation	YD-101 Type I	PG	17-05-27	60/40	Not tested[10]	Not tested[10]	-30	-22
Beijing Yadilite Aviation Advanced Materials Corporation	YD-101A Type I	EG	17-11-01	70/30	Not tested[10]	Not tested[10]	-38	-36.4
Boryszew S.A.	Borygo Plane I	PG	17-12-04	75/25	-25	-13	-30	-22
CHEMCO Inc.	CHEMR EG I	EG	20-04-01	70/30	-37	-34.6	-43	-45.4
CHEMCO Inc.	*CHEMR REG I*	*EG*	*16-07-08*[9]	*75/25*	*-36*	*-32.8*	*-40.5*	*-40.9*
Clariant Produkte (Deutschland) GmbH	*EcoFlo Concentrate*	*NCG*	*13-07-06*[9]	*65/35*	*Not tested*[10]	*Not tested*[10]	*-30.5*	*-22.9*
Clariant Produkte (Deutschland) GmbH	*EcoFlo 2 Concentrate*	*NCG*	*13-07-25*[9]	*65/35*	*Not tested*[10]	*Not tested*[10]	*-29*	*-20.2*
Clariant Produkte (Deutschland) GmbH	Octaflo EF Concentrate	PG	18-03-20	65/35	-25	-13	-33	-27.4
Clariant Produkte (Deutschland) GmbH	*Octaflo EF-80*	*PG*	*13-12-21*[9]	*70/30*	*-25*	*-13*	*-33*	*-27.4*
Clariant Produkte (Deutschland) GmbH	Octaflo EG Concentrate	EG	17-07-23	70/30	-40.5	-40.9	-44	-47.2
Clariant Produkte (Deutschland) GmbH	Octaflo LYOD	EG	20-03-16	70/30	-40	-40	-45.5	-49.9
Clariant Produkte (Deutschland) GmbH	Safewing EG I 1996 (88)	EG	19-10-15	70/30	-39.5	-39.1	-41.5	-42.7

TABLE 8-1 (cont'd)

LIST OF TYPE I FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE

(see cautions and notes on page 55)

Company Name	Fluid Name	Type of Glycol[1]	Expiry[2] (Y-M-D)	Lowest Operational Use Temperature[3]: Dilution[4,5] (Fluid/Water)	Low Speed Aerodynamic Test[6] °C	Low Speed Aerodynamic Test[6] °F	High Speed Aerodynamic Test[6] °C	High Speed Aerodynamic Test[6] °F
Clariant Produkte (Deutschland) GmbH	Safewing MP I 1938 ECO	PG	20-05-11	65/35	-25.5	-13.9	-32	-25.6
Clariant Produkte (Deutschland) GmbH	Safewing MP I 1938 ECO (80)	PG	20-05-20	71/29	-25	-13	-32.5	-26.5
Clariant Produkte (Deutschland) GmbH	Safewing MP I 1938 ECO (80) Premix 55% i.g. ready-to-use	PG	17-03-13	as supplied	Not tested[10]	Not tested[10]	-19	-2.2
Clariant Produkte (Deutschland) GmbH	Safewing MP I ECO PLUS (80)	PG	19-03-13	71/29	-25	-13	-33	-27.4
Cryotech Deicing Technology	Polar Plus®	PG	20-01-13	63/37	-27	-16.6	-32	-25.6
Cryotech Deicing Technology	Polar Plus® LT	PG	20-01-26	63/37	-27	-16.6	-33	-27.4
Cryotech Deicing Technology	Polar Plus® LT (80)	PG	20-04-12	70/30	-27	-16.6	-33	-27.4
Cryotech Deicing Technology	Polar Plus® (80)	PG	17-09-12	70/30	-24.5	-12.1	-32.5	-26.5
Deicing Solutions LLC	Safetemp® ES Plus (Multiple Location)	PG	18-08-29	65/35	-25.5	-13.9	-31	-23.8
Dow Chemical Company	UCAR™ ADF Concentrate	EG	19-05-11	75/25	-36	-32.8	-45	-49
Dow Chemical Company	UCAR™ ADF XL54[17]	EG	19-05-11	as supplied	-33	-27.4	-33	-27.4
Dow Chemical Company	UCAR™ PG ADF Concentrate	PG	19-05-11	65/35	-25	-13	-32	-25.6
Dow Chemical Company	UCAR™ PG ADF Dilute 55/45[18]	PG	19-05-11	as supplied	-24	-11.2	-25	-13
DR Energy Group LTD.	Northern Guard I	EG	17-06-16	65/35	Not tested[10]	Not tested[10]	-39.5	-39.1
Heilongjiang Hangjie Aero-chemical Technology Co. Ltd.	HJF-1	EG	17-10-02	65/35	Not tested[10]	Not tested[10]	-42	-43.6
Heilongjiang Hangjie Aero-chemical Technology Co. Ltd.	HJF-1A	EG	16-09-02	75/25	Not tested[10]	Not tested[10]	-40.5	-40.9
HOC Industries	SafeTemp® ES Plus	PG	20-04-12	65/35	-25.5	-13.9	-29	-20.2
Inland Technologies CANADA Inc.	DuraGly-E Type I ADF Concentrate	EG	19-01-13	60/40	-33	-27.4	-33	-27.4
Inland Technologies CANADA Inc.	*DuraGly-P Type I ADF Concentrate*	*PG*	*15-02-04[9]*	*60/40*	*-25*	*-13*	*-25*	*-13*
Inland Technologies CANADA Inc.	Inland ADF Concentrate[12] (Multiple Location)	EG	Y-M-D[12]	75/25	-36	-32.8	-42.5	-44.5
Kilfrost Limited	Kilfrost DF Plus	PG	19-07-16	69/31	-25.5	-13.9	-32	-25.6
Kilfrost Limited	Kilfrost DF Plus (80)	PG	20-05-02	69/31	-26	-14.8	-31.5	-24.7
Kilfrost Limited	Kilfrost DF Plus (88)	PG	19-07-16	63/37	-25.5	-13.9	-32	-25.6
Kilfrost Limited	Kilfrost DF[Sustain]	NCG	19-08-06	68/32	-34	-29.2	-41	-41.8

TABLE 8-1 (cont'd)

LIST OF TYPE I FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE

(see cautions and notes on page 55)

Company Name	Fluid Name	Type of Glycol[1]	Expiry[2] (Y-M-D)	Lowest Operational Use Temperature[3]				
				Dilution[4,5] (Fluid/Water)	Low Speed Aerodynamic Test[6]		High Speed Aerodynamic Test[6]	
					°C	°F	°C	°F
LNT Solutions	LNT E188	EG	17-10-01	70/30	-30.5	-22.9	-41	-41.8
LNT Solutions	LNT P180	PG	17-10-04	69/31	-26	-14.8	-32	-25.6
LNT Solutions	LNT P188	PG	18-11-28	70/30	-24.5	-12.1	-31.5	-24.7
Newave Aerochemical Co. Ltd.	FCY-1A	EG	19-02-20	75/25	-40	-40	-40	-40
Newave Aerochemical Co. Ltd.	*FCY-1Bio+*	*EG*	*16-07-08[13]*	*75/25*	*Not tested[10]*	*Not tested[10]*	*-40.5*	*-40.9*
Oksayd Co. Ltd.	*DEFROST ECO 1*	*NG*	*16-07-09[9]*	*70/30*	*Not tested[10]*	*Not tested[10]*	*-36*	*-32.8*
Oksayd Co. Ltd.	DEFROST EG 88.1	EG	17-09-02	70/30	Not tested[10]	Not tested[10]	-44.5	-48.1
Shaanxi Cleanway Aviation Chemical Co., Ltd	Cleansurface I	EG	17-09-12	75/25	*-32.5[14]*	*-26.5[14]*	-40.5	-40.9
Shaanxi Cleanway Aviation Chemical Co., Ltd	Cleansurface I-BIO	EG	18-07-11	75/25	Not tested[10]	Not tested[10]	-37	-34.6
Velvana a.s.	AIRVEL OK 1	PG	17-01-28	70/30	-26	-14.8	-30	-22

TABLE 8-2

LIST OF TYPE II FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE

(see cautions and notes on page 55)

Company Name	Fluid Name	Type of Glycol[1]	Expiry[2] (Y-M-D)	Dilution (Fluid/Water)	Lowest Operational Use Temperature[3] High Speed Aerodynamic Test[6] °C	°F	Lowest On-Wing Viscosity[7,8] (mPa.s) Manufacturer Method	AS 9968 Method
ABAX Industries	Ecowing 26	PG	17-04-28	100/0	-25	-13	4 900 (f)	4 600 (a)
				75/25	-14	7	2 200 (a)	2 200 (a)
				50/50	-3	27	50 (a)	50 (a)
Aviation Shaanxi Hi-Tech Physical Chemical Co. Ltd.	Cleanwing II	PG	17-05-20	100/0	-29	-20.2	4 650 (d)	4 500 (a)
				75/25	-14	7	9 450 (d)	10 000 (a)
				50/50	-3	27	10 150 (d)	10 200 (a)
Beijing Yadilite Aviation Advanced Materials Corporation	YD-102 Type II	PG	18-02-26	100/0	-29	-20.2	4 500 (a)	4 500 (a)
				75/25	-14	7	12 850 (a)	12 850 (a)
				50/50	-3	27	820 (a)	300 (k)
Clariant Produkte (Deutschland) GmbH	Safewing MP II FLIGHT	PG	18-05-11	100/0	-29	-20.2	3 340 (a)	3 340 (a)
				75/25	-14	7	12 900 (c)	12 900 (c)
				50/50	-3	27	11 500 (a)	11 500 (a)
Clariant Produkte (Deutschland) GmbH	Safewing MP II FLIGHT PLUS	PG	18-04-06	100/0	-29	-20.2	3 650 (l)	3 100 (a)
				75/25	-14	7	12 400 (l)	10 450 (a)
				50/50	-3	27	7 800 (l)	7 050 (a)
Cryotech Deicing Technology	Polar Guard® II	PG	17-03-11	100/0	-30.5	-22.9	4 400 (e)	4 050 (a)
				75/25	-14	7	11 600 (e)	9 750 (a)
				50/50	-3	27	80 (a)	80 (a)
Kilfrost Limited	ABC-3	PG	16-10-08	100/0	-27	-16.6	2 500 (d)	2 500 (a)
				75/25	-14	7	2 000 (d)	2 000 (a)
				50/50	-3	27	400 (d)	400 (a)
Kilfrost Limited	ABC-Ice Clear II	PG	17-05-13	100/0	-29.5	-21.1	7 720 (a)	7 720 (a)
				75/25	-14	7	5 660 (a)	5 660 (a)
				50/50	-3	27	580 (a)	558 (k)
Kilfrost Limited	ABC-K Plus	PG	16-11-24	100/0	-29	-20.2	2 850 (d)	2 640 (a)
				75/25	-14	7	12 650 (d)	12 650 (c)
				50/50	-3	27	4 200 (d)	5 260 (a)
Newave Aerochemical Co. Ltd.	FCY-2	PG	17-02-20	100/0	-28	-18.4	7 000 (d)	8 920 (a)
				75/25	-14	7	18 550 (d)	18 550 (c)
				50/50	-3	27	6 750 (d)	7 030 (a)

TABLE 8-2 (cont'd)

LIST OF TYPE II FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE

(see cautions and notes on page 55)

COMPANY NAME	FLUID NAME	TYPE OF GLYCOL[1]	EXPIRY[2] (Y-M-D)	DILUTION (FLUID/WATER)	LOWEST OPERATIONAL USE TEMPERATURE[3] HIGH SPEED AERODYNAMIC TEST[6] °C	°F	LOWEST ON-WING VISCOSITY[7,8] (mPa.s) MANUFACTURER METHOD	AS 9968 METHOD
Newave Aerochemical Co. Ltd.	FCY-2 Bio+	PG	17-05-06	100/0	-28.5	-19.3	7 210 (a)	7 210 (a)
				75/25	-14	7	21 400 (c)	21 400 (c)
				50/50	-3	27	1 900 (a)	1 900 (a)

TABLE 8-3

LIST OF TYPE III FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE

(see cautions and notes on page 55)

Company Name	Fluid Name	Type of Glycol[1]	Expiry[2] (Y-M-D)	Dilution (Fluid/Water)	Lowest Operational Use Temperature[3] Low Speed Aerodynamic Test[6] °C	Low Speed Aerodynamic Test[6] °F	High Speed Aerodynamic Test[6] °C	High Speed Aerodynamic Test[6] °F	Lowest On-Wing Viscosity[7,8] (mPa.s) Manufacturer Method	AS 9968 Method
AllClear Systems LLC	AeroClear MAX	EG	16-12-22[15]	100/0	-16	3.2	-35	-31	7 300 (j)	Not Available[16]
				75/25	Dilution Not Applicable		Dilution Not Applicable		Dilution Not Applicable	
				50/50	Dilution Not Applicable		Dilution Not Applicable		Dilution Not Applicable	
Clariant Produkte (Deutschland) GmbH	*Safewing MP III 2031 ECO*	*PG*	*15-08-15*[9]	*100/0*	*-16.5*	*2.3*	*-29*	*-20.2*	*120 (k)*	*120 (k)*
				75/25	*-9*	*15.8*	*-10*	*14*	*86 (k)*	*86 (k)*
				50/50	*-3*	*27*	*-3*	*27*	*16 (k)*	*16 (k)*

TABLE 8-4

LIST OF TYPE IV FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE

(see cautions and notes on page 55)

Company Name	Fluid Name	Type of Glycol[1]	Expiry[2] (Y-M-D)	Dilution (Fluid/Water)	Lowest Operational Use Temperature[3] High Speed Aerodynamic Test[6] °C	°F	Lowest On-Wing Viscosity[7,8] (mPa.s) Manufacturer Method	AS 9968 Method
ABAX Industries	Ecowing AD-49	PG	18-04-22	100/0	-26	-14.8	12 150 (g)	11 000 (a)
				75/25	-14	7	30 700 (g)	32 350 (c)
				50/50	-3	27	19 450 (g)	21 150 (c)
Clariant Produkte (Deutschland) GmbH	*Max Flight 04*	*PG*	*16-07-23*[9]	*100/0*	*-23.5*	*-10.3*	*5 540 (b)*	*5 540 (a)*
				75/25	*Dilution Not Applicable*		*Dilution Not Applicable*	
				50/50	*Dilution Not Applicable*		*Dilution Not Applicable*	
Clariant Produkte (Deutschland) GmbH	Max Flight AVIA	EG	18-04-25	100/0	-28.5	-19.3	1 000 (k)	1 000 (k)
				75/25	Dilution Not Applicable		Dilution Not Applicable	
				50/50	Dilution Not Applicable		Dilution Not Applicable	
Clariant Produkte (Deutschland) GmbH	Max Flight SNEG	PG	18-03-09	100/0	-29	-20.2	8 700 (m)	8 050 (a)
				75/25	-14	7	20 200 (n)	21 800 (c)
				50/50	-3	27	13 600(n)	15 000 (c)
Clariant Produkte (Deutschland) GmbH	Safewing EG IV NORTH	EG	18-04-06	100/0	-30	-22	830 (k)	830 (k)
				75/25	Dilution Not Applicable		Dilution Not Applicable	
				50/50	Dilution Not Applicable		Dilution Not Applicable	
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH	PG	18-05-05	100/0	-28.5	-19.3	7 550 (a)	7 550 (a)
				75/25	-14	7	18 000 (a)	18 000 (a)
				50/50	-3	27	17 800 (a)	17 800 (a)
Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH PLUS	PG	17-03-24	100/0	-29	-20.2	8 700 (m)	8 450 (a)
				75/25	-14	7	18 800 (n)	17 200 (c)
				50/50	-3	27	9 700 (m)	12 150 (a)
Cryotech Deicing Technology	Polar Guard® Advance	PG	17-03-11	100/0	-30.5	-22.9	4 400 (e)	4 050 (a)
				75/25	-14	7	11 600 (e)	9 750 (a)
				50/50	-3	27	80 (a)	80 (a)
Deicing Solutions LLC	ECO-SHIELD®	PG	18-02-22	100/0	-25.5	-13.9	11 050 (a)	11 050 (a)
				75/25	Dilution Not Applicable		Dilution Not Applicable	
				50/50	Dilution Not Applicable		Dilution Not Applicable	
Dow Chemical Company	UCAR™ Endurance EG106 De/Anti-Icing Fluid	EG	17-05-20	100/0	-27	-16.6	24 850 (h)	2 230 (a)
				75/25	Dilution Not Applicable		Dilution Not Applicable	
				50/50	Dilution Not Applicable		Dilution Not Applicable	

TABLE 8-4 (cont'd)

LIST OF TYPE IV FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE

(see cautions and notes on page 55)

Company Name	Fluid Name	Type of Glycol[1]	Expiry[2] (Y-M-D)	Dilution (Fluid/Water)	Lowest Operational Use Temperature[3] High Speed Aerodynamic Test[6] °C	°F	Lowest On-Wing Viscosity[7,8] (mPa.s) Manufacturer Method	AS 9968 Method
Dow Chemical Company	UCAR™ FlightGuard AD-49	PG	17-05-20	100/0	-26	-14.8	12 150 (g)	11 000 (a)
				75/25	-14	7	30 700 (g)	32 350 (c)
				50/50	-3	27	19 450 (g)	21 150 (c)
Kilfrost Limited	ABC-S Plus	PG	17-06-16	100/0	-28	-18.4	17 900 (d)	17 900 (c)
				75/25	-14	7	18 300 (d)	18 300 (c)
				50/50	-3	27	7 500 (d)	7 500 (a)
LNT Solutions	LNT E450	EG	17-07-29	100/0	-22.5	-8.5	45 300 (i)	Not Available[16]
				75/25	Dilution Not Applicable		Dilution Not Applicable	
				50/50	Dilution Not Applicable		Dilution Not Applicable	
Newave Aerochemical Co. Ltd.	FCY 9311	PG	18-01-18	100/0	-29.5	-21.1	14 100 (c)	14 100 (c)
				75/25	Dilution Not Applicable		Dilution Not Applicable	
				50/50	Dilution Not Applicable		Dilution Not Applicable	
Shaanxi Cleanway Aviation Chemical Co., Ltd	Cleansurface IV	PG	17-05-25	100/0	-28.5	-19.3	15 200 (c)	15 200 (c)
				75/25	-14	7	28 500 (c)	28 500 (c)
				50/50	-3	27	17 500 (c)	17 500 (c)

CAUTIONS AND NOTES FOR TABLES 8-1, 8-2, 8-3, 8-4

CAUTIONS

- This table lists fluids that have been tested with respect to anti-icing performance and aerodynamic acceptance (Type I: SAE AMS1424 §3.5.2 and §3.5.3; Type II/ III/ IV: SAE AMS1428 §3.2.4 and §3.2.5) only. These tests were conducted by Anti-icing Materials International Laboratory: www.uqac.ca/amil. The end user is responsible for contacting the fluid manufacturer to confirm all other SAE AMS1424/1428 technical requirement tests, such as fluid stability, toxicity, materials compatibility, etc. have been conducted.
- LOUT data provided in these tables is based strictly on the manufacturer's data; the end user is responsible for verifying the validity of this data.
- Type I fluids supplied in concentrated form must not be used in that form and must be diluted.

