TP 15228E

Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2012-13 Winter

Prepared for

Transportation Development Centre

In cooperation with

Civil Aviation
Transport Canada

and

The Federal Aviation Administration
William J. Hughes Technical Center

Prepared by

APS Aviation Inc.

March 2014

Final Version 1.0

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Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2012-13 Winter

by

Stephanie Bendickson

APS Aviation Inc.

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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 specific 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 weather data from previous winters that can have an impact on the format of the holdover time guidelines;
- To conduct general and exploratory de/anti-icing research;
- To conduct tests to evaluate the effect of deployed flaps and slats prior to anti-icing;
- To conduct tests and research on surfaces treated with ice phobic products;
- To conduct tests to evaluate holdover times in heavy snow conditions;
- To develop an SAE AIR for the evaluation of aircraft coatings;
- To support the evaluation of the National Research Council Canada propulsion icing wind tunnel to determine its flow characteristics;
- To develop holdover time guidance for operation in ice crystal conditions;
- To continue research for development of ice detection capabilities for pre-deicing, engine deicing and departing aircraft at the runway threshold;
- To develop a performance specification for electronic holdover time applications;
- To investigate pre-takeoff contamination check 5-minute allowance;
- To conduct full-scale general aviation aircraft windshield washer fluid deicing testing to substantiate and support flat plate testing results;
- To update the regression coefficient report with the newly-qualified de/anti-icing fluids; and
- To develop Type II/IV holdover times in light and very light snow conditions.

The research activities of the program conducted on behalf of Transport Canada during the winter of 2012-13 are documented in seven reports. The titles of the reports are as follows:

- TP 15227E Winter Weather Impact on Holdover Time Table Format (1995-2013);
- TP 15228E Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2012-13 Winter;
- TP 15229E Regression Coefficients and Equations Used to Develop the Winter 2013-14 Aircraft Ground Deicing Holdover Time Tables;
- TP 15230E Aircraft Ground Icing General Research Activities During the 2012-13 Winter;
- TP 15231E Cold Climate Technologies – Investigation of Sensor Technologies as an Alternative Means of Detecting Aircraft Icing (Year 2 of 3);

- TP 15232E Wind Tunnel Trials to Examine Anti-Icing Fluid Flow-Off Characteristics and to Support the Development of Ice Pellet Allowance Times, Winters 2009-10 to 2012-13; and
- TP 15233E Exploratory Wind Tunnel Aerodynamic Research, Winter 2012-13.

In addition, the following two interim reports are being prepared:

- *Evaluation of Endurance Times on Extended Flaps and Slats; and*
- *Investigation of Ice Phobic Technologies to Reduce Aircraft Icing in Northern and Cold Climates (Year 2 of 3).*

This report, TP 15228E 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.

The 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, the Meteorological Service of Canada, and several fluid manufacturers.

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, Kirby Bennett; Patrick Caines; John D’Avirro, Jesse Dybka, Derek Foebel; Benjamin Guthrie, Dany Posteraro, Marco Ruggi, James Smyth, Fillipo Suriano; David Youssef and Victoria Zoitakis.

Special thanks are extended to Howard Posluns, Yvan Chabot, Doug Ingold and Warren Underwood, 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

APS Aviation Inc. would like to acknowledge the contributions of the following organizations to this project: Meteorological Services Canada and Aéroports de Montréal for providing an outdoor testing location, and the fluid manufacturers for providing support and funding.

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15. Supplementary Notes (Funding programs, titles of related publications, etc.)

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 2012-13 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 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 snow, artificial snow, simulated freezing fog, simulated freezing drizzle, simulated light freezing rain, and simulated rain on a cold-soaked wing. A total of 494 tests were conducted with eight fluids. Supplemental testing/analysis was also completed in support of the development of light and very light snow holdover times for Type II/IV fluids.

Changes to the holdover time guidelines for the winter of 2013-14 include:

- Fluid-specific HOT guidelines were added for two new fluids: Cryotech Polar Guard II (Type II) and Clariant Safewing MP IV Launch Plus (Type IV);
- Changes to the Clariant Safewing MP II Flight Plus 100/0 and 75/25 snow holdover times as the result of supplemental testing;
- LNT Solutions P250 (Type II) and Kilfrost ABC-4sustain (Type IV) were removed from the guidelines at the request of the manufacturers. The fluids were never commercialized;
- Clariant Max Flight 04 75/25 and 50/50 dilutions were removed from the guidelines at the request of the manufacturer;
- Light and very light snow holdover times were added to many of the Type II and Type IV fluid-specific HOT tables. The "snow" column in these tables was renamed "moderate snow;"
- The FAA increased its cap on snow holdover times from 2 to 3 hours. This resulted in several increases to Type IV holdover times;
- Nine increases were made to the Type IV generic HOT guidelines as a result of removed fluids; and
- Ice crystals were added to the freezing fog column of all HOT tables.

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 holdover time guidelines. It is also recommended that fluid-specific and fluid application temperature specific holdover time guidelines for Type III fluids be developed in the winter of 2013-14 and that further testing be carried out to evaluate holdover times of Type III fluids applied heated to composite surfaces.

17. Key Words	18. Distribution Statement
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15. Remarques additionnelles (programmes de financement, titres de publications connexes, etc.)

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 2012-2013 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 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 494 essais ont été menés, avec huit liquides. Des essais et analyses supplémentaires ont également été effectués afin d'appuyer l'établissement de durées d'efficacité dans des conditions de neige faible et très faible pour les liquides de type II ou de type IV.

Parmi les changements apportés aux lignes directrices relatives aux durées d'efficacité pour l'hiver 2013-2014, on note ce qui suit.

- Des lignes directrices relatives aux durées d'efficacité spécifiques à deux nouveaux liquides, soit Cryotech Polar Guard II (type II) et Clariant Safewing MP IV Launch Plus (type IV), ont été ajoutées.
- À la suite de tests supplémentaires, des modifications ont été apportées aux durées d'efficacité dans des conditions de neige du liquide Clariant Safewing MP II Flight Plus 100/0 et 75/25.
- À la demande des fabricants, les liquides LNT Solutions P250 (type II) et Kilfrost ABC-4sustain (type IV) ont été retirés des lignes directrices. Ces liquides n'ont jamais été commercialisés.
- À la demande du fabricant, les dilutions 75/25 et 50/50 du liquide Clariant Max Flight 04 ont été retirées des lignes directrices.
- Des durées d'efficacité dans des conditions de neige faible et très faible ont été ajoutées à plusieurs des tableaux des durées d'efficacité spécifiques aux liquides de type II et de type IV. La colonne « neige » de ces tableaux a été renommée « neige modérée ».
- La FAA a procédé à une hausse de son plafond des durées d'efficacité dans des conditions de neige, le faisant passer de 2 à 3 heures. Cette hausse a entraîné de nombreuses augmentations des durées d'efficacité des liquides de type IV.
- Le retrait de certains liquides a entraîné l'augmentation, dans neuf cas, des durées d'efficacité génériques des liquides de type IV.
- L'élément « cristaux de glace » a été ajouté à la colonne sur le brouillard verglaçant de tous les tableaux 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 tableaux des durées d'efficacité. Il est également recommandé que l'élaboration de lignes directrices sur les durées d'efficacité spécifiques aux liquides de type III et à leurs températures d'application soit amorcée au cours de l'hiver 2013-2014, et que des essais supplémentaires soient menés dans le but d'évaluer les durées d'efficacité des liquides de type III appliqués chauffés sur des surfaces composites.

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 2013-14.

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 2012-13 test season, data was collected during natural snow events at the APS test site at Montreal-Trudeau Airport in Montreal and in simulated precipitation conditions, including freezing drizzle, light freezing rain, freezing fog, and rain on cold-soaked surfaces, at the National Research Council Canada (NRC) Climatic Engineering Facility (CEF) in Ottawa.

APS conducted 494 tests in the winter of 2012-13. The results of testing were incorporated into the winter 2013-14 HOT guidelines.

Changes to the HOT Guidelines

The changes below were made to the HOT guidelines for winter 2013-14.

1. Fluid-specific HOT guidelines were added for two new fluids: Cryotech Polar Guard II (Type II) and Clariant Safewing MP IV Launch Plus (Type IV).

2. Changes were made to the Clariant Safewing MP II Flight Plus 100/0 and 75/25 snow holdover times as the result of supplemental testing.

3. LNT Solutions P250 (Type II) and Kilfrost ABC-4^{sustain} (Type IV) were removed from the guidelines at the request of the manufacturers. The fluids were never commercialized.

4. Clariant Max Flight 04 75/25 and 50/50 dilutions were removed from the guidelines at the request of the manufacturer.

5. Light and very light snow holdover times were added to many of the Type II and Type IV fluid-specific HOT tables. The "snow" column in these tables was renamed "moderate snow."

6. The FAA increased its cap on snow holdover times from 2 to 3 hours. This resulted in several increases to Type IV snow holdover times.

7. Nine increases were made to the Type IV generic HOT guidelines as a result of removed fluids (see above).

8. Ice crystals were added to the freezing fog column of all HOT 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. It is also recommended that fluid-specific and fluid application temperature specific HOT guidelines for Type III fluids be developed in the winter of 2013-14 and that further testing be carried out to evaluate holdover times of Type III fluids applied heated to composite surfaces.

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 2013-2014.

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 2012-2013 concernaient des tests sous neige naturelle menés à l'installation d'essai d'APS, à l'aéroport Montréal-Trudeau, à Montréal, ainsi que dans des conditions de précipitations simulées incluant de la bruine verglaçante, de la pluie verglaçante faible, du brouillard verglaçant et de la 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 2012-2013, un total de 494 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 2013-2014.

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 2013-2014.

1. Des lignes directrices relatives aux durées d'efficacité spécifiques à deux nouveaux liquides, soit Cryotech Polar Guard II (type II) et Clariant Safewing MP IV Launch Plus (type IV), ont été ajoutées.

2. À la suite de tests supplémentaires, des modifications ont été apportées aux durées d'efficacité dans des conditions de neige du liquide Clariant Safewing MP II Flight Plus 100/0 et 75/25.

3. À la demande des fabricants, les liquides LNT Solutions P250 (type II) et Kilfrost ABC-4^{sustain} (type IV) ont été retirés des lignes directrices. Ces liquides n'ont jamais été commercialisés.

4. À la demande du fabricant, les dilutions 75/25 et 50/50 du liquide Clariant Max Flight 04 ont été retirées des lignes directrices.

5. Des durées d'efficacité dans des conditions de neige faible et très faible ont été ajoutées à plusieurs des tableaux des durées d'efficacité spécifiques aux liquides de type II et de type IV. La colonne « neige » de ces tableaux a été renommée « neige modérée ».

6. La FAA a procédé à une hausse de son plafond des durées d'efficacité dans des conditions de neige, le faisant passer de 2 à 3 heures. Cette hausse a entraîné de nombreuses augmentations des durées d'efficacité dans des conditions de neige des liquides de type IV.

7. Le retrait de certains liquides (voir ci-dessus) a entraîné l'augmentation, dans neuf cas, des durées d'efficacité génériques des liquides de type IV.

8. L'élément « cristaux de glace » a été ajouté à la colonne sur le brouillard verglaçant de tous les tableaux des durées d'efficacité.

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 tableaux des durées d'efficacité. Il est également recommandé que l'élaboration de lignes directrices sur les durées d'efficacité spécifiques aux liquides de type III et à leurs températures d'application soit amorcée au cours de l'hiver 2013-2014, et que des essais supplémentaires soient menés dans le but d'évaluer les durées d'efficacité des liquides de type III appliqués chauffés sur des surfaces composites.

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GLOSSARY

AIR	Aerospace Information Report
AMS	Aerospace Material Specification
APS	APS Aviation Inc.
ARP	Aerospace Recommended Practice
CEF	Climatic Engineering Facility
FAA	Federal Aviation Administration
HDNF	Historical Did Not Fail
HOT	Holdover Time
HOTDS	Holdover Time Determination System
LOUT	Lowest Operational Use Temperature
LOWV	Lowest On-Wing Viscosity
LUPR	Lowest Usable Precipitation Rate
LWES	Liquid Water Equivalent System
MSC	Meteorological Service of Canada
NRC	National Research Council Canada
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), the Meteorological Service of Canada (MSC), 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 2012-13 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 2013-14.

The detailed objectives of the 2012-13 test program are provided in the work statement given 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 / Ice Pellet 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 / Ice Pellet 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 / Ice Pellet 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 / Ice Pellet 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)

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 the 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 2012-13 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 supplemental testing and analysis completed to determine light and very light snow holdover times for select Type II and Type IV fluids;

g) Section 8 presents conclusions derived from the test program; and

h) Section 9 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 2012-13 FAA HOT guidelines are intended to be used in conjunction with N 8900.238, *Revised FAA-Approved Deicing Program Updates, Winter 2013-2014* (3), which provides additional guidance and reference material. N 8900.238 (3) is also available on the FAA website.

2. TESTING IN 2012-13

An overview of the testing completed in the winter of 2012-13 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 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 SAE 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 2012-13 winter are included in Appendix B. They include:

1. Test Requirements for Natural Precipitation Flat Plate Testing;
2. Determination of Endurance Times of Type I Fluids Under Natural Snow Precipitation at Dorval;
3. Test Requirements for Simulated Freezing Precipitation Flat Plate Testing;
4. Overall Program of Tests at NRC, April 2013; and
5. Overall Program of Tests at NRC, September 2013.

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 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 procedure provides detailed test plans, personnel assignments, fluid requirements and the precipitation schedule.

The fifth procedure was developed to coordinate testing at a supplemental test session at the NRC climate chamber in September 2013.

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).

2.2 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 a mobile test site at Montreal Mirabel Airport.

Artificial snow testing was required in the winter of 2012-13 (see Section 3.1). It was conducted at the APS test site at the Montreal airport.

2.3 Fluids Tested

Eight fluids underwent endurance time testing in the winter of 2012-13. As described in Section 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).

The fluids tested in 2012-13 are summarized below.

- <u>Baltic Ground Services Defrosol ADF</u>: This Type I fluid underwent testing in freezing and artificial snow conditions in September 2013. The detailed test results are provided in Appendix C.

- <u>Clariant Safewing MP II Flight Plus</u>: This Type II fluid underwent endurance time testing in winter 2011-12; however, natural snow testing was not completed due to the late submission of the fluid. Natural snow testing was therefore completed in the winter of 2012-13. The detailed test results from both winters are provided in Appendix D.

- Clariant Safewing MP IV Launch Plus: This new Type IV fluid underwent a complete set of testing in winter 2012-13 and was expected to be commercialized in the winter of 2013-14. The detailed test results are provided in Appendix E.

- LNT P250: This Type II fluid underwent endurance time testing in winter 2011-12; however, natural snow testing was not completed due to the late submission of the fluid. Natural snow testing was therefore completed in the winter of 2012-13. At the request of the manufacturer, the fluid was removed from the HOT Guidelines following testing. The detailed results of testing with this fluid are therefore not included in this report.

- Type III Fluid: A Type III fluid was submitted for testing using the heated application test protocol. Due to the late submission of the fluid in the winter, testing in natural snow could not be completed. Testing is expected to be completed in winter 2013-14. As the test results will not be incorporated into the HOT guidelines at this time, they are not provided in this report.

- Type II Experimental Fluids: Two Type II experimental fluids were submitted for testing. Testing was cancelled midway through the winter. These fluids will not be commercialized and therefore the results are not provided in this report.

Additional relevant fluid receipt data for the three tested commercialized fluids is provided in Tables 2.1 (fluid receipt data), 2.2 (fluid viscosity and Brix), and 2.3 (fluid freeze point, lowest operational use temperature (LOUT) and water spray endurance test (WSET) information).

Table 2.1: Fluid Receipt Data (Commercialized Fluids)

Fluid Manufacturer	Fluid Name	Fluid Type	Fluid Formulation	Date Received	Dilution(s) Received	Batch #
Baltic Ground Services	Defrosol ADF	I	Non-Glycol (Propylene Glycol and Glycerine)	24-Jul-13	Concentrate	56-130619
Clariant	Safewing MP II Flight Plus	II	Propylene Glycol	1-Mar-12	100%, 75%, 50%	TV 513
Clariant	Safewing MP IV Launch Plus	IV	Propylene Glycol	13-Feb-13	100%, 75%, 50%	TV 523

Table 2.2: Fluid Brix and Viscosity (Commercialized Fluids)

Fluid	Fluid Dilution	Brix Measured	Viscosity (Manufacturer Method)		Viscosity (AIR 9968 Method)	
			Stated (mPa.s)	**Measured** (mPa.s)	**Stated** (mPa.s)	**Measured** (mPa.s)
BGS Defrosol ADF	Conc.	>50°	n/a	n/a	n/a	n/a
Clariant Safewing MP II Flight Plus	100%	35.25°	3,520 [1]	3,650 [1]	3,400 [2]	3,100 [2]
	75%	28.25°	8,660 [1]	12,400 [1]	9,040 [2]	10,450 [2]
	50%	19.75°	5,500 [1]	7,800 [1]	6,970 [2]	7,050 [2]
Clariant Safewing MP IV Launch Plus	100%	35.0°	8,400 [3]	8,700 [3]	8,300 [2]	8,450 [2]
	75%	28.75°	17,400 [4]	18,800 [4]	19,100 [5]	17,200 [5]
	50%	18.75°	15,200 [4]	9,700 [3]	14,100 [5]	12,150 [2]

[1] Spindle LV1, big sample adapter, 50 mL of fluid, 20°C, 0.3 rpm, for 10 minutes 0 seconds
[2] Spindle LV1 with guard leg, 600 mL beaker, 500 mL of fluid, 20°C, 0.3 rpm, for 10 minutes 0 seconds
[3] Spindle LV1, big sample adapter, 55 mL of fluid, 20°C, 0.3 rpm, for 10 minutes 0 seconds
[4] Spindle LV2-disc, big sample adapter, 60 mL of fluid, 20°C, 0.3 rpm, for 10 minutes 0 seconds
[5] Spindle LV2-disc with guard leg, 600 mL beaker, 500 mL of fluid, 20°C, 0.3 rpm, for 10 minutes 0 seconds

Table 2.3: Fluid Freeze Point, LOUT and WSET (Commercialized Fluids)

Fluid	Fluid Dilution	WSET (AMIL)	Freeze Point (Stated)	LOUT (Stated)
BGS Defrosol ADF	Conc.	5.0 mins (50/50)	-34°C (60/40) -40°C (65/35) -45°C (70/30)	-25°C [1] -30°C [2]
Clariant Safewing MP II Flight Plus	100%	62 mins	-36°C	-29°C
	75%	n/a	-21°C	-14°C
	50%	n/a	-10°C	-3°C
Clariant Safewing MP IV Launch Plus	100%	87 mins	-36°C	-29°C
	75%	n/a	-21°C	-14°C
	50%	n/a	-11°C	-3°C

[1] Low speed ramp (65/35 dilution)
[2] High speed ramp (65/35 dilution)

2.4 Description of Tests

In total, 494 endurance time tests were conducted during the winter of 2012-13. A summary of the total number of tests conducted is shown by precipitation condition in Table 2.4. Details for each test are included in the detailed reports provided to the manufacturers (see Subsection 2.5).

Table 2.4: Summary of Tests Conducted

Precipitation Condition	Tests Conducted
Natural Snow	263
Artificial Snow	3
Freezing Fog	82
Freezing Drizzle	64
Light Freezing Rain	57
Rain on Cold-Soaked Surface	25
Total	**494**

2.5 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 C, D and E.

2.6 Light and Very Light Snow Holdover Times for Type II and Type IV Fluids

Testing and analysis was completed in the winter of 2012-13 in support of the development of light and very light snow holdover times for select Type II and Type IV fluids. This work is described in Section 7.

2.7 Ice Crystals Research

Tests conducted in 2012-13 demonstrated that freezing fog holdover times can be used in conditions of ice crystals. This research is documented in the Transport Canada report, TP 15230E, *Aircraft Ground Icing General Research Activities During the 2012-13 Winter* (6). As a result of this research, the title of the freezing fog column in all of the HOT tables (Types I, II, III and IV) was modified to include ice crystals.

3. CHANGES TO THE TYPE I HOT GUIDELINES

Changes made to the Type I HOT guidelines for the winter of 2013-14 are documented in this chapter. The Transport Canada and FAA 2013-14 Type I HOT guidelines are included in Appendix F.

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.

One new Type I fluid was submitted for endurance time testing in 2012-13. **Baltic Ground Services Defrosol ADF** underwent testing in simulated precipitation and in artificial snow. Defrosol ADF performed similarly to Type I fluids tested in past years and therefore can be used with the generic Type I HOT guidelines. The detailed test results are provided in Appendix C.

Natural snow testing will be conducted with this fluid in the winter of 2013-14 to confirm the artificial snow results.

3.2 Changes to HOT Guidelines Format

The freezing fog column in both Type I HOT tables was modified to include ice crystals (see Subsection 2.7).

The FAA increased its cap on snow holdover times from 2 to 3 hours for winter 2013-14. This did not impact the existing Type I snow holdover times.

3.3 Type I Generic Holdover Time Values

No changes were made to the Type I generic holdover times for the winter of 2013-14.

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4. CHANGES TO THE TYPE II HOT GUIDELINES

Changes made to the Type II HOT guidelines for the winter of 2013-14 are documented in this chapter. The Transport Canada and FAA 2013-14 Type II HOT guidelines are included in Appendix F.

4.1 New Fluids/Data

One new Type II fluid was added to the HOT guidelines for the winter of 2013-14. **Cryotech Polar Guard II** is a rebranding of a currently qualified Type IV fluid, Cryotech Polar Guard Advance. As a result, no new testing or data was required to create a fluid-specific HOT table for this fluid.

New natural snow data was collected for Clariant Safewing MP II Flight Plus 100/0 and 75/25 in the winter of 2012-13 and incorporated into the 2013-14 HOT guidelines. This (cold temperature) data had not been collected in 2011-12 when the fluid was first submitted for testing, due to late submission of the fluid in the test season and subsequent lack of appropriate weather. The detailed test results are provided in Appendix D.

4.2 Removed Fluids/Data

The protocol for removing obsolete holdover time data is given in SAE ARP5718, *Qualification Process for SAE AMS1428 Type II, III, and IV Fluids* (7).

At the request of the manufacturer, LNT Solutions P250 was removed from the Type II HOT guidelines for the winter of 2013-14. This fluid had never been commercialized and therefore could be removed immediately following the request.

4.3 Changes to HOT Guidelines Format

Several changes were made to the format of the Type II HOT guidelines for winter 2013-14.

1. The freezing fog column in all Type II HOT tables was modified to include ice crystals (see Subsection 1.1).

2. Light and very light snow holdover times were added to many of the Type II fluid-specific HOT tables (see Section 7). The “snow” column in these tables was renamed “moderate snow.” The affected tables are:

- ABAX Ecowing 26;
- Clariant Safewing MP II Flight; and
- Cryotech Polar Guard II.

3. The FAA increased its cap on snow holdover times from 2 to 3 hours. This did not impact the existing Type II snow holdover times.

4.4 Type II Generic Holdover Time Values

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:

- All fluids on the Transport Canada and FAA list of Type II fluids;
- 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
- 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 Transport Canada and FAA list of fluids contains fluids whose qualifications have recently expired (i.e. within four years). Fluids are only removed from the generic analysis when they are removed from the Transport Canada and FAA list.

It should also be noted that a fluid-specific table is no longer produced for Clariant Safewing MP II 1951, but the fluid is still available for use with the generic HOT guidelines and therefore it is included in the generic analysis.

4.4.1 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 were determined based on historical data and analysis.

In the winter of 2013-14, light snow and very light snow holdover times were added to many Type II HOT tables. Generic very cold snow values for these snow intensities were correspondingly determined. Details are provided in Subsection 7.7.1.

4.4.2 Impact of New and Removed Fluids/Data

The addition of the new and removed Type II fluid/data did not impact the Type II generic holdover times.

4.4.3 Fluids Responsible for Type II Generic Holdover Time Values

The fluids responsible for the values in the generic Type II HOT guidelines in 2012-13 are shown in Table 4.1. “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. 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.

4.4.4 Evolution of Type II Generic Holdover Time Values

The history of Type II fluid testing and the evolution of the fluid-specific and generic Type II holdover time values are illustrated in Tables 4.2 to 4.25. Each table represents one cell in the HOT guidelines and the title of the table links the table to the appropriate cell. Fluids that are no longer used in the generic analysis (see Subsection 4.2) are not included.

The first row in each table contains the generic values from testing in 1998-99, also known as the “grandfathered” fluid data. Each subsequent set of two rows represents a winter test season and the subsequent winter’s HOT table values. The final line contains the generic and fluid-specific holdover time values for use in 2013-14 winter operations.

Underlined values indicate the fluid or fluids responsible for the generic holdover time. If the value in the first row is underlined, it indicates that the generic value is based on the “grandfathered” fluid data set.

Strikethrough values indicate endurance time test results that are not valid; this is typically a result of testing in multiple years (details are usually provided in the HOT report written in the most recent year the fluid underwent testing).

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

- ABAX Ecowing 26 (A-E26);
- Aviation Shaanxi Hi-tech Cleanwing II (AS CII);
- Clariant Safewing MP II 1951 (C-1951);
- Clariant Safewing MP II Flight (C-Flight);
- Clariant Safewing MP II Flight Plus (C-Flight+);
- Cryotech Polar Guard II (CR-PGII);
- Kilfrost ABC-2000 (K2000);
- Kilfrost ABC-K Plus (ABC-K+); and
- Newave Aerochemical FCY-2 (N-FCY-2).

Table 4.1: Fluids Responsible for Type II Generic Holdover Time Values

OAT °C	OAT °F	Fluid Dilution	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)				
			Freezing Fog	Snow	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing
-3 and above	27 and above	100/0	Grandfather **(B)**	Grandfather **(B)** C-1951 **(B)**	Grandfather **(L)** C-1951 **(U)**	Grandfather **(B)** C-1951 **(U)**	N-FCY-2 **(L)** Grandfather **(U)**
		75/25	Grandfather **(B)**	Grandfather **(B)** C-1951 **(L)**	Grandfather **(B)** C-1951 **(U)** N-FCY-2 **(U)**	Grandfather **(B)** C-1951 **(U)** N-FCY-2 **(U)**	Grandfather **(B)** N-FCY-2 **(B)**
		50/50	Grandfather **(L)** C-1951 **(U)**	Grandfather **(B)** C-1951 **(U)** ABC-K+ **(U)** Type IV **(U)**	C-1951 **(B)**	Grandfather **(L)** C-1951 **(U)**	
below -3 to -14	below 27 to 7	100/0	Type IV **(L)** ABC-K+ **(U)**	N-FCY-2 **(B)** Grandfather **(L)**	N-FCY-2 **(B)** Type IV **(L)**	Grandfather **(L)** K2000 **(L)** Type IV **(L)** N-FCY-2 **(U)**	
		75/25	Type IV **(B)** Grandfather **(L)** ABC-K+ **(L)** C-Flight **(L)**	N-FCY-2 **(B)**	N-FCY-2 **(B)** Type IV **(L)**	N-FCY-2 **(B)**	
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	Type IV **(L)** N-FCY-2 **(U)**	Historic Generic **(B)** Grandfather **(B)**			

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

Table 4.2: Type II Neat Fluid, Snow, -3°C and Above

	GENERIC	C-1951	A-E26	K2000	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII
1998-99 HOT Table Values	0:20-0:45									
1998-99 ETTest Results										
1999-00 HOT Table Values	0:20-0:45									
1999-00 ET Test Results		0:20-0:45								
2000-01 HOT Table Values	0:20-0:45	0:20-0:45								
2000-01 ET Test Results			0:40-1:00							
2001-02 HOT Table Values	0:20-0:45	0:20-0:45	0:40-1:00							
2001-02 ET Test Results				0:30-1:00						
2002-03 HOT Table Values	0:20-0:45		0:40-1:00	0:30-1:00						
2002-03 ET Test Results										
2003-04 HOT Table Values	0:20-0:45		0:40-1:00	0:30-1:00						
2003-04 ET Test Results										
2004-05 HOT Table Values	0:20-0:45		0:40-1:00	0:30-1:00						
2004-05 ET Test Results										
2005-06 HOT Table Values	0:20-0:45		0:40-1:00	0:30-1:00						
2005-06 ET Test Results					1:00-1:35					
2006-07 HOT Table Values	0:20-0:45		0:40-1:00	0:30-1:00	1:00-1:35					
2006-07 ET Test Results						0:30-0:55				
2007-08 HOT Table Values	0:20-0:45		0:40-1:00	0:30-1:00	1:00-1:35	0:30-0:55				
2007-08 ET Test Results							1:00-1:40			
2008-09 HOT Table Values	0:20-0:45		0:40-1:00	0:30-1:00	1:00-1:35	0:30-0:55	1:00-1:40			
2008-09 ET Test Results								0:30-0:55		
2009-10 HOT Table Values	0:20-0:45		0:40-1:00	0:30-1:00	1:00-1:35	0:30-0:55	1:00-1:40	0:30-0:55		
2009-10 ET Test Results										
2010-11 HOT Table Values	0:20-0:45		0:40-1:00	0:30-1:00	1:00-1:35	0:30-0:55	1:00-1:40	0:30-0:55		
2010-11 ET Test Results										1:20-1:50
2011-12 HOT Table Values	0:20-0:45		0:40-1:00	0:30-1:00	1:00-1:35	0:30-0:55	1:00-1:40	0:30-0:55		
2011-12 ET Test Results									~~1:05-2:00~~	
2012-13 HOT Table Values	0:20-0:45		0:40-1:00	0:30-1:00	1:00-1:35	0:30-0:55	1:00-1:40	0:30-0:55	1:05-2:00	
2012-13 ET Test Results									0:50-1:50	
2013-14 HOT Table Values	0:20-0:45		0:40-1:00	0:30-1:00	1:00-1:35	0:30-0:55	1:00-1:40	0:30-0:55	0:50-1:50	1:20-1:50

Table 4.3: Type II 75/25 Fluid, Snow, -3°C and Above

	GENERIC	C-1951	A-E26	K2000	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII
1998-99 HOT Table Values	0:15-0:30									
1998-99 ETTest Results										
1999-00 HOT Table Values	0:15-0:30									
1999-00 ET Test Results		0:15-0:35								
2000-01 HOT Table Values	0:15-0:30	0:15-0:35								
2000-01 ET Test Results			0:25-0:45							
2001-02 HOT Table Values	0:15-0:30	0:15-0:35	0:25-0:45							
2001-02 ET Test Results				0:30-1:05						
2002-03 HOT Table Values	0:15-0:30		0:25-0:45	0:30-1:05						
2002-03 ET Test Results										
2003-04 HOT Table Values	0:15-0:30		0:25-0:45	0:30-1:05						
2003-04 ET Test Results										
2004-05 HOT Table Values	0:15-0:30		0:25-0:45	0:30-1:05						
2004-05 ET Test Results										
2005-06 HOT Table Values	0:15-0:30		0:25-0:45	0:30-1:05						
2005-06 ET Test Results					0:40-1:20					
2006-07 HOT Table Values	0:15-0:30		0:25-0:45	0:30-1:05	0:40-1:20					
2006-07 ET Test Results						0:20-0:40				
2007-08 HOT Table Values	0:15-0:30		0:25-0:45	0:30-1:05	0:40-1:20	0:20-0:40				
2007-08 ET Test Results							0:35-1:10			
2008-09 HOT Table Values	0:15-0:30		0:25-0:45	0:30-1:05	0:40-1:20	0:20-0:40	0:35-1:10			
2008-09 ET Test Results								0:25-0:45		
2009-10 HOT Table Values	0:15-0:30		0:25-0:45	0:30-1:05	0:40-1:20	0:20-0:40	0:35-1:10	0:25-0:45		
2009-10 ET Test Results					~~1:00-2:00~~					
2010-11 HOT Table Values	0:15-0:30		0:25-0:45	0:30-1:05	0:40-1:20	0:20-0:40	0:35-1:10	0:25-0:45		
2010-11 ET Test Results										0:45-1:20
2011-12 HOT Table Values	0:15-0:30		0:25-0:45	0:30-1:05	0:40-1:20	0:20-0:40	0:35-1:10	0:25-0:45		
2011-12 ET Test Results									~~0:55-1:35~~	
2012-13 HOT Table Values	0:15-0:30		0:25-0:45	0:30-1:05	0:40-1:20	0:20-0:40	0:35-1:10	0:25-0:45	0:55-1:35	
2012-13 ET Test Results									1:00-1:45	
2013-14 HOT Table Values	0:15-0:30		0:25-0:45	0:30-1:05	0:40-1:20	0:20-0:40	0:35-1:10	0:25-0:45	1:00-1:45	0:45-1:20

Table 4.4: Type II 50/50 Fluid, Snow, -3°C and Above

	GENERIC	C-1951	A-E26	K2000	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII
1998-99 HOT Table Values	0:05-0:15									
1998-99 ETTest Results										
1999-00 HOT Table Values	0:05-0:15									
1999-00 ET Test Results		0:06-0:15								
2000-01 HOT Table Values	0:05-0:15	0:05-0:15								
2000-01 ET Test Results			0:10-0:20							
2001-02 HOT Table Values	0:05-0:15	0:05-0:15	0:10-0:20							
2001-02 ET Test Results				0:15-0:30						
2002-03 HOT Table Values	0:05-0:15		0:10-0:20	0:15-0:30						
2002-03 ET Test Results										
2003-04 HOT Table Values	0:05-0:15		0:10-0:20	0:15-0:30						
2003-04 ET Test Results										
2004-05 HOT Table Values	0:05-0:15		0:10-0:20	0:15-0:30						
2004-05 ET Test Results										
2005-06 HOT Table Values	0:05-0:15		0:10-0:20	0:15-0:30						
2005-06 ET Test Results					0:10-0:25					
2006-07 HOT Table Values	0:05-0:15		0:10-0:20	0:15-0:30	0:10-0:25					
2006-07 ET Test Results						0:15-0:25				
2007-08 HOT Table Values	0:05-0:15		0:10-0:20	0:15-0:30	0:10-0:25	0:15-0:25				
2007-08 ET Test Results							0:07-0:15			
2008-09 HOT Table Values	0:05-0:15		0:10-0:20	0:15-0:30	0:10-0:25	0:15-0:25	0:05-0:15			
2008-09 ET Test Results								0:15-0:30		
2009-10 HOT Table Values	0:05-0:15		0:10-0:20	0:15-0:30	0:10-0:25	0:15-0:25	0:05-0:15	0:15-0:30		
2009-10 ET Test Results										
2010-11 HOT Table Values	0:05-0:15		0:10-0:20	0:15-0:30	0:10-0:25	0:15-0:25	0:05-0:15	0:15-0:30		
2010-11 ET Test Results										0:15-0:35
2011-12 HOT Table Values	0:05-0:15		0:10-0:20	0:15-0:30	0:10-0:25	0:15-0:25	0:07-0:15	0:15-0:30		
2011-12 ET Test Results									0:15-0:25	
2012-13 HOT Table Values	0:05-0:15		0:10-0:20	0:15-0:30	0:10-0:25	0:15-0:25	0:07-0:15	0:15-0:30	0:15-0:25	
2012-13 ET Test Results										
2013-14 HOT Table Values	0:05-0:15		0:10-0:20	0:15-0:30	0:10-0:25	0:15-0:25	0:07-0:15	0:15-0:30	0:15-0:25	0:15-0:35

Table 4.5: Type II Neat Fluid, Snow, Below -3°C to -14°C

	GENERIC	C-1951	A-E26	K2000	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII
1998-99 HOT Table Values	0:15-0:40									
1998-99 ETTest Results										
1999-00 HOT Table Values	0:15-0:35									
1999-00 ET Test Results		0:20-0:40								
2000-01 HOT Table Values	0:15-0:35	0:20-0:40								
2000-01 ET Test Results			0:35-0:55							
2001-02 HOT Table Values	0:15-0:35	0:20-0:40	0:35-0:55							
2001-02 ET Test Results				0:25-0:45						
2002-03 HOT Table Values	0:15-0:35		0:35-0:55	0:25-0:45						
2002-03 ET Test Results										
2003-04 HOT Table Values	0:15-0:35		0:35-0:55	0:25-0:45						
2003-04 ET Test Results										
2004-05 HOT Table Values	0:15-0:35		0:35-0:55	0:25-0:45						
2004-05 ET Test Results										
2005-06 HOT Table Values	0:15-0:35		0:35-0:55	0:25-0:45						
2005-06 ET Test Results					0:40-1:05					
2006-07 HOT Table Values	0:15-0:35		0:35-0:55	0:25-0:45	0:40-1:05					
2006-07 ET Test Results						0:15-0:30				
2007-08 HOT Table Values	0:15-0:30		0:35-0:55	0:25-0:45	0:40-1:05	0:15-0:30				
2007-08 ET Test Results							0:50-1:25			
2008-09 HOT Table Values	0:15-0:30		0:35-0:55	0:25-0:45	0:40-1:05	0:15-0:30	0:50-1:25			
2008-09 ET Test Results								0:30-0:55		
2009-10 HOT Table Values	0:15-0:30		0:35-0:55	0:25-0:45	0:40-1:05	0:15-0:30	0:50-1:25	0:30-0:55		
2009-10 ET Test Results										
2010-11 HOT Table Values	0:15-0:30		0:35-0:55	0:25-0:45	0:40-1:05	0:15-0:30	0:50-1:25	0:30-0:55		
2010-11 ET Test Results										0:55-1:15
2011-12 HOT Table Values	0:15-0:30		0:35-0:55	0:25-0:45	0:40-1:05	0:15-0:30	0:50-1:25	0:30-0:55		
2011-12 ET Test Results									~~0:15-0:30~~	
2012-13 HOT Table Values	0:15-0:30		0:35-0:55	0:25-0:45	0:40-1:05	0:15-0:30	0:50-1:25	0:30-0:55	0:15-0:30	
2012-13 ET Test Results									0:35-1:15	
2013-14 HOT Table Values	0:15-0:30		0:35-0:55	0:25-0:45	0:40-1:05	0:15-0:30	0:50-1:25	0:30-0:55	0:35-1:15	0:55-1:15

Table 4.6: Type II 75/25 Fluid, Snow, Below -3ºC to -14ºC

	GENERIC	C-1951	A-E26	K2000	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII
1998-99 HOT Table Values	0:15-0:30									
1998-99 ETTest Results										
1999-00 HOT Table Values	0:15-0:25									
1999-00 ET Test Results		0:15-0:25								
2000-01 HOT Table Values	0:15-0:25	0:15-0:25								
2000-01 ET Test Results			0:25-0:40							
2001-02 HOT Table Values	0:15-0:25	0:15-0:25	0:25-0:40							
2001-02 ET Test Results				0:25-0:50						
2002-03 HOT Table Values	0:15-0:25		0:25-0:40	0:25-0:50						
2002-03 ET Test Results										
2003-04 HOT Table Values	0:15-0:25		0:25-0:40	0:25-0:50						
2003-04 ET Test Results										
2004-05 HOT Table Values	0:15-0:25		0:25-0:40	0:25-0:50						
2004-05 ET Test Results										
2005-06 HOT Table Values	0:15-0:25		0:25-0:40	0:25-0:50						
2005-06 ET Test Results					0:20-0:40					
2006-07 HOT Table Values	0:15-0:25		0:25-0:40	0:25-0:50	0:20-0:40					
2006-07 ET Test Results						~~0:100:20~~				
2007-08 HOT Table Values	0:10-0:20		0:25-0:40	0:25-0:50	0:20-0:40	0:10-0:20				
2007-08 ET Test Results							0:35-1:05			
2008-09 HOT Table Values	0:10-0:20		0:25-0:40	0:25-0:50	0:20-0:40	0:10-0:20	0:35-1:05			
2008-09 ET Test Results								0:25-0:45		
2009-10 HOT Table Values	0:10-0:20		0:25-0:40	0:25-0:50	0:20-0:40	0:10-0:20	0:35-1:05	0:25-0:45		
2009-10 ET Test Results					~~1:00-2:00~~					
2010-11 HOT Table Values	0:10-0:20		0:25-0:40	0:25-0:50	0:20-0:40	0:10-0:20	0:35-1:05	0:25-0:45		
2010-11 ET Test Results										0:35-1:00
2011-12 HOT Table Values	0:10-0:20		0:25-0:40	0:25-0:50	0:20-0:40	0:10-0:20	0:35-1:05	0:25-0:45		
2011-12 ET Test Results									~~0:10-0:20~~	
2012-13 HOT Table Values	0:10-0:20		0:25-0:40	0:25-0:50	0:20-0:40	0:10-0:20	0:35-1:05	0:25-0:45	0:10-0:20	
2012-13 ET Test Results									0:55-1:40	
2013-14 HOT Table Values	0:10-0:20		0:25-0:40	0:25-0:50	0:20-0:40	0:10-0:20	0:35-1:05	0:25-0:45	0:55-1:40	0:35-1:00