NOTES

1 PG = conventional glycol (propylene glycol); EG = conventional glycol (ethylene glycol); DEG = conventional glycol (diethylene glycol); NCG = non-conventional glycol (organic non-ionic diols and triols, e.g. 1,3-propanediol, glycerine) and mixtures of non-conventional glycol and conventional glycol; NG = non-glycol (e.g. organic salts) and mixtures of non-glycol and glycol.

2 Expiry date is the earlier expiry date of the Aerodynamic Test(s) or Water Spray Endurance Test. Fluids that are tested after the issuance of this list will appear in a later update.

3 The values in this table were determined using test results from pre-production fluid samples when available. In some cases, the fluid manufacturer requested the publication of a more conservative value than the pre-production test value. The lowest operational use temperature (LOUT) for a given fluid is the higher (warmer) of:

a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type;
b) The actual freezing point of the fluid plus its freezing point buffer (Type I = 10°C/18°F; Type II/III/IV = 7°C/13°F); or
c) For diluted Type II/III/IV fluids, the coldest temperature for which holdover times are published.

4 The LOUT for Type I fluids that are intended to be diluted is derived from a dilution that provides the lowest operational use temperature. For other Type I dilutions, determine the freezing point of the fluid and add a 10°C freezing point buffer, as a dilution will usually yield a higher and more restrictive operational use temperature. Consult the fluid manufacturer or fluid documentation for further clarification and guidance on establishing the appropriate operational use temperature of a diluted fluid.

5 Type I concentrate fluids have also been tested at 50/50 (glycol/water) dilution.

6 If uncertain whether the aircraft to be treated conforms to the low speed or the high speed aerodynamic test, consult the aircraft manufacturer. The aerodynamic test is defined in SAE AS5900 (latest version).

7 The viscosity values in this table are those of the fluids provided by the manufacturers for holdover time testing. For the holdover times to be valid, the viscosity of the fluid on the wing shall not be lower than that in this table. The user should periodically ensure that the viscosity of a fluid sample taken from the wing surface is not lower than that listed.

8 The SAE AS9968 viscosity method should only be used for field verification and auditing purposes; when in doubt as to which method is appropriate, use the manufacturer method. Viscosity measurement methods are indicated as letters (in parentheses) beside each viscosity value. Details of each measurement method are shown in the table below. The exact measurement method (spindle, container, fluid volume, temperature, speed, duration) must be used to compare the viscosity of a sample to a viscosity given in this table.

Method	Brookfield Spindle*	Container	Fluid Volume	Temp.**	Speed	Duration
a	LV1 (with guard leg)	600 mL low form (Griffin) beaker	575 mL***	20°C	0.3 rpm	10.0 minutes
b	LV1 (with guard leg)	600 mL low form (Griffin) beaker	575 mL***	20°C	0.3 rpm	33.3 minutes
c	LV2-disc (with guard leg)	600 mL low form (Griffin) beaker	425 mL***	20°C	0.3 rpm	10.0 minutes
d	LV2-disc (with guard leg)	150 mL tall form (Berzelius) beaker	135 mL***	20°C	0.3 rpm	10.0 minutes
e	SC4-34/13R	small sample adapter	10 mL	20°C	0.3 rpm	10.0 minutes
f	SC4-34/13R	small sample adapter	10 mL	20°C	0.3 rpm	30.0 minutes
g	SC4-31/13R	small sample adapter	10 mL	20°C	0.3 rpm	10.0 minutes
h	SC4-31/13R	small sample adapter	10 mL	0°C	0.3 rpm	10.0 minutes
i	SC4-31/13R	small sample adapter	9 mL	0°C	0.3 rpm	10.0 minutes
j	SC4-31/13R	small sample adapter	9 mL	0°C	0.3 rpm	30.0 minutes
k	LV0	ultra low adapter	16 mL	20°C	0.3 rpm	10.0 minutes
l	LV1	big sample adapter	50 mL	20°C	0.3 rpm	10.0 minutes
m	LV1	big sample adapter	55 mL	20°C	0.3 rpm	10.0 minutes
n	LV2-disc	big sample adapter	60 mL	20°C	0.3 rpm	10.0 minutes

* Spindle must be attached to a Brookfield viscometer model equipped with an LV spring.
** Sample temperature will affect readings; ensure sufficient time is allowed for sample to reach thermal equilibrium before starting test. Use of a cooling bath strongly recommended.
*** If necessary, adjust fluid volume to ensure fluid is level with notch on the spindle shaft.

9 Fluids listed in italics have expired and will be removed from this listing four years after expiry.

10 Manufacturer has indicated fluid was not tested.

11 Manufacturer has not provided fluid information as required in SAE ARP5718A; fluid may be removed from this listing in subsequent revisions.

12 Dow UCAR™ ADF Concentrate, sold under the product name Inland ADF Concentrate, qualified from 2015-09-04.

13 Currently in the test/re-test process.

14 Fluid was not retested for low speed aerodynamics. This data will be removed four years after the expiry of the last low speed test.

15 Fluid did not meet the minimum Water Spray Endurance Test requirement for a Type III fluid in AMS1428G; Transport Canada and the FAA have proposed a change to the SAE G-12 for this requirement.

16 Measurements using the SAE AS9968 method do not provide stable, reliable results. Use the manufacturer method to evaluate viscosity.

17 For UCAR™ ADF XL54, refer to primary site qualification of UCAR™ ADF Concentrate.

18 For UCAR™ PG ADF Dilute 55/45, refer to primary site qualification of UCAR™ PG ADF Concentrate.

TABLE 9. GUIDELINES FOR THE APPLICATION OF SAE TYPE I FLUID

Outside Air Temperature (OAT)[1]	One-Step Procedure De/Anti-icing	Two-Step Procedure	
		First Step: Deicing	Second Step: Anti-icing[2]
0 °C (32 °F) and above	Heated mix of fluid and water with a freezing point of at least 10 °C (18 °F) below OAT	Heated water or a heated fluid/water mixture	Heated mix of fluid and water with a freezing point of at least 10 °C (18 °F) below OAT
Below 0 °C (32 °F) to LOUT		Heated fluid/water mixture with a freezing point at OAT or below	

1) Fluids must not be used at temperatures below their lowest operational use temperature (LOUT).
2) To be applied before first-step fluid freezes, typically within 3 minutes. (This time may be higher than 3 minutes in some conditions, but potentially lower in heavy precipitation, colder temperatures, or for critical surfaces constructed of composite materials. If necessary, the second step shall be applied area by area.)

NOTES:

- This table is applicable for the use of Type I holdover time guidelines in all conditions, including active frost. If holdover times are not required, a temperature of 60 °C (140 °F) at the nozzle is desirable.
- If holdover times are required, the temperature of water or fluid/water mixtures shall be at least 60 °C (140 °F) at the nozzle. Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendations.
- To use Type I Holdover Times Guidelines in all conditions including active frost, an additional minimum of 1 litre/m^2 (~2 gal./100 sq. ft.) of heated Type I fluid mixture must be applied to the surfaces after all frozen contamination is removed. This application is necessary to heat the surfaces, as heat contributes significantly to the Type I fluid holdover times. The required protection can be provided using a 1-step method by applying more fluid than is strictly needed to just remove all of the frozen contamination (the same additional amount stated above is required).
- The lowest operational use temperature (LOUT) for a given Type I fluid is the higher (warmer) of:
  a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type, or
  b) The actual freezing point of the fluid plus a freezing point buffer of 10 °C (18 °F).

CAUTION:

- **Wing skin temperatures may differ and, in some cases, be lower than OAT. A stronger mix (more glycol) may be needed under these conditions.**

TABLE 10. GUIDELINES FOR THE APPLICATION OF SAE TYPE II AND IV FLUID (FLUID CONCENTRATIONS IN % VOLUME)

Outside Air Temperature (OAT)[1]	One-Step Procedure De/Anti-icing	Two-Step Procedure	
		First Step: Deicing	Second Step: Anti-icing[2]
0 °C (32 °F) and above	100/0, 75/25 or 50/50 Heated[3] Type II or IV fluid/water mixture	Heated water or a heated Type I, II, III, or IV fluid/water mixture	100/0, 75/25 or 50/50 Type II or IV fluid/water mixture
Below 0 °C (32 °F) to -3°C (27°F)	100/0, 75/25 or 50/50 Heated[3] Type II or IV fluid/water mixture	Heated Type I, II, III, or IV fluid/water mixture with a freezing point at OAT or below	100/0, 75/25 or 50/50 Type II or IV fluid/water mixture
Below -3 °C (27 °F) to -14 °C (7 °F)	100/0 or 75/25 Heated[3] Type II or IV fluid/water mixture	Heated Type I, II, III, or IV fluid/water mixture with a freezing point at OAT or below	100/0 or 75/25 Type II or IV fluid/water mixture
Below -14 °C (7 °F) to LOUT	100/0 Heated[3] Type II or IV fluid/water mixture	Heated Type I, II, III, or IV fluid/water mixture with a freezing point at OAT or below	100/0 Type II or IV fluid/water mixture

1) Fluids must not be used at temperatures below their lowest operational use temperature (LOUT). Consideration should be given to the use of Type I/III fluid when Type II/IV fluid cannot be used due to LOUT limitations (see Table 9, 11-U, 11-H). The LOUT for a given Type II/IV fluid is the higher (warmer) of:
   a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type;
   b) The actual freezing point of the fluid plus its freezing point buffer of 7 °C (13 °F); or
   c) For diluted Type II/IV fluids, the coldest temperature for which holdover times are published.
2) To be applied before first step fluid freezes, typically within 3 minutes. (Time may be longer than 3 minutes in some conditions, but potentially shorter in heavy precipitation, in colder temperatures, or for critical surfaces constructed of composite materials. If necessary, the second step shall be applied area by area.)
3) Clean aircraft may be anti-iced with unheated fluid.

NOTES:
- For heated fluids, a fluid temperature not less than 60 °C (140 °F) at the nozzle is desirable.
- Upper temperature limit shall not exceed fluid and aircraft manufacturer's recommendations.

CAUTIONS:
- **Wing skin temperatures may differ and in some cases may be lower than OAT. A stronger mix (more glycol) may be needed under these conditions.**
- **Whenever frost or ice occurs on the lower surface of the wing in the area of the fuel tank, indicating a cold soaked wing, the 50/50 dilutions of Type II or IV shall not be used for the anti-icing step because fluid freezing may occur.**
- **An insufficient amount of anti-icing fluid, especially in the second step of a two-step procedure, may cause a substantial loss of holdover time, particularly when using a Type I fluid mixture for the first step (deicing) of a two-step procedure.**

TABLE 11-H. GUIDELINES FOR THE APPLICATION OF HEATED SAE TYPE III FLUID (FLUID CONCENTRATIONS IN % VOLUME)

Outside Air Temperature (OAT)[1]	One-Step Procedure De/Anti-icing	Two-Step Procedure	
		First Step: Deicing	Second Step: Anti-icing[2]
0°C (32°F) and above	100/0, 75/25 or 50/50 Heated Type III fluid/water mixture	Heated[3] water or a heated[3] Type I, II, III, or IV fluid/water mixture	100/0, 75/25 or 50/50 Heated Type III fluid/water mixture
Below 0°C (32°F) to -3°C (27°F)	100/0, 75/25 or 50/50 Heated Type III fluid/water mixture	Heated[3] Type I, II, III, or IV fluid/water mixture with a freezing point at OAT or below	100/0, 75/25 or 50/50 Heated Type III fluid/water mixture
Below -3°C (27°F) to -10°C (14°F)	100/0 or 75/25 Heated Type III fluid/water mixture	Heated[3] Type I, II, III, or IV fluid/water mixture with a freezing point at OAT or below	100/0 or 75/25 Heated Type III fluid/water mixture
Below -10°C (14°F) to LOUT	100/0 Heated Type III fluid/water mixture	Heated[3] Type I, II, III, or IV fluid/water mixture with a freezing point at OAT or below	100/0 Heated Type III fluid/water mixture

1 Fluids must not be used at temperatures below their lowest operational use temperature (LOUT). Consider the use of Type I when Type III fluid cannot be used (see Table 9). The LOUT for a given Type III fluid is the higher (warmer) of:
   a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type;
   b) The actual freezing point of the fluid plus its freezing point buffer of 7°C (13°F); or
   c) For diluted Type III fluid, the coldest temperature for which holdover times are published.

2 To be applied before first step fluid freezes, typically within 3 minutes. (Time may be longer than 3 minutes in some conditions, but potentially shorter in heavy precipitation, in colder temperatures, or for critical surfaces constructed of composite materials. If necessary, the second step shall be applied area by area.)

3 For heated fluids, a fluid temperature not less than 60°C (140°F) at the nozzle is desirable.

NOTES

- To use Type III Holdover Times Guidelines in all conditions including active frost, an additional minimum of 1 litre/m^2 (~2 gal./100 sq. ft.) of heated Type III fluid mixture must be applied to the surfaces after all frozen contamination is removed. This application is necessary to heat the surfaces, as heat contributes significantly to the Type III fluid holdover times. The required protection can be provided using a 1-step method by applying more fluid than is strictly needed to just remove all of the frozen contamination (the same additional amount stated above is required).
- If holdover times are required, the temperature of fluid/water mixtures shall be at least 60°C (140°F) at the nozzle. Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendations.

CAUTIONS

- **Wing skin temperatures may differ and in some cases may be lower than outside air temperatures; a stronger mix (more glycol) may be needed under these conditions.**
- **Whenever frost or ice occurs on the lower surface of the wing in the area of the fuel tank, indicating a cold soaked wing, the 50/50 dilutions of Type III shall not be used for the anti-icing step because fluid freezing may occur.**
- **An insufficient amount of anti-icing fluid may cause a substantial loss of holdover time. This is particularly true when using a Type I fluid mixture for the first step in a two-step procedure.**

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TABLE 11-U. GUIDELINES FOR THE APPLICATION OF UNHEATED SAE TYPE III FLUID (FLUID CONCENTRATIONS IN % VOLUME)

Outside Air Temperature (OAT)[1]	One-Step Procedure Anti-icing Only[4]	Two-Step Procedure	
		First Step: Deicing	Second Step: Anti-icing[2]
0°C (32°F) and above	100/0, 75/25 or 50/50 Unheated Type III fluid/water mixture	Heated[3] water or a heated[3] Type I, II, III, or IV fluid/water mixture	100/0, 75/25 or 50/50 Unheated Type III fluid/water mixture
Below 0°C (32°F) to -3°C (27°F)	100/0, 75/25 or 50/50 Unheated Type III fluid/water mixture	Heated[3] Type I, II, III, or IV fluid/water mixture with a freezing point at OAT or below	100/0, 75/25 or 50/50 Unheated Type III fluid/water mixture
Below -3°C (27°F) to -10°C (14°F)	100/0 or 75/25 Unheated Type III fluid/water mixture	Heated[3] Type I, II, III, or IV fluid/water mixture with a freezing point at OAT or below	100/0 or 75/25 Unheated Type III fluid/water mixture
Below -10°C (14°F) to LOUT	100/0 Unheated Type III fluid/water mixture	Heated[3] Type I, II, III, or IV fluid/water mixture with a freezing point at OAT or below	100/0 Unheated Type III fluid/water mixture

1 Fluids must not be used at temperatures below their lowest operational use temperature (LOUT). Consider the use of Type I when Type III fluid cannot be used (see Table 9). The LOUT for a given Type III fluid is the higher (warmer) of:
   a) The lowest temperature at which the fluid meets the aerodynamic acceptance test for a given aircraft type;
   b) The actual freezing point of the fluid plus its freezing point buffer of 7°C (13°F); or
   c) For diluted Type III fluid, the coldest temperature for which holdover times are published.

2 To be applied before first step fluid freezes, typically within 3 minutes. (This time may be longer than 3 minutes in some conditions, but potentially shorter in heavy precipitation, in colder temperatures, or for critical surfaces constructed of composite materials. If necessary, the second step shall be applied area by area.)

3 For heated fluids, a fluid temperature not less than 60°C (140°F) at the nozzle is desirable.

4 One-step procedure with unheated Type III fluid is only possible on a clean aircraft. If deicing is required, a two-step procedure must be used.

NOTES

- Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendations.

CAUTIONS

- **Wing skin temperatures may differ and in some cases may be lower than outside air temperatures; a stronger mix (more glycol) may be needed under these conditions.**
- **Whenever frost or ice occurs on the lower surface of the wing in the area of the fuel tank, indicating a cold soaked wing, the 50/50 dilutions of Type III shall not be used for the anti-icing step because fluid freezing may occur.**
- **An insufficient amount of anti-icing fluid may cause a substantial loss of holdover time. This is particularly true when using a Type I fluid mixture for the first step in a two-step procedure.**

FAA Holdover Time Guidelines — Winter 2016-2017

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 0-90%. 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES FOR SAE TYPE I, TYPE II, TYPE III, AND TYPE IV FLUIDS IN ACTIVE FROST

Outside Air Temperature[1,2] Degrees Celsius	Outside Air Temperature[1,2] Degrees Fahrenheit	Approximate Holdover Times (hours:minutes) Active Frost Type I
-1 and above	30 and above	0:41 (0:32)[4]
below -1 to -3	below 30 to 27	
below -3 to -10	below 27 to 14	
below -10 to -14	below 14 to 7	
below -14 to -21	below 7 to -6	
below -21 to LOUT	below -6 to LOUT	

Outside Air Temperature[2] Degrees Celsius	Outside Air Temperature[2] Degrees Fahrenheit	Concentration Neat Fluid/Water (Volume %/ Volume %)	Approximate Holdover Times (hours:minutes) Active Frost Type II	Type III[3]	Type IV
-1 and above	30 and above	100/0	7:12	1:48	10:48
		75/25	4:30	0:54	4:30
		50/50	2:42	0:27	2:42
below -1 to -3	below 30 to 27	100/0	7:12	1:48	10:48
		75/25	4:30	0:54	4:30
		50/50	1:21	0:27	2:42
below -3 to -10	below 27 to 14	100/0	7:12	1:48	9:00
		75/25	4:30	0:54	4:30
below -10 to -14	below 14 to 7	100/0	5:24	1:48	5:24
		75/25	0:54	0:54	0:54
below -14 to -21	below 7 to -6	100/0	5:24	1:48	5:24
below -21 to -25	below -6 to -13	100/0	1:48	1:48	3:36
Below -25	Below -13	No holdover time guidelines exist			

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

1 Type I Fluid / Water Mixture must be selected so that the freezing point of the mixture is at least 10 °C (18 °F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 To use the Type III fluid frost holdover times, the fluid brand being used must be known. AllClear AeroClear MAX must be applied unheated. Clariant Safewing MP III 2031 ECO must be applied heated.
4 Value in parentheses is for aircraft with critical surfaces that are predominantly or entirely constructed of composite materials.