Table 4.7: Type II Neat Fluid, Snow, Below -14°C to -25°C

	GENERIC	C-1951	A-E26	K2000	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII
1998-99 HOT Table Values	0:15-0:30									
1998-99 ETTest Results										
1999-00 HOT Table Values	0:15-0:30									
1999-00 ET Test Results		0:20-0:35								
2000-01 HOT Table Values	0:15-0:30	0:20-0:35								
2000-01 ET Test Results			0:30-0:50							
2001-02 HOT Table Values	0:15-0:30	0:20-0:35	0:30-0:50							
2001-02 ET Test Results				0:20-0:40						
2002-03 HOT Table Values	0:15-0:30		0:30-0:50	0:15-0:30						
2002-03 ET Test Results										
2003-04 HOT Table Values	0:15-0:30		0:30-0:50	0:15-0:30						
2003-04 ET Test Results										
2004-05 HOT Table Values	0:15-0:30		0:15-0:30*	0:15-0:30*						
2004-05 ET Test Results										
2005-06 HOT Table Values	0:15-0:30		0:15-0:30*	0:15-0:30*						
2005-06 ET Test Results										
2006-07 HOT Table Values	0:15-0:30		0:15-0:30*	0:15-0:30*	0:15-0:30*					
2006-07 ET Test Results										
2007-08 HOT Table Values	0:15-0:30		0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*				
2007-08 ET Test Results										
2008-09 HOT Table Values	0:15-0:30		0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*			
2008-09 ET Test Results										
2009-10 HOT Table Values	0:15-0:30		0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*		
2009-10 ET Test Results										
2010-11 HOT Table Values	0:15-0:30		0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*		
2010-11 ET Test Results										
2011-12 HOT Table Values	0:15-0:30		0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*		
2011-12 ET Test Results										
2012-13 HOT Table Values	0:15-0:30		0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	
2012-13 ET Test Results										
2013-14 HOT Table Values	0:15-0:30		0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*

*Generic HOT values used in this cell

Table 4.8: Type II Neat Fluid, Freezing Drizzle, -3°C and Above

	GENERIC	C-1951	A-E26	K2000	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII
1998-99 HOT Table Values	0:30-1:00									
1998-99 ETTest Results										
1999-00 HOT Table Values	0:30-1:00									
1999-00 ET Test Results		0:35-0:55								
2000-01 HOT Table Values	0:30-0:55	0:35-0:55								
2000-01 ET Test Results			0:50-1:35							
2001-02 HOT Table Values	0:30-0:55	0:35-0:55	0:50-1:35							
2001-02 ET Test Results				0:55-1:35						
2002-03 HOT Table Values	0:30-0:55		0:50-1:35	0:55-1:35						
2002-03 ET Test Results										
2003-04 HOT Table Values	0:30-0:55		0:50-1:35	0:55-1:35						
2003-04 ET Test Results										
2004-05 HOT Table Values	0:30-0:55		0:50-1:35	0:55-1:35						
2004-05 ET Test Results										
2005-06 HOT Table Values	0:30-0:55		0:50-1:35	0:55-1:35						
2005-06 ET Test Results					1:20-2:00					
2006-07 HOT Table Values	0:30-0:55		0:50-1:35	0:55-1:35	1:20-2:00					
2006-07 ET Test Results						0:35-1:05				
2007-08 HOT Table Values	0:30-0:55		0:50-1:35	0:55-1:35	1:20-2:00	0:35-1:05				
2007-08 ET Test Results							1:50-2:00			
2008-09 HOT Table Values	0:30-0:55		0:50-1:35	0:55-1:35	1:20-2:00	0:35-1:05	1:50-2:00			
2008-09 ET Test Results								0:35-1:05		
2009-10 HOT Table Values	0:30-0:55		0:50-1:35	0:55-1:35	1:20-2:00	0:35-1:05	1:50-2:00	0:35-1:05		
2009-10 ET Test Results										
2010-11 HOT Table Values	0:30-0:55		0:50-1:35	0:55-1:35	1:20-2:00	0:35-1:05	1:50-2:00	0:35-1:05		
2010-11 ET Test Results										1:35-2:00
2011-12 HOT Table Values	0:30-0:55		0:50-1:35	0:55-1:35	1:20-2:00	0:35-1:05	1:50-2:00	0:35-1:05		
2011-12 ET Test Results									1:25-2:00	
2012-13 HOT Table Values	0:30-0:55		0:50-1:35	0:55-1:35	1:20-2:00	0:35-1:05	1:50-2:00	0:35-1:05	1:25-2:00	
2012-13 ET Test Results										
2013-14 HOT Table Values	0:30-0:55		0:50-1:35	0:55-1:35	1:20-2:00	0:35-1:05	1:50-2:00	0:35-1:05	1:25-2:00	1:35-2:00

Table 4.9: Type II 75/25 Fluid, Freezing Drizzle, -3°C and Above

	GENERIC	C-1951	A-E26	K2000	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII
1998-99 HOT Table Values	0:20-0:45									
1998-99 ETTest Results										
1999-00 HOT Table Values	0:20-0:45									
1999-00 ET Test Results		0:25-0:45								
2000-01 HOT Table Values	0:20-0:45	0:25-0:45								
2000-01 ET Test Results			0:45-1:05							
2001-02 HOT Table Values	0:20-0:45	0:25-0:45	0:45-1:05							
2001-02 ET Test Results				0:45-1:15						
2002-03 HOT Table Values	0:20-0:45		0:45-1:05	0:45-1:15						
2002-03 ET Test Results										
2003-04 HOT Table Values	0:20-0:45		0:45-1:05	0:45-1:15						
2003-04 ET Test Results										
2004-05 HOT Table Values	0:20-0:45		0:45-1:05	0:45-1:15						
2004-05 ET Test Results										
2005-06 HOT Table Values	0:20-0:45		0:45-1:05	0:45-1:15						
2005-06 ET Test Results					1:15-2:00					
2006-07 HOT Table Values	0:20-0:45		0:45-1:05	0:45-1:15	1:15-2:00					
2006-07 ET Test Results						0:25-0:45				
2007-08 HOT Table Values	0:20-0:45		0:45-1:05	0:45-1:15	1:15-2:00	0:25-0:45				
2007-08 ET Test Results							1:25-2:00			
2008-09 HOT Table Values	0:20-0:45		0:45-1:05	0:45-1:15	1:15-2:00	0:25-0:45	1:25-2:00			
2008-09 ET Test Results								0:35-1:00		
2009-10 HOT Table Values	0:20-0:45		0:45-1:05	0:45-1:15	1:15-2:00	0:25-0:45	1:25-2:00	0:35-1:00		
2009-10 ET Test Results					1:10-1:30					
2010-11 HOT Table Values	0:20-0:45		0:45-1:05	0:45-1:15	1:10-1:30	0:25-0:45	1:25-2:00	0:35-1:00		
2010-11 ET Test Results										1:40-2:00
2011-12 HOT Table Values	0:20-0:45		0:45-1:05	0:45-1:15	1:10-1:30	0:25-0:45	1:25-2:00	0:35-1:00		
2011-12 ET Test Results									1:35-2:00	
2012-13 HOT Table Values	0:20-0:45		0:45-1:05	0:45-1:15	1:10-1:30	0:25-0:45	1:25-2:00	0:35-1:00	1:35-2:00	
2012-13 ET Test Results										
2013-14 HOT Table Values	0:20-0:45		0:45-1:05	0:45-1:15	1:10-1:30	0:25-0:45	1:25-2:00	0:35-1:00	1:35-2:00	1:40-2:00

Table 4.10: Type II 50/50 Fluid, Freezing Drizzle, -3ºC and Above

	GENERIC	C-1951	A-E26	K2000	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII
1998-99 HOT Table Values	0:10-0:20									
1998-99 ETTest Results										
1999-00 HOT Table Values	0:05-0:20									
1999-00 ET Test Results		~~0:08-0:15~~								
2000-01 HOT Table Values	0:05-0:15	0:05-0:15								
2000-01 ET Test Results			0:15-0:25							
2001-02 HOT Table Values	0:05-0:15	0:05-0:15	0:15-0:25							
2001-02 ET Test Results				0:15-0:25						
2002-03 HOT Table Values	0:05-0:15		0:15-0:25	0:15-0:25						
2002-03 ET Test Results										
2003-04 HOT Table Values	0:05-0:15		0:15-0:25	0:15-0:25						
2003-04 ET Test Results										
2004-05 HOT Table Values	0:05-0:15		0:15-0:25	0:15-0:25						
2004-05 ET Test Results										
2005-06 HOT Table Values	0:05-0:15		0:15-0:25	0:15-0:25						
2005-06 ET Test Results					0:20-0:30					
2006-07 HOT Table Values	0:05-0:15		0:15-0:25	0:15-0:25	0:20-0:30					
2006-07 ET Test Results						0:10-0:20				
2007-08 HOT Table Values	0:05-0:15		0:15-0:25	0:15-0:25	0:20-0:30	0:10-0:20				
2007-08 ET Test Results							0:20-0:30			
2008-09 HOT Table Values	0:05-0:15		0:15-0:25	0:15-0:25	0:20-0:30	0:10-0:20	0:20-0:30			
2008-09 ET Test Results								0:20-0:40		
2009-10 HOT Table Values	0:05-0:15		0:15-0:25	0:15-0:25	0:20-0:30	0:10-0:20	0:20-0:30	0:20-0:40		
2009-10 ET Test Results										
2010-11 HOT Table Values	0:05-0:15		0:15-0:25	0:15-0:25	0:20-0:30	0:10-0:20	0:20-0:30	0:20-0:40		
2010-11 ET Test Results										0:20-0:45
2011-12 HOT Table Values	0:08-0:15		0:15-0:25	0:15-0:25	0:20-0:30	0:10-0:20	0:20-0:30	0:20-0:40		
2011-12 ET Test Results									0:30-1:05	
2012-13 HOT Table Values	0:08-0:15		0:15-0:25	0:15-0:25	0:20-0:30	0:10-0:20	0:20-0:30	0:20-0:40	0:30-1:05	
2012-13 ET Test Results										
2013-14 HOT Table Values	0:08-0:15		0:15-0:25	0:15-0:25	0:20-0:30	0:10-0:20	0:20-0:30	0:20-0:40	0:30-1:05	0:20-0:45

Table 4.11: Type II Neat Fluid, Freezing Drizzle, Below -3°C to -10°C

	GENERIC	C-1951	A-E26	K2000	C-Flight	N-FCY-2	ABC-K +	AS CII	C-Flight +	CR-PGII
1998-99 HOT Table Values	0:30-1:00									
1998-99 ETTest Results										
1999-00 HOT Table Values	0:15-0:45									
1999-00 ET Test Results		0:25-0:50								
2000-01 HOT Table Values	0:15-0:45	0:25-0:50								
2000-01 ET Test Results			0:30-1:10							
2001-02 HOT Table Values	0:15-0:45	0:25-0:50	0:30-1:10							
2001-02 ET Test Results				0:25-0:50						
2002-03 HOT Table Values	0:15-0:45		0:30-1:10	0:25-0:50						
2002-03 ET Test Results										
2003-04 HOT Table Values	0:15-0:45		0:30-1:10	0:25-0:50						
2003-04 ET Test Results										
2004-05 HOT Table Values	0:15-0:45		0:30-1:10	0:25-0:50						
2004-05 ET Test Results										
2005-06 HOT Table Values	0:15-0:45		0:30-1:10	0:25-0:50						
2005-06 ET Test Results					0:35-1:30					
2006-07 HOT Table Values	0:15-0:45		0:30-1:10	0:25-0:50	0:35-1:30					
2006-07 ET Test Results						0:20-0:45				
2007-08 HOT Table Values	0:15-0:45		0:30-1:10	0:25-0:50	0:35-1:30	0:20-0:45				
2007-08 ET Test Results							0:25-1:00			
2008-09 HOT Table Values	0:15-0:45		0:30-1:10	0:25-0:50	0:35-1:30	0:20-0:45	0:25-1:00			
2008-09 ET Test Results								0:30-0:55		
2009-10 HOT Table Values	0:20-0:45		0:30-1:10	0:25-0:50	0:35-1:30	0:20-0:45	0:25-1:00	0:30-0:55		
2009-10 ET Test Results										
2010-11 HOT Table Values	0:20-0:45		0:30-1:10	0:25-0:50	0:35-1:30	0:20-0:45	0:25-1:00	0:30-0:55		
2010-11 ET Test Results										0:35-1:35
2011-12 HOT Table Values	0:20-0:45		0:30-1:10	0:25-0:50	0:35-1:30	0:20-0:45	0:25-1:00	0:30-0:55		
2011-12 ET Test Results									0:35-1:25	
2012-13 HOT Table Values	0:20-0:45		0:30-1:10	0:25-0:50	0:35-1:30	0:20-0:45	0:25-1:00	0:30-0:55	0:35-1:25	
2012-13 ET Test Results										
2013-14 HOT Table Values	0:20-0:45		0:30-1:10	0:25-0:50	0:35-1:30	0:20-0:45	0:25-1:00	0:30-0:55	0:35-1:25	0:35-1:35

Table 4.12: Type II 75/25 Fluid, Freezing Drizzle, Below -3°C to -10°C

	GENERIC	C-1951	A-E26	K2000	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII
1998-99 HOT Table Values	0:20-0:45									
1998-99 ETTest Results										
1999-00 HOT Table Values	0:15-0:30									
1999-00 ET Test Results		0:20-0:35								
2000-01 HOT Table Values	0:15-0:30	0:20-0:35								
2000-01 ET Test Results			0:20-0:50							
2001-02 HOT Table Values	0:15-0:30	0:20-0:35	0:20-0:50							
2001-02 ET Test Results				0:25-0:55						
2002-03 HOT Table Values	0:15-0:30		0:20-0:50	0:25-0:55						
2002-03 ET Test Results										
2003-04 HOT Table Values	0:15-0:30		0:20-0:50	0:25-0:55						
2003-04 ET Test Results										
2004-05 HOT Table Values	0:15-0:30		0:20-0:50	0:25-0:55						
2004-05 ET Test Results										
2005-06 HOT Table Values	0:15-0:30		0:20-0:50	0:25-0:55						
2005-06 ET Test Results					0:25-1:10					
2006-07 HOT Table Values	0:15-0:30		0:20-0:50	0:25-0:55	0:25-1:10					
2006-07 ET Test Results						~~0:150:30~~				
2007-08 HOT Table Values	0:15-0:30		0:20-0:50	0:25-0:55	0:25-1:10	0:15-0:30				
2007-08 ET Test Results							0:20-0:55			
2008-09 HOT Table Values	0:15-0:30		0:20-0:50	0:25-0:55	0:25-1:10	0:15-0:30	0:20-0:55			
2008-09 ET Test Results								0:35-0:40		
2009-10 HOT Table Values	0:15-0:30		0:20-0:50	0:25-0:55	0:25-1:10	0:15-0:30	0:20-0:55	0:35-0:40		
2009-10 ET Test Results					~~0:25-1:15~~					
2010-11 HOT Table Values	0:15-0:30		0:20-0:50	0:25-0:55	0:25-1:10	0:15-0:30	0:20-0:55	0:35-0:40		
2010-11 ET Test Results										0:25-1:05
2011-12 HOT Table Values	0:15-0:30		0:20-0:50	0:25-0:55	0:25-1:10	0:15-0:30	0:20-0:55	0:35-0:40		
2011-12 ET Test Results									0:25-1:10	
2012-13 HOT Table Values	0:15-0:30		0:20-0:50	0:25-0:55	0:25-1:10	0:15-0:30	0:20-0:55	0:35-0:40	0:25-1:10	
2012-13 ET Test Results										
2013-14 HOT Table Values	0:15-0:30		0:20-0:50	0:25-0:55	0:25-1:10	0:15-0:30	0:20-0:55	0:35-0:40	0:25-1:10	0:25-1:05

Table 4.13: Type II Neat Fluid, Light Freezing Rain, -3°C and Above

	GENERIC	C-1951	A-E26	K2000	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII
1998-99 HOT Table Values	0:150:30									
1998-99 ETTest Results										
1999-00 HOT Table Values	0:15-0:30									
1999-00 ET Test Results		0:200:30								
2000-01 HOT Table Values	0:15-0:30	0:20-0:30								
2000-01 ET Test Results			0:40-0:50							
2001-02 HOT Table Values	0:15-0:30	0:20-0:30	0:40-0:50							
2001-02 ET Test Results				0:40-0:50						
2002-03 HOT Table Values	0:15-0:30		0:40-0:50	0:40-0:50						
2002-03 ET Test Results										
2003-04 HOT Table Values	0:15-0:30		0:40-0:50	0:40-0:50						
2003-04 ET Test Results										
2004-05 HOT Table Values	0:15-0:30		0:40-0:50	0:40-0:50						
2004-05 ET Test Results										
2005-06 HOT Table Values	0:15-0:30		0:40-0:50	0:40-0:50						
2005-06 ET Test Results					0:45-1:25					
2006-07 HOT Table Values	0:15-0:30		0:40-0:50	0:40-0:50	0:45-1:25					
2006-07 ET Test Results						0:25-0:35				
2007-08 HOT Table Values	0:15-0:30		0:40-0:50	0:40-0:50	0:45-1:25	0:25-0:35				
2007-08 ET Test Results							1:00-1:25			
2008-09 HOT Table Values	0:15-0:30		0:40-0:50	0:40-0:50	0:45-1:25	0:25-0:35	1:00-1:25			
2008-09 ET Test Results								0:25-0:35		
2009-10 HOT Table Values	0:15-0:30		0:40-0:50	0:40-0:50	0:45-1:25	0:25-0:35	1:00-1:25	0:25-0:35		
2009-10 ET Test Results										
2010-11 HOT Table Values	0:15-0:30		0:40-0:50	0:40-0:50	0:45-1:25	0:25-0:35	1:00-1:25	0:25-0:35		
2010-11 ET Test Results										1:15-1:30
2011-12 HOT Table Values	0:15-0:30		0:40-0:50	0:40-0:50	0:45-1:25	0:25-0:35	1:00-1:25	0:25-0:35		
2011-12 ET Test Results									0:45-1:00	
2012-13 HOT Table Values	0:15-0:30		0:40-0:50	0:40-0:50	0:45-1:25	0:25-0:35	1:00-1:25	0:25-0:35	0:45-1:00	
2012-13 ET Test Results										
2013-14 HOT Table Values	0:15-0:30		0:40-0:50	0:40-0:50	0:45-1:25	0:25-0:35	1:00-1:25	0:25-0:35	0:45-1:00	1:15-1:30

Table 4.14: Type II 75/25 Fluid, Light Freezing Rain, -3°C and Above

	GENERIC	C-1951	A-E26	K2000	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII
1998-99 HOT Table Values	0:100:25									
1998-99 ETTest Results										
1999-00 HOT Table Values	0:10-0:25									
1999-00 ET Test Results		0:150:25								
2000-01 HOT Table Values	0:10-0:25	0:15-0:25								
2000-01 ET Test Results			0:25-0:35							
2001-02 HOT Table Values	0:10-0:25	0:15-0:25	0:25-0:35							
2001-02 ET Test Results				0:40-0:50						
2002-03 HOT Table Values	0:10-0:25		0:25-0:35	0:40-0:50						
2002-03 ET Test Results										
2003-04 HOT Table Values	0:10-0:25		0:25-0:35	0:40-0:50						
2003-04 ET Test Results										
2004-05 HOT Table Values	0:10-0:25		0:25-0:35	0:40-0:50						
2004-05 ET Test Results										
2005-06 HOT Table Values	0:10-0:25		0:25-0:35	0:40-0:50						
2005-06 ET Test Results					~~0:30-0:55~~					
2006-07 HOT Table Values	0:10-0:25		0:25-0:35	0:40-0:50	0:30-0:55					
2006-07 ET Test Results						0:150:25				
2007-08 HOT Table Values	0:10-0:25		0:25-0:35	0:40-0:50	0:30-0:55	0:15-0:25				
2007-08 ET Test Results							0:50-1:10			
2008-09 HOT Table Values	0:10-0:25		0:25-0:35	0:40-0:50	0:30-0:55	0:15-0:25	0:50-1:10			
2008-09 ET Test Results								0:20-0:30		
2009-10 HOT Table Values	0:10-0:25		0:25-0:35	0:40-0:50	0:30-0:55	0:15-0:25	0:50-1:10	0:20-0:30		
2009-10 ET Test Results					0:30-0:55					
2010-11 HOT Table Values	0:10-0:25		0:25-0:35	0:40-0:50	0:30-0:55	0:15-0:25	0:50-1:10	0:20-0:30		
2010-11 ET Test Results										0:40-1:10
2011-12 HOT Table Values	0:10-0:25		0:25-0:35	0:40-0:50	0:30-0:55	0:15-0:25	0:50-1:10	0:20-0:30		
2011-12 ET Test Results									0:50-1:15	
2012-13 HOT Table Values	0:10-0:25		0:25-0:35	0:40-0:50	0:30-0:55	0:15-0:25	0:50-1:10	0:20-0:30	0:50-1:15	
2012-13 ET Test Results										
2013-14 HOT Table Values	0:10-0:25		0:25-0:35	0:40-0:50	0:30-0:55	0:15-0:25	0:50-1:10	0:20-0:30	0:50-1:15	0:40-1:10