CAUTIONS:
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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FAA Holdover Time Guidelines **Winter 2016-2017**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 1A-90%. 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES FOR SAE TYPE I FLUID ON CRITICAL AIRCRAFT SURFACES COMPOSED PREDOMINANTLY OF ALUMINUM

Outside Air Temperature[1,2]		Wing Surface	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	Aluminum	0:10-0:15	0:16-0:20	0:10-0:16	0:05-0:10	0:08-0:12	0:02-0:05	0:02-0:05	CAUTION: No holdover time guidelines exist
below -3 to -6	below 27 to 21	Aluminum	0:07-0:12	0:13-0:15	0:07-0:13	0:05-0:07	0:05-0:08	0:02-0:05		
below -6 to -10	below 21 to 14	Aluminum	0:05-0:09	0:10-0:12	0:05-0:10	0:04-0:05	0:04-0:06	0:02-0:05		
Below -10	below 14	Aluminum	0:05-0:08	0:06-0:07	0:04-0:06	0:02-0:04				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Type I fluid / water mixture must be selected so that the freezing point of the mixture is at least 10 °C (18 °F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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FAA Holdover Time Guidelines **Winter 2016-2017**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 1C-90%. 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES FOR SAE TYPE I FLUID ON CRITICAL AIRCRAFT SURFACES COMPOSED PREDOMINANTLY OF COMPOSITES

Outside Air Temperature[1,2]		Wing Surface	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
				Snow, Snow Grains or Snow Pellets[3]						
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Very Light[4]	Light[4]	Moderate	Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
-3 and above	27 and above	Composite	0:08-0:14	0:11-0:14	0:05-0:11	0:03-0:05	0:07-0:12	0:02-0:05	0:01-0:05	CAUTION: No holdover time guidelines exist
below -3 to -6	below 27 to 21	Composite	0:05-0:07	0:10-0:12	0:05-0:10	0:02-0:05	0:05-0:08	0:02-0:05	CAUTION: No holdover time guidelines exist	
below -6 to -10	below 21 to 14	Composite	0:04-0:07	0:08-0:11	0:05-0:08	0:02-0:05	0:04-0:06	0:02-0:05		
Below -10	below 14	Composite	0:04-0:06	0:06-0:07	0:04-0:06	0:02-0:04				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Type I fluid / water mixture must be selected so that the freezing point of the mixture is at least 10 °C (18 °F) below outside air temperature.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

FAA Holdover Time Guidelines **Winter 2016-2017**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2-GENERIC-90%. 90 PERCENT ADJUSTED TYPE II HOLDOVER TIME GUIDELINES FOR SAE TYPE II FLUID

Outside Air Temperature[1]		Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2,3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	0:32-1:21	0:18-0:41	0:27-0:54	0:14-0:27	0:06-0:36	
		75/25	0:23-0:50	0:14-0:23	0:14-0:36	0:09-0:18	0:04-0:23	
		50/50	0:14-0:23	0:05-0:09	0:07-0:14	0:05-0:08	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:18-0:59	0:14-0:27	0:18-0:41[7]	0:09-0:18[7]		
		75/25	0:23-0:45	0:07-0:18	0:14-0:23[7]	0:07-0:14[7]		
Below -14 to LOUT	Below 7 to LOUT	100/0	0:18-0:32[8]	0:07-0:09[8]				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).
8 If the LOUT is unknown, no holdover time guidelines exist below -22.5 °C (-8.5 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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FAA Holdover Time Guidelines **Winter 2016-2017**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2A-90%. 90 PERCENT ADJUSTED TYPE II HOLDOVER TIME GUIDELINES FOR ABAX ECOWING 26

Outside Air Temperature[1]		Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	1:17-2:20	1:26-1:39	0:54-1:26	0:36-0:54	0:45-1:26	0:36-0:45	0:18-1:17	CAUTION: No holdover time guidelines exist
		75/25	0:59-1:44	1:08-1:17	0:41-1:08	0:23-0:41	0:41-0:59	0:23-0:32	0:09-0:54	
		50/50	0:27-0:41	0:36-0:45	0:18-0:36	0:09-0:18	0:14-0:23	0:07-0:09		
below -3 to -14	below 27 to 7	100/0	0:41-2:02	1:17-1:30	0:50-1:17	0:32-0:50	0:27-1:03[7]	0:14-0:32[7]		
		75/25	0:32-1:08	0:50-0:59	0:36-0:50	0:23-0:36	0:18-0:45[7]	0:14-0:23[7]		
below -14 to -25	below 7 to -13	100/0	0:23-0:41	0:18-0:23	0:09-0:18	0:07-0:09				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2B-90%. 90 PERCENT ADJUSTED TYPE II HOLDOVER TIME GUIDELINES FOR AVIATION SHAANXI HI-TECH CLEANWING II

Outside Air Temperature[1]		Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	**Degrees Fahrenheit**		**Freezing Fog or Ice Crystals**	**Snow, Snow Grains or Snow Pellets[2,3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	0:50-1:39	0:27-0:50	0:32-0:59	0:23-0:32	0:09-0:50	
		75/25	0:45-1:12	0:23-0:41	0:32-0:54	0:18-0:27	0:06-0:45	
		50/50	0:32-0:54	0:14-0:27	0:18-0:36	0:09-0:18		
below -3 to -14	below 27 to 7	100/0	0:41-1:39	0:27-0:50	0:27-0:50[7]	0:18-0:23[7]	CAUTION: No holdover time guidelines exist	
		75/25	0:36-1:35	0:23-0:41	0:32-0:36[7]	0:18-0:23[7]		
below -14 to -29	below 7 to -20.2	100/0	0:18-0:45	0:07-0:09				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

FAA Holdover Time Guidelines **Winter 2016-2017**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2C-90%. 90 PERCENT ADJUSTED TYPE II HOLDOVER TIME GUIDELINES FOR BEIJING YADILITE AVIATION YD-102 TYPE II

Outside Air Temperature[1]		Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	1:03-1:48	1:30-1:48	0:45-1:30	0:23-0:45	0:36-1:08	0:32-0:36	0:09-0:54	
		75/25	0:23-0:50	0:45-0:59	0:23-0:45	0:14-0:23	0:14-0:36	0:09-0:18	0:04-0:23	
		50/50	0:14-0:23	0:23-0:27	0:09-0:23	0:05-0:09	0:07-0:14	0:06-0:08	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:41-1:21	0:54-1:08	0:27-0:54	0:14-0:27	0:32-0:45[7]	0:23-0:23[7]		
		75/25	0:27-0:45	0:32-0:41	0:18-0:32	0:07-0:18	0:14-0:23[7]	0:08-0:14[7]		
Below -14 to -29	Below 7 to -20.2	100/0	0:18-0:41	0:18-0:23	0:09-0:18	0:07-0:09				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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FAA Holdover Time Guidelines Winter 2016-2017

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2D-90%. 90 PERCENT ADJUSTED TYPE II HOLDOVER TIME GUIDELINES FOR CLARIANT SAFEWING MP II FLIGHT

Outside Air Temperature[1] Degrees Celsius	Outside Air Temperature[1] Degrees Fahrenheit	Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Snow, Snow Grains or Snow Pellets[2] Light[3]	Snow, Snow Grains or Snow Pellets[2] Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	3:09-3:36	2:20-2:47	1:26-2:20	0:54-1:26	1:12-1:48	0:41-1:17	0:09-1:21	CAUTION: No holdover time guidelines exist
		75/25	1:39-2:29	2:20-2:51	1:12-2:20	0:36-1:12	1:03-1:21	0:27-0:50	0:05-0:45	
		50/50	0:50-1:35	0:41-0:50	0:23-0:41	0:09-0:23	0:18-0:27	0:09-0:14		
below -3 to -14	below 27 to 7	100/0	0:50-1:35	1:39-1:57	0:59-1:39	0:36-0:59	0:32-1:21[7]	0:23-0:41[7]		
		75/25	0:23-0:59	1:12-1:30	0:36-1:12	0:18-0:36	0:23-1:03[7]	0:18-0:32[7]		
Below -14 to -29	Below 7 to -20.2	100/0	0:27-0:45	0:18-0:23	0:09-0:18	0:07-0:09				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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FAA Holdover Time Guidelines **Winter 2016-2017**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2E-90%. 90 PERCENT ADJUSTED TYPE II HOLDOVER TIME GUIDELINES FOR CLARIANT SAFEWING MP II FLIGHT PLUS

Outside Air Temperature[1]		Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2,3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:24-3:36	0:45-1:39	1:17-1:48	0:41-0:54	0:14-1:48	
		75/25	2:20-3:36	0:54-1:35	1:26-1:48	0:45-1:08	0:14-1:08	
		50/50	0:59-2:06	0:14-0:23	0:27-0:59	0:14-0:18	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:36-2:06	0:32-1:08	0:32-1:17[7]	0:32-0:50[7]		
		75/25	0:27-1:35	0:50-1:30	0:23-1:03[7]	0:27-0:41[7]		
Below -14 to -29	Below 7 to -20.2	100/0	0:18-0:36	0:07-0:09				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2F-90%. 90 PERCENT ADJUSTED TYPE II HOLDOVER TIME GUIDELINES FOR CRYOTECH POLAR GUARD® II

Outside Air Temperature[1]		Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	2:33-3:36	2:20-2:33	1:39-2:20	1:12-1:39	1:26-1:48	1:08-1:21	0:14-1:48	
		75/25	2:15-3:36	2:11-2:38	1:12-2:11	0:41-1:12	1:30-1:48	0:36-1:03	0:08-1:30	
		50/50	0:45-1:17	1:12-1:35	0:32-1:12	0:14-0:32	0:18-0:41	0:08-0:18	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:50-2:15	1:35-1:44	1:08-1:35	0:50-1:08	0:32-1:26[7]	0:32-0:41[7]		
		75/25	0:36-1:21	1:35-1:53	0:54-1:35	0:32-0:54	0:23-0:59[7]	0:32-0:41[7]		
Below -14 to -30.5	Below 7 to -22.9	100/0	0:23-0:45	0:18-0:23	0:09-0:18	0:07-0:09				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

FAA Holdover Time Guidelines — Winter 2016-2017

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2G-90%. 90 PERCENT ADJUSTED TYPE II HOLDOVER TIME GUIDELINES FOR KILFROST ABC-ICE CLEAR II

Outside Air Temperature[1]		Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	0:54-1:35	1:35-1:57	0:45-1:35	0:23-0:45	0:36-0:59	0:23-0:32	0:06-0:41	
		75/25	0:45-1:03	1:12-1:35	0:36-1:12	0:18-0:36	0:27-0:41	0:18-0:27	0:05-0:32	
		50/50	0:14-0:27	0:18-0:23	0:14-0:18	0:07-0:14	0:09-0:18	0:06-0:09	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:36-1:26	1:08-1:26	0:32-1:08	0:18-0:32	0:23-0:54[7]	0:14-0:27[7]		
		75/25	0:36-1:12	0:50-1:03	0:23-0:50	0:14-0:23	0:23-0:41[7]	0:14-0:18[7]		
Below -14 to -29.5	Below 7 to -21.1	100/0	0:18-0:36	0:18-0:23	0:09-0:18	0:07-0:09				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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FAA Holdover Time Guidelines — Winter 2016-2017

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2H-90%. 90 PERCENT ADJUSTED TYPE II HOLDOVER TIME GUIDELINES FOR KILFROST ABC-K PLUS

Outside Air Temperature[1]		Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2,3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:02-3:23	0:54-1:30	1:39-1:48	0:54-1:17	0:18-1:48	CAUTION: No holdover time guidelines exist
		75/25	1:30-2:15	0:32-1:03	1:17-1:48	0:45-1:03	0:14-1:48	
		50/50	0:32-0:59	0:06-0:14	0:18-0:27	0:09-0:14		
below -3 to -14	below 27 to 7	100/0	0:27-0:59	0:45-1:17	0:23-0:54[7]	0:14-0:32[7]		
		75/25	0:23-1:17	0:32-0:59	0:18-0:50[7]	0:08-0:27[7]		
below -14 to -29	below 7 to -20.2	100/0	0:27-0:50	0:07-0:09				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

FAA Holdover Time Guidelines Winter 2016-2017

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2I-90%. 90 PERCENT ADJUSTED TYPE II HOLDOVER TIME GUIDELINES FOR NEWAVE AEROCHEMICAL FCY-2

Outside Air Temperature[1]		Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2,3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:08-2:11	0:27-0:50	0:32-0:59	0:23-0:32	0:07-0:41	CAUTION: No holdover time guidelines exist
		75/25	0:45-1:21	0:18-0:36	0:23-0:41	0:14-0:23	0:05-0:23	
		50/50	0:23-0:32	0:14-0:23	0:09-0:18	0:06-0:09		
below -3 to -14	below 27 to 7	100/0	0:41-1:21	0:14-0:27	0:18-0:41[7]	0:14-0:18[7]		
		75/25	0:27-0:59	0:09-0:18	0:14-0:27[7]	0:07-0:14[7]		
below -14 to -28	below 7 to -18.4	100/0	0:23-0:32	0:07-0:09				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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FAA Holdover Time Guidelines — Winter 2016-2017

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 2J-90%. 90 PERCENT ADJUSTED TYPE II HOLDOVER TIME GUIDELINES FOR NEWAVE AEROCHEMICAL FCY-2 BIO+

Outside Air Temperature[1]		Type II Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:17-2:15	2:06-2:38	0:59-2:06	0:27-0:59	0:45-1:12	0:23-0:41	0:07-1:08	
		75/25	0:41-1:12	1:12-1:30	0:36-1:12	0:18-0:36	0:23-0:45	0:14-0:23	0:05-0:32	
		50/50	0:14-0:27	0:23-0:27	0:14-0:23	0:07-0:14	0:09-0:18	0:07-0:09	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:36-1:21	0:54-1:08	0:27-0:54	0:14-0:27	0:32-0:59[7]	0:14-0:27[7]		
		75/25	0:27-0:59	0:32-0:41	0:18-0:32	0:07-0:18	0:18-0:32[7]	0:14-0:18[7]		
below -14 to -28.5	below 7 to -19.3	100/0	0:18-0:54	0:18-0:23	0:09-0:18	0:07-0:09				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 3A-LS-90%. 90 PERCENT ADJUSTED LOW SPEED TYPE III HOLDOVER TIME GUIDELINES FOR ALLCLEAR AEROCLEAR MAX, APPLIED UNHEATED[1]

FOR AIRCRAFT CONFORMING TO THE SAE AS5900 LOW SPEED AERODYNAMIC TEST CRITERION

Outside Air Temperature[2]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3] Very Light[4]	Light[4]	Moderate	Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
-3 and above	27 and above	100/0	0:41-1:03	0:54-1:08	0:27-0:54	0:13-0:27	0:18-0:41	0:13-0:18	0:05-0:36	
		75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		50/50	N/A	N/A	N/A	N/A	N/A	N/A	CAUTION: No holdover time guidelines exist	
below -3 to -10	below 27 to 14	100/0	0:41-1:17	0:54-1:08	0:27-0:54	0:13-0:27	0:18-0:36	0:14-0:23		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -10 to -16	below 14 to 3.2	100/0	0:27-0:59	0:54-1:08	0:27-0:54	0:13-0:27				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Fluid must be applied unheated to use these holdover times. No holdover times exist for this fluid applied heated.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type III fluid cannot be used.
3 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

FAA Holdover Time Guidelines **Winter 2016-2017**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 3A-HS-90%. 90 PERCENT ADJUSTED HIGH SPEED TYPE III HOLDOVER TIME GUIDELINES FOR ALLCLEAR AEROCLEAR MAX, APPLIED UNHEATED[1]

FOR AIRCRAFT CONFORMING TO THE SAE AS5900 HIGH SPEED AERODYNAMIC TEST CRITERION

Outside Air Temperature[2]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3] Very Light[4]	Light[4]	Moderate	Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
-3 and above	27 and above	100/0	0:41-1:03	0:54-1:08	0:27-0:54	0:13-0:27	0:18-0:41	0:13-0:18	0:05-0:36	
		75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		50/50	N/A	N/A	N/A	N/A	N/A	N/A		
below -3 to -10	below 27 to 14	100/0	0:41-1:17	0:54-1:08	0:27-0:54	0:13-0:27	0:18-0:36	0:14-0:23	CAUTION: No holdover time guidelines exist	
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -10 to -25	below 14 to -13	100/0	0:27-0:59	0:54-1:08	0:27-0:54	0:13-0:27				
below -25 to -35	below -13 to -31	100/0	0:14-0:36	0:36-0:45	0:17-0:36	0:08-0:17				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Fluid must be applied unheated to use these holdover times. No holdover times exist for this fluid applied heated.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type III fluid cannot be used.
3 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 5-90% provides allowance times for ice pellets and small hail).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 3B-LS-90%. 90 PERCENT ADJUSTED LOW SPEED TYPE III HOLDOVER TIME GUIDELINES FOR CLARIANT SAFEWING MP III 2031 ECO, APPLIED HEATED[1]

FOR AIRCRAFT CONFORMING TO THE SAE AS5900 LOW SPEED AERODYNAMIC TEST CRITERION

Outside Air Temperature[2]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3] Very Light[4]	Light[4]	Moderate	Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
-3 and above	27 and above	100/0	0:23-0:45	0:36-0:50	0:18-0:36	0:09-0:18	0:15-0:27	0:09-0:13	0:05-0:27	
		75/25	0:17-0:36	0:32-0:41	0:14-0:32	0:06-0:14	0:12-0:18	0:07-0:08	0:03-0:16	
		50/50	0:12-0:16	0:23-0:27	0:12-0:23	0:06-0:12	0:12-0:13	0:06-0:06	CAUTION: No holdover time guidelines exist	
below -3 to -10	below 27 to 14	100/0	0:32-1:08	0:36-0:45	0:18-0:36	0:09-0:18	0:13-0:27	0:08-0:12		
		75/25	0:17-0:41[8]	0:23-0:32[8]	0:11-0:23[8]	0:05-0:11[8]	0:08-0:14[8]	0:05-0:07[8]		
below -10 to -16.5	below 14 to 2.3	100/0	0:23-0:41	0:36-0:41	0:17-0:36	0:08-0:17				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Fluid must be applied heated to use these holdover times. No holdover times exist for this fluid applied unheated.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type III fluid cannot be used.
3 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail.
8 No holdover time guidelines exist for 75/25 fluid below -9 °C (15.8 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

FAA Holdover Time Guidelines **Winter 2016-2017**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 3B-HS-90%. 90 PERCENT ADJUSTED HIGH SPEED TYPE III HOLDOVER TIME GUIDELINES FOR CLARIANT SAFEWING MP III 2031 ECO, APPLIED HEATED[1]