Table 4.15: Type II 50/50 Fluid, Light Freezing Rain, -3°C and Above

	GENERIC	C-1951	A-E26	K2000	C-Flight	N-FCY-2	ABC-K +	AS CII	C-Flight +	CR-PGII
1998-99 HOT Table Values	0:05-0:10									
1998-99 ETTest Results										
1999-00 HOT Table Values	0:05-0:10									
1999-00 ET Test Results		0:06-0:09								
2000-01 HOT Table Values	0:05-0:10	0:05-0:10								
2000-01 ET Test Results			0:08-0:10							
2001-02 HOT Table Values	0:05-0:10	0:05-0:10	0:05-0:10							
2001-02 ET Test Results				0:08-0:15						
2002-03 HOT Table Values	0:05-0:10		0:05-0:10	0:05-0:15						
2002-03 ET Test Results										
2003-04 HOT Table Values	0:05-0:10		0:05-0:10	0:05-0:15						
2003-04 ET Test Results										
2004-05 HOT Table Values	0:05-0:10		0:05-0:10	0:05-0:15						
2004-05 ET Test Results										
2005-06 HOT Table Values	0:05-0:10		0:05-0:10	0:05-0:15						
2005-06 ET Test Results					0:10-0:15					
2006-07 HOT Table Values	0:05-0:10		0:05-0:10	0:05-0:15	0:10-0:15					
2006-07 ET Test Results						0:07-0:10				
2007-08 HOT Table Values	0:05-0:10		0:05-0:10	0:05-0:15	0:10-0:15	0:05-0:10				
2007-08 ET Test Results							0:10-0:15			
2008-09 HOT Table Values	0:05-0:10		0:05-0:10	0:05-0:15	0:10-0:15	0:05-0:10	0:10-0:15			
2008-09 ET Test Results								0:10-0:20		
2009-10 HOT Table Values	0:05-0:10		0:05-0:10	0:05-0:15	0:10-0:15	0:05-0:10	0:10-0:15	0:10-0:20		
2009-10 ET Test Results										
2010-11 HOT Table Values	0:05-0:10		0:05-0:10	0:05-0:15	0:10-0:15	0:05-0:10	0:10-0:15	0:10-0:20		
2010-11 ET Test Results										0:09-0:20
2011-12 HOT Table Values	0:05-0:09		0:08-0:10	0:08-0:15	0:10-0:15	0:07-0:10	0:10-0:15	0:10-0:20		
2011-12 ET Test Results									0:15-0:20	
2012-13 HOT Table Values	0:05-0:09		0:08-0:10	0:08-0:15	0:10-0:15	0:07-0:10	0:10-0:15	0:10-0:20	0:15-0:20	
2012-13 ET Test Results										
2013-14 HOT Table Values	0:05-0:09		0:08-0:10	0:08-0:15	0:10-0:15	0:07-0:10	0:10-0:15	0:10-0:20	0:15-0:20	0:09-0:20

Table 4.16: Type II Neat Fluid, Light Freezing Rain, Below -3°C to -10°C

	GENERIC	C-1951	A-E26	K2000	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII
1998-99 HOT Table Values	0:10-0:30									
1998-99 ETTest Results										
1999-00 HOT Table Values	0:10-0:30									
1999-00 ET Test Results		0:15-0:30								
2000-01 HOT Table Values	0:10-0:30	0:15-0:30								
2000-01 ET Test Results			0:15-0:35							
2001-02 HOT Table Values	0:10-0:25*	0:15-0:30	0:15-0:35							
2001-02 ET Test Results				0:10-0:30						
2002-03 HOT Table Values	0:10-0:25*		0:15-0:35	0:10-0:30						
2002-03 ET Test Results										
2003-04 HOT Table Values	0:10-0:25*		0:15-0:35	0:10-0:30						
2003-04 ET Test Results										
2004-05 HOT Table Values	0:10-0:25*		0:15-0:35	0:10-0:30						
2004-05 ET Test Results										
2005-06 HOT Table Values	0:10-0:25*		0:15-0:35	0:10-0:30						
2005-06 ET Test Results					0:25-0:45					
2006-07 HOT Table Values	0:10-0:25*		0:15-0:35	0:10-0:30	0:25-0:45					
2006-07 ET Test Results						0:15-0:20				
2007-08 HOT Table Values	0:10-0:20		0:15-0:35	0:10-0:30	0:25-0:45	0:15-0:20				
2007-08 ET Test Results							0:15-0:35			
2008-09 HOT Table Values	0:10-0:20		0:15-0:35	0:10-0:30	0:25-0:45	0:15-0:20	0:15-0:35			
2008-09 ET Test Results								0:20-0:25		
2009-10 HOT Table Values	0:10-0:20		0:15-0:35	0:10-0:30	0:25-0:45	0:15-0:20	0:15-0:35	0:20-0:25		
2009-10 ET Test Results										
2010-11 HOT Table Values	0:10-0:20		0:15-0:35	0:10-0:30	0:25-0:45	0:15-0:20	0:15-0:35	0:20-0:25		
2010-11 ET Test Results										0:35-0:45
2011-12 HOT Table Values	0:10-0:20		0:15-0:35	0:10-0:30	0:25-0:45	0:15-0:20	0:15-0:35	0:20-0:25		
2011-12 ET Test Results									0:35-0:55	
2012-13 HOT Table Values	0:10-0:20		0:15-0:35	0:10-0:30	0:25-0:45	0:15-0:20	0:15-0:35	0:20-0:25	0:35-0:55	
2012-13 ET Test Results										
2013-14 HOT Table Values	0:10-0:20		0:15-0:35	0:10-0:30	0:25-0:45	0:15-0:20	0:15-0:35	0:20-0:25	0:35-0:55	0:35-0:45

Table 4.17: Type II 75/25 Fluid, Light Freezing Rain, Below -3°C to -10°C

	GENERIC	C-1951	A-E26	K2000	C-Flight	N-FCY-2	ABC-K +	AS CII	C-Flight +	CR-PGII
1998-99 HOT Table Values	0:10-0:25									
1998-99 ETTest Results										
1999-00 HOT Table Values	0:10-0:20									
1999-00 ET Test Results		0:15-0:20								
2000-01 HOT Table Values	0:10-0:20	0:15-0:20								
2000-01 ET Test Results			0:15-0:25							
2001-02 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:25							
2001-02 ET Test Results				0:15-0:30						
2002-03 HOT Table Values	0:10-0:20		0:15-0:25	0:15-0:30						
2002-03 ET Test Results										
2003-04 HOT Table Values	0:10-0:20		0:15-0:25	0:15-0:30						
2003-04 ET Test Results										
2004-05 HOT Table Values	0:10-0:20		0:15-0:25	0:15-0:30						
2004-05 ET Test Results										
2005-06 HOT Table Values	0:10-0:20		0:15-0:25	0:15-0:30						
2005-06 ET Test Results					~~0:30-0:40~~					
2006-07 HOT Table Values	0:10-0:20		0:15-0:25	0:15-0:30	0:30-0:40					
2006-07 ET Test Results						~~0:08-0:15~~				
2007-08 HOT Table Values	0:05-0:15		0:15-0:25	0:15-0:30	0:30-0:40	0:05-0:15				
2007-08 ET Test Results							0:09-0:30			
2008-09 HOT Table Values	0:05-0:15		0:15-0:25	0:15-0:30	0:30-0:40	0:05-0:15	0:05-0:30			
2008-09 ET Test Results								0:20-0:25		
2009-10 HOT Table Values	0:05-0:15		0:15-0:25	0:15-0:30	0:30-0:40	0:05-0:15	0:05-0:30	0:20-0:25		
2009-10 ET Test Results					0:20-0:35					
2010-11 HOT Table Values	0:05-0:15		0:15-0:25	0:15-0:30	0:20-0:35	0:05-0:15	0:05-0:30	0:20-0:25		
2010-11 ET Test Results										0:35-0:45
2011-12 HOT Table Values	0:08-0:15		0:15-0:25	0:15-0:30	0:20-0:35	0:08-0:15	0:09-0:30	0:20-0:25		
2011-12 ET Test Results									0:30-0:45	
2012-13 HOT Table Values	0:08-0:15		0:15-0:25	0:15-0:30	0:20-0:35	0:08-0:15	0:09-0:30	0:20-0:25	0:30-0:45	
2012-13 ET Test Results										
2013-14 HOT Table Values	0:08-0:15		0:15-0:25	0:15-0:30	0:20-0:35	0:08-0:15	0:09-0:30	0:20-0:25	0:30-0:45	0:35-0:45

Table 4.18: Type II Neat Fluid, Freezing Fog, -3°C and Above

	GENERIC	C-1951	A-E26	K2000	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII
1998-99 HOT Table Values	0:35-1:30									
1998-99 ETTest Results										
1999-00 HOT Table Values	0:35-1:30									
1999-00 ET Test Results		0:55-1:40								
2000-01 HOT Table Values	0:35-1:30	0:55-1:40								
2000-01 ET Test Results			1:25-2:35							
2001-02 HOT Table Values	0:35-1:30	0:55-1:40	1:25-2:35							
2001-02 ET Test Results				1:30-3:05						
2002-03 HOT Table Values	0:35-1:30		1:25-2:35	1:30-3:05						
2002-03 ET Test Results										
2003-04 HOT Table Values	0:35-1:30		1:25-2:35	1:30-3:05						
2003-04 ET Test Results										
2004-05 HOT Table Values	0:35-1:30		1:25-2:35	1:30-3:05						
2004-05 ET Test Results										
2005-06 HOT Table Values	0:35-1:30		1:25-2:35	1:30-3:05						
2005-06 ET Test Results					3:30-4:00					
2006-07 HOT Table Values	0:35-1:30		1:25-2:35	1:30-3:05	3:30-4:00					
2006-07 ET Test Results						1:15-2:25				
2007-08 HOT Table Values	0:35-1:30		1:25-2:35	1:30-3:05	3:30-4:00	1:15-2:25				
2007-08 ET Test Results							2:15-3:45			
2008-09 HOT Table Values	0:35-1:30		1:25-2:35	1:30-3:05	3:30-4:00	1:15-2:25	2:15-3:45			
2008-09 ET Test Results								0:55-1:50		
2009-10 HOT Table Values	0:35-1:30		1:25-2:35	1:30-3:05	3:30-4:00	1:15-2:25	2:15-3:45	0:55-1:50		
2009-10 ET Test Results										
2010-11 HOT Table Values	0:35-1:30		1:25-2:35	1:30-3:05	3:30-4:00	1:15-2:25	2:15-3:45	0:55-1:50		
2010-11 ET Test Results										2:50-4:00
2011-12 HOT Table Values	0:35-1:30		1:25-2:35	1:30-3:05	3:30-4:00	1:15-2:25	2:15-3:45	0:55-1:50		
2011-12 ET Test Results									2:40-4:00	
2012-13 HOT Table Values	0:35-1:30		1:25-2:35	1:30-3:05	3:30-4:00	1:15-2:25	2:15-3:45	0:55-1:50	2:40-4:00	
2012-13 ET Test Results										
2013-14 HOT Table Values	0:35-1:30		1:25-2:35	1:30-3:05	3:30-4:00	1:15-2:25	2:15-3:45	0:55-1:50	2:40-4:00	2:50-4:00

Table 4.19: Type II 75/25 Fluid, Freezing Fog, -3°C and Above

	GENERIC	C-1951	A-E26	K2000	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII
1998-99 HOT Table Values	~~0:25-1:00~~									
1998-99 ETTest Results										
1999-00 HOT Table Values	0:25-1:00									
1999-00 ET Test Results		0:45-1:15								
2000-01 HOT Table Values	0:25-1:00	0:45-1:15								
2000-01 ET Test Results			1:05-1:55							
2001-02 HOT Table Values	0:25-1:00	0:45-1:15	1:05-1:55							
2001-02 ET Test Results				1:40-3:30						
2002-03 HOT Table Values	0:25-1:00		1:05-1:55	1:40-3:30						
2002-03 ET Test Results										
2003-04 HOT Table Values	0:25-1:00		1:05-1:55	1:40-3:30						
2003-04 ET Test Results										
2004-05 HOT Table Values	0:25-1:00		1:05-1:55	1:40-3:30						
2004-05 ET Test Results										
2005-06 HOT Table Values	0:25-1:00		1:05-1:55	1:40-3:30						
2005-06 ET Test Results					~~2:30-4:00~~					
2006-07 HOT Table Values	0:25-1:00		1:05-1:55	1:40-3:30	2:30-4:00					
2006-07 ET Test Results						0:50-1:30				
2007-08 HOT Table Values	0:25-1:00		1:05-1:55	1:40-3:30	2:30-4:00	0:50-1:30				
2007-08 ET Test Results							1:40-2:30			
2008-09 HOT Table Values	0:25-1:00		1:05-1:55	1:40-3:30	2:30-4:00	0:50-1:30	1:40-2:30			
2008-09 ET Test Results								0:50-1:20		
2009-10 HOT Table Values	0:25-1:00		1:05-1:55	1:40-3:30	2:30-4:00	0:50-1:30	1:40-2:30	0:50-1:20		
2009-10 ET Test Results					1:50-2:45					
2010-11 HOT Table Values	0:25-1:00		1:05-1:55	1:40-3:30	1:50-2:45	0:50-1:30	1:40-2:30	0:50-1:20		
2010-11 ET Test Results										2:30-4:00
2011-12 HOT Table Values	0:25-1:00		1:05-1:55	1:40-3:30	1:50-2:45	0:50-1:30	1:40-2:30	0:50-1:20		
2011-12 ET Test Results									2:35-4:00	
2012-13 HOT Table Values	0:25-1:00		1:05-1:55	1:40-3:30	1:50-2:45	0:50-1:30	1:40-2:30	0:50-1:20	2:35-4:00	
2012-13 ET Test Results										
2013-14 HOT Table Values	0:25-1:00		1:05-1:55	1:40-3:30	1:50-2:45	0:50-1:30	1:40-2:30	0:50-1:20	2:35-4:00	2:30-4:00

Table 4.20: Type II 50/50 Fluid, Freezing Fog, -3°C and Above

	GENERIC	C-1951	A-E26	K2000	C-Flight	N-FCY-2	ABC-K +	AS CII	C-Flight +	CR-PGII
1998-99 HOT Table Values	0:150:45									
1998-99 ETTest Results										
1999-00 HOT Table Values	0:15-0:35									
1999-00 ET Test Results		0:200:30								
2000-01 HOT Table Values	0:15-0:30	0:20-0:30								
2000-01 ET Test Results			0:30-0:45							
2001-02 HOT Table Values	0:15-0:30	0:20-0:30	0:30-0:45							
2001-02 ET Test Results				1:00-2:10						
2002-03 HOT Table Values	0:15-0:30		0:30-0:45	1:00-2:10						
2002-03 ET Test Results										
2003-04 HOT Table Values	0:15-0:30		0:30-0:45	1:00-2:10						
2003-04 ET Test Results										
2004-05 HOT Table Values	0:15-0:30		0:30-0:45	1:00-2:10						
2004-05 ET Test Results										
2005-06 HOT Table Values	0:15-0:30		0:30-0:45	1:00-2:10						
2005-06 ET Test Results					0:55-1:45					
2006-07 HOT Table Values	0:15-0:30		0:30-0:45	1:00-2:10	0:55-1:45					
2006-07 ET Test Results						0:25-0:35				
2007-08 HOT Table Values	0:15-0:30		0:30-0:45	1:00-2:10	0:55-1:45	0:25-0:35				
2007-08 ET Test Results							0:35-1:05			
2008-09 HOT Table Values	0:15-0:30		0:30-0:45	1:00-2:10	0:55-1:45	0:25-0:35	0:35-1:05			
2008-09 ET Test Results								0:35-1:00		
2009-10 HOT Table Values	0:15-0:30		0:30-0:45	1:00-2:10	0:55-1:45	0:25-0:35	0:35-1:05	0:35-1:00		
2009-10 ET Test Results										
2010-11 HOT Table Values	0:15-0:30		0:30-0:45	1:00-2:10	0:55-1:45	0:25-0:35	0:35-1:05	0:35-1:00		
2010-11 ET Test Results										0:50-1:25
2011-12 HOT Table Values	0:15-0:30		0:30-0:45	1:00-2:10	0:55-1:45	0:25-0:35	0:35-1:05	0:35-1:00		
2011-12 ET Test Results									1:05-2:20	
2012-13 HOT Table Values	0:15-0:30		0:30-0:45	1:00-2:10	0:55-1:45	0:25-0:35	0:35-1:05	0:35-1:00	1:05-2:20	
2012-13 ET Test Results										
2013-14 HOT Table Values	0:15-0:30		0:30-0:45	1:00-2:10	0:55-1:45	0:25-0:35	0:35-1:05	0:35-1:00	1:05-2:20	0:50-1:25

Table 4.21: Type II Neat Fluid, Freezing Fog, Below -3°C to -14°C

	GENERIC	C-1951	A-E26	K2000	C-Flight	N-FCY-2	ABC-K +	AS CII	C-Flight +	CR-PGII
1998-99 HOT Table Values	0:35-1:30									
1998-99 ETTest Results										
1999-00 HOT Table Values	0:30-1:05									
1999-00 ET Test Results		0:45-1:25								
2000-01 HOT Table Values	0:20*-1:05	0:45-1:25								
2000-01 ET Test Results			0:45-2:15							
2001-02 HOT Table Values	0:20*-1:05	0:45-1:25	0:45-2:15							
2001-02 ET Test Results				0:35-1:25						
2002-03 HOT Table Values	0:20*-1:05		0:45-2:15	0:35-1:25						
2002-03 ET Test Results										
2003-04 HOT Table Values	0:20*-1:05		0:45-2:15	0:35-1:25						
2003-04 ET Test Results										
2004-05 HOT Table Values	0:20*-1:05		0:45-2:15	0:35-1:25						
2004-05 ET Test Results										
2005-06 HOT Table Values	0:20*-1:05		0:45-2:15	0:35-1:25						
2005-06 ET Test Results					0:55-1:45					
2006-07 HOT Table Values	0:20*-1:05		0:45-2:15	0:35-1:25	0:55-1:45					
2006-07 ET Test Results						0:45-1:30				
2007-08 HOT Table Values	0:20*-1:05		0:45-2:15	0:35-1:25	0:55-1:45	0:45-1:30				
2007-08 ET Test Results							0:30-1:05			
2008-09 HOT Table Values	0:20*-1:05		0:45-2:15	0:35-1:25	0:55-1:45	0:45-1:30	0:30-1:05			
2008-09 ET Test Results								0:45-1:50		
2009-10 HOT Table Values	0:20*-1:05		0:45-2:15	0:35-1:25	0:55-1:45	0:45-1:30	0:30-1:05	0:45-1:50		
2009-10 ET Test Results										
2010-11 HOT Table Values	0:20*-1:05		0:45-2:15	0:35-1:25	0:55-1:45	0:45-1:30	0:30-1:05	0:45-1:50		
2010-11 ET Test Results										0:55-2:30
2011-12 HOT Table Values	0:20*-1:05		0:45-2:15	0:35-1:25	0:55-1:45	0:45-1:30	0:30-1:05	0:45-1:50		
2011-12 ET Test Results									0:40-2:20	
2012-13 HOT Table Values	0:20*-1:05		0:45-2:15	0:35-1:25	0:55-1:45	0:45-1:30	0:30-1:05	0:45-1:50	0:40-2:20	
2012-13 ET Test Results										
2013-14 HOT Table Values	0:20*-1:05		0:45-2:15	0:35-1:25	0:55-1:45	0:45-1:30	0:30-1:05	0:45-1:50	0:40-2:20	0:55-2:30

* Value in Type II generic table can not be more than value in Type IV generic table; values were reduced for this reason

Table 4.22: Type II 75/25 Fluid, Freezing Fog, Below -3°C to -14°C

	GENERIC	C-1951	A-E26	K2000	C-Flight	N-FCY-2	ABC-K +	AS CII	C-Flight +	CR-PGII
1998-99 HOT Table Values	0:25-1:00									
1998-99 ETTest Results										
1999-00 HOT Table Values	0:20-0:55									
1999-00 ET Test Results		0:35-1:00								
2000-01 HOT Table Values	0:20-0:55	0:35-1:00								
2000-01 ET Test Results			0:35-1:15							
2001-02 HOT Table Values	0:20-0:55	0:35-1:00	0:35-1:15							
2001-02 ET Test Results				0:35-1:15						
2002-03 HOT Table Values	0:20-0:55		0:35-1:15	0:35-1:15						
2002-03 ET Test Results										
2003-04 HOT Table Values	0:20-0:55		0:35-1:15	0:35-1:15						
2003-04 ET Test Results										
2004-05 HOT Table Values	0:20-0:55		0:35-1:15	0:35-1:15						
2004-05 ET Test Results										
2005-06 HOT Table Values	0:20-0:55		0:35-1:15	0:35-1:15						
2005-06 ET Test Results					~~0:40-1:10~~					
2006-07 HOT Table Values	0:20-0:55		0:35-1:15	0:35-1:15	0:40-1:10					
2006-07 ET Test Results						0:30-1:05				
2007-08 HOT Table Values	0:20-0:55		0:35-1:15	0:35-1:15	0:40-1:10	0:30-1:05				
2007-08 ET Test Results							0:25-1:25			
2008-09 HOT Table Values	0:20-0:55		0:35-1:15	0:35-1:15	0:40-1:10	0:30-1:05	0:25-1:25			
2008-09 ET Test Results								0:40-1:45		
2009-10 HOT Table Values	0:25-0:50*		0:35-1:15	0:35-1:15	0:40-1:10	0:30-1:05	0:25-1:25	0:40-1:45		
2009-10 ET Test Results					0:25-1:05					
2010-11 HOT Table Values	0:25-0:50*		0:35-1:15	0:35-1:15	0:25-1:05	0:30-1:05	0:25-1:25	0:40-1:45		
2010-11 ET Test Results										0:40-1:30
2011-12 HOT Table Values	0:25-0:50*		0:35-1:15	0:35-1:15	0:25-1:05	0:30-1:05	0:25-1:25	0:40-1:45		
2011-12 ET Test Results									0:30-1:45	
2012-13 HOT Table Values	0:25-0:50*		0:35-1:15	0:35-1:15	0:25-1:05	0:30-1:05	0:25-1:25	0:40-1:45	0:30-1:45	
2012-13 ET Test Results										
2013-14 HOT Table Values	0:25-0:50*		0:35-1:15	0:35-1:15	0:25-1:05	0:30-1:05	0:25-1:25	0:40-1:45	0:30-1:45	0:40-1:30

* Value in Type II generic table can not be more than value in Type IV generic table; values were reduced for this reason

Table 4.23: Type II Neat Fluid, Freezing Fog, Below -14ºC to -25ºC

	GENERIC	C-1951	A-E26	K2000	C-Flight	N-FCY-2	ABC-K+	AS CII	C-Flight+	CR-PGII
1998-99 HOT Table Values	0:20-1:30									
1998-99 ETTest Results										
1999-00 HOT Table Values	0:15-0:20									
1999-00 ET Test Results		0:20-0:40								
2000-01 HOT Table Values	0:15-0:20	0:20-0:40								
2000-01 ET Test Results			0:25-0:45							
2001-02 HOT Table Values	0:15-0:20	0:20-0:40	0:25-0:45							
2001-02 ET Test Results				0:20-0:45						
2002-03 HOT Table Values	0:15-0:20		0:25-0:45	0:20-0:45						
2002-03 ET Test Results										
2003-04 HOT Table Values	0:15-0:20		0:25-0:45	0:20-0:45						
2003-04 ET Test Results										
2004-05 HOT Table Values	0:15-0:20		0:25-0:45	0:20-0:45						
2004-05 ET Test Results										
2005-06 HOT Table Values	0:15-0:20		0:25-0:45	0:20-0:45						
2005-06 ET Test Results					0:30-0:50					
2006-07 HOT Table Values	0:15-0:20		0:25-0:45	0:20-0:45	0:30-0:50					
2006-07 ET Test Results						0:25-0:35				
2007-08 HOT Table Values	0:15-0:20		0:25-0:45	0:20-0:45	0:30-0:50	0:25-0:35				
2007-08 ET Test Results							0:30-0:55			
2008-09 HOT Table Values	0:15-0:20		0:25-0:45	0:20-0:45	0:30-0:50	0:25-0:35	0:30-0:55			
2008-09 ET Test Results								0:20-0:50		
2009-10 HOT Table Values	0:15*-0:35		0:25-0:45	0:20-0:45	0:30-0:50	0:25-0:35	0:30-0:55	0:20-0:50		
2009-10 ET Test Results										
2010-11 HOT Table Values	0:15*-0:35		0:25-0:45	0:20-0:45	0:30-0:50	0:25-0:35	0:30-0:55	0:20-0:50		
2010-11 ET Test Results										0:25-0:50
2011-12 HOT Table Values	0:15*-0:35		0:25-0:45	0:20-0:45	0:30-0:50	0:25-0:35	0:30-0:55	0:20-0:50		
2011-12 ET Test Results									0:20-0:40	
2012-13 HOT Table Values	0:15*-0:35		0:25-0:45	0:20-0:45	0:30-0:50	0:25-0:35	0:30-0:55	0:20-0:50	0:20-0:40	
2012-13 ET Test Results										
2013-14 HOT Table Values	0:15*-0:35		0:25-0:45	0:20-0:45	0:30-0:50	0:25-0:35	0:30-0:55	0:20-0:50	0:20-0:40	0:25-0:50

* Value in Type II generic table can not be more than value in Type IV generic table; values were reduced for this reason

Table 4.24: Type II Neat Fluid, Rain on Cold-Soaked Wing, Above 0°C

	GENERIC	C-1951	A-E26	K2000	C-Flight	N-FCY-2	ABC-K +	AS CII	C-Flight +	CR-PGII
1998-99 HOT Table Values	0:100:40									
1998-99 ETTest Results										
1999-00 HOT Table Values	0:05-0:40									
1999-00 ET Test Results		0:10-0:50								
2000-01 HOT Table Values	0:05-0:40	0:10-0:50								
2000-01 ET Test Results			0:20-1:25							
2001-02 HOT Table Values	0:05-0:40	0:10-0:50	0:20-1:25							
2001-02 ET Test Results				0:15-1:10						
2002-03 HOT Table Values	0:05-0:40		0:20-1:25	0:15-1:10						
2002-03 ET Test Results										
2003-04 HOT Table Values	0:05-0:40		0:20-1:25	0:15-1:10						
2003-04 ET Test Results										
2004-05 HOT Table Values	0:05-0:40		0:20-1:25	0:15-1:10						
2004-05 ET Test Results										
2005-06 HOT Table Values	0:05-0:40		0:20-1:25	0:15-1:10						
2005-06 ET Test Results					0:10-1:30					
2006-07 HOT Table Values	0:05-0:40		0:20-1:25	0:15-1:10	0:10-1:30					
2006-07 ET Test Results						0:08-0:45				
2007-08 HOT Table Values	0:05-0:40		0:20-1:25	0:15-1:10	0:10-1:30	0:05-0:45				
2007-08 ET Test Results							0:20-2:00			
2008-09 HOT Table Values	0:05-0:40		0:20-1:25	0:15-1:10	0:10-1:30	0:05-0:45	0:20-2:00			
2008-09 ET Test Results								0:10-0:55		
2009-10 HOT Table Values	0:05-0:40		0:20-1:25	0:15-1:10	0:10-1:30	0:05-0:45	0:20-2:00	0:10-0:55		
2009-10 ET Test Results										
2010-11 HOT Table Values	0:05-0:40		0:20-1:25	0:15-1:10	0:10-1:30	0:05-0:45	0:20-2:00	0:10-0:55		
2010-11 ET Test Results										0:15-2:00
2011-12 HOT Table Values	0:08-0:40		0:20-1:25	0:15-1:10	0:10-1:30	0:08-0:45	0:20-2:00	0:10-0:55		
2011-12 ET Test Results									0:15-2:00	
2012-13 HOT Table Values	0:08-0:40		0:20-1:25	0:15-1:10	0:10-1:30	0:08-0:45	0:20-2:00	0:10-0:55	0:15-2:00	
2012-13 ET Test Results										
2013-14 HOT Table Values	0:08-0:40		0:20-1:25	0:15-1:10	0:10-1:30	0:08-0:45	0:20-2:00	0:10-0:55	0:15-2:00	0:15-2:00

Table 4.25: Type II 75/25 Fluid, Rain on Cold-Soaked Wing, Above 0°C

	GENERIC	C-1951	A-E26	K2000	C-Flight	N-FCY-2	ABC-K +	AS CII	C-Flight +	CR-PGII
1998-99 HOT Table Values	~~0:05-0:25~~									
1998-99 ETTest Results										
1999-00 HOT Table Values	0:05-0:25									
1999-00 ET Test Results		0:07-0:40								
2000-01 HOT Table Values	0:05-0:25	0:05-0:40								
2000-01 ET Test Results			0:10-1:00							
2001-02 HOT Table Values	0:05-0:25	0:05-0:40	0:10-1:00							
2001-02 ET Test Results				0:15-1:40						
2002-03 HOT Table Values	0:05-0:25		0:10-1:00	0:15-1:40						
2002-03 ET Test Results										
2003-04 HOT Table Values	0:05-0:25		0:10-1:00	0:15-1:40						
2003-04 ET Test Results										
2004-05 HOT Table Values	0:05-0:25		0:10-1:00	0:15-1:40						
2004-05 ET Test Results										
2005-06 HOT Table Values	0:05-0:25		0:10-1:00	0:15-1:40						
2005-06 ET Test Results					~~0:07-1:20~~					
2006-07 HOT Table Values	0:05-0:25		0:10-1:00	0:15-1:40	0:05-1:20					
2006-07 ET Test Results						~~0:05-0:25~~				
2007-08 HOT Table Values	0:05-0:25		0:10-1:00	0:15-1:40	0:05-1:20	0:05-0:25				
2007-08 ET Test Results							0:15-2:00			
2008-09 HOT Table Values	0:05-0:25		0:10-1:00	0:15-1:40	0:05-1:20	0:05-0:25	0:15-2:00			
2008-09 ET Test Results								0:07-0:50		
2009-10 HOT Table Values	0:05-0:25		0:10-1:00	0:15-1:40	0:05-1:20	0:05-0:25	0:15-2:00	0:05-0:50		
2009-10 ET Test Results					0:06-0:50					
2010-11 HOT Table Values	0:05-0:25		0:10-1:00	0:15-1:40	0:05-0:50	0:05-0:25	0:15-2:00	0:05-0:50		
2010-11 ET Test Results										0:09-1:40
2011-12 HOT Table Values	0:05-0:25		0:10-1:00	0:15-1:40	0:06-0:50	0:05-0:25	0:15-2:00	0:07-0:50		
2011-12 ET Test Results									0:15-1:15	
2012-13 HOT Table Values	0:05-0:25		0:10-1:00	0:15-1:40	0:06-0:50	0:05-0:25	0:15-2:00	0:07-0:50	0:15-1:15	
2012-13 ET Test Results										
2013-14 HOT Table Values	0:05-0:25		0:10-1:00	0:15-1:40	0:06-0:50	0:05-0:25	0:15-2:00	0:07-0:50	0:15-1:15	0:09-1:40

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5. CHANGES TO THE TYPE III HOT GUIDELINES

Changes made to the Type III HOT guidelines for the winter of 2013-14 are documented in this chapter. The Transport Canada and FAA 2013-14 generic Type III HOT guidelines are included in Appendix F.

5.1 New Fluids/Data

No new Type III fluids/data were incorporated into the guidelines for 2013-14.

5.2 Changes to HOT Guidelines Format

The freezing fog column in the Type III HOT table was modified to include ice crystals (see Subsection 2.7).

The FAA increased its cap on snow holdover times from 2 to 3 hours for winter 2013-14. This did not impact the Type III snow holdover times.

5.3 Type III Generic Holdover Time Values

The current Type III generic holdover time values are based on the endurance times of Clariant Safewing MP III 2031 ECO, which was the first fluid qualified as a new generation Type III fluid. Holdover time testing was conducted with a neat sample of the fluid in 2003-04 and with diluted fluid samples (75/25 and 50/50) the following winter. The fluid-specific endurance times calculated for Clariant Safewing MP III 2031 ECO were reduced by 10 percent and changed to reasonably round values to obtain the generic values.

No changes have since been made to the Type III generic holdover time values.

5.4 Future Changes to the Type III HOT Guidelines

Tests conducted in previous winters have shown fluid temperature at the time of application can affect the endurance times of Type III fluids. Endurance times are generally longer when fluid is applied heated and shorter when fluid is applied at ambient temperature. However, the effect of heat is not the same in all conditions and heated fluid was found to have shorter endurance times in some cases.

A review of this research was completed in the winter of 2008-09 and is documented in the Transport Canada report, TP 14936E, *Aircraft Ground Icing General Research Activities During the 2008-09 Winter* (8). The review concluded that Type III fluids should be tested with fluid applied either at ambient temperature, or heated, or both, depending on how the fluid will be used in operations, and that regulators should publish fluid-specific and application temperature-specific HOT tables for Type III fluids.

Since then, several fluids have undergone testing. However, a complete set of testing has not been completed for any fluid. It is expected this testing will be completed in the winter of 2013-14 and that fluid-specific and application temperature-specific tables will be published for winter 2014-15.

5.5 Supplemental Research – Endurance Times of Type III Fluids on Composite Surfaces

Several tests were conducted in the winter of 2011-12 to investigate the impact of test surface material on endurance times of Type III fluids applied heated. Five runs were conducted in freezing precipitation. Each run consisted of a baseline test where Type III fluid was applied heated to an aluminum surface and a comparative test where the same fluid was applied heated to a composite surface. The results are shown in Figure 5.1. The results were counterintuitive; further testing was recommended.

Six additional runs were conducted in the winter of 2012-13. The results are shown in Figure 5.2. Many of the tests show similar endurance times on aluminum and composite surfaces, while some tests show longer endurance times on aluminum surfaces. These results, which were obtained with a different fluid sample, are somewhat inconsistent with the 2011-12 results.

Together the results seem to indicate that there are not significant differences in endurance times on aluminum and composite surfaces. Therefore, no immediate action is needed. However, due to the inconsistency in the results, further tests are recommended. These tests should be conducted under more test conditions and should include Brix and temperature profile measurements.

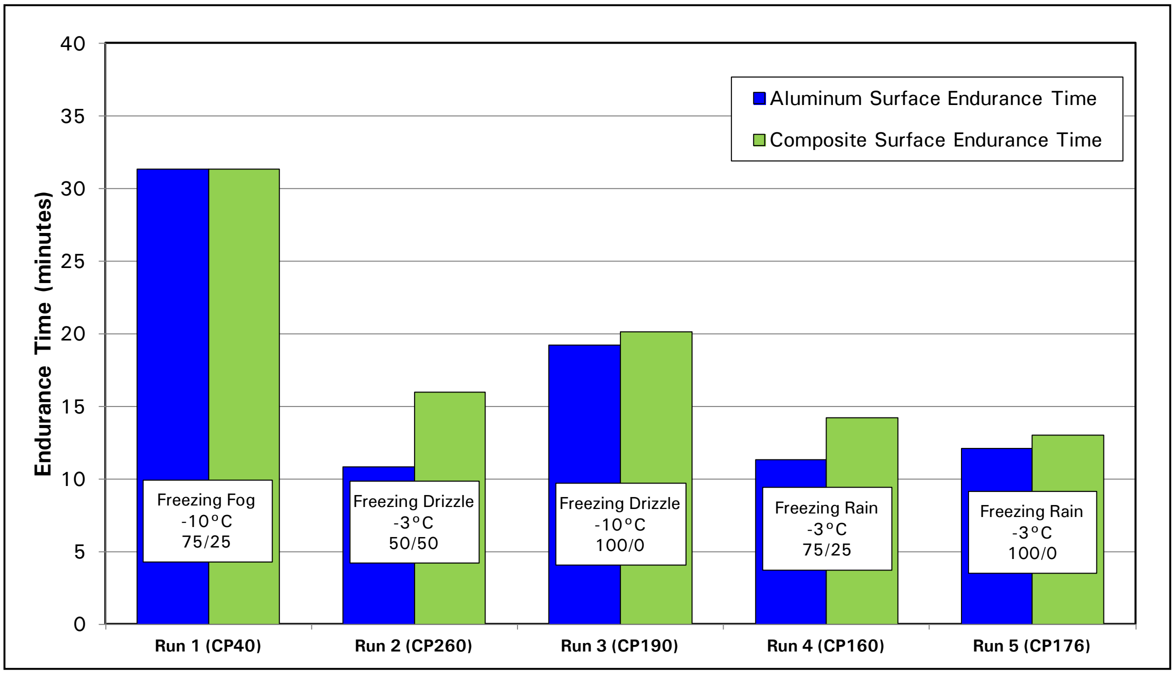

Figure 5.1: Type III Composite vs. Aluminum Test Results (2011-12)

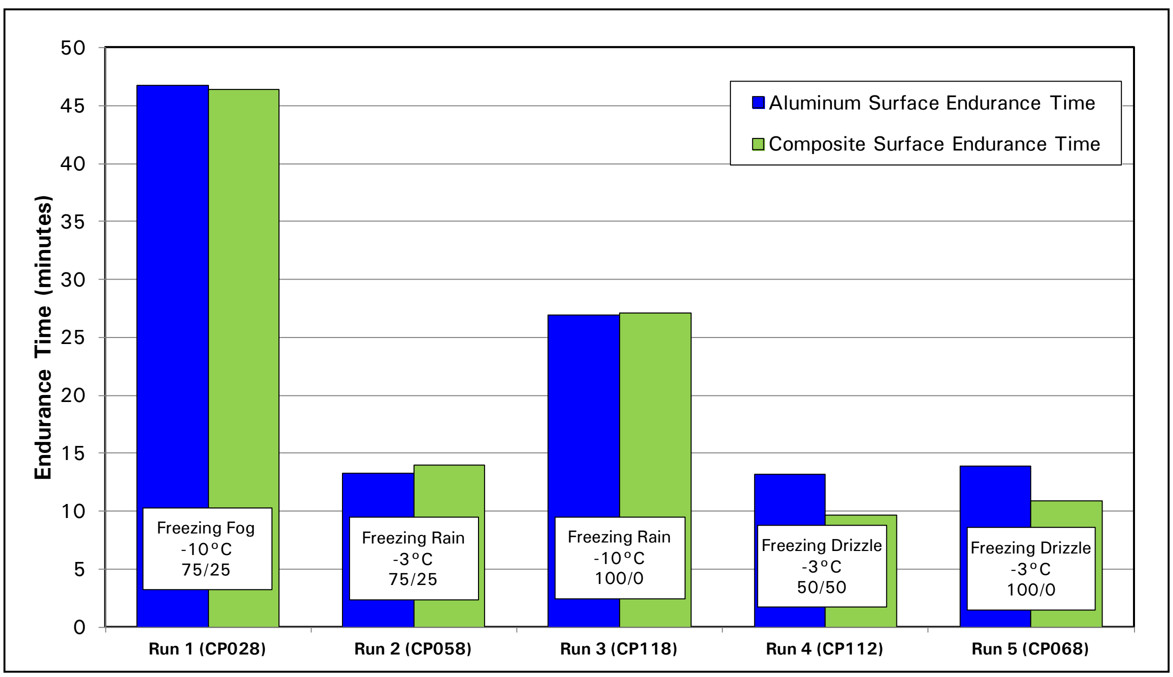

Figure 5.2: Type III Composite vs. Aluminum Test Results (2012-13)

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6. CHANGES TO THE TYPE IV HOT GUIDELINES

Changes made to the Type IV HOT guidelines for the winter of 2013-14 are documented in this chapter. The Transport Canada and FAA 2013-14 Type IV HOT guidelines are included in Appendix F.

6.1 New Fluids/Data

One new Type IV fluid, **Clariant Safewing MP IV Launch Plus**, was added to the HOT guidelines for the winter of 2013-14. This is a new Type IV fluid that underwent endurance time testing in the winter of 2012-13. The detailed Launch Plus test results are provided in Appendix E.

6.2 Removed Fluids/Data

The protocol for removing obsolete holdover time data is given in ARP5718 (7).

At the request of the manufacturer, Kilfrost ABC-4^{sustain} was removed from the Type IV HOT guidelines for the winter of 2013-14. This fluid had never been commercialized and therefore could be removed immediately.

At the request of the manufacturer, Clariant Max Flight 04 75/25 and 50/50 dilutions were removed from the Type IV HOT guidelines for the winter of 2013-14.

6.3 Changes to HOT Guidelines Format

Several changes were made to the format of the Type IV HOT guidelines for winter 2013-14.

1. The freezing fog column in all Type IV HOT tables was modified to include ice crystals (see Subsection 1.1).

2. Light and very light snow holdover times were added to many of the Type IV fluid-specific HOT tables (see Section 7). The “snow” column in these tables was renamed “moderate snow.” The affected tables are:
    - ABAX Ecowing AD-49;
    - Kilfrost ABC-S Plus;
    - Clariant Max Flight 04;
    - Clariant Safewing MP IV Launch;
    - Clariant Safewing MP IV Launch Plus;
    - Cryotech Polar Guard Advance;

- Dow UCAR™ Endurance EG106; and
- Dow UCAR™ FlightGuard AD-49.