FOR AIRCRAFT CONFORMING TO THE SAE AS5900 HIGH SPEED AERODYNAMIC TEST CRITERION

Outside Air Temperature[2]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[3]			Freezing Drizzle[5]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[7]
				Very Light[4]	Light[4]	Moderate				
-3 and above	27 and above	100/0	0:23-0:45	0:36-0:50	0:18-0:36	0:09-0:18	0:15-0:27	0:09-0:13	0:05-0:27	
		75/25	0:17-0:36	0:32-0:41	0:14-0:32	0:06-0:14	0:12-0:18	0:07-0:08	0:03-0:16	
		50/50	0:12-0:16	0:23-0:27	0:12-0:23	0:06-0:12	0:12-0:13	0:06-0:06		
below -3 to -10	below 27 to 14	100/0	0:32-1:08	0:36-0:45	0:18-0:36	0:09-0:18	0:13-0:27	0:08-0:12	CAUTION: No holdover time guidelines exist	
		75/25	0:17-0:41	0:23-0:32	0:11-0:23	0:05-0:11	0:08-0:14	0:05-0:07		
below -10 to -25	below 14 to -13	100/0	0:23-0:41	0:36-0:41	0:17-0:36	0:08-0:17				
below -25 to -29	below -13 to 20.2	100/0	0:23-0:41	0:36-0:41	0:17-0:36	0:08-0:17				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Fluid must be applied heated to use these holdover times. No holdover times exist for this fluid applied unheated.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type III fluid cannot be used.
3 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
4 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
5 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
6 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
7 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 5-90% provides allowance times for ice pellets and small hail).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4-GENERIC-90%. 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR SAE TYPE IV FLUIDS

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:08-2:24	2:06-2:29	1:03-2:06	0:32-1:03	0:36-1:21	0:32-0:36	0:07-1:17	
		75/25	1:17-2:24	1:53-2:02	1:08-1:53	0:41-1:08	0:45-1:12	0:27-0:41	0:08-1:08	
		50/50	0:23-0:45	0:36-0:41	0:23-0:36	0:14-0:23	0:14-0:27	0:08-0:14	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:18-1:26	1:12-1:30	0:41-1:12	0:23-0:41	0:23-1:12[7]	0:18-0:23[7]		
		75/25	0:27-1:03	1:30-1:48	0:41-1:30	0:18-0:41	0:14-0:59[7]	0:14-0:23[7]		
below -14 to -26	below 7 to -14.8	100/0	0:18-0:36[8]	0:18-0:23[8]	0:09-0:18[8]	0:07-0:09[8]				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).
8 If the LOUT is unknown, no holdover time guidelines exist below -22.5 °C (-8.5 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

FAA Holdover Time Guidelines — Winter 2016-2017

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4A-90%. 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR ABAX ECOWING AD-49

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	3:00-3:36	2:33-2:51	1:39-2:33	1:03-1:39	1:17-1:48	0:54-1:17	0:09-1:44	CAUTION: No holdover time guidelines exist
		75/25	2:11-3:36	1:53-2:02	1:30-1:53	1:12-1:30	1:44-1:48	0:45-1:21	0:09-1:30	
		50/50	0:23-0:45	0:36-0:41	0:23-0:36	0:14-0:23	0:14-0:27	0:09-0:14	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:18-1:26	2:33-2:51	1:39-2:33	1:03-1:39	0:23-1:17[7]	0:18-0:23[7]		
		75/25	0:27-1:03	1:53-2:02	1:30-1:53	1:12-1:30	0:14-0:59[7]	0:14-0:23[7]		
below -14 to -26	below 7 to -14.8	100/0	0:23-0:36	0:18-0:23	0:09-0:18	0:07-0:09	CAUTION: No holdover time guidelines exist			

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

FAA Holdover Time Guidelines — Winter 2016-2017

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4B-90%. 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR CLARIANT MAX FLIGHT 04

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:24-3:36	3:00-3:00	2:29-3:00	1:17-2:29	1:48-1:48	1:03-1:21	0:18-1:48	CAUTION: No holdover time guidelines exist
		75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		50/50	N/A	N/A	N/A	N/A	N/A	N/A	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:45-2:15	2:06-2:33	1:03-2:06	0:32-1:03	0:23-1:21[7]	0:18-0:36[7]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -23.5	below 7 to -10.3	100/0	0:18-0:41	0:18-0:23	0:09-0:18	0:07-0:09	CAUTION: No holdover time guidelines exist			

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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FAA Holdover Time Guidelines **Winter 2016-2017**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4C-90%. 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR CLARIANT MAX FLIGHT AVIA

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	2:47-3:36	2:42-3:00	1:35-2:42	0:54-1:35	1:17-1:48	0:50-1:03	0:08-1:48	
		75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		50/50	N/A	N/A	N/A	N/A	N/A	N/A	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	1:35-3:32	1:57-2:20	1:08-1:57	0:36-1:08	1:03-1:48[7]	0:50-1:21[7]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -28.5	below 7 to -19.3	100/0	0:32-1:17	0:18-0:23	0:09-0:18	0:07-0:09				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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FAA Holdover Time Guidelines Winter 2016-2017

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4D-90%. 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR CLARIANT MAX FLIGHT SNEG

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:11-3:36	2:29-2:51	1:30-2:29	0:59-1:30	1:48-1:48	0:45-1:30	0:18-1:21	
		75/25	3:36-3:36	2:11-2:33	1:21-2:11	0:50-1:21	1:21-1:48	0:59-1:12	0:14-1:35	
		50/50	1:21-3:09	1:35-2:06	0:41-1:35	0:18-0:41	0:32-1:03	0:14-0:27	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:41-2:06	1:48-2:06	1:08-1:48	0:41-1:08	0:27-1:17[7]	0:23-0:36[7]		
		75/25	0:27-1:17	1:30-1:48	0:54-1:30	0:36-0:54	0:18-0:59[7]	0:18-0:36[7]		
below -14 to -29	below 7 to -20.2	100/0	0:18-0:45	0:18-0:23	0:09-0:18	0:07-0:09				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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FAA Holdover Time Guidelines **Winter 2016-2017**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4E-90%. 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR CLARIANT SAFEWING EG IV NORTH

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	2:06-3:32	2:42-3:00	1:30-2:42	0:45-1:30	1:21-1:48	0:45-0:50	0:07-1:48	
		75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		50/50	N/A	N/A	N/A	N/A	N/A	N/A	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	1:35-3:36	2:29-3:00	1:21-2:29	0:45-1:21	0:59-1:39[7]	0:50-1:17[7]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -30	below 7 to -22	100/0	0:36-1:12	0:18-0:23	0:09-0:18	0:07-0:09				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4F-90%. 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR CLARIANT SAFEWING MP IV LAUNCH

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	3:36-3:36	2:33-3:00	1:35-2:33	0:59-1:35	1:21-1:48	0:54-1:30	0:14-1:30	
		75/25	3:18-3:36	2:47-3:00	1:35-2:47	0:54-1:35	1:30-1:48	0:41-1:08	0:09-1:35	
		50/50	1:17-2:29	1:17-1:30	0:41-1:17	0:23-0:41	0:27-0:45	0:18-0:23	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:54-1:44	1:57-2:15	1:12-1:57	0:45-1:12	0:32-1:30[7]	0:23-0:41[7]		
		75/25	0:36-1:12	2:11-2:38	1:17-2:11	0:41-1:17	0:23-1:03[7]	0:23-0:41[7]		
below -14 to -28.5	below 7 to -19.3	100/0	0:27-0:45	0:18-0:23	0:09-0:18	0:07-0:09				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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FAA Holdover Time Guidelines **Winter 2016-2017**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4G-90%. 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR CLARIANT SAFEWING MP IV LAUNCH PLUS

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Snow, Snow Grains or Snow Pellets[2] Light[3]	Snow, Snow Grains or Snow Pellets[2] Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	3:32-3:36	3:00-3:00	1:53-3:00	0:50-1:53	1:48-1:48	0:54-1:48	0:18-1:48	CAUTION: No holdover time guidelines exist
		75/25	3:32-3:36	3:00-3:00	1:44-3:00	0:45-1:44	1:48-1:48	1:12-1:17	0:18-1:39	
		50/50	1:08-1:39	1:26-1:48	0:41-1:26	0:18-0:41	0:23-0:54	0:14-0:18		
below -3 to -14	below 27 to 7	100/0	0:50-2:02	2:56-3:00	1:17-2:56	0:36-1:17	0:23-1:26[7]	0:23-0:36[7]		
		75/25	0:36-1:48	2:38-3:00	1:08-2:38	0:27-1:08	0:18-0:59[7]	0:18-0:27[7]		
below -14 to -29	below 7 to -20.2	100/0	0:23-0:45	0:18-0:23	0:09-0:18	0:07-0:09				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

FAA Holdover Time Guidelines **Winter 2016-2017**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4H-90%. 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR CRYOTECH POLAR GUARD® ADVANCE

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Snow, Snow Grains or Snow Pellets[2] Light[3]	Snow, Snow Grains or Snow Pellets[2] Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:33-3:36	2:20-2:33	1:39-2:20	1:12-1:39	1:26-1:48	1:08-1:21	0:14-1:48	CAUTION: No holdover time guidelines exist
		75/25	2:15-3:36	2:11-2:38	1:12-2:11	0:41-1:12	1:30-1:48	0:36-1:03	0:08-1:30	
		50/50	0:45-1:17	1:12-1:35	0:32-1:12	0:14-0:32	0:18-0:41	0:08-0:18		
below -3 to -14	below 27 to 7	100/0	0:50-2:15	1:35-1:44	1:08-1:35	0:50-1:08	0:32-1:26[7]	0:32-0:41[7]		
		75/25	0:36-1:21	1:35-1:53	0:54-1:35	0:32-0:54	0:23-0:59[7]	0:32-0:41[7]		
Below -14 to -30.5	Below 7 to -22.9	100/0	0:23-0:45	0:18-0:23	0:09-0:18	0:07-0:09				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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FAA Holdover Time Guidelines **Winter 2016-2017**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4I-90%. 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR DEICING SOLUTIONS ECO-SHIELD®

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:08-2:24	2:11-2:33	1:12-2:11	0:41-1:12	0:36-1:21	0:32-0:36	0:14-1:26	
		75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		50/50	N/A	N/A	N/A	N/A	N/A	N/A	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	1:03-2:20	1:44-2:02	0:59-1:44	0:32-0:59	0:45-1:17[7]	0:27-0:36[7]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -25.5	below 7 to -13.9	100/0	0:27-0:54	0:18-0:23	0:09-0:18	0:07-0:09				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

FAA Holdover Time Guidelines Winter 2016-2017

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4J-90%. 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR DOW CHEMICAL UCAR™ ENDURANCE EG106

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:53-2:51	2:29-3:00	1:12-2:29	0:36-1:12	1:03-1:48	0:45-1:08	0:18-1:48	
		75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		50/50	N/A	N/A	N/A	N/A	N/A	N/A	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	1:39-3:00	1:57-2:29	0:59-1:57	0:27-0:59	0:50-1:39[7]	0:41-1:03[7]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -27	below 7 to -16.6	100/0	0:27-0:59	0:18-0:23	0:09-0:18	0:07-0:09				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures**

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THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4K-90%. 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR DOW CHEMICAL UCAR™ FLIGHTGUARD AD-49

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Snow, Snow Grains or Snow Pellets[2] Light[3]	Snow, Snow Grains or Snow Pellets[2] Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	3:00-3:36	2:33-2:51	1:39-2:33	1:03-1:39	1:17-1:48	0:54-1:17	0:09-1:44	
		75/25	2:11-3:36	1:53-2:02	1:30-1:53	1:12-1:30	1:44-1:48	0:45-1:21	0:09-1:30	
		50/50	0:23-0:45	0:36-0:41	0:23-0:36	0:14-0:23	0:14-0:27	0:09-0:14	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:18-1:26	2:33-2:51	1:39-2:33	1:03-1:39	0:23-1:17[7]	0:18-0:23[7]		
		75/25	0:27-1:03	1:53-2:02	1:30-1:53	1:12-1:30	0:14-0:59[7]	0:14-0:23[7]		
below -14 to -26	below 7 to -14.8	100/0	0:23-0:36	0:18-0:23	0:09-0:18	0:07-0:09				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

FAA Holdover Time Guidelines — Winter 2016-2017

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4L-90%. 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR KILFROST ABC-S PLUS

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:57-3:36	3:00-3:00	1:53-3:00	1:08-1:53	1:39-1:48	0:59-1:48	0:23-1:48	
		75/25	1:17-2:24	1:53-2:11	1:08-1:53	0:41-1:08	0:54-1:12	0:27-0:45	0:09-1:12	
		50/50	0:27-0:50	0:54-1:03	0:27-0:54	0:14-0:27	0:14-0:36	0:14-0:18	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:50-3:09	2:38-3:00	1:35-2:38	0:54-1:35	0:23-1:26[7]	0:18-0:27[7]		
		75/25	0:41-1:39	1:35-1:48	0:54-1:35	0:32-0:54	0:18-1:03[7]	0:14-0:23[7]		
below -14 to -28	below 7 to -18.4	100/0	0:36-0:54	0:18-0:23	0:09-0:18	0:07-0:09				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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FAA Holdover Time Guidelines — Winter 2016-2017

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4M-90%. 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR LNT SOLUTIONS E450

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Snow, Snow Grains or Snow Pellets[2] Light[3]	Snow, Snow Grains or Snow Pellets[2] Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:39-2:38	2:11-2:29	1:26-2:11	0:54-1:26	1:26-1:48	0:50-1:12	0:23-1:48	CAUTION: No holdover time guidelines exist
		75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		50/50	N/A	N/A	N/A	N/A	N/A	N/A		
below -3 to -14	below 27 to 7	100/0	1:21-3:32	1:39-1:53	1:03-1:39	0:41-1:03	1:35-1:48[7]	0:59-1:30[7]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -22.5	below 7 to -8.5	100/0	0:32-0:59	0:18-0:23	0:09-0:18	0:07-0:09				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4N-90%. 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR NEWAVE AEROCHEMICAL FCY 9311

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	1:44-3:36	2:06-2:38	1:03-2:06	0:32-1:03	1:03-1:48	0:36-0:59	0:14-1:17	
		75/25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
		50/50	N/A	N/A	N/A	N/A	N/A	N/A	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:32-1:53	1:26-1:48	0:45-1:26	0:23-0:45	0:32-1:12[7]	0:18-0:32[7]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -29.5	below 7 to -21.1	100/0	0:27-0:50	0:18-0:23	0:09-0:18	0:07-0:09				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

FAA Holdover Time Guidelines | **Winter 2016-2017**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 4O-90%. 90 PERCENT ADJUSTED TYPE IV HOLDOVER TIME GUIDELINES FOR SHAANXI CLEANWAY AVIATION CLEANSURFACE IV

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]			Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
				Very Light[3]	Light[3]	Moderate				
-3 and above	27 and above	100/0	2:33-3:36	3:00-3:00	1:44-3:00	0:54-1:44	1:48-1:48	1:17-1:21	0:14-1:48	
		75/25	2:20-3:36	3:00-3:00	1:26-3:00	0:41-1:26	0:45-1:48	0:32-0:41	0:08-1:08	
		50/50	0:59-2:11	1:30-2:06	0:36-1:30	0:14-0:36	0:23-0:45	0:14-0:18	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:54-2:47	1:12-1:30	0:41-1:12	0:23-0:41	0:32-1:35[7]	0:18-0:32[7]		
		75/25	0:45-1:44	1:30-1:57	0:41-1:30	0:18-0:41	0:27-1:12[7]	0:23-0:36[7]		
below -14 to -28.5	below 7 to -19.3	100/0	0:27-0:45	0:18-0:23	0:09-0:18	0:07-0:09				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6-90% provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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FAA Holdover Time Guidelines Winter 2016-2017

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 5-90%. 90 PERCENT ADJUSTED ICE PELLET AND SMALL HAIL ALLOWANCE TIMES FOR SAE TYPE III FLUIDS[1]

This table is for use with SAE Type III undiluted (100/0) fluids applied unheated only

Precipitation Type	Outside Air Temperature		
	-5°C and above	Below -5 to -10°C	Below -10°C[2]
Light Ice Pellets	9 minutes	9 minutes	**Caution: No allowance times currently exist**
Light Ice Pellets Mixed with Light Snow	9 minutes	9 minutes	
Light Ice Pellets Mixed with Moderate Snow	9 minutes	5 minutes	
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	6 minutes	5 minutes	
Light Ice Pellets Mixed with Light Freezing Rain	6 minutes	5 minutes	
Light Ice Pellets Mixed with Light Rain	6 minutes[3]		
Light Ice Pellets Mixed with Moderate Rain			
Moderate Ice Pellets (or Small Hail)[4]	5 minutes	5 minutes	

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

NOTES

1 These allowance times are for use with aircraft with rotation speeds of 100 knots or greater.
2 Ensure that the lowest operational use temperature (LOUT) is respected.
3 No allowance times exist in this condition for temperatures below 0 °C; consider use of light ice pellets mixed with light freezing rain.
4 If no intensity is reported with small hail, use the "moderate ice pellets or small hail" allowance times. If an intensity is reported with small hail, the ice pellet condition with the equivalent intensity can be used, e.g. if light small hail is reported, the "light ice pellets" allowance times can be used. This also applies in mixed conditions, e.g. if light small hail mixed with light snow is reported, use the "light ice pellets mixed with light snow" allowance times.

CAUTIONS:

- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**
- **Allowance time cannot be extended by an inspection of the aircraft critical surfaces.**
- **Takeoff is allowed up to 90 minutes after start of fluid application if the precipitation stops at or before the allowance time expires and does not restart. The OAT must not decrease during the 90 minutes to use this guidance in conditions of light ice pellets mixed with either: light or moderate freezing drizzle, light freezing rain, or light rain.**

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THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE 6-90%. 90 PERCENT ADJUSTED ICE PELLET AND SMALL HAIL ALLOWANCE TIMES FOR SAE TYPE IV FLUIDS[1]

This table is for use with SAE Type IV undiluted (100/0) fluids only. All Type IV fluids are propylene glycol based with the exception of Clariant Max Flight AVIA, Clariant Safewing EG IV NORTH, Dow EG106 and LNT E450 which are ethylene glycol based.

Precipitation Type	Outside Air Temperature			
	-5°C and above	Below -5 to -10°C	Below -10 to -16°C	Below -16 to -22°C[2]
Light Ice Pellets	45 minutes	27 minutes	27 minutes[3]	27 minutes[3]
Light Ice Pellets Mixed with Light Snow	36 minutes	14 minutes	14 minutes[3]	
Light Ice Pellets Mixed with Moderate Snow	18 minutes	6 minutes	5 minutes[3]	
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	23 minutes	9 minutes	**Caution: No allowance times currently exist**	
Light Ice Pellets Mixed with Light Freezing Rain	23 minutes	9 minutes		
Light Ice Pellets Mixed with Light Rain	23 minutes[4]			
Light Ice Pellets Mixed with Moderate Rain	23 minutes[5]			
Moderate Ice Pellets (or Small Hail)[6]	23 minutes[7]	9 minutes	9 minutes[3]	9 minutes[8]
Moderate Ice Pellets (or Small Hail)[6] Mixed with Moderate Freezing Drizzle	9 minutes	6 minutes	**Caution: No allowance times currently exist**	
Moderate Ice Pellets (or Small Hail)[6] Mixed with Moderate Rain	9 minutes[5]			

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

NOTES

1. These allowance times are for use with aircraft with rotation speeds of 100 knots or greater.
2. Ensure that the lowest operational use temperature (LOUT) is respected.
3. No allowance times exist for propylene glycol (PG) fluids when used on aircraft with rotation speeds less than 115 knots. (For these aircraft, if the fluid type is not known, assume zero allowance time.)
4. No allowance times exist in this condition for temperatures below 0 °C; consider use of light ice pellets mixed with light freezing rain.
5. No allowance times exist in this condition for temperatures below 0 °C.
6. If no intensity is reported with small hail, use the "moderate ice pellets or small hail" allowance times. If an intensity is reported with small hail, the ice pellet condition with the equivalent intensity can be used, e.g. if light small hail is reported, the "light ice pellets" allowance times can be used. This also applies in mixed conditions, e.g. if light small hail mixed with light snow is reported, use the "light ice pellets mixed with light snow" allowance times.
7. Allowance time is 14 minutes for propylene glycol (PG) fluids or when the fluid type is unknown.
8. No allowance times exist for propylene glycol (PG) fluids in this condition for temperatures below -16 °C.