3. The FAA increased its cap on snow holdover times from 2 to 3 hours. This resulted in the following increases to the FAA holdover times (Transport Canada did not change its 2 hour cap on snow holdover times):
    - Clariant Max Flight 04, 100/0, moderate snow, -3°C and above: from 2:00 to 2:45; and
    - Kilfrost ABC-S Plus, 100/0, moderate snow, -3°C and above: from 2:00 to 2:05.

6.4 Type IV Generic Holdover Time Values

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

6.4.1 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 were determined based on historical data and analysis.

In the winter of 2013-14, light snow and very light snow holdover times were added to many Type IV HOT tables. Generic very cold snow values for these snow intensities were correspondingly determined. Details are provided in Subsection 7.7.1.

6.4.2 Impact of New and Removed Fluids/Data

The removal of Kilfrost ABC-4^{sustain} resulted in eight increases to the Type IV generic holdover times: one 10-minute increase, six 5-minute increases and one 1-minute increase. The removal of Clariant Max Flight 04 75/25 and 50/50 dilutions resulted in one 5-minute increase to the Type IV generic holdover times.

6.4.3 Fluids Responsible for the Type IV Generic Holdover Time Values

The fluids responsible for the values in the 2013-14 Type IV generic HOT guidelines are shown in Table 6.1. A "U" indicates a fluid is responsible for the upper value in the cell; an "L" indicates a 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.

Table 6.1: Fluids Responsible for the Type IV Generic Holdover Time Values

OAT		Fluid Dilution	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)				
°C	°F		Freezing Fog	Snow	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing
-3 and above	27 and above	100/0	D-E106 **(U)** L-AS **(B)**	A/D-480 **(B)** D-E106 **(B)**	A/D-480 **(B)**	A/D-480 **(B)**	A/D-49 **(L)** K-ABCS **(U)**
		75/25	K-ABCS **(B)**	K-ABCS **(B)** A/D-480 **(L)**	K-ABCS **(B)**	A/D-480 **(B)** L-AS **(B)** K-ABCS+ **(L)**	L-AS **(L)** CR-PGA **(L)** K-ABCS **(U)**
		50/50	K-ABCS **(B)**	K-ABCS **(B)** CR-PG **(U)**	K-ABCS **(B)** K-ABCS+ **(L)** A/D-480 **(L)** A/D-49 **(L)** CR-PG **(L)**	K-ABCS **(B)**	
below -3 to -14	below 27 to 7	100/0	A/D-480 **(B)** A/D-49 **(L)**	A/D-480 **(B)** CR-PG **(B)** D-E106 **(L)**	K-ABCS **(B)**	K-ABCS **(L)** A/D-49 **(U)**	
		75/25	A/D-480 **(B)** K-ABCS **(L)**	CR-PG **(B)** A/D-480 **(L)**	A/D-49 **(B)** A/D-480 **(U)** CR-PG **(U)** CR-PGA **(U)** C-L+ **(U)**	K-ABCS **(L)** K-ABCS+ **(U)** A/D-49 **(U)**	
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	A/D-480 **(B)** K-ABCS **(U)** A/D-49 **(U)** CR-PG **(U)**	Historic Generic **(B)**			

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

6.4.4 Evolution of Type IV Generic Holdover Time Values

The history of testing with Type IV fluids and the evolution of the fluid-specific and generic Type IV holdover time values are illustrated through a series of tables given in Tables 6.2 to 6.25. Each table represents one cell in the HOT guidelines and the title of each table links the table to the appropriate cell. Fluids that are no longer used in the generic analysis (see Subsection 6.2) are not included.

The first row in each table contains the values obtained in testing in 1996-97. These values were used as the holdover time values in 1997-98 winter operations. Each subsequent set of two rows represents a winter test season and the subsequent winter's holdover time values. The final line contains the generic and fluid-specific holdover time values for use in 2013-14 winter operations. It should be noted that because no Type IV fluids were tested in the winter of 2001-02 and the generic values did not change, no line has been included for the 2001-02 winter test season or the 2002-03 holdover time values.

Underlined values indicate the fluid(s) responsible for the generic holdover time. Strikethrough values indicate endurance time test results that are no longer valid. If a fluid is no longer qualified, such as the Octagon Max-Flight 1998-99 low viscosity sample, the test results become invalid. Alternately, if a fluid has been tested on multiple occasions, then only one test result, usually the shortest endurance time, is valid for a given fluid in a given cell. Details are typically provided in the HOT report written in the most recent year the fluid underwent testing.

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

- ABAX AD-480 / Dow UCAR FlightGuard AD-480 (A/D-480);
- ABAX Ecowing AD-49 / Dow UCAR FlightGuard AD-49 (A/D-49);
- Clariant Max-Flight 04 (C-Max 04);
- Clariant Safewing MP IV Launch (C-Launch);
- Clariant Safewing MP IV Launch Plus (C-L+);
- Cryotech Polar Guard (CR-PG);
- Cryotech Polar Guard Advance (CR-PGA);
- Dow UCAR Endurance EG106 (D-E106);
- Kilfrost ABC-S (K-ABCS);
- Kilfrost ABC-S PLUS (K-ABCS+); and
- Lyondell ARCTIC Shield® (L-AS).

Table 6.2: Type IV Neat Fluid, Snow, -3°C and Above

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A/D-49	CR-PG	CR-PGA	C-L+
1996-97 Test Results and Table Values used in 97-98	0:35-1:00	1:00-1:40										
1997-98 ET Test Results			~~1:05-2:00~~									
1998-99 HOT Table Values	0:35-1:00	1:00-1:40	1:05-2:00									
1998-99 ETTest Results		1:00-1:40	~~1:05-1:50~~									
1999-00 HOT Table Values	0:30-0:55	1:00-1:40	1:05-1:50									
1999-00 ET Test Results			~~0:40-1:20~~									
2000-01 HOT Table Values	0:30-0:55	1:00-1:40	0:40-1:20									
2000-01 ET Test Results				1:25-2:45								
2001-02 HOT Table Values	0:30-0:55	1:00-1:40	0:40-1:20									
2002-03 ET Test Results												
2003-04 HOT Table Values	0:30-0:55	1:00-1:40	0:40-1:20									
2003-04 ET Test Results												
2004-05 HOT Table Values	0:30-0:55	1:00-1:40	0:40-1:20	1:25-2:00								
2004-05 ET Test Results												
2005-06 HOT Table Values	0:35-1:15	1:00-1:40	0:40-1:20	1:25-2:00								
2005-06 ET Test Results					~~1:00-1:35~~	~~0:40-1:20~~	~~0:45-1:25~~					
2006-07 HOT Table Values	0:35-1:15	1:00-1:40	0:40-1:20	1:25-2:00	1:00-1:35	0:40-1:20	0:45-1:25					
2006-07 ET Test Results					1:05-1:45		1:15-2:05	0:50-1:25				
2007-08 HOT Table Values	0:35-1:15	1:00-1:40	0:40-1:20	1:25-2:00	1:05-1:45	0:40-1:20	1:15-2:00	0:50-1:25				
2007-08 ET Test Results												
2008-09 HOT Table Values	0:35-1:15	1:00-1:40	0:40-1:20	1:25-2:00	1:05-1:45	0:40-1:20	1:15-2:00	0:50-1:25				
2008-09 ET Test Results									1:10-1:50			
2009-10 HOT Table Values	0:35-1:15	1:00-1:40	0:40-1:20	1:25-2:00	1:05-1:45	0:40-1:20	1:15-2:00	0:50-1:25	1:10-1:50			
2009-10 ET Test Results										0:50-1:30		
2010-11 HOT Table Values	0:35-1:15	1:00-1:40	0:40-1:20	1:25-2:00	1:05-1:45	0:40-1:20	1:15-2:00	0:50-1:25	1:10-1:50	0:50-1:30		
2010-11 ET Test Results											1:20-1:50	
2011-12 HOT Table Values	0:35-1:15	1:00-1:40	0:40-1:20	1:25-2:00	1:05-1:45	0:40-1:20	1:15-2:00	0:50-1:25	1:10-1:50	0:50-1:30	1:20-1:50	
2011-12 ET Test Results												
2012-13 HOT Table Values	0:40-1:20	1:00-1:40	0:40-1:20	1:25-2:00	1:05-1:45	0:40-1:20	1:15-2:00	0:50-1:25	1:10-1:50	0:50-1:30	1:20-1:50	
2012-13 ET Test Results												0:55-2:00
2013-14 HOT Table Values (TC)	0:40-1:20	1:00-1:40	0:40-1:20	1:25-2:00	1:05-1:45	0:40-1:20	1:15-2:00	0:50-1:25	1:10-1:50	0:50-1:30	1:20-1:50	0:55-2:00
2013-14 HOT Table Values	0:40-1:20	1:00-1:40	0:40-1:20	1:25-2:45	1:05-1:45	0:40-1:20	1:15-2:05	0:50-1:25	1:10-1:50	0:50-1:30	1:20-1:50	0:55-2:00

Table 6.3: Type IV 75/25 Fluid, Snow, -3ºC and Above

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A/D-49	CR-PG	CR-PGA	C-L+
1996-97 Test Results and Table Values used in 97-98	0:20-0:35	~~0:35-1:05~~										
1997-98 ET Test Results			~~0:45-1:25~~									
1998-99 HOT Table Values	0:20-0:35	0:35-1:05	0:45-1:25									
1998-99 ETTest Results		0:30-0:55	~~0:45-1:25~~									
1999-00 HOT Table Values	0:20-0:35	0:30-0:55	0:45-1:25									
1999-00 ET Test Results			0:30-1:05									
2000-01 HOT Table Values	0:20-0:35	0:30-0:55	0:30-1:05									
2000-01 ET Test Results				~~1:05-2:00~~								
2001-02 HOT Table Values	0:25-0:50	0:30-0:55	0:30-1:05									
2002-03 ET Test Results												
2003-04 HOT Table Values	0:25-0:50	0:30-0:55	0:30-1:05									
2003-04 ET Test Results												
2004-05 HOT Table Values	0:25-0:50	0:30-0:55	0:30-1:05	1:05-2:00								
2004-05 ET Test Results												
2005-06 HOT Table Values	0:20-0:55	0:30-0:55	0:30-1:05	1:05-2:00								
2005-06 ET Test Results					~~0:40-1:20~~		~~0:25-0:55~~					
2006-07 HOT Table Values	0:20-0:55	0:30-0:55	0:30-1:05	1:05-2:00	0:40-1:20		0:25-0:55					
2006-07 ET Test Results					1:00-1:45		0:45-1:15	0:40-1:05				
2007-08 HOT Table Values	0:20-0:55	0:30-0:55	0:30-1:05	1:05-2:00	1:00-1:45		0:45-1:15	0:40-1:05				
2007-08 ET Test Results												
2008-09 HOT Table Values	0:20-0:55	0:30-0:55	0:30-1:05	1:05-2:00	1:00-1:45		0:45-1:15	0:40-1:05				
2008-09 ET Test Results									1:20-1:40			
2009-10 HOT Table Values	0:20-0:55	0:30-0:55	0:30-1:05	1:05-2:00	1:00-1:45		0:45-1:15	0:40-1:05	1:20-1:40			
2009-10 ET Test Results										0:35-1:10		
2010-11 HOT Table Values	0:20-0:55	0:30-0:55	0:30-1:05	1:05-2:00	1:00-1:45		0:45-1:15	0:40-1:05	1:20-1:40	0:35-1:10		
2010-11 ET Test Results											0:45-1:20	
2011-12 HOT Table Values	0:30-0:55	0:30-0:55	0:30-1:05	1:05-2:00	1:00-1:45		0:45-1:15	0:40-1:05	1:20-1:40	0:35-1:10	0:45-1:20	
2011-12 ET Test Results												
2012-13 HOT Table Values	0:30-0:55	0:30-0:55	0:30-1:05	1:05-2:00	1:00-1:45		0:45-1:15	0:40-1:05	1:20-1:40	0:35-1:10	0:45-1:20	
2012-13 ET Test Results												0:50-1:55
2013-14 HOT Table Values	0:30-0:55	0:30-0:55	0:30-1:05		1:00-1:45		0:45-1:15	0:40-1:05	1:20-1:40	0:35-1:10	0:45-1:20	0:50-1:55

Table 6.4: Type IV 50/50 Fluid, Snow, -3ºC and Above

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A/D-49	CR-PG	CR-PGA	C-L+
1996-97 Test Results and Table Values used in 97-98	0:05-0:15	~~0:05-0:15~~										
1997-98 ET Test Results			~~0:10-0:30~~									
1998-99 HOT Table Values	0:05-0:15	0:05-0:15	0:10-0:30									
1998-99 ETTest Results	0:05-0:15	0:07-0:15										
1999-00 HOT Table Values	0:05-0:15	0:05-0:15	0:10-0:30									
1999-00 ET Test Results			0:09-0:20									
2000-01 HOT Table Values	0:05-0:15	0:05-0:15	0:10-0:20									
2000-01 ET Test Results				~~0:25-1:15~~								
2001-02 HOT Table Values	0:05-0:15	0:05-0:15	0:10-0:20									
2002-03 ET Test Results												
2003-04 HOT Table Values	0:05-0:15	0:05-0:15	0:10-0:20									
2003-04 ET Test Results												
2004-05 HOT Table Values	0:05-0:15	0:05-0:15	0:10-0:20	0:25-1:15								
2004-05 ET Test Results												
2005-06 HOT Table Values	0:05-0:15	0:05-0:15	0:10-0:20	0:25-1:15								
2005-06 ET Test Results					~~0:10-0:25~~		~~0:05-0:15~~					
2006-07 HOT Table Values	0:05-0:15	0:05-0:15	0:10-0:20	0:25-1:15	0:10-0:25		0:05-0:15					
2006-07 ET Test Results					0:25-0:45		0:15-0:30	0:20-0:35				
2007-08 HOT Table Values	0:05-0:15	0:05-0:15	0:10-0:20	0:25-1:15	0:25-0:45		0:15-0:30	0:20-0:35				
2007-08 ET Test Results												
2008-09 HOT Table Values	0:05-0:15	0:05-0:15	0:10-0:20	0:25-1:15	0:25-0:45		0:15-0:30	0:20-0:35				
2008-09 ET Test Results									0:15-0:25			
2009-10 HOT Table Values	0:05-0:15	0:05-0:15	0:10-0:20	0:25-1:15	0:25-0:45		0:15-0:30	0:20-0:35	0:15-0:25			
2009-10 ET Test Results										0:100:15		
2010-11 HOT Table Values	0:05-0:15	0:05-0:15	0:10-0:20	0:25-1:15	0:25-0:45		0:15-0:30	0:20-0:35	0:15-0:25	0:10-0:15		
2010-11 ET Test Results											0:15-0:35	
2011-12 HOT Table Values	0:07-0:15	0:07-0:15	0:09-0:20	0:25-1:15	0:25-0:45		0:15-0:30	0:20-0:35	0:15-0:25	0:10-0:15	0:15-0:35	
2011-12 ET Test Results												
2012-13 HOT Table Values	0:07-0:15	0:07-0:15	0:09-0:20	0:25-1:15	0:25-0:45		0:15-0:30	0:20-0:35	0:15-0:25	0:10-0:15	0:15-0:35	
2012-13 ET Test Results												0:20-0:45
2013-14 HOT Table Values	0:07-0:15	0:07-0:15	0:09-0:20		0:25-0:45		0:15-0:30	0:20-0:35	0:15-0:25	0:10-0:15	0:15-0:35	0:20-0:45

Table 6.5: Type IV Neat Fluid, Snow, Below -3°C to -14°C

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A/D-49	CR-PG	CR-PGA	C-L+
1996-97 Test Results and Table Values used in 97-98	0:20-0:40	0:45-1:20										
1997-98 ET Test Results			~~0:20-0:40~~									
1998-99 HOT Table Values	0:20-0:40	0:45-1:20	0:20-0:40									
1998-99 ETTest Results		0:45-1:20	0:30-0:55									
1999-00 HOT Table Values	0:20-0:40	0:45-1:20	0:30-0:55									
1999-00 ET Test Results			~~0:30~~-0:55									
2000-01 HOT Table Values	0:20-0:40	0:45-1:20	0:30-0:55									
2000-01 ET Test Results				0:35-1:10								
2001-02 HOT Table Values	0:20-0:40	0:45-1:20	0:30-0:55									
2002-03 ET Test Results												
2003-04 HOT Table Values	0:20-0:40	0:45-1:20	0:30-0:55									
2003-04 ET Test Results												
2004-05 HOT Table Values	0:20-0:40	0:45-1:20	0:30-0:55	0:35-1:10								
2004-05 ET Test Results												
2005-06 HOT Table Values	0:20-0:40	0:45-1:20	0:30-0:55	0:35-1:10								
2005-06 ET Test Results					~~0:40-1:05~~	~~0:30~~-1:05	~~0:35-1:00~~					
2006-07 HOT Table Values	0:20-0:40	0:45-1:20	0:30-0:55	0:35-1:10	0:40-1:05	0:30-1:05	0:35-1:00					
2006-07 ET Test Results					0:50-1:20		1:00-1:45	0:45-1:15				
2007-08 HOT Table Values	0:20-0:40	0:45-1:20	0:30-0:55	0:35-1:10	0:50-1:20	0:30-1:05	1:00-1:45	0:45-1:15				
2007-08 ET Test Results												
2008-09 HOT Table Values	0:20-0:40	0:45-1:20	0:30-0:55	0:35-1:10	0:50-1:20	0:30-1:05	1:00-1:45	0:45-1:15				
2008-09 ET Test Results									1:10-1:50			
2009-10 HOT Table Values	0:20-0:40	0:45-1:20	0:30-0:55	0:35-1:10	0:50-1:20	0:30-1:05	1:00-1:45	0:45-1:15	1:10-1:50			
2009-10 ET Test Results										~~0:30~~-0:55		
2010-11 HOT Table Values	0:20-0:40	0:45-1:20	0:30-0:55	0:35-1:10	0:50-1:20	0:30-1:05	1:00-1:45	0:45-1:15	1:10-1:50	0:30-0:55		
2010-11 ET Test Results											0:55-1:15	
2011-12 HOT Table Values	0:25-0:50	0:45-1:20	0:30-0:55	0:35-1:10	0:50-1:20	0:30-1:05	1:00-1:45	0:45-1:15	1:10-1:50	0:30-0:55	0:55-1:15	
2011-12 ET Test Results												
2012-13 HOT Table Values	0:30-0:55	0:45-1:20	0:30-0:55	0:35-1:10	0:50-1:20	0:30-1:05	1:00-1:45	0:45-1:15	1:10-1:50	0:30-0:55	0:55-1:15	
2012-13 ET Test Results												0:40-1:25
2013-14 HOT Table Values	0:30-0:55	0:45-1:20	0:30-0:55	0:35-1:10	0:50-1:20	0:30-1:05	1:00-1:45	0:45-1:15	1:10-1:50	0:30-0:55	0:55-1:15	0:40-1:25

Table 6.6: Type IV 75/25 Fluid, Snow, Below -3ºC to -14ºC

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A/D-49	CR-PG	CR-PGA	C-L+
1996-97 Test Results and Table Values used in 97-98	0:15-0:30	~~0:35-1:05~~										
1997-98 ET Test Results			~~0:15-0:25~~									
1998-99 HOT Table Values	0:15-0:25	0:35-1:05	0:15-0:25									
1998-99 ETTest Results		0:25-0:50	~~0:25-0:45~~									
1999-00 HOT Table Values	0:15-0:25	0:25-0:50	0:25-0:45									
1999-00 ET Test Results			0:20-0:45									
2000-01 HOT Table Values	0:15-0:25	0:25-0:50	0:20-0:45									
2000-01 ET Test Results				~~0:40-1:20~~								
2001-02 HOT Table Values	0:15-0:25	0:25-0:50	0:20-0:45									
2002-03 ET Test Results												
2003-04 HOT Table Values	0:20-0:35	0:25-0:50	0:20-0:45									
2003-04 ET Test Results												
2004-05 HOT Table Values	0:20-0:35	0:25-0:50	0:20-0:45	0:40-1:20								
2004-05 ET Test Results												
2005-06 HOT Table Values	0:15-0:35	0:25-0:50	0:20-0:45	0:40-1:20								
2005-06 ET Test Results					~~0:20-0:40~~		~~0:25-0:50~~					
2006-07 HOT Table Values	0:15-0:35	0:25-0:50	0:20-0:45	0:40-1:20	0:20-0:40		0:25-0:50					
2006-07 ET Test Results					0:45-1:25		0:35-1:00	0:35-0:55				
2007-08 HOT Table Values	0:15-0:35	0:25-0:50	0:20-0:45	0:40-1:20	0:45-1:25		0:35-1:00	0:35-0:55				
2007-08 ET Test Results												
2008-09 HOT Table Values	0:15-0:35	0:25-0:50	0:20-0:45	0:40-1:20	0:45-1:25		0:35-1:00	0:35-0:55				
2008-09 ET Test Results									1:20-1:40			
2009-10 HOT Table Values	0:15-0:35	0:25-0:50	0:20-0:45	0:40-1:20	0:45-1:25		0:35-1:00	0:35-0:55	1:20-1:40			
2009-10 ET Test Results										0:20-0:40		
2010-11 HOT Table Values	0:15-0:35	0:25-0:50	0:20-0:45	0:40-1:20	0:45-1:25		0:35-1:00	0:35-0:55	1:20-1:40	0:20-0:40		
2010-11 ET Test Results											0:35-1:00	
2011-12 HOT Table Values	0:20-0:35	0:25-0:50	0:20-0:45	0:40-1:20	0:45-1:25		0:35-1:00	0:35-0:55	1:20-1:40	0:20-0:40	0:35-1:00	
2011-12 ET Test Results												
2012-13 HOT Table Values	0:20-0:40	0:25-0:50	0:20-0:45	0:40-1:20	0:45-1:25		0:35-1:00	0:35-0:55	1:20-1:40	0:20-0:40	0:35-1:00	
2012-13 ET Test Results												0:30-1:15
2013-14 HOT Table Values	0:20-0:40	0:25-0:50	0:20-0:45		0:45-1:25		0:35-1:00	0:35-0:55	1:20-1:40	0:20-0:40	0:35-1:00	0:30-1:15