CAUTIONS:

- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**
- **Allowance time cannot be extended by an inspection of the aircraft critical surfaces.**
- **Takeoff is allowed up to 90 minutes after start of fluid application if the precipitation stops at or before the allowance time expires and does not restart. The OAT must not decrease during the 90 minutes to use this guidance in conditions of light ice pellets mixed with either: light or moderate freezing drizzle, light freezing rain, light rain, or moderate rain.**

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APPENDIX K

SUPPLEMENTAL HOLDOVER TIME GUIDANCE:
TRANSPORT CANADA ADVISORY CIRCULAR 007-040 AND
FAA WINTER 2016-2017 HOLDOVER TIME GUIDELINES ADDENDUM 1

TRANSPORT CANADA ADVISORY CIRCULAR 007-040

Transport Canada / Transports Canada

Advisory Circular

Subject:	**Supplemental Holdover Timetables and Regression Information for Society of Automotive Engineers (SAE) Type II and IV Fluids**		
Issuing Office:	Civil Aviation, Standards	Document No.:	AC 700-040
File Classification No.:	Z 5000-34	Issue No.:	01
RDIMS No.:	12291120-V11	Effective Date:	2016-09-30

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Canada

1.1 INTRODUCTION

(1) This Advisory Circular (AC) is provided for information and guidance purposes. It describes an example of an acceptable means, but not the only means, of demonstrating compliance with regulations and standards. This AC on its own does not change, create, amend or permit deviations from regulatory requirements, nor does it establish minimum standards.

1.1 Purpose

(1) This AC provides:

(a) Supplemental holdover timetables and regression information for SAE Type II and IV fluids for use by:

(i) Air operators or private operators who incorporate the holdover time guidelines as part of their Ground Icing Program (GIP).

(ii) Manufacturers of Holdover Time Determination Systems (HOTDS).

(iii) Developers of electronic holdover time applications (eHOT) applications.

(iv) All Transport Canada Civil Aviation (TCCA) inspectors with surveillance duties and to individuals and organizations that exercise privileges granted to them under an External Ministerial Delegation of Authority. This document is also aimed at the aviation industry at large for information purposes.

1.2 Applicability

(1) This document applies to TCCA employees and to all individuals, organizations and industries that are involved in aircraft winter operations and utilize the *Transport Canada Holdover Time (HOT) Guidelines, Winter 2016-2017*.

1.3 Description of Changes

(1) Not applicable.

2.0 REFERENCES AND REQUIREMENTS

2.1 Reference Documents

(1) It is intended that the following reference materials be used in conjunction with this document:

(a) *Aeronautics Act* (R.S., 1985, c. A-2);

(b) Part VI, Subpart 02, Section 11 of the *Canadian Aviation Regulations* (CARs) — *Aircraft Icing*;

(c) Part VI, Subpart 02 of the CARs, General Operating Flight Rules Standard (GOFR) 622.11 — *Ground Icing Operations;*

(d) Transport Canada Publication — *Transport Canada Holdover Time (HOT) Guidelines Winter 2016-2017*;

(e) Transport Canada Publication — *Holdover Time (HOT) Guidelines Regression Information Winter 2016-2017*.

(f) Transport Canada Publication (TP) 14052, Edition 02, April 2005 — *Guidelines for Aircraft Ground Icing Operations*.

2.2 Cancelled Documents

(1) Not applicable.

(2) By default, it is understood that the publication of a new issue of a document automatically renders any earlier issues of the same document null and void.

2.3 Definitions and Abbreviations

(1) The following **definitions** are used in this document:

(a) **Electronic holdover time application (eHOT app):** software program for portable or tablet computers that provides holdover times for aircraft ground de/anti-icing fluids.

(b) **Holdover Time Determination System (HOTDS)**: a near real-time system that samples a number of atmospheric inputs and uses these in conjunction with HOT regression curves and associated coefficients for specific de/anti-icing fluids to produce a holdover time determination report.

(c) **HOT Guidelines:** Guidance document containing holdover time tables that provide an estimate of the length of time that de/anti-icing fluids will be effective. Because holdover time is influenced by a number of factors, established times may be adjusted by the pilot-in-command (PIC) according to the weather or other conditions. Air Operators' manuals must describe the procedures to be followed for using holdover time guidelines. When the guidelines are used as decision-making criteria, the procedures to be followed by the pilot-in-command for varying the established values must also be specified.

(2) The following **abbreviations** are used in this document:

(a) **AC:** advisory circular;

(b) **ADF:** aircraft de-icing/anti-icing fluids;

(c) **CARs:** Canadian Aviation Regulations;

(d) **eHOT:** electronic holdover time, i.e. holdover time provided by eHOT app;

(e) **GOFR:** General Operating Flight Rules Standard;

(f) **HOT:** holdover time;

(g) **HOTDS:** holdover time determination system;

(h) **SAE :** Society of Automotive Engineers;

(i) **TCCA:** Transport Canada Civil Aviation.

3.0 BACKGROUND

(1) Section 602.11 of the *Canadian Aviation Regulations* (CARs) states, in part that: *"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";* and the associated General Operating Flight Rules Standard (GOFR) 622.11, outlines the requirements of a Ground Icing Program (GIP), including the use of HOT timetables.

(2) Transport Canada Civil Aviation (TCCA) annually publishes the *HOT Guidelines* to allow users (e.g. operators, service providers) to prepare and update their respective GIP for the upcoming winter season.

(3) TCCA annually publishes the *HOT Guidelines Regression Information* allow users (e.g. operators, service providers) to prepare and update their respective GIP for the upcoming winter season.

(4) Preliminary research findings collected in the winter of 2014-15 indicated that the HOT information for some of the aircraft de-icing/anti-icing fluids (ADF) listed in the HOT Guidelines for temperatures below -14°C in snow conditions did not meet the published times. Further evaluation was required in order to assess the magnitude of the potential safety risk.

(5) Initial analysis from this evaluation in winter 2015-2016 confirmed that some of the ADF did not meet the published HOTs. Consequently, as safety measure TCCA published the *2016-2017 HOT Guidelines* with reduced holdover times for all Society of Automotive Engineers SAE Type II and Type IV fluids.

4.0 CURRENT STATUS

(1) At the request of industry, TCCA and the Federal Aviation Administration (FAA) re-examined the performance of ethylene glycol (EG) and propylene glycol (PG) based fluids and the theoretical performance of fluids at -18°C. The analysis determined that the historic snow holdover times (those published in the *2015-2016 HOT Guidelines*) can be retained for:

(a) SAE Type IV EG based fluids in the below -14°C to Lowest Operational Use Temperature (LOUT) temperature band; and

(b) SAE Type II and Type IV PG based fluids in the below -14 to -18°C temperature band.

5.0 ACTION

(1) End users of the *Winter 2016-2017 Transport Canada Holdover (HOT) Guidelines* (e.g. air operators, service providers) are advised to incorporate the supplemental guidance provided in Appendix A to their GIP and operations manuals.

(2) End users of the *Winter 2016-2017 Transport Canada Holdover Time (HOT) Guidelines Regression Information* (e.g. holdover time determination systems (HOTDS) manufacturers, eHOT application developers) are advised to incorporate the supplemental guidance provided in Appendix B into their GIP and operations manuals.

6.0 FUTURE DISPOSITION

(1) These changes are interim. Additional analysis and/or research will be carried out to determine appropriate long term solutions.

7.0 INFORMATION MANAGEMENT

(1) Not applicable.

8.0 DOCUMENT HISTORY

(1) Not applicable.

9.0 CONTACT OFFICE

For more information, please contact:

Commercial Flight Standards Division (AARTF)
E-mail: **AARTInfoDoc@tc.gc.ca**

Suggestions for amendment to this document are invited, and should be submitted via the same e-mail as above.

[Original signed by]

Robert Sincennes
Director, Standards
Civil Aviation

APPENDIX A – SUPPLEMENT 1: HOLDOVER TIMETABLES FOR SAE TYPE II AND IV FLUIDS

TABLE EG

SAE TYPE IV ETHYLENE GLYCOL BASED FLUID[9] HOLDOVER TIME GUIDELINES FOR SNOW, SNOW GRAINS OR SNOW PELLETS BELOW -14°C (7°F) TO LOUT

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

<table>
<tr><th colspan="2">Outside Air Temperature[1]</th><th rowspan="3">Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)</th><th colspan="8">Approximate Holdover Times Under Various Weather Conditions (hours: minutes)</th></tr>
<tr><th rowspan="2">Degrees Celsius</th><th rowspan="2">Degrees Fahrenheit</th><th rowspan="2">Freezing Fog or Ice Crystals</th><th colspan="3">Snow, Snow Grains or Snow Pellets[2]</th><th rowspan="2">Freezing Drizzle[4]</th><th rowspan="2">Light Freezing Rain</th><th rowspan="2">Rain on Cold Soaked Wing[5]</th><th rowspan="2">Other[6]</th></tr>
<tr><th>Very Light[3]</th><th>Light[3]</th><th>Moderate</th></tr>
<tr><td rowspan="3">-3 and above</td><td rowspan="3">27 and above</td><td>100/0</td><td colspan="6" rowspan="5">Refer to holdover times provided in the appropriate fluid-specific or generic holdover time table published in the Transport Canada Holdover Time (HOT) Guidelines Winter 2016-2017 Original Issue: August 5, 2016</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>75/25</td></tr>
<tr><td>50/50</td><td colspan="2" rowspan="4">CAUTION: No holdover time guidelines exist</td></tr>
<tr><td rowspan="2">below -3 to -14</td><td rowspan="2">below 27 to 7</td><td>100/0</td></tr>
<tr><td>75/25</td></tr>
<tr><td>below -14 to LOUT[8]</td><td>below 7 to LOUT[8]</td><td>100/0</td><td></td><td>0:40</td><td>0:30 – 0:40</td><td>0:15 – 0:30</td><td></td><td></td></tr>
</table>

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10°C (14°F).
8 Refer to the fluid-specific HOT table in the document *Transport Canada HOT Guidelines Winter 2016-2017, Original Issue: August 5, 2016* for the LOUT of each fluid. This information is also provided in Table 8 of the same document. If the LOUT is unknown, no holdover time guidelines exist below -22.5°C (-8.5°F).
9 Table 8 table in the document *Transport Canada HOT Guidelines Winter 2016-2017, Original Issue: August 5, 2016* provides the glycol base information for each fluid. If the fluid base is unknown, assume it is propylene glycol for the purpose of determining holdover times.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

TABLE PG

SAE TYPE II AND TYPE IV PROPYLENE GLYCOL BASED FLUID[9] HOLDOVER TIME GUIDELINES FOR SNOW, SNOW GRAINS OR SNOW PELLETS BELOW -14°C (7°F) TO LOUT

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type II/IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	Refer to holdover times provided in the appropriate fluid-specific or generic holdover time table published in the *Transport Canada Holdover Time (HOT) Guidelines Winter 2016-2017* *Original Issue: August 5, 2016*							CAUTION: No holdover time guidelines exist
		75/25								
		50/50							CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0								
		75/25								
below -14 to -18	below 7 to 0	100/0		0:40	0:30 – 0:40	0:15 – 0:30				
below -18 to LOUT[8]	below 0 to LOUT[8]	100/0		0:20	0:10 – 0:20	0:08 – 0:10				

NOTES

1. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II/IV fluid cannot be used.
2. To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3. Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5. No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7. No holdover time guidelines exist for this condition below -10°C (14°F).
8. Refer to the fluid-specific HOT table in the document *Transport Canada HOT Guidelines Winter 2016-2017, Original Issue: August 5, 2016* for the LOUT of each fluid. This information is also provided in Table 8 of the same document. If the LOUT is unknown, no holdover time guidelines exist below -22.5°C (-8.5°F).
9. Table 8 table in the document *Transport Canada HOT Guidelines Winter 2016-2017, Original Issue: August 5, 2016* provides the glycol base information for each fluid. If the fluid base is unknown, assume it is propylene glycol for the purpose of determining holdover times.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE EG-90%

SAE TYPE IV ETHYLENE GLYCOL BASED FLUID[9]
90% ADJUSTED HOLDOVER TIME GUIDELINES
FOR SNOW, SNOW GRAINS OR SNOW PELLETS BELOW -14°C (7°F) TO LOUT

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	Refer to holdover times provided in the appropriate fluid-specific or generic holdover time table published in the *Transport Canada Holdover Time (HOT) Guidelines Winter 2016-2017 Original Issue: August 5, 2016*							CAUTION: No holdover time guidelines exist
		75/25								
		50/50								
below -3 to -14	below 27 to 7	100/0								
		75/25								
below -14 to LOUT[8]	below 7 to LOUT[8]	100/0		0:36	0:27 – 0:36	0:14 – 0:27				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10°C (14°F).
8 Refer to the fluid-specific HOT table in the document *Transport Canada HOT Guidelines Winter 2016-2017, Original Issue: August 5, 2016* for the LOUT of each fluid. This information is also provided in Table 8 of the same document. If the LOUT is unknown, no holdover time guidelines exist below -22.5°C (-8.5°F).
9 Table 8 table in the document *Transport Canada HOT Guidelines Winter 2016-2017, Original Issue: August 5, 2016* provides the glycol base information for each fluid. If the fluid base is unknown, assume it is propylene glycol for the purpose of determining holdover times.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE PG-90%

SAE TYPE II AND TYPE IV PROPYLENE GLYCOL BASED FLUID[9]
90% ADJUSTED HOLDOVER TIME GUIDELINES
FOR SNOW, SNOW GRAINS OR SNOW PELLETS BELOW -14°C (7°F) TO LOUT

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type II/IV Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	Refer to holdover times provided in the appropriate fluid-specific or generic holdover time table published in the *Transport Canada Holdover Time (HOT) Guidelines Winter 2016-2017 Original Issue: August 5, 2016*							
		75/25								
		50/50								
below -3 to -14	below 27 to 7	100/0							CAUTION: No holdover time guidelines exist	
		75/25								
below -14 to -18	below 7 to 0	100/0		0:36	0:27 – 0:36	0:14 – 0:27				
below -18 to LOUT[8]	below 0 to LOUT[8]	100/0		0:18	0:09 – 0:18	0:07 – 0:09				

NOTES

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II/IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10°C (14°F).
8 Refer to the fluid-specific HOT table in the document *Transport Canada HOT Guidelines Winter 2016-2017, Original Issue: August 5, 2016* for the LOUT of each fluid. This information is also provided in Table 8 of the same document. If the LOUT is unknown, no holdover time guidelines exist below -22.5°C (-8.5°F).
9 Table 8 table in the document *Transport Canada HOT Guidelines Winter 2016-2017, Original Issue: August 5, 2016* provides the glycol base information for each fluid. If the fluid base is unknown, assume it is propylene glycol for the purpose of determining holdover times.

CAUTIONS

- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content. High wind velocity or jet blast may reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

APPENDIX B – SUPPLEMENT 2: REGRESSION INFORMATION FOR SAE TYPE II AND IV FLUIDS

TABLE RC EG

SAE TYPE IV ETHYLENE GLYCOL BASED FLUID[4]
(SNOW, SNOW GRAINS OR SNOW PELLETS BELOW -14°C TO LOUT)
REGRESSION COEFFICIENTS TABLE AND VERIFICATION TABLE

Outside Air Temperature		Fluid Dilution	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals[1]	Snow, Snow Grains or Snow Pellets[2,3] < 4 g/dm²/h	4 to <10 g/dm²/h	≥ 10 g/dm²/h	Freezing Drizzle[1]	Light Freezing Rain[1]	Rain on Cold Soaked Wing[1]	Other
-3 and above	27 and above	100/0	Refer to the regression coefficients provided in the appropriate fluid-specific regression coefficients table published in the document *Transport Canada HOT Guidelines Regression Information Winter 2016-2017, Original Issue: August 5, 2016*							
		75/25								
		50/50								
below -3 to -14	below 27 to 7	100/0							CAUTION: No holdover time guidelines exist	
		75/25								
below -14 to LOUT[5]	below 7 to LOUT[5]	100/0		I = 2.0691 A = -0.7757 B = 0.0000	I = 1.7911 A = -0.3140 B = 0.0000	I = 2.2336 A = -0.7565 B = 0.0000				

1 Regression Equation: $t = 10^{I} R^{A}$, where R = precipitation rate (g/dm²/h)
2 Regression Equation: $t = 10^{I} R^{A} (2-T)^{B}$, where R = precipitation rate (g/dm²/h) and T = temperature (in °C)
3 CAUTION: Use of these coefficients is limited by the lowest usable precipitation rates provided in Table 5 in the document *Transport Canada HOT Guidelines Regression Information Winter 2016-2017, Original Issue: August 5, 2016*.
4 Table 8 in the document *Transport Canada HOT Guidelines Winter 2016-2017, Original Issue: August 5, 2016* provides the glycol base information for each fluid. If the fluid base is unknown, assume it is propylene glycol for the purpose of determining regression coefficients.
5 Table 8 in the document *Transport Canada HOT Guidelines Winter 2016-2017, Original Issue: August 5, 2016* provides the LOUT of each fluid. If the LOUT is unknown, no holdover times can be provided below -22.5°C (-8.5°F).

Outside Air Temp. (°C)	Fluid Dilution	HOTDS Verification Times Under Various Weather Conditions (minutes) *As Calculated from Regression Coefficients*										
		Freezing Fog or Ice Crystals (g/dm²/h)		Snow, Snow Grains or Snow Pellets* (g/dm²/h)			Freezing Drizzle (g/dm²/h)		Light Freezing Rain (g/dm²/h)		Rain on Cold Soaked Wing (g/dm²/h)	
		5	2	25	10	3	13	5	25	13	75	5
+1 / -3 **	100/0	Refer to the verification times provided in the appropriate fluid-specific regression coefficients table published in the document *Transport Canada HOT Guidelines Regression Information Winter 2016-2017, Original Issue: August 5, 2016*										
	75/25											
	50/50											
-10 / -14 ***	100/0											
	75/25											
-25	100/0			15.0	30.0	50.0						

* Refer to Table 5 in the document *Transport Canada HOT Guidelines Regression Information Winter 2016-2017, Original Issue: August 5, 2016* for the lowest usable precipitation rates in snow
** Rain on cold soaked wing calculated at +1°C; all other conditions calculated at -3°C
*** Freezing fog and snow calculated at -14°C; freezing drizzle and light freezing rain calculated at -10°C

TABLE RC-PG

SAE TYPE II AND TYPE IV PROPYLENE GLYCOL BASED FLUID[4] (SNOW, SNOW GRAINS OR SNOW PELLETS BELOW -14°C TO LOUT) REGRESSION COEFFICIENTS TABLE AND VERIFICATION TABLE

Outside Air Temperature		Fluid Dilution	Regression Coefficients for Calculating Holdover Times Under Various Weather Conditions							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals[1]	Snow, Snow Grains or Snow Pellets[2,3] < 4 g/dm²/h	Snow, Snow Grains or Snow Pellets[2,3] 4 to <10 g/dm²/h	Snow, Snow Grains or Snow Pellets[2,3] ≥ 10 g/dm²/h	Freezing Drizzle[1]	Light Freezing Rain[1]	Rain on Cold Soaked Wing[1]	Other
-3 and above	27 and above	100/0	Refer to the regression coefficients provided in the appropriate fluid-specific regression coefficients table published in the document *Transport Canada HOT Guidelines Regression Information Winter 2016-2017, Original Issue: August 5, 2016*							CAUTION: No holdover time guidelines exist
		75/25								
		50/50								
below -3 to -14	below 27 to 7	100/0								
		75/25								
below -14 to -18	below 7 to 0	100/0		I = 2.0691 A = -0.7757 B = 0.0000	I = 1.7911 A = -0.3140 B = 0.0000	I = 2.2336 A = -0.7565 B = 0.0000				
below -18 to LOUT[5]	below 0 to LOUT[5]	100/0		I = 1.7680 A = -0.7757 B = 0.0000	I = 1.7565 A = -0.7565 B = 0.0000	I = 1.2435 A = -0.2435 B = 0.0000				

1 Regression Equation: $t = 10^{I} R^{A}$, where R = precipitation rate (g/dm²/h)
2 Regression Equation: $t = 10^{I} R^{A} (2\text{-}T)^{B}$, where R = precipitation rate (g/dm²/h) and T = temperature (in °C)
3 CAUTION: Use of these coefficients is limited by the lowest usable precipitation rates provided in Table 5 in the document *Transport Canada HOT Guidelines Regression Information Winter 2016-2017, Original Issue: August 5, 2016.*
4 Table 8 in the document *Transport Canada HOT Guidelines Winter 2016-2017, Original Issue: August 5, 2016* provides the glycol base information for each fluid. If the fluid base is unknown, assume it is propylene glycol for the purpose of determining regression coefficients.
5 Table 8 in the document *Transport Canada HOT Guidelines Winter 2016-2017, Original Issue: August 5, 2016* provides the LOUT of each fluid. If the LOUT is unknown, no holdover times can be provided below -22.5°C (-8.5°F).

Outside Air Temp. (°C)	Fluid Dilution	HOTDS Verification Times Under Various Weather Conditions (minutes) *As Calculated from Regression Coefficients*										
		Freezing Fog or Ice Crystals (g/dm²/h)		Snow, Snow Grains or Snow Pellets* (g/dm²/h)			Freezing Drizzle (g/dm²/h)		Light Freezing Rain (g/dm²/h)		Rain on Cold Soaked Wing (g/dm²/h)	
		5	2	25	10	3	13	5	25	13	75	5
+1 / -3 **	100/0	Refer to the verification times provided in the appropriate fluid-specific regression coefficients table published in the document *Transport Canada HOT Guidelines Regression Information Winter 2016-2017, Original Issue: August 5, 2016*										
	75/25											
	50/50											
-10 / -14 ***	100/0											
	75/25											
-18	100/0			15.0	30.0	50.0						
-25	100/0			8.0	10.0	25.0						

* Refer to Table 5 in the document *Transport Canada HOT Guidelines Regression Information Winter 2016-2017, Original Issue: August 5, 2016* for the lowest usable precipitation rates in snow
** Rain on cold soaked wing calculated at +1°C; all other conditions calculated at -3°C
*** Freezing fog and snow calculated at -14°C; freezing drizzle and light freezing rain calculated at -10°C

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FAA
WINTER 2016-2017
HOLDOVER TIME GUIDELINES ADDENDUM 1

FAA
HOLDOVER TIME GUIDELINES

WINTER 2016-2017

ADDENDUM 1: Sept. 30, 2016

The information contained in this document provides supplemental information to the official FAA Holdover Time Guidelines for the 2016-2017 winter season. The information in this document must be used in conjunction with the official FAA Holdover Time Guidelines Original Issue document and with the FAA N 8900 series notice "Revised FAA-Approved Deicing Program Updates, Winter 2016-2017."

Questions concerning FAA aircraft ground de/anti-icing requirements or Flight Standards policies should be addressed to charles.j.enders@faa.gov or 202-267-4557.

Questions on the technical content of the holdover time tables should be addressed to warren.underwood@faa.gov or 404-305-6652.

Questions regarding editorial content or web access issues should be addressed to sung.shin@faa.gov or 202-267-8086.

ADDENDUM 1

SAE TYPE II AND TYPE IV SNOW HOLDOVER TIMES BELOW -14 °C (7 °F)

PURPOSE

- This addendum has been created to communicate changes to the SAE Type II and Type IV snow, snow grain and snow pellet holdover times (HOTs) at outside air temperatures below -14 °C (7 °F). These changes are optional; the HOTs published in the Original Issue document are more conservative and can continue to be used if preferred by the operator.

BACKGROUND

- Preliminary research conducted in the winter of 2014-2015 indicated that some SAE Type II and Type IV fluids do not meet the published HOTs for temperatures below -14 °C (7 °F) in snow conditions. Further research was required to confirm and assess the magnitude of the associated potential safety risk.
- Additional research was carried out in the winter of 2015-2016. The additional research confirmed that many SAE Type II and Type IV fluids do not meet the published HOTs in these conditions. Consequently, as a safety measure, FAA published the 2016-2017 HOT Guidelines with reduced HOTs for all SAE Type II and Type IV fluids.

SUBSEQUENT DEVELOPMENTS

- Feedback from operators has indicated the new HOTs will have a significant impact on certain operations. As a result, further analysis was carried out. This analysis examined the performance of ethylene glycol (EG) vs. propylene glycol (PG) based fluids and the theoretical performance of fluids at -18 °C (0 °F).
- The analysis determined that the historic snow HOTs (those published in the 2015-2016 HOT Guidelines) can be retained for:
  - SAE Type IV EG based fluids in the below -14 °C (7 °F) to lowest operational use temperature (LOUT) temperature band; and
  - SAE Type II and Type IV PG based fluids in the below -14 to -18 °C (below 7 to 0 °F) temperature band.
- These changes are interim. Additional analysis and/or research will be carried out to determine appropriate long term solutions.

GUIDANCE

- The tables on the following pages provide the updated HOTs for the conditions described above. The tables include:
  - Table EG: Updated snow HOTs for Type IV EG fluids for temperatures below -14 °C (7 °F).
  - Table PG: Updated snow HOTs for Type II and Type IV PG fluids for temperatures below -14 to -18 °C (below 7 to 0 °F).
  - Table EG-90%: Updated snow HOTs for Type IV EG fluids for temperatures below -14 °C (7 °F), adjusted to 90% of standard HOTs (for use when flaps/slats are deployed prior to de/anti-icing).
  - Table PG-90%: Updated snow HOTs for Type II and Type IV PG fluids for temperatures below -14 to -18 °C (below 7 to 0 °F), adjusted to 90% of standard HOTs (for use when flaps/slats are deployed prior to de/anti-icing).
- Note: Refer to the fluid-specific HOT Table in the document *FAA Holdover Time Guidelines Winter 2016-2017 Original Issue: August 5, 2016* for the LOUT of each fluid. This information is also provided in Table 8 of the same document.
- Note: Table 8 in the document *FAA Holdover Time Guidelines Winter 2016-2017 Original Issue: August 5, 2016* provides the glycol base information for each fluid. If the fluid base is unknown, assume it is propylene glycol for the purpose of determining HOTs.

TABLE EG. HOLDOVER TIME GUIDELINES FOR
SAE TYPE IV ETHYLENE GLYCOL BASED FLUIDS[9]
IN SNOW, SNOW GRAINS OR SNOW PELLETS BELOW -14 °C (7 °F) TO LOUT

Outside Air Temperature[1]		Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	Refer to holdover times provided in the appropriate fluid-specific or generic holdover time table published in the document *FAA Holdover Time Guidelines Winter 2016-2017 Original Issue: August 5, 2016*							CAUTION: No holdover time guidelines exist
		75/25								
		50/50								
below -3 to -14	below 27 to 7	100/0								
		75/25								
below -14 to LOUT[8]	below 7 to LOUT[8]	100/0		0:40-0:50	0:30-0:40	0:15-0:30				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).
8 Refer to the fluid-specific holdover time (HOT) table in the document *FAA Holdover Time Guidelines Winter 2016-2017, Original Issue: August 5, 2016* for the LOUT of each fluid. This information is also provided in Table 8 of the same document. If the LOUT is unknown, no holdover times exist below -22.5 °C (-8.5 °F).
9 Table 8 in the document *FAA Holdover Time Guidelines Winter 2016-2017, Original Issue: August 5, 2016* provides the glycol base information for each fluid. If the fluid base is unknown, assume it is propylene glycol for the purpose of determining holdover times.

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce HOT below the lowest time stated in the range. HOT may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

TABLE PG. HOLDOVER TIME GUIDELINES FOR

SAE TYPE II AND TYPE IV PROPYLENE GLYCOL BASED FLUIDS[9]

IN SNOW, SNOW GRAINS OR SNOW PELLETS BELOW -14 °C (7 °F) TO LOUT

Outside Air Temperature[1]		Type II/IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2]: Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	Refer to holdover times provided in the appropriate fluid-specific or generic holdover time table published in the document *FAA Holdover Time Guidelines Winter 2016-2017 Original Issue: August 5, 2016*							CAUTION: No holdover time guidelines exist
		75/25								
		50/50								
below -3 to -14	below 27 to 7	100/0								
		75/25								
below -14 to -18	below 7 to 0	100/0		0:40-0:50	0:30-0:40	0:15-0:30				
below -18 to LOUT[8]	below 0 to LOUT[8]	100/0		0:20-0:25	0:10-0:20	0:08-0:10				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II/IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).
8 Refer to the fluid-specific holdover time (HOT) table in the document *FAA Holdover Time Guidelines Winter 2016-2017, Original Issue: August 5, 2016* for the LOUT of each fluid. This information is also provided in Table 8 of the same document. If the LOUT is unknown, no holdover times exist below -22.5 °C (-8.5 °F).
9 Table 8 in the document *FAA Holdover Time Guidelines Winter 2016-2017, Original Issue: August 5, 2016* provides the glycol base information for each fluid. If the fluid base is unknown, assume it is propylene glycol for the purpose of determining holdover times.

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce HOT below the lowest time stated in the range. HOT may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE EG-90%. 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES FOR SAE TYPE IV ETHYLENE GLYCOL BASED FLUIDS[9] IN SNOW, SNOW GRAINS OR SNOW PELLETS BELOW -14 °C (7 °F) TO LOUT

Outside Air Temperature[1] Degrees Celsius	Outside Air Temperature[1] Degrees Fahrenheit	Type IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Snow, Snow Grains or Snow Pellets[2] Light[3]	Snow, Snow Grains or Snow Pellets[2] Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	Refer to holdover times provided in the appropriate fluid-specific or generic holdover time table published in the document *FAA Holdover Time Guidelines Winter 2016-2017 Original Issue: August 5, 2016*							CAUTION: No holdover time guidelines exist
		75/25								
		50/50								
below -3 to -14	below 27 to 7	100/0								
		75/25								
below-14 to LOUT[8]	below 7 to LOUT[8]	100/0		0:36-0:45	0:27-0:36	0:14-0:27				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).
8 Refer to the fluid-specific holdover time (HOT) table in the document *FAA Holdover Time Guidelines Winter 2016-2017, Original Issue: August 5, 2016* for the LOUT of each fluid. This information is also provided in Table 8 of the same document. If the LOUT is unknown, no holdover times exist below -22.5 °C (-8.5 °F).
9 Table 8 in the document *FAA Holdover Time Guidelines Winter 2016-2017, Original Issue: August 5, 2016* provides the glycol base information for each fluid. If the fluid base is unknown, assume it is propylene glycol for the purpose of determining holdover times.

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce HOT below the lowest time stated in the range. HOT may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

FAA Holdover Time Guidelines **Winter 2016-2017**

THIS TABLE IS FOR USE WHEN FLAPS/SLATS ARE DEPLOYED PRIOR TO DE/ANTI-ICING

TABLE PG-90%. 90 PERCENT ADJUSTED HOLDOVER TIME GUIDELINES FOR SAE TYPE II AND TYPE IV PROPYLENE GLYCOL BASED FLUIDS[9] IN SNOW, SNOW GRAINS OR SNOW PELLETS BELOW -14 °C (7 °F) TO LOUT

Outside Air Temperature[1]		Type II/IV Fluid Concentration Neat-Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets[2] Very Light[3]	Snow, Snow Grains or Snow Pellets[2] Light[3]	Snow, Snow Grains or Snow Pellets[2] Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	Refer to holdover times provided in the appropriate fluid-specific or generic holdover time table published in the document *FAA Holdover Time Guidelines Winter 2016-2017 Original Issue: August 5, 2016*							CAUTION: No holdover time guidelines exist
		75/25								
		50/50							CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0								
		75/25								
below -14 to -18	below 7 to 0	100/0		0:36-0:45	0:27-0:36	0:14-0:27	CAUTION: No holdover time guidelines exist			
below -18 to LOUT[8]	Below 0 to LOUT[8]	100/0		0:18-0:23	0:09-0:18	0:07-0:09				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I fluid when Type II/IV fluid cannot be used.
2 To determine snowfall intensity, the Snowfall Intensities as a Function of Prevailing Visibility table (Table 7) is required.
3 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
4 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
5 No holdover time guidelines exist for this condition for 0 °C (32 °F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, small hail and hail (Table 6 provides allowance times for ice pellets and small hail).
7 No holdover time guidelines exist for this condition below -10 °C (14 °F).
8 Refer to the fluid-specific holdover time (HOT) table in the document *FAA Holdover Time Guidelines Winter 2016-2017, Original Issue: August 5, 2016* for the LOUT of each fluid. This information is also provided in Table 8 of the same document. If the LOUT is unknown, no holdover times exist below -22.5 °C (-8.5 °F).
9 Table 8 in the document *FAA Holdover Time Guidelines Winter 2016-2017, Original Issue: August 5, 2016* provides the glycol base information for each fluid. If the fluid base is unknown, assume it is propylene glycol for the purpose of determining holdover times.

CAUTIONS:

- **The time of protection will be shortened in heavy weather conditions. Heavy precipitation rates or high moisture content, high wind velocity, or jet blast may reduce HOT below the lowest time stated in the range. HOT may be reduced when aircraft skin temperature is lower than outside air temperature.**
- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**
- **This table is for departure planning only and should be used in conjunction with pretakeoff check procedures.**

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APPENDIX L

TEST PLAN 2015-16:
CONDUCT HOT TESTING IN NORTHERN LOCATIONS TO VALIDATE HOT DATA AT -25°C AND CLOSE TO LOUT TO SUPPORT GENERIC HOTS – TEST REQUIREMENTS FOR NATURAL PRECIPITATION FLAT PLATE TESTING

CM2480.002

TEST PLAN 2015-16

CONDUCT HOT TESTING IN NORTHERN LOCATIONS TO VALIDATE HOT DATA AT -25°C AND CLOSE TO LOUT TO SUPPORT GENERIC HOTs

TEST REQUIREMENTS
FOR NATURAL PRECIPITATION FLAT PLATE TESTING

Winter 2015-16

Prepared for

Transportation Development Centre
Transport Canada

Prepared by: David Youssef

Reviewed by: John D'Avirro

APS Aviation Inc.

December, 2015
Final Version 1.1

TEST PLAN 2015-16

CONDUCT HOT TESTING IN NORTHERN LOCATIONS TO VALIDATE HOT DATA AT -25°C AND CLOSE TO LOUT TO SUPPORT GENERIC HOTs

1. OBJECTIVE

To conduct holdover time testing in northern locations to validate the generic holdover time data at -25 °C and close to the LOUT in the evaluation of generic holdover times.

APS plans to track the weather trends in various locations in the far North, in order to find an opportunity for testing around -25 °C, with enough snowfall to allow for a few days of testing.

2. PROCEDURE

Endurance time tests will be conducted using the procedures outlined in the program procedure: *Test Requirements: For Natural Precipitation Flat Plate Testing, December 23rd 2004.* In addition the following criteria will be followed:

- Transport Canada and the FAA should be present for this testing;
- More frequent Brix and thickness measurements should be recorded;
- All tests will be with Neat Dilutions; and
- Ideally rates higher than $5g/dm^2/hr$ should be targeted.

A request was sent out for LOWV fluids from all manufacturers that currently have commercialized fluids on the guidelines. At the time of this publication only a select amount of fluids were confirmed to be used in this testing. In some cases, it was agreed upon to test with MID viscosity fluid, where LOWV was not to be provided by the manufacturer. Although mid viscosity is not ideal, it was determined that it would be better to have mid viscosity data vs. having no data at all.

Table 1 provides a comprehensive test plan of all fluids that were requested. Testing will take place with only the fluids that were actually sent.

TEST REQUIREMENTS: FOR NATURAL PRECIPITATION FLAT PLATE TESTING

Table 1: Proposed Test Plan for 2015-16

FLUID TYPE	FLUID	Batch #	Viscosity	# of Tests Expected	Status
I	DOW EG[1] (Requires Hard Water)	LNT E188	-	2	Ready
	DOW PG[1] (Requires Hard Water)	Octaflo EF STD MIX	-	2	Ready
II	ABAX Ecowing 26	L15-320	LOWV	4	Needs Viscosity
	Aviation Shaanxi Cleanwing II		LOWV	4	Not Received Yet
	Newave FCY-2 Bio+	201412012 LS	LOWV	4	Needs Falling Ball
	Newave FCY-2	20151026001L	LOWV	4	Needs Viscosity
	Borygo Plane II	151028	LOWV	4	Needs Viscosity
	Kilfrost ABC-Ice Clear II	X/1/2/15	LOWV	4	Needs Viscosity
	Kilfrost ABC-3		MID	4	Not Received Yet
	Kilfrost ABC-K PLUS		MID	4	Not Received Yet
	Clariant Flight	DEG 4145408	MID	4	Needs Viscosity
	Clariant Flight Plus		MID	4	Not Received Yet
	LNT Solutions P250		LOWV	4	Not Received Yet
III	AllClear AeroClear MAX	CB1-PB8000A2	LOWV	4	Ready
IV	Kilfrost ABC S+	WT.12.13.ABC-S+	MID	4	Ready
	Cryotech Polar Guard Advance	PGA151209PA	LOWV	4	Needs Viscosity
	LNT Solutions E450		LOWV	4	Not Received Yet
	ABAX Ecowing AD 49	L 15-316	LOWV	4	Needs Viscosity
	Newave FCY 9311	201509001L	LOWV	4	Needs Viscosity
	Shaanxi Cleanway Cleansurface IV	15031901	LOWV	4	Needs Viscosity
	Clariant Safewing EG IV NORTH		LOWV	4	Not Received Yet
	Clariant Max Flight AVIA		LOWV	4	Not Received Yet

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Table 2: Proposed Test Plan for 2015-16 (Cont'd)

IV	DOW EG106	201400469-66	LOWV	4	Ready
	Clariant Max Flight O4	U49E0011966	LOWV	4	Needs Viscosity
	Clariant Sneg	TV534	LOWV	4	Needs Viscosity
	Clariant Launch	WT 11/12	MID	4	Needs Viscosity
	Clariant Launch Plus	TV523	LOWV	4	Needs Viscosity
Note: Some 2015-16 Submitted HOT fluids are listed above, however if new fluids are received, they should also be tested.					