Table 6.7: Type IV Neat Fluid, Snow, Below -14ºC to -25ºC

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A/D-49	CR-PG	CR-PGA	C-L+
1996-97 Test Results and Table Values used in 97-98	0:150:30	0:40-1:10										
1997-98 ET Test Results			~~0:15-0:30~~									
1998-99 HOT Table Values	0:15-0:30	0:40-1:10	0:15-0:30									
1998-99 ETTest Results		0:40-1:10	0:25-0:40									
1999-00 HOT Table Values	0:15-0:30	0:40-1:10	0:25-0:40									
1999-00 ET Test Results			~~0:25-0:50~~									
2000-01 HOT Table Values	0:15-0:30	0:40-1:10	0:25-0:40									
2000-01 ET Test Results				0:25-0:50								
2001-02 HOT Table Values	0:15-0:30	0:40-1:10	0:25-0:40									
2002-03 ET Test Results												
2003-04 HOT Table Values	0:15-0:30	0:40-1:10	0:25-0:40									
2003-04 ET Test Results												
2004-05 HOT Table Values	0:15-0:30	0:15-0:30*	0:15-0:30*	0:15-0:30*								
2004-05 ET Test Results												
2005-06 HOT Table Values	0:15-0:30	0:15-0:30*	0:15-0:30*	0:15-0:30*								
2005-06 ET Test Results					~~0:35-0:55~~		~~0:30-0:50~~					
2006-07 HOT Table Values	0:15-0:30	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*					
2006-07 ET Test Results					0:45-1:10		0:55-1:35					
2007-08 HOT Table Values	0:15-0:30	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*				
2007-08 ET Test Results												
2008-09 HOT Table Values	0:15-0:30	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*				
2008-09 ET Test Results												
2009-10 HOT Table Values	0:15-0:30	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*			
2009-10 ET Test Results												
2010-11 HOT Table Values	0:15-0:30	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*		
2010-11 ET Test Results												
2011-12 HOT Table Values	0:15-0:30	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	
2011-12 ET Test Results												
2012-13 HOT Table Values	0:15-0:30	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	
2012-13 ET Test Results												
2013-14 HOT Table Values	0:15-0:30	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*	0:15-0:30*

*Generic HOT values used in this cell

Table 6.8: Type IV Neat Fluid, Freezing Drizzle, -3ºC and Above

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A/D-49	CR-PG	CR-PGA	C-L+
1996-97 Test Results and Table Values used in 97-98	0:40-1:00	1:20-1:50										
1997-98 ET Test Results		~~1:55-2:00~~	~~1:05-2:00~~									
1998-99 HOT Table Values	0:40-1:00	1:20-1:50	1:05-2:00									
1998-99 ETTest Results		~~2:00-2:00~~										
1999-00 HOT Table Values	0:40-1:00	1:20-1:50	1:05-2:00									
1999-00 ET Test Results			~~0:50-1:30~~									
2000-01 HOT Table Values	0:40-1:00	1:20-1:50	0:50-1:30									
2000-01 ET Test Results				2:00-2:00								
2001-02 HOT Table Values	0:40-1:10	1:20-1:50	0:50-1:30									
2002-03 ET Test Results												
2003-04 HOT Table Values	0:40-1:10	1:20-1:50	0:50-1:30									
2003-04 ET Test Results												
2004-05 HOT Table Values	0:40-1:10	1:20-1:50	0:50-1:30	2:00-2:00								
2004-05 ET Test Results												
2005-06 HOT Table Values	0:40-1:10	1:20-1:50	0:50-1:30	2:00-2:00								
2005-06 ET Test Results					1:30-2:00	1:10-2:00	~~1:15-1:55~~					
2006-07 HOT Table Values	0:40-1:10	1:20-1:50	0:50-1:30	2:00-2:00	1:30-2:00	1:10-2:00	1:15-1:55					
2006-07 ET Test Results							1:50-2:00	0:55-1:40				
2007-08 HOT Table Values	0:40-1:10	1:20-1:50	0:50-1:30	2:00-2:00	1:30-2:00	1:10-2:00	1:50-2:00	0:55-1:40				
2007-08 ET Test Results												
2008-09 HOT Table Values	0:40-1:10	1:20-1:50	0:50-1:30	2:00-2:00	1:30-2:00	1:10-2:00	1:50-2:00	0:55-1:40				
2008-09 ET Test Results									1:25-2:00			
2009-10 HOT Table Values	0:40-1:10	1:20-1:50	0:50-1:30	2:00-2:00	1:30-2:00	1:10-2:00	1:50-2:00	0:55-1:40	1:25-2:00			
2009-10 ET Test Results										1:15-2:00		
2010-11 HOT Table Values	0:40-1:10	1:20-1:50	0:50-1:30	2:00-2:00	1:30-2:00	1:10-2:00	1:50-2:00	0:55-1:40	1:25-2:00	1:15-2:00		
2010-11 ET Test Results											1:35-2:00	
2011-12 HOT Table Values	0:45-1:30	1:20-1:50	0:50-1:30	2:00-2:00	1:30-2:00	1:10-2:00	1:50-2:00	0:55-1:40	1:25-2:00	1:15-2:00	1:35-2:00	
2011-12 ET Test Results												
2012-13 HOT Table Values	0:50-1:30	1:20-1:50	0:50-1:30	2:00-2:00	1:30-2:00	1:10-2:00	1:50-2:00	0:55-1:40	1:25-2:00	1:15-2:00	1:35-2:00	
2012-13 ET Test Results												2:00-2:00
2013-14 HOT Table Values	0:50-1:30	1:20-1:50	0:50-1:30	2:00-2:00	1:30-2:00	1:10-2:00	1:50-2:00	0:55-1:40	1:25-2:00	1:15-2:00	1:35-2:00	2:00-2:00

Table 6.9: Type IV 75/25 Fluid, Freezing Drizzle, -3°C and Above

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A/D-49	CR-PG	CR-PGA	C-L+
1996-97 Test Results and Table Values used in 97-98	0:30-1:00	~~0:50-1:25~~										
1997-98 ET Test Results		~~0:50-1:10~~	~~0:50-1:20~~									
1998-99 HOT Table Values	0:30-1:00	0:50-1:10	0:50-1:20									
1998-99 ETTest Results		~~0:45-1:10~~										
1999-00 HOT Table Values	0:30-1:00	0:45-1:10	0:50-1:20									
1999-00 ET Test Results			0:50-1:15									
2000-01 HOT Table Values	0:30-1:00	0:45-1:10	0:50-1:15									
2000-01 ET Test Results				~~1:50-2:00~~								
2001-02 HOT Table Values	0:35-0:50	0:45-1:10	0:50-1:15									
2002-03 ET Test Results												
2003-04 HOT Table Values	0:35-0:50	0:45-1:10	0:50-1:15									
2003-04 ET Test Results												
2004-05 HOT Table Values	0:35-0:50	0:45-1:10	0:50-1:15	1:50-2:00								
2004-05 ET Test Results												
2005-06 HOT Table Values	0:35-0:50	0:45-1:10	0:50-1:15	1:50-2:00								
2005-06 ET Test Results					1:40-2:00		~~0:45-1:10~~					
2006-07 HOT Table Values	0:35-0:50	0:45-1:10	0:50-1:15	1:50-2:00	1:40-2:00		0:45-1:10					
2006-07 ET Test Results							1:00-1:20	0:55-1:25				
2007-08 HOT Table Values	0:35-0:50	0:45-1:10	0:50-1:15	1:50-2:00	1:40-2:00		1:00-1:20	0:55-1:25				
2007-08 ET Test Results												
2008-09 HOT Table Values	0:35-0:50	0:45-1:10	0:50-1:15	1:50-2:00	1:40-2:00		1:00-1:20	0:55-1:25				
2008-09 ET Test Results									1:55-2:00			
2009-10 HOT Table Values	0:35-0:50	0:45-1:10	0:50-1:15	1:50-2:00	1:40-2:00		1:00-1:20	0:55-1:25	1:55-2:00			
2009-10 ET Test Results										1:05-1:25		
2010-11 HOT Table Values	0:35-0:50	0:45-1:10	0:50-1:15	1:50-2:00	1:40-2:00		1:00-1:20	0:55-1:25	1:55-2:00	1:05-1:25		
2010-11 ET Test Results											1:40-2:00	
2011-12 HOT Table Values	0:35-1:05	0:45-1:10	0:50-1:15	1:50-2:00	1:40-2:00		1:00-1:20	0:55-1:25	1:55-2:00	1:05-1:25	1:40-2:00	
2011-12 ET Test Results												
2012-13 HOT Table Values	0:40-1:05	0:45-1:10	0:50-1:15	1:50-2:00	1:40-2:00		1:00-1:20	0:55-1:25	1:55-2:00	1:05-1:25	1:40-2:00	
2012-13 ET Test Results												2:00-2:00
2013-14 HOT Table Values	0:45-1:10	0:45-1:10	0:50-1:15		1:40-2:00		1:00-1:20	0:55-1:25	1:55-2:00	1:05-1:25	1:40-2:00	2:00-2:00

Table 6.10: Type IV 50/50 Fluid, Freezing Drizzle, -3ºC and Above

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A/D-49	CR-PG	CR-PGA	C-L+
1996-97 Test Results and Table Values used in 97-98	0:10-0:20	0:15~~0:25~~										
1997-98 ET Test Results		0:150:20	~~0:15-0:35~~									
1998-99 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:35									
1998-99 ETTest Results		0:150:20										
1999-00 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:35									
1999-00 ET Test Results			0:150:25									
2000-01 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:25									
2000-01 ET Test Results				~~0:35-1:10~~								
2001-02 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:25									
2002-03 ET Test Results												
2003-04 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:25									
2003-04 ET Test Results												
2004-05 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:25	0:35-1:10								
2004-05 ET Test Results												
2005-06 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:25	0:35-1:10								
2005-06 ET Test Results					0:30-0:50		~~0:10-0:20~~					
2006-07 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:25	0:35-1:10	0:30-0:50		0:10-0:20					
2006-07 ET Test Results							0:150:40	0:20-0:30				
2007-08 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:25	0:35-1:10	0:30-0:50		0:15-0:40	0:20-0:30				
2007-08 ET Test Results												
2008-09 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:25	0:35-1:10	0:30-0:50		0:15-0:40	0:20-0:30				
2008-09 ET Test Results									0:150:30			
2009-10 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:25	0:35-1:10	0:30-0:50		0:15-0:40	0:20-0:30	0:15-0:30			
2009-10 ET Test Results										0:150:25		
2010-11 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:25	0:35-1:10	0:30-0:50		0:15-0:40	0:20-0:30	0:15-0:30	0:15-0:25		
2010-11 ET Test Results											0:20-0:45	
2011-12 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:25	0:35-1:10	0:30-0:50		0:15-0:40	0:20-0:30	0:15-0:30	0:15-0:25	0:20-0:45	
2011-12 ET Test Results												
2012-13 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:25	0:35-1:10	0:30-0:50		0:15-0:40	0:20-0:30	0:15-0:30	0:15-0:25	0:20-0:45	
2012-13 ET Test Results												0:25-1:00
2013-14 HOT Table Values	0:15-0:20	0:15-0:20	0:15-0:25		0:30-0:50		0:15-0:40	0:20-0:30	0:15-0:30	0:15-0:25	0:20-0:45	0:25-1:00

Table 6.11: Type IV Neat Fluid, Freezing Drizzle, Below -3°C to -10°C

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A/D-49	CR-PG	CR-PGA	C-L+
1996-97 Test Results and Table Values used in 97-98	0:30-1:00	0:35-1:00										
1997-98 ET Test Results		0:40-1:20	0:25-1:20									
1998-99 HOT Table Values	0:25-1:00	0:35-1:00	0:25-1:20									
1998-99 ETTest Results		0:20-1:30										
1999-00 HOT Table Values	0:20-0:55	0:20-1:00	0:25-1:20									
1999-00 ET Test Results			0:25-1:20									
2000-01 HOT Table Values	0:20-0:55	0:20-1:00	0:25-1:20									
2000-01 ET Test Results				0:25-1:30								
2001-02 HOT Table Values	0:20-0:45	0:20-1:00	0:25-1:20									
2002-03 ET Test Results												
2003-04 HOT Table Values	0:20-0:45	0:20-1:00	0:25-1:20									
2003-04 ET Test Results												
2004-05 HOT Table Values	0:20-0:45	0:20-1:00	0:25-1:20	0:25-1:30								
2004-05 ET Test Results												
2005-06 HOT Table Values	0:20-0:45	0:20-1:00	0:25-1:20	0:25-1:30								
2005-06 ET Test Results					0:35-1:40	0:55-1:50	0:30-1:35					
2006-07 HOT Table Values	0:20-0:45	0:20-1:00	0:25-1:20	0:25-1:30	0:35-1:40	0:55-1:50	0:30-1:35					
2006-07 ET Test Results							0:25-1:35	0:25-1:30				
2007-08 HOT Table Values	0:20-0:45	0:20-1:00	0:25-1:20	0:25-1:30	0:35-1:40	0:55-1:50	0:25-1:35	0:25-1:30				
2007-08 ET Test Results												
2008-09 HOT Table Values	0:20-0:45	0:20-1:00	0:25-1:20	0:25-1:30	0:35-1:40	0:55-1:50	0:25-1:35	0:25-1:30				
2008-09 ET Test Results									0:25-1:25			
2009-10 HOT Table Values	0:20-0:45	0:20-1:00	0:25-1:20	0:25-1:30	0:35-1:40	0:55-1:50	0:25-1:35	0:25-1:30	0:25-1:25			
2009-10 ET Test Results										0:25-1:10		
2010-11 HOT Table Values	0:20-0:45	0:20-1:00	0:25-1:20	0:25-1:30	0:35-1:40	0:55-1:50	0:25-1:35	0:25-1:30	0:25-1:25	0:25-1:10		
2010-11 ET Test Results											0:35-1:35	
2011-12 HOT Table Values	0:20-1:00	0:20-1:00	0:25-1:20	0:25-1:30	0:35-1:40	0:55-1:50	0:25-1:35	0:25-1:30	0:25-1:25	0:25-1:10	0:35-1:35	
2011-12 ET Test Results												
2012-13 HOT Table Values	0:20-1:00	0:20-1:00	0:25-1:20	0:25-1:30	0:35-1:40	0:55-1:50	0:25-1:35	0:25-1:30	0:25-1:25	0:25-1:10	0:35-1:35	
2012-13 ET Test Results												0:25-1:35
2013-14 HOT Table Values	0:20-1:00	0:20-1:00	0:25-1:20	0:25-1:30	0:35-1:40	0:55-1:50	0:25-1:35	0:25-1:30	0:25-1:25	0:25-1:10	0:35-1:35	0:25-1:35

Table 6.12: Type IV 75/25 Fluid, Freezing Drizzle, Below -3ºC to -10ºC

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A/D-49	CR-PG	CR-PGA	C-L+
1996-97 Test Results and Table Values used in 97-98	0:30-1:00	~~0:50-1:25~~										
1997-98 ET Test Results		~~0:30~~ 1:10	~~0:30-1:15~~									
1998-99 HOT Table Values	0:30-1:00	0:30-1:10	0:30-1:15									
1998-99 ETTest Results		0:20~~-1:30~~										
1999-00 HOT Table Values	0:20-0:55	0:20-1:10	0:30-1:15									
1999-00 ET Test Results			0:25-1:05									
2000-01 HOT Table Values	0:20-0:50	0:20-1:10	0:25-1:05									
2000-01 ET Test Results				~~0:20-1:00~~								
2001-02 HOT Table Values	0:15-0:30	0:20-1:10	0:25-1:05									
2002-03 ET Test Results												
2003-04 HOT Table Values	0:15-0:30	0:20-1:10	0:25-1:05									
2003-04 ET Test Results												
2004-05 HOT Table Values	0:15-0:30	0:20-1:10	0:25-1:05	0:20-1:00								
2004-05 ET Test Results												
2005-06 HOT Table Values	0:15-0:30	0:20-1:10	0:25-1:05	0:20-1:00								
2005-06 ET Test Results					0:25-1:10		~~0:25-1:15~~					
2006-07 HOT Table Values	0:15-0:30	0:20-1:10	0:25-1:05	0:20-1:00	0:25-1:10		0:25-1:15					
2006-07 ET Test Results							0:20-1:10	0:30-1:15				
2007-08 HOT Table Values	0:15-0:30	0:20-1:10	0:25-1:05	0:20-1:00	0:25-1:10		0:20-1:10	0:30-1:15				
2007-08 ET Test Results												
2008-09 HOT Table Values	0:15-0:30	0:20-1:10	0:25-1:05	0:20-1:00	0:25-1:10		0:20-1:10	0:30-1:15				
2008-09 ET Test Results									0:15-1:05			
2009-10 HOT Table Values	0:15-0:30	0:20-1:10	0:25-1:05	0:20-1:00	0:25-1:10		0:20-1:10	0:30-1:15	0:15-1:05			
2009-10 ET Test Results										0:25-1:05		
2010-11 HOT Table Values	0:15-0:30	0:20-1:10	0:25-1:05	0:20-1:00	0:25-1:10		0:20-1:10	0:30-1:15	0:15-1:05	0:25-1:05		
2010-11 ET Test Results											0:25-1:05	
2011-12 HOT Table Values	0:15-1:00	0:20-1:10	0:25-1:05	0:20-1:00	0:25-1:10		0:20-1:10	0:30-1:15	0:15-1:05	0:25-1:05	0:25-1:05	
2011-12 ET Test Results												
2012-13 HOT Table Values	0:15-1:00	0:20-1:10	0:25-1:05	0:20-1:00	0:25-1:10		0:20-1:10	0:30-1:15	0:15-1:05	0:25-1:05	0:25-1:05	
2012-13 ET Test Results												0:20-1:05
2013-14 HOT Table Values	0:15-1:05	0:20-1:10	0:25-1:05		0:25-1:10		0:20-1:10	0:30-1:15	0:15-1:05	0:25-1:05	0:25-1:05	0:20-1:05