3. PERSONNEL

Two employees will be required to travel for this testing including one senior individual.

4. EQUIPMENT

A detailed list of equipment will be required prior to departure. This is based upon the standard holdover time testing equipment. It is also recommended to review the list of equipment that is used for northern travel.

5. DATA FORMS

The following data form will be used to document fluid endurance time, Brix, and thickness data:

- Attachment I: End Condition Data Form

Rate measurements will be recorded using the electronic rate form typically used for endurance time testing.

ATTACHMENT I: END CONDITION FORM FOR ENDURANCE TIME TESTING

REMEMBER TO SYNCHRONIZE TIME WITH MSC - USE LOCAL TIME

LOCATION:	DATE:	RUN NUMBER:	STAND # :

TIME TO FAILURE FOR INDIVIDUAL CROSSHAIRS (real time)

	Plate 1	Plate 2	Plate 3	Plate 4	Plate 5	Plate 6
Time of Fluid Application:						
Initial Plate Temperature (°C) (NEEDS TO BE WITHIN 2°C OF AIR TEMP)						
Initial Fluid Temperature (°C) (NEEDS TO BE WITHIN 3°C OF AIR TEMP)						
FLUID NAME/DILUTION						
B1 B2 B3						
C1 C2 C3						
D1 D2 D3						
E1 E2 E3						
F1 F2 F3						
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA						

	Plate 7	Plate 8	Plate 9	Plate 10	Plate 11	Plate 12
Time of Fluid Application:						
Initial Plate Temperature (°C) (NEEDS TO BE WITHIN 2°C OF AIR TEMP)						
Initial Fluid Temperature (°C) (NEEDS TO BE WITHIN 3°C OF AIR TEMP)						
FLUID NAME/DILUTION						
B1 B2 B3						
C1 C2 C3						
D1 D2 D3						
E1 E2 E3						
F1 F2 F3						
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA						

AMBIENT TEMPERATURE: ________ °C

COMMENTS: ______________________________

NOTE: PLEASE ENSURE CORRECT FUNCTIONING OF PLATE TEMPERATURE LOGGING SYSTEM AT START OF TEST. AT THE END OF TEST SESSION, SAVE THE ELECTRONIC LOGGER FILE ON A FLOPPY DISK AND ALSO E-MAIL IT TO THE OFFICE. LABEL THE DISKETTE AND PLACE IT WITHIN THE DATA FORM ENVELOPE.

FAILURES CALLED BY: ______________________

LEADER / MANAGER: ______________________

APPENDIX M

TEST PLAN:
CONDUCT SNOWMAKER TESTS TO SUPPORT NATURAL SNOW DATA CLOSE TO -25°C FOR THE EVALUATION OF THE GENERIC HOTS

CM2480.002

TEST PLAN:
CONDUCT SNOWMAKER TESTS TO SUPPPORT NATURAL SNOW DATA CLOSE TO -25°C FOR THE EVALUATION OF THE GENERIC HOTs

Winter 2015-16

Prepared for

Transportation Development Centre
Transport Canada

Prepared by: David Youssef

and

John D'Avirro, Eng.

Reviewed by: John D'Avirro, Eng.

March 14, 2016
Final Version 1.0

TEST PLAN:
CONDUCT SNOWMAKER TESTS TO SUPPPORT NATURAL SNOW DATA CLOSE TO -25ºC FOR THE EVALUATION OF THE GENERIC HOTs

1. OBJECTIVE

There are two objectives to this research:

1. To support natural snow data collected in 2015-16 in northern locations during two events close to -25°C. The snowmaker data will be used to support the natural snow data and to further develop a correlation between the snowmaker and natural snow; and
2. To validate (-25°C) and possibly help develop (-35°C) Type III HOT values at cold temperatures.

In addition, a limited set of tests at high rates to replicate heavy snow conditions at -25°C have been planned.

2. PROCEDURE

Endurance time tests will be conducted using the procedures outlined in the program procedure: *Endurance Time Test Requirements for Simulated Snow Flat Plate Testing: Type II, III, AND IV Fluids,* January 23, 2008.

3. TEST PLAN

The test plan is provided in Table 3.1. This plan was developed to run tests with a selection of Lowest on Wing Viscosity (LOWV) fluids requested at the start of the winter. Tests were developed at rates of 3, 4, 10, 25, and 50 g/dm^2/h. Type III fluids were also included in this testing. A total of 160 tests were developed. Due to budgetary and priority limitations, it is expected that just over one-third will be completed.

The matrix was prioritized based on the following general notes and criteria:

- Expected number of tests for the 9 long days (6am to 6pm) is 48 tests. 1-day setup/calibration/dismantle; 6 tests per day planned but should be able to do more;

- Run a set of 5 (6) tests in its entirety for the lower performing natural snow ET fluids: pick lowest Type II and IV commercial LOWV fluids only;
- When doing triage on the sets of fluids, rates of 4, 10 and 25 g/dm^2/h are more important; rate of 4 or 10 is probably most appropriate as there is more natural data at this rate range;
- Priority 1's are a must; 2's are maybe and 3's are lower priority. About half are allocated to priority 1 and 2;
- Type III's are priority 1; TC has requested that -35°C tests are high priority. A second duplicate set of tests has been added with a priority 2;
- If fluids are not LOWV, then those tests (mid viscosity) become priority 3;
- All fluids (LOWV) are planned to be tested; at least one test should be conducted at rate of 10 g/dm^2/h; and
- Fluids that have a low highest useable precipitation rate (HUPR) were set as priority 1.

Table 3.1: Test Plan

Test #	Fluid	Batch #	Mid or LOWV fluid viscosity	Type	Dilution	Condition Temperature (°C)	Plate Set Temperature (°C)	Priority	Comments
1	FCY-2	20151026001L	LOWV	II	100	-23.4	6.1	1.0	
2	ABC-Ice Clear II	X/1/2/15	LOWV	II	100	-23.4	6.3	1.0	
3	FCY-2 Bio+	201412012 LS	LOWV	II	100	-23.4	6.4	1.0	
4	FCY 9311	201509001L	LOWV	IV	100	-22.6	5.0	1.0	
5	MP IV LAUNCH PLUS	TV523	LOWV	IV	100	-22.6	4.9	1.0	
6	All Clear Type III	CB1-PB8000A-2	LOWV	III	100	-22.9	5.7	1.0	
7	All Clear Type III	CB1-PB8000A-2	LOWV	III	100	-25	3.0	1.0	Boulder CO
8	All Clear Type III	CB1-PB8000A-2	LOWV	III	100	-25	4	1.0	Boulder CO
9	All Clear Type III	CB1-PB8000A-2	LOWV	III	100	-25	10	1.0	Boulder CO
10	All Clear Type III	CB1-PB8000A-2	LOWV	III	100	-25	25	1.0	Boulder CO
11	All Clear Type III	CB1-PB8000A-2	LOWV	III	100	-25	50	1.0	
12	ECOWING 26	L 15-320	LOWV	II	100	-25	10.0	1.0	
13	ECOWING 26	L 15-320	LOWV	II	100	-25	50.0	1.0	HUPR
14	FCY-2	20151026001L	LOWV	II	100	-25	3.0	1.0	
15	FCY-2	20151026001L	LOWV	II	100	-25	4.0	1.0	
16	FCY-2	20151026001L	LOWV	II	100	-25	10.0	1.0	
17	FCY-2	20151026001L	LOWV	II	100	-25	25.0	1.0	
18	FCY-2	20151026001L	LOWV	II	100	-25	50.0	1.0	
19	Cleanwing II	AvShaanxi/Cleanwing/LOWV	LOWV	II	100	-25	10.0	1.0	
20	Cleanwing II	AvShaanxi/Cleanwing/LOWV	LOWV	II	100	-25	50.0	1.0	HUPR
21	LNT P250	LNT/P250/LOUT	LOWV	II	100	-25	10.0	1.0	
22	ABC-Ice Clear II	X/1/2/15	LOWV	II	100	-25	3.0	1.0	
23	ABC-Ice Clear II	X/1/2/15	LOWV	II	100	-25	4.0	1.0	
24	ABC-Ice Clear II	X/1/2/15	LOWV	II	100	-25	10.0	1.0	
25	ABC-Ice Clear II	X/1/2/15	LOWV	II	100	-25	25.0	1.0	
26	ABC-Ice Clear II	X/1/2/15	LOWV	II	100	-25	50.0	1.0	
27	FCY-2 Bio+	201412012 LS	LOWV	II	100	-25	10.0	1.0	

Table 3.1: Test Plan (cont'd)

Test #	Fluid	Batch #	Mid or LOWV fluid viscosity	Type	Dilution	Condition Temperature (°C)	Plate Set Temperature (°C)	Priority	Comments
28	FCY-2 Bio+	201412012 LS	LOWV	II	100	-25	50.0	1.0	HUPR
29	ABC-3	(P2601)	Mid	II	100	-25	10.0	1.0	
30	YD-102	20121220	LOWV	II	100	-25	10.0	1.0	
31	Dow EG106	201400469-66	LOWV	IV	100	-25	10.0	1.0	
32	Dow EG106	201400469-66	LOWV	IV	100	-25	50.0	1.0	HUPR
33	Ecowing AD-49	L 15-316	LOWV_degraded	IV	100	-25	10.0	1.0	
34	Ecowing AD-49	L 15-316	LOWV_degraded	IV	100	-25	50.0	1.0	HUPR
35	FCY 9311	201509001L	LOWV	IV	100	-25	3.0	1.0	
36	FCY 9311	201509001L	LOWV	IV	100	-25	4.0	1.0	
37	FCY 9311	201509001L	LOWV	IV	100	-25	10.0	1.0	
38	FCY 9311	201509001L	LOWV	IV	100	-25	25.0	1.0	
39	FCY 9311	201509001L	LOWV	IV	100	-25	50.0	1.0	HUPR
40	Polar Guard	PGA151209PA	LOWV	IV	100	-25	10.0	1.0	
41	Polar Guard	PGA151209PA	LOWV	IV	100	-25	50.0	1.0	HUPR
42	LNT E450	LNT/E450/LOWV	LOWV	IV	100	-25	10.0	1.0	
43	Max Flight 04	U49e0011966	LOWV	IV	100	-25	10.0	1.0	
44	Max Flight 04	U49e0011966	LOWV	IV	100	-25	50.0	1.0	HUPR
45	Max Flight SNEG	TV534	LOWV	IV	100	-25	10.0	1.0	
46	Max Flight SNEG	TV534	LOWV	IV	100	-25	50.0	1.0	HUPR
47	MP IV LAUNCH PLUS	TV523	LOWV	IV	100	-25	3.0	1.0	
48	MP IV LAUNCH PLUS	TV523	LOWV	IV	100	-25	4.0	1.0	
49	MP IV LAUNCH PLUS	TV523	LOWV	IV	100	-25	10.0	1.0	
50	MP IV LAUNCH PLUS	TV523	LOWV	IV	100	-25	25.0	1.0	
51	MP IV LAUNCH PLUS	TV523	LOWV	IV	100	-25	50.0	1.0	
52	ABC-S Plus	WT 13-14 ABC-S+	Mid	IV	100	-25	10.0	1.0	
53	Cleansurface IV	15031901	LOWV	IV	100	-25	10.0	1.0	
54	Max Flight AVIA	TV 548	LOWV	IV	100	-25	10.0	1.0	

CONDUCT SNOWMAKER TESTS TO SUPPPORT NATURAL SNOW DATA CLOSE TO -25°C FOR THE EVALUATION OF THE GENERIC HOTs

Table 3.1: Test Plan (cont'd)

Test #	Fluid	Batch #	Mid or LOWV fluid viscosity	Type	Dilution	Condition Temperature (°C)	Plate Set Temperature (°C)	Priority	Comments
55	Max Flight AVIA	TV 548	LOWV	IV	100	-25	50.0	1.0	HUPR
56	EG IV NORTH	TV 549	LOWV	IV	100	-25	10.0	1.0	
57	EG IV NORTH	TV 549	LOWV	IV	100	-25	50.0	1.0	HUPR
58	ECO-SHIELD	160108D-CC	LOWV	IV	100	-25	10.0	1.0	
59	ECO-SHIELD	160108D-CC	LOWV	IV	100	-25	50.0	1.0	HUPR
60	All Clear Type III	CB1-PB8000A-2	LOWV	III	100	-35	3	1.0	Boulder CO
61	All Clear Type III	CB1-PB8000A-2	LOWV	III	100	-35	4	1.0	Boulder CO
62	All Clear Type III	CB1-PB8000A-2	LOWV	III	100	-35	10	1.0	Boulder CO
63	All Clear Type III	CB1-PB8000A-2	LOWV	III	100	-35	25	1.0	Boulder CO
64	All Clear Type III	CB1-PB8000A-2	LOWV	III	100	-35	50	1.0	Boulder CO
65	ECOWING 26	L 15-320	LOWV	II	100	TBD	TBD	3.0	
66	ECOWING 26	L 15-320	LOWV	II	100	-25	3.0	3.0	
67	ECOWING 26	L 15-320	LOWV	II	100	-25	4.0	2.0	
68	ECOWING 26	L 15-320	LOWV	II	100	-25	25.0	2.0	
69	Cleanwing II	AvShaanxi/Cleanwing/LOWV	LOWV	II	100	TBD	TBD	3.0	
70	Cleanwing II	AvShaanxi/Cleanwing/LOWV	LOWV	II	100	-25	3.0	3.0	
71	Cleanwing II	AvShaanxi/Cleanwing/LOWV	LOWV	II	100	-25	4.0	2.0	
72	Cleanwing II	AvShaanxi/Cleanwing/LOWV	LOWV	II	100	-25	25.0	2.0	
73	LNT P250	LNT/P250/LOUT	LOWV	II	100	TBD	TBD	3.0	
74	LNT P250	LNT/P250/LOUT	LOWV	II	100	-25	3.0	3.0	
75	LNT P250	LNT/P250/LOUT	LOWV	II	100	-25	4.0	2.0	
76	LNT P250	LNT/P250/LOUT	LOWV	II	100	-25	25.0	2.0	
77	LNT P250	LNT/P250/LOUT	LOWV	II	100	-25	50.0	3.0	
78	FCY-2 Bio+	201412012 LS	LOWV	II	100	-25	3.0	3.0	
79	FCY-2 Bio+	201412012 LS	LOWV	II	100	-25	4.0	2.0	
80	FCY-2 Bio+	201412012 LS	LOWV	II	100	-25	25.0	2.0	
81	MP II FLIGHT	DEG 4145408	Mid	II	100	TBD	TBD	3.0	

Table 3.1: Test Plan (cont'd)

Test #	Fluid	Batch #	Mid or LOWV fluid viscosity	Type	Dilution	Condition Temperature (°C)	Plate Set Temperature (°C)	Priority	Comments
82	MP II FLIGHT	DEG 4145408	Mid	II	100	-25	3.0	3.0	
83	MP II FLIGHT	DEG 4145408	Mid	II	100	-25	4.0	3.0	
84	MP II FLIGHT	DEG 4145408	Mid	II	100	-25	10.0	3.0	
85	MP II FLIGHT	DEG 4145408	Mid	II	100	-25	25.0	3.0	
86	MP II FLIGHT	DEG 4145408	Mid	II	100	-25	50.0	3.0	
87	ABC-3	(P2601)	Mid	II	100	TBD	TBD	3.0	
88	ABC-3	(P2601)	Mid	II	100	-25	3.0	3.0	
89	ABC-3	(P2601)	Mid	II	100	-25	4.0	3.0	
90	ABC-3	(P2601)	Mid	II	100	-25	25.0	3.0	
91	ABC-3	(P2601)	Mid	II	100	-25	50.0	3.0	
92	ABC-K Plus	K-112/1/16 (P2602)	Mid	II	100	TBD	TBD	3.0	
93	ABC-K Plus	K-112/1/16 (P2602)	Mid	II	100	-25	3.0	3.0	
94	ABC-K Plus	K-112/1/16 (P2602)	Mid	II	100	-25	4.0	3.0	
95	ABC-K Plus	K-112/1/16 (P2602)	Mid	II	100	-25	10.0	3.0	
96	ABC-K Plus	K-112/1/16 (P2602)	Mid	II	100	-25	25.0	3.0	
97	ABC-K Plus	K-112/1/16 (P2602)	Mid	II	100	-25	50.0	3.0	
98	YD-102	20121220	LOWV	II	100	TBD	TBD	3.0	
99	YD-102	20121220	LOWV	II	100	-25	3.0	3.0	
100	YD-102	20121220	LOWV	II	100	-25	4.0	2.0	
101	YD-102	20121220	LOWV	II	100	-25	25.0	2.0	
102	YD-102	20121220	LOWV	II	100	-25	50.0	3.0	
103	Dow EG106	201400469-66	LOWV	IV	100	TBD	TBD	3.0	
104	Dow EG106	201400469-66	LOWV	IV	100	-25	3.0	3.0	
105	Dow EG106	201400469-66	LOWV	IV	100	-25	4.0	2.0	
106	Dow EG106	201400469-66	LOWV	IV	100	-25	25.0	2.0	
107	Ecowing AD-49	L 15-316	LOWV_degraded	IV	100	TBD	TBD	3.0	
108	Ecowing AD-49	L 15-316	LOWV_degraded	IV	100	-25	3.0	3.0	

Table 3.1: Test Plan (cont'd)

Test #	Fluid	Batch #	Mid or LOWV fluid viscosity	Type	Dilution	Condition Temperature (°C)	Plate Set Temperature (°C)	Priority	Comments
109	Ecowing AD-49	L 15-316	LOWV_degraded	IV	100	-25	4.0	2.0	
110	Ecowing AD-49	L 15-316	LOWV_degraded	IV	100	-25	25.0	2.0	
111	Polar Guard	PGA151209PA	LOWV	IV	100	TBD	TBD	3.0	
112	Polar Guard	PGA151209PA	LOWV	IV	100	-25	3.0	3.0	
113	Polar Guard	PGA151209PA	LOWV	IV	100	-25	4.0	2.0	
114	Polar Guard	PGA151209PA	LOWV	IV	100	-25	25.0	2.0	
115	LNT E450	LNT/E450/LOWV	LOWV	IV	100	TBD	TBD	3.0	
116	LNT E450	LNT/E450/LOWV	LOWV	IV	100	-25	3.0	3.0	
117	LNT E450	LNT/E450/LOWV	LOWV	IV	100	-25	4.0	2.0	
118	LNT E450	LNT/E450/LOWV	LOWV	IV	100	-25	25.0	2.0	
119	LNT E450	LNT/E450/LOWV	LOWV	IV	100	-25	50.0	3.0	
120	Max Flight 04	U49e0011966	LOWV	IV	100	TBD	TBD	3.0	
121	Max Flight 04	U49e0011966	LOWV	IV	100	-25	3.0	3.0	
122	Max Flight 04	U49e0011966	LOWV	IV	100	-25	4.0	2.0	
123	Max Flight 04	U49e0011966	LOWV	IV	100	-25	25.0	2.0	
124	Max Flight SNEG	TV534	LOWV	IV	100	TBD	TBD	3.0	
125	Max Flight SNEG	TV534	LOWV	IV	100	-25	3.0	3.0	
126	Max Flight SNEG	TV534	LOWV	IV	100	-25	4.0	2.0	
127	Max Flight SNEG	TV534	LOWV	IV	100	-25	25.0	2.0	
128	MP IV LAUNCH	WT 11/12	Mid	IV	100	TBD	TBD	3.0	
129	MP IV LAUNCH	WT 11/12	Mid	IV	100	-25	3.0	3.0	
130	MP IV LAUNCH	WT 11/12	Mid	IV	100	-25	4.0	3.0	
131	MP IV LAUNCH	WT 11/12	Mid	IV	100	-25	10.0	3.0	
132	MP IV LAUNCH	WT 11/12	Mid	IV	100	-25	25.0	3.0	
133	MP IV LAUNCH	WT 11/12	Mid	IV	100	-25	50.0	3.0	
134	ABC-S Plus	WT 13-14 ABC-S+	Mid	IV	100	TBD	TBD	3.0	
135	ABC-S Plus	WT 13-14 ABC-S+	Mid	IV	100	-25	3.0	3.0	

Table 3.1: Test Plan (cont'd)

Test #	Fluid	Batch #	Mid or LOWV fluid viscosity	Type	Dilution	Condition Temperature (°C)	Plate Set Temperature (°C)	Priority	Comments
136	ABC-S Plus	WT 13-14 ABC-S+	Mid	IV	100	-25	4.0	3.0	
137	ABC-S Plus	WT 13-14 ABC-S+	Mid	IV	100	-25	25.0	3.0	
138	ABC-S Plus	WT 13-14 ABC-S+	Mid	IV	100	-25	50.0	3.0	
139	Cleansurface IV	15031901	LOWV	IV	100	TBD	TBD	3.0	
140	Cleansurface IV	15031901	LOWV	IV	100	-25	3.0	3.0	
141	Cleansurface IV	15031901	LOWV	IV	100	-25	4.0	2.0	
142	Cleansurface IV	15031901	LOWV	IV	100	-25	25.0	2.0	
143	Cleansurface IV	15031901	LOWV	IV	100	-25	50.0	3.0	
144	Max Flight AVIA	TV 548	LOWV	IV	100	TBD	TBD	3.0	
145	Max Flight AVIA	TV 548	LOWV	IV	100	-25	3.0	3.0	
146	Max Flight AVIA	TV 548	LOWV	IV	100	-25	4.0	2.0	
147	Max Flight AVIA	TV 548	LOWV	IV	100	-25	25.0	2.0	
148	EG IV NORTH	TV 549	LOWV	IV	100	TBD	TBD	3.0	
149	EG IV NORTH	TV 549	LOWV	IV	100	-25	3.0	3.0	
150	EG IV NORTH	TV 549	LOWV	IV	100	-25	4.0	2.0	
151	EG IV NORTH	TV 549	LOWV	IV	100	-25	25.0	2.0	
152	ECO-SHIELD	160108D-CC	LOWV	IV	100	TBD	TBD	3.0	
153	ECO-SHIELD	160108D-CC	LOWV	IV	100	-25	3.0	3.0	
154	ECO-SHIELD	160108D-CC	LOWV	IV	100	-25	4.0	2.0	
155	ECO-SHIELD	160108D-CC	LOWV	IV	100	-25	25.0	2.0	
156	All Clear Type III	CB1-PB8000A-2	LOWV	III	100	-35	3	2.0	
157	All Clear Type III	CB1-PB8000A-2	LOWV	III	100	-35	4	2.0	
158	All Clear Type III	CB1-PB8000A-2	LOWV	III	100	-35	10	2.0	
159	All Clear Type III	CB1-PB8000A-2	LOWV	III	100	-35	25	2.0	
160	All Clear Type III	CB1-PB8000A-2	LOWV	III	100	-35	50	2.0	

4. DAILY SCHEDULE

Testing will take place at PMG Technologies over the course of 9 days. A typical day will take place from 06:00 to 18:00; the early part of the day will be to cool the cold chamber to the desired temperature and testing is expected to start around 09:00. The daily schedule of testing is provided in Table 4.1.

Table 4.1: Daily Schedule

Day #	Day	Objective	Temp.	People
Setup	Wednesday March 9, 2016	Delivery of Snow machine to PMG (DY/DP)		
Setup	Thursday March 10, 2016	Packing of Support Equipment in Panel Van		
1	Friday March 11, 2016	Setup and Calibration	-25°C	DP/DY
2	Monday, March 14, 2016	see detailed plan	-25°C	DP/JD/DY
3	Tuesday, March 15, 2016	see detailed plan	-25°C	DP/DY
4	Wednesday March 16, 2016	see detailed plan	-25°C	DP/Junior
5	Thursday March 17, 2016	see detailed plan	-25°C	DP/Junior
6	Friday March 18, 2016	see detailed plan	-23.5°C	DP/Junior
7	Monday, March 21, 2016	see detailed plan	-25°C	DP/Junior
8	Tuesday, March 22, 2016	see detailed plan	-25°C	DP/Junior
9	Wednesday March 23, 2016	Testing at -35°C and dismantle at 4pm	-35°C	DP/DY/Junior
Tear down	Thursday March 24, 2016	Packing and Return of Snow machine to Test Site (DY/DP/other)		

5. SETUP, EQUIPMENT and FLUIDS

Due to the complexity of this testing and because the snow machine needs to be moved, a series of tasks were developed that mostly relate to the movement of the snow machine; these are included in Table 5.1. A special equipment list was prepared and is included in Table 5.2. A list of fluids to be tested is included in Table 5.3.

Table 5.1: Task List

Check that all cables will reach the new location of the Snowmaker.
Insulate Telephone cable wire X 2 (need back up).
Purchase anti-vibration mats from hardware store.
Cut out center of anti-vibration mats so scale and granite block are isolated from snowmaker enclosure.
Make sure that adaptive plug for Revco freezer that was made last time is found and ready.
Finalize list of participants for PMG.
Finalize Contract with PMG.
Contact an arrange shipping of snowmaker.
Check with NRC Climate Chamber Planner about Steve coming with Truck to Montreal.
Finalize test plan with JD.
Verify Fluid List.
Test Backup scale.
Develop Excel file for Daily Communication of results.
Develop Personnel Plan.
Develop drop-off equipment day plan (setting up freezer, water, ice core tubes etc.).
Dismantling of snowmaker and packing.
Assembly of snowmaker at PMG.
Finalize test matrix.
Input batch numbers in Matrix.

Table 5.2: Equipment List

EQUIPMENT	LOCATION	STATUS
Snow making machine and related equipment	Site	
NCAR Computer, Monitor and Control Box	Site	
NCAR Weigh Scale x2	Site	
Air Compressor	Site	
Heat Gun	Site	
Small Important Allen Keys	Site	
Revco Freezer	Site	
All Large Ice Core Molds, 2-3 short Ice core molds	Site	
Styrofoam Covers for Ice Core Molds	Site	
PVC Pipe for Temporary Storage of Ice Cores	Site	
Clean Bucket and Clean Funnel for Ice Core Filling	Site	
18 liter containers of water (3)	Site	
Sartorius 2 g Scale with Cabling for Comm with Laptop	Site	
Aluminum plates with heating pads	Site	
Insulated box for heated tests	Site	
Snow Distribution Pans 100mm X 150mm (6 Pans)	Site	
Extra Wizz Pads	Site	
Additional PVC Wizz Pad Apparatus	Site	
Backup Drill Bit	Site	
Extra Coupler and GTCA coupler	Site	
2 additional Small Folding Tables	Site	
Electronic NCAR files	Site	
Squeegee/scraper	Site	
Extension cord	Site	
Wet vacuum	Site	
Blue Towel	Site	
Waste Container	Site	
Measuring Cup	Site	
Thermos x 1 and spreader x 1	Site	
Microwave	Site	
Small box to transport small Allen keys and other equip	Site	
NCAR tool box	Site	
Rate Distribution Excel file	Office	
Data Forms	Office	
NCAR Manual	Office	
Procedures	Office	

Table 5.3: List of Fluids

#	Fluid Name	Batch #	Viscosity Type	Type	Quantity Needed (l) Priority		
					1	2	3
1	Newave FCY-2	20151026001L	LOWV	II	6	0	0
2	Kilfrost ABC-Ice Clear II	X/1/2/15	LOWV	II	6	0	0
3	Newave FCY-2 Bio+	201412012 LS	LOWV	II	3	2	1
4	Abax ECOWING 26	L 15-320	LOWV	II	2	2	2
5	Aviation Shananxi Cleanwing II	AvShaanxi/Cleanwing/LOWV	LOWV	II	2	2	2
6	LNT P250	LNT/P250/LOUT	LOWV	II	1	2	3
7	Kilfrost ABC-3	(P2601)	MID	II	1	0	5
8	Yadilite YD-102	20121220	LOWV	II	1	2	3
9	Clariant MP II FLIGHT	DEG 4145408	MID	II	0	0	6
10	Kilfrost ABC-K Plus	K-112/1/16 (P2602)	MID	II	0	0	6
11	All Clear AeroClear MAX	CB1-PB8000A-2	LOWV	III	11	5	0
12	Newave FCY 9311	201509001L	LOWV	IV	6	0	0
13	Clariant MP IV LAUNCH PLUS	TV523	LOWV	IV	6	0	0
14	Dow EG106	201400469-66	LOWV	IV	2	2	2
15	Cryotech Polar Guard Advance	PGA151209PA	LOWV	IV	2	2	2
16	LNT E450	LNT/E450/LOWV	LOWV	IV	1	2	3
17	Clariant Max Flight 04	U49e0011966	LOWV	IV	2	2	2
18	Clariant Max Flight SNEG	TV534	LOWV	IV	2	2	2
19	Clariant MP IV LAUNCH	WT 11/12	MID	IV	0	0	6
20	Kilfrost ABC-S Plus	WT 13-14 ABC-S+	LOWV	IV	1	0	5
21	Aviation Shananxi Cleansurface IV	15031901	LOWV	IV	1	2	3
22	Clariant Max Flight AVIA	TV 548	LOWV	IV	2	2	2
23	Clariant EG IV NORTH	TV 549	LOWV	IV	2	2	2
24	Clariant ECO-SHIELD	160108D-CC	LOWV	IV	2	2	2
25	Abax Ecowing AD-49	L 15-316 (degraded)	LOWV	IV	2	2	2

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APPENDIX N

TEST PLAN:
ENDURANCE TIME TESTING IN FROST
WITH TYPE I, II, III AND IV FLUIDS —
FURTHER SUBSTANTIATION OF FROST HOLDOVER TIMES

CM2480.002

TEST PLAN:
ENDURANCE TIME TESTING IN FROST WITH TYPE I, II, III AND IV FLUIDS

Further Substantiation of Frost Holdover Times

Winter 2015-16

Prepared for

Transportation Development Centre
Transport Canada

Prepared by: Ben Bernier

and by: Chloë Bernier

Reviewed by: John D'Avirro

January, 2016
Final Version 2.0

TEST PLAN:
ENDURANCE TIME TESTING IN FROST
WITH TYPE I, II, III AND IV FLUIDS

Further Substantiation of Frost Holdover Times

1. OBJECTIVE

To conduct tests in natural frost conditions using LOWV samples of commercialized fluids, to further substantiate (validate) the current frost holdover times.

2. PROCEDURE

Endurance time tests will be conducted using the procedures outlined in the program procedure: *Endurance Time Testing in Frost with Type I, II, III and IV Fluids, November 13, 2003.*

3. TEST PLAN

The initial test plan is provided in Table 3.1. As testing events are completed, an updated test plan will be created.

At the time that this test plan was written, the table shows some fluids that have been ordered but not yet received.

Table 3.1: Test Plan for Further Frost Substantiation

LOWV Fluid	TYPE	Dilution	TEST						Comments
			≥ -1	<-1 to -3	<-3 to -10	<-10 to -14	<-14 to -21	<-21	
ABAX Ecowing 26	2	100	yes	yes	no	no	no	yes	
ABAX Ecowing 26	2	75	yes	yes	no	no	N/A	N/A	
ABAX Ecowing 26	2	50	yes	no	N/A	N/A	N/A	N/A	
ABAX Ecowing AD 49	4	100	yes	yes	yes	yes	no	yes	
ABAX Ecowing AD 49	4	75	yes	yes	yes	yes	N/A	N/A	
ABAX Ecowing AD 49	4	50	yes	yes	N/A	N/A	N/A	N/A	
AllClear AeroClear MAX	3	100	no	yes	yes	no	no	yes	
Aviation Shaanxi Cleanwing II	2	100	yes	yes	yes	yes	yes	yes	Not received yet
Aviation Shaanxi Cleanwing II	2	75	yes	yes	yes	yes	N/A	N/A	Not received yet
Aviation Shaanxi Cleanwing II	2	50	yes	yes	N/A	N/A	N/A	N/A	Not received yet
Clariant LAUNCH PLUS	4	100	yes	yes	no	yes	no	yes	Inventory: TV523
Clariant LAUNCH PLUS	4	50	no	no	N/A	N/A	N/A	N/A	Inventory: TV523
Clariant Max Flight 04	4	100	yes	yes	yes	yes	no	yes	Inventory: U49e0011966
Clariant Max Flight SNEG	4	100	yes	yes	yes	yes	no	yes	Inventory: TV534
Cryotech Polar Guard Advance	4	100	yes	yes	yes	yes	no	yes	
Cryotech Polar Guard Advance	4	75	yes	yes	yes	yes	N/A	N/A	
Cryotech Polar Guard Advance	4	50	yes	yes	N/A	N/A	N/A	N/A	
Dow EG 106	4	100	yes	yes	no	yes	no	yes	
Kilfrost ABC-Ice Clear II	2	100	yes	yes	no	no	no	yes	
Kilfrost ABC-Ice Clear II	2	75	yes	yes	no	no	N/A	N/A	
Kilfrost ABC-Ice Clear II	2	50	no	no	N/A	N/A	N/A	N/A	
LNT Solutions E450	4	100	yes	yes	yes	yes	no	no	Not received yet
LNT Solutions P250	2	100	yes	no	no	no	yes	yes	Not received yet
LNT Solutions P250	2	75	no	no	no	no	N/A	N/A	Not received yet
LNT Solutions P250	2	50	no	no	N/A	N/A	N/A	N/A	Not received yet
Newave FCY 9311	4	100	yes	yes	yes	yes	no	yes	
Newave FCY-2	2	100	yes	yes	no	yes	no	yes	
Newave FCY-2	2	75	yes	yes	yes	no	N/A	N/A	
Newave FCY-2	2	50	yes	yes	N/A	N/A	N/A	N/A	
Newave FCY-2 Bio+	2	100	yes	yes	no	no	no	no	
Newave FCY-2 Bio+	2	75	yes	yes	no	no	N/A	N/A	
Newave FCY-2 Bio+	2	50	no	no	N/A	N/A	N/A	N/A	
HOT Fluids	**TYPE**	**Dilution**	**≥ -1**	**<-1**	**<-3**	**<-10**	**<-14**	**<-21**	**Comments**
HOT Fluid #1	4	100	yes	yes	yes	yes	no	yes	
HOT Fluid #1	4	75	yes	yes	yes	yes	N/A	N/A	
HOT Fluid #1	4	50	yes	yes	N/A	N/A	N/A	N/A	
HOT Fluid #2	4	100	yes	yes	yes	yes	no	yes	
HOT Fluid #2	4	75	yes	yes	yes	yes	N/A	N/A	
HOT Fluid #2	4	50	yes	yes	N/A	N/A	N/A	N/A	
HOT Fluid #3	2	100	yes	yes	yes	yes	no	yes	
HOT Fluid #3	2	75	yes	yes	yes	yes	N/A	N/A	
HOT Fluid #3	2	50	yes	yes	N/A	N/A	N/A	N/A	
HOT Fluid #4	4	100	yes	yes	yes	yes	no	yes	
HOT Fluid #4	4	75	yes	yes	yes	yes	N/A	N/A	
HOT Fluid #4	4	50	yes	yes	N/A	N/A	N/A	N/A	
HOT Fluid #5	2	100	yes	yes	yes	yes	yes	yes	
HOT Fluid #5	2	75	yes	yes	yes	yes	N/A	N/A	
HOT Fluid #5	2	50	yes	yes	N/A	N/A	N/A	N/A	

Note: The following fluids were requested but will not be provided by the manufacturer: Clariant Safewing MP II FLIGHT 100/0, 75/25, 50/50; Kilfrost ABC-3 100/0, 75/25, 50/50; Kilfrost ABC-K Plus 100/0, 75/25, 50/50; Clariant Safewing MP III 2031 ECO 75/25; Clariant Safewing MP IV LAUNCH 100/0, 75/25, 50/50; Kilfrost ABC-S Plus 100/0, 75/25, 50/50.

The test plan was developed based upon the analysis that was conducted and reported in the TC report, TP 15304E, *Aircraft Ground Icing General Research Activities during the 2014-15 Winter.* Table 3.2 shows an excerpt of this analysis that was used in the creation of the test plan.

If not all tests marked "Yes" for testing can be poured during a given frost event, priority should be given to the tests that fill a needed cell as per Table 3.2.

Table 3.2 – Frost Data Targets for Winter 2015-16 Testing Season

OAT (°C)	Fluid Conc.	Cells to Target For Data Acquisition			
		Type I	Type II	Type III	Type IV
-1 and Above	100/0	OK	Not OK	OK	Not OK
	75/25		OK	No Fluid	Not OK
	50/50		OK	OK	Not OK
Below -1 to -3	100/0	OK	OK	Not OK	Not OK
	75/25		OK	No Fluid	OK
	50/50		OK	No Fluid	OK
Below -3 to -10	100/0	OK	OK	OK	OK
Below -10 to -14	100/0	OK	OK	OK	Not OK
	75/25		OK	OK	Not OK
Below -14 to -21	100/0	OK	OK	OK	OK
Below -21 to -25	100/0	OK	Not OK	Not OK	Not OK
The minimum targets are 2 data points per holdover time table cell.					

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