Table 6.13: Type IV Neat Fluid, Light Freezing Rain, -3°C and Above

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A/D-49	CR-PG	CR-PGA	C-L+
1996-97 Test Results and Table Values used in 97-98	0:35-0:55	1:00-1:25										
1997-98 ET Test Results		~~1:20-2:00~~	~~0:50-1:10~~									
1998-99 HOT Table Values	0:35-0:55	1:00-1:25	0:50-1:10									
1998-99 ETTest Results		~~1:20-2:00~~										
1999-00 HOT Table Values	0:25-0:40	1:00-1:25	0:50-1:10									
1999-00 ET Test Results			~~0:35-0:55~~									
2000-01 HOT Table Values	0:25-0:40	1:00-1:25	0:35-0:55									
2000-01 ET Test Results				1:10-1:30								
2001-02 HOT Table Values	0:25-0:40	1:00-1:25	0:35-0:55									
2002-03 ET Test Results												
2003-04 HOT Table Values	0:25-0:40	1:00-1:25	0:35-0:55									
2003-04 ET Test Results												
2004-05 HOT Table Values	0:25-0:40	1:00-1:25	0:35-0:55	1:10-1:30								
2004-05 ET Test Results												
2005-06 HOT Table Values	0:25-0:40	1:00-1:25	0:35-0:55	1:10-1:30								
2005-06 ET Test Results					1:00-1:40	0:50-1:15	~~0:50-1:10~~					
2006-07 HOT Table Values	0:25-0:40	1:00-1:25	0:35-0:55	1:10-1:30	1:00-1:40	0:50-1:15	0:50-1:10					
2006-07 ET Test Results							1:05-2:00	0:45-1:05				
2007-08 HOT Table Values	0:25-0:40	1:00-1:25	0:35-0:55	1:10-1:30	1:00-1:40	0:50-1:15	1:05-2:00	0:45-1:05				
2007-08 ET Test Results												
2008-09 HOT Table Values	0:25-0:40	1:00-1:25	0:35-0:55	1:10-1:30	1:00-1:40	0:50-1:15	1:05-2:00	0:45-1:05				
2008-09 ET Test Results									1:00-1:25			
2009-10 HOT Table Values	0:25-0:40	1:00-1:25	0:35-0:55	1:10-1:30	1:00-1:40	0:50-1:15	1:05-2:00	0:45-1:05	1:00-1:25			
2009-10 ET Test Results										0:50-1:15		
2010-11 HOT Table Values	0:25-0:40	1:00-1:25	0:35-0:55	1:10-1:30	1:00-1:40	0:50-1:15	1:05-2:00	0:45-1:05	1:00-1:25	0:50-1:15		
2010-11 ET Test Results											1:15-1:30	
2011-12 HOT Table Values	0:25-0:40	1:00-1:25	0:35-0:55	1:10-1:30	1:00-1:40	0:50-1:15	1:05-2:00	0:45-1:05	1:00-1:25	0:50-1:15	1:15-1:30	
2011-12 ET Test Results												
2012-13 HOT Table Values	0:35-0:55	1:00-1:25	0:35-0:55	1:10-1:30	1:00-1:40	0:50-1:15	1:05-2:00	0:45-1:05	1:00-1:25	0:50-1:15	1:15-1:30	
2012-13 ET Test Results												1:00-2:00
2013-14 HOT Table Values	0:35-0:55	1:00-1:25	0:35-0:55	1:10-1:30	1:00-1:40	0:50-1:15	1:05-2:00	0:45-1:05	1:00-1:25	0:50-1:15	1:15-1:30	1:00-2:00

Table 6.14: Type IV 75/25 Fluid, Light Freezing Rain, -3°C and Above

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A/D-49	CR-PG	CR-PGA	C-L+
1996-97 Test Results and Table Values used in 97-98	0:15-0:30	0:35-0:50										
1997-98 ET Test Results		~~0:40-0:55~~	~~0:35-0:50~~									
1998-99 HOT Table Values	0:15-0:30	0:35-0:50	0:35-0:50									
1998-99 ETTest Results		0:35-0:50										
1999-00 HOT Table Values	0:15-0:30	0:35-0:50	0:35-0:50									
1999-00 ET Test Results			0:30~~-0:45~~									
2000-01 HOT Table Values	0:15-0:30	0:35-0:50	0:30-0:45									
2000-01 ET Test Results				~~1:00-1:20~~								
2001-02 HOT Table Values	0:15-0:30	0:35-0:50	0:30-0:45									
2002-03 ET Test Results												
2003-04 HOT Table Values	0:15-0:30	0:35-0:50	0:30-0:45									
2003-04 ET Test Results												
2004-05 HOT Table Values	0:15-0:30	0:35-0:50	0:30-0:45	1:00-1:20								
2004-05 ET Test Results												
2005-06 HOT Table Values	0:15-0:30	0:35-0:50	0:30-0:45	1:00-1:20								
2005-06 ET Test Results					0:45-1:15		~~0:30-0:45~~					
2006-07 HOT Table Values	0:15-0:30	0:35-0:50	0:30-0:45	1:00-1:20	0:45-1:15		0:30-0:45					
2006-07 ET Test Results							~~0:30~~0:50	0:30~~-0:45~~				
2007-08 HOT Table Values	0:15-0:30	0:35-0:50	0:30-0:45	1:00-1:20	0:45-1:15		0:30-0:50	0:30-0:45				
2007-08 ET Test Results												
2008-09 HOT Table Values	0:15-0:30	0:35-0:50	0:30-0:45	1:00-1:20	0:45-1:15		0:30-0:50	0:30-0:45				
2008-09 ET Test Results									0:50-1:30			
2009-10 HOT Table Values	0:15-0:30	0:35-0:50	0:30-0:45	1:00-1:20	0:45-1:15		0:30-0:50	0:30-0:45	0:50-1:30			
2009-10 ET Test Results										0:35-1:00		
2010-11 HOT Table Values	0:15-0:30	0:35-0:50	0:30-0:45	1:00-1:20	0:45-1:15		0:30-0:50	0:30-0:45	0:50-1:30	0:35-1:00		
2010-11 ET Test Results											0:40-1:10	
2011-12 HOT Table Values	0:25-0:35	0:35-0:50	0:30-0:45	1:00-1:20	0:45-1:15		0:30-0:50	0:30-0:45	0:50-1:30	0:35-1:00	0:40-1:10	
2011-12 ET Test Results												
2012-13 HOT Table Values	0:25-0:40	0:35-0:50	0:30-0:45	1:00-1:20	0:45-1:15		0:30-0:50	0:30-0:45	0:50-1:30	0:35-1:00	0:40-1:10	
2012-13 ET Test Results												1:20-1:25
2013-14 HOT Table Values	0:30-0:45	0:35-0:50	0:30-0:45		0:45-1:15		0:30-0:50	0:30-0:45	0:50-1:30	0:35-1:00	0:40-1:10	1:20-1:25

Table 6.15: Type IV 50/50 Fluid, Light Freezing Rain, -3ºC and Above

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A/D-49	CR-PG	CR-PGA	C-L+
1996-97 Test Results and Table Values used in 97-98	0:05-0:10	~~0:10-0:15~~										
1997-98 ET Test Results	0:05-0:10	~~0:10-0:15~~	~~0:10-0:25~~									
1998-99 HOT Table Values	0:05-0:10	0:10-0:15	0:10-0:25									
1998-99 ETTest Results	0:05-0:10	0:08-0:10										
1999-00 HOT Table Values	0:05-0:10	0:05-0:10	0:10-0:25									
1999-00 ET Test Results			0:09-0:15									
2000-01 HOT Table Values	0:05-0:10	0:05-0:10	0:05-0:15									
2000-01 ET Test Results				~~0:25-0:35~~								
2001-02 HOT Table Values	0:05-0:10	0:05-0:10	0:05-0:15									
2002-03 ET Test Results												
2003-04 HOT Table Values	0:05-0:10	0:05-0:10	0:05-0:15									
2003-04 ET Test Results												
2004-05 HOT Table Values	0:05-0:10	0:05-0:10	0:05-0:15	0:25-0:35								
2004-05 ET Test Results												
2005-06 HOT Table Values	0:05-0:10	0:05-0:10	0:05-0:15	0:25-0:35								
2005-06 ET Test Results					0:20-0:25		~~0:05-0:10~~					
2006-07 HOT Table Values	0:05-0:10	0:05-0:10	0:05-0:15	0:25-0:35	0:20-0:25		0:05-0:10					
2006-07 ET Test Results							0:15-0:20	0:10-0:15				
2007-08 HOT Table Values	0:05-0:10	0:05-0:10	0:05-0:15	0:25-0:35	0:20-0:25		0:15-0:20	0:10-0:15				
2007-08 ET Test Results												
2008-09 HOT Table Values	0:05-0:10	0:05-0:10	0:05-0:15	0:25-0:35	0:20-0:25		0:15-0:20	0:10-0:15				
2008-09 ET Test Results									0:10-0:15			
2009-10 HOT Table Values	0:05-0:10	0:05-0:10	0:05-0:15	0:25-0:35	0:20-0:25		0:15-0:20	0:10-0:15	0:10-0:15			
2009-10 ET Test Results										0:10-0:15		
2010-11 HOT Table Values	0:05-0:10	0:05-0:10	0:05-0:15	0:25-0:35	0:20-0:25		0:15-0:20	0:10-0:15	0:10-0:15	0:10-0:15		
2010-11 ET Test Results											0:09-0:20	
2011-12 HOT Table Values	0:07-0:10	0:08-0:10	0:09-0:15	0:25-0:35	0:20-0:25		0:15-0:20	0:10-0:15	0:10-0:15	0:10-0:15	0:09-0:20	
2011-12 ET Test Results												
2012-13 HOT Table Values	0:07-0:10	0:08-0:10	0:09-0:15	0:25-0:35	0:20-0:25		0:15-0:20	0:10-0:15	0:10-0:15	0:10-0:15	0:09-0:20	
2012-13 ET Test Results												0:15-0:20
2013-14 HOT Table Values	0:08-0:10	0:08-0:10	0:09-0:15		0:20-0:25		0:15-0:20	0:10-0:15	0:10-0:15	0:10-0:15	0:09-0:20	0:15-0:20

Table 6.16: Type IV Neat Fluid, Light Freezing Rain, Below -3°C to -10°C

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A/D-49	CR-PG	CR-PGA	C-L+
1996-97 Test Results and Table Values used in 97-98	0:30-0:45	~~0:30-0:45~~										
1997-98 ET Test Results		~~0:20-0:40~~	~~0:20-0:40~~									
1998-99 HOT Table Values	0:15-0:30	0:20-0:40	0:20-0:40									
1998-99 ETTest Results		~~0:10~~0:30										
1999-00 HOT Table Values	0:10-0:30	0:10-0:30	0:20-0:40									
1999-00 ET Test Results			0:15-0:30									
2000-01 HOT Table Values	0:10-0:30	0:10-0:30	0:15-0:30									
2000-01 ET Test Results				0:20-0:40								
2001-02 HOT Table Values	0:10-0:25	0:10-0:30	0:15-0:30									
2002-03 ET Test Results												
2003-04 HOT Table Values	0:10-0:25	0:10-0:30	0:15-0:30									
2003-04 ET Test Results												
2004-05 HOT Table Values	0:10-0:25	0:10-0:30	0:15-0:30	0:20-0:40								
2004-05 ET Test Results												
2005-06 HOT Table Values	0:10-0:25	0:10-0:30	0:15-0:30	0:20-0:40								
2005-06 ET Test Results					0:25-0:45	0:45-1:10	~~0:25-0:35~~					
2006-07 HOT Table Values	0:10-0:25	0:10-0:30	0:15-0:30	0:20-0:40	0:25-0:45	0:45-1:10	0:25-0:35					
2006-07 ET Test Results							0:20-0:30	0:25-0:30				
2007-08 HOT Table Values	0:10-0:25	0:10-0:30	0:15-0:30	0:20-0:40	0:25-0:45	0:45-1:10	0:20-0:30	0:25-0:30				
2007-08 ET Test Results												
2008-09 HOT Table Values	0:10-0:25	0:10-0:30	0:15-0:30	0:20-0:40	0:25-0:45	0:45-1:10	0:20-0:30	0:25-0:30				
2008-09 ET Test Results									0:20~~0:25~~			
2009-10 HOT Table Values	0:10-0:25	0:10-0:30	0:15-0:30	0:20-0:40	0:25-0:45	0:45-1:10	0:20-0:30	0:25-0:30	0:20-0:25			
2009-10 ET Test Results										0:15-0:35		
2010-11 HOT Table Values	0:10-0:25	0:10-0:30	0:15-0:30	0:20-0:40	0:25-0:45	0:45-1:10	0:20-0:30	0:25-0:30	0:20-0:25	0:15-0:35		
2010-11 ET Test Results											0:35-0:45	
2011-12 HOT Table Values	0:10-0:25	0:10-0:30	0:15-0:30	0:20-0:40	0:25-0:45	0:45-1:10	0:20-0:30	0:25-0:30	0:20-0:25	0:15-0:35	0:35-0:45	
2011-12 ET Test Results												
2012-13 HOT Table Values	0:10-0:25	0:10-0:30	0:15-0:30	0:20-0:40	0:25-0:45	0:45-1:10	0:20-0:30	0:25-0:30	0:20-0:25	0:15-0:35	0:35-0:45	
2012-13 ET Test Results												0:25-0:40
2013-14 HOT Table Values	0:10-0:25	0:10-0:30	0:15-0:30	0:20-0:40	0:25-0:45	0:45-1:10	0:20-0:30	0:25-0:30	0:20-0:25	0:15-0:35	0:35-0:45	0:25-0:40

Table 6.17: Type IV 75/25 Fluid, Light Freezing Rain, Below -3ºC to -10ºC

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A/D-49	CR-PG	CR-PGA	C-L+
1996-97 Test Results and Table Values used in 97-98	0:15-0:30	~~0:35-0:50~~										
1997-98 ET Test Results		~~0:25~~0:35	~~0:20-0:35~~									
1998-99 HOT Table Values	0:15-0:30	0:25-0:35	0:20-0:35									
1998-99 ETTest Results		~~0:10~~0:35										
1999-00 HOT Table Values	0:10-0:30	0:10-0:35	0:20-0:35									
1999-00 ET Test Results			0:15-0:30									
2000-01 HOT Table Values	0:10-0:25	0:10-0:35	0:15-0:30									
2000-01 ET Test Results				~~0:15-0:30~~								
2001-02 HOT Table Values	0:10-0:20	0:10-0:35	0:15-0:30									
2002-03 ET Test Results												
2003-04 HOT Table Values	0:10-0:20	0:10-0:35	0:15-0:30									
2003-04 ET Test Results												
2004-05 HOT Table Values	0:10-0:20	0:10-0:35	0:15-0:30	0:15-0:30								
2004-05 ET Test Results												
2005-06 HOT Table Values	0:10-0:20	0:10-0:35	0:15-0:30	0:15-0:30								
2005-06 ET Test Results					0:25-0:45		~~0:30-0:40~~					
2006-07 HOT Table Values	0:10-0:20	0:10-0:35	0:15-0:30	0:15-0:30	0:25-0:45		0:30-0:40					
2006-07 ET Test Results							0:150:25	0:25-0:30				
2007-08 HOT Table Values	0:10-0:20	0:10-0:35	0:15-0:30	0:15-0:30	0:25-0:45		0:15-0:25	0:25-0:30				
2007-08 ET Test Results												
2008-09 HOT Table Values	0:10-0:20	0:10-0:35	0:15-0:30	0:15-0:30	0:25-0:45		0:15-0:25	0:25-0:30				
2008-09 ET Test Results									0:150:25			
2009-10 HOT Table Values	0:10-0:20	0:10-0:35	0:15-0:30	0:15-0:30	0:25-0:45		0:15-0:25	0:25-0:30	0:15-0:25			
2009-10 ET Test Results										0:20-0:30		
2010-11 HOT Table Values	0:10-0:20	0:10-0:35	0:15-0:30	0:15-0:30	0:25-0:45		0:15-0:25	0:25-0:30	0:15-0:25	0:20-0:30		
2010-11 ET Test Results											0:35-0:45	
2011-12 HOT Table Values	0:10-0:25	0:10-0:35	0:15-0:30	0:15-0:30	0:25-0:45		0:15-0:25	0:25-0:30	0:15-0:25	0:20-0:30	0:35-0:45	
2011-12 ET Test Results												
2012-13 HOT Table Values	0:10-0:25	0:10-0:35	0:15-0:30	0:15-0:30	0:25-0:45		0:15-0:25	0:25-0:30	0:15-0:25	0:20-0:30	0:35-0:45	
2012-13 ET Test Results												0:20-0:30
2013-14 HOT Table Values	0:10-0:25	0:10-0:35	0:15-0:30		0:25-0:45		0:15-0:25	0:25-0:30	0:15-0:25	0:20-0:30	0:35-0:45	0:20-0:30

Table 6.18: Type IV Neat Fluid, Freezing Fog, -3°C and Above

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A/D-49	CR-PG	CR-PGA	C-L+
1996-97 Test Results and Table Values used in 97-98	2:20-3:00											
1997-98 ET Test Results												
1998-99 HOT Table Values	2:00-3:00											
1998-99 ETTest Results		2:35-4:00										
1999-00 HOT Table Values	1:05-2:15	2:35-4:00	1:05-2:15									
1999-00 ET Test Results			2:00-3:30									
2000-01 HOT Table Values	1:05-2:15	2:35-4:00	2:00-3:30									
2000-01 ET Test Results				2:40-4:00								
2001-02 HOT Table Values	1:05-2:15	2:35-4:00	2:00-3:30									
2002-03 ET Test Results												
2003-04 HOT Table Values	1:05-2:15	2:35-4:00	2:00-3:30									
2003-04 ET Test Results												
2004-05 HOT Table Values	1:05-2:15	2:35-4:00	2:00-3:30	2:40-4:00								
2004-05 ET Test Results												
2005-06 HOT Table Values	1:15-2:30	2:35-4:00	2:00-3:30	2:40-4:00								
2005-06 ET Test Results					4:00-4:00	2:05-3:10	~~1:50-3:40~~					
2006-07 HOT Table Values	1:15-2:30	2:35-4:00	2:00-3:30	2:40-4:00	4:00-4:00	2:05-3:10	1:50-3:40					
2006-07 ET Test Results							2:10-4:00	1:55-3:10				
2007-08 HOT Table Values	1:15-2:30	2:35-4:00	2:00-3:30	2:40-4:00	4:00-4:00	2:05-3:10	2:10-4:00	1:55-3:10				
2007-08 ET Test Results												
2008-09 HOT Table Values	1:15-2:30	2:35-4:00	2:00-3:30	2:40-4:00	4:00-4:00	2:05-3:10	2:10-4:00	1:55-3:10				
2008-09 ET Test Results									3:20-4:00			
2009-10 HOT Table Values	1:15-2:30	2:35-4:00	2:00-3:30	2:40-4:00	4:00-4:00	2:05-3:10	2:10-4:00	1:55-3:10	3:20-4:00			
2009-10 ET Test Results										2:15-3:30		
2010-11 HOT Table Values	1:15-2:30	2:35-4:00	2:00-3:30	2:40-4:00	4:00-4:00	2:05-3:10	2:10-4:00	1:55-3:10	3:20-4:00	2:15-3:30		
2010-11 ET Test Results											2:50-4:00	
2011-12 HOT Table Values	1:20-3:10	2:35-4:00	2:00-3:30	2:40-4:00	4:00-4:00	2:05-3:10	2:10-4:00	1:55-3:10	3:20-4:00	2:15-3:30	2:50-4:00	
2011-12 ET Test Results												
2012-13 HOT Table Values	1:45-3:10	2:35-4:00	2:00-3:30	2:40-4:00	4:00-4:00	2:05-3:10	2:10-4:00	1:55-3:10	3:20-4:00	2:15-3:30	2:50-4:00	
2012-13 ET Test Results												3:55-4:00
2013-14 HOT Table Values	1:55-3:10	2:35-4:00	2:00-3:30	2:40-4:00	4:00-4:00	2:05-3:10	2:10-4:00	1:55-3:10	3:20-4:00	2:15-3:30	2:50-4:00	3:55-4:00

Table 6.19: Type IV 75/25 Fluid, Freezing Fog, -3ºC and Above

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A/D-49	CR-PG	CR-PGA	C-L+
1996-97 Test Results and Table Values used in 97-98	1:05-2:00											
1997-98 ET Test Results												
1998-99 HOT Table Values	1:05-2:00											
1998-99 ETTest Results		~~1:051:45~~										
1999-00 HOT Table Values	1:05-1:45	1:05-1:45	1:05-1:45									
1999-00 ET Test Results			1:30-2:45									
2000-01 HOT Table Values	1:05-1:45	1:05-1:45	1:30-2:45									
2000-01 ET Test Results				~~2:05-3:15~~								
2001-02 HOT Table Values	1:05-1:45	1:05-1:45	1:30-2:45									
2002-03 ET Test Results												
2003-04 HOT Table Values	1:05-1:45	1:05-1:45	1:30-2:45									
2003-04 ET Test Results												
2004-05 HOT Table Values	1:05-1:45	1:05-1:45	1:30-2:45	2:05-3:15								
2004-05 ET Test Results												
2005-06 HOT Table Values	1:05-1:45	1:05-1:45	1:30-2:45	2:05-3:15								
2005-06 ET Test Results					3:40-4:00		~~1:10-2:10~~					
2006-07 HOT Table Values	1:05-1:45	1:05-1:45	1:30-2:45	2:05-3:15	3:40-4:00		1:10-2:10					
2006-07 ET Test Results							1:25-2:40	1:20-2:15				
2007-08 HOT Table Values	1:05-1:45	1:05-1:45	1:30-2:45	2:05-3:15	3:40-4:00		1:25-2:40	1:20-2:15				
2007-08 ET Test Results												
2008-09 HOT Table Values	1:05-1:45	1:05-1:45	1:30-2:45	2:05-3:15	3:40-4:00		1:25-2:40	1:20-2:15				
2008-09 ET Test Results									2:25-4:00			
2009-10 HOT Table Values	1:00-1:45	1:05-1:45	1:30-2:45	2:05-3:15	3:40-4:00		1:25-2:40	1:20-2:15	2:25-4:00			
2009-10 ET Test Results										1:40-2:40		
2010-11 HOT Table Values	1:00-1:45	1:05-1:45	1:30-2:45	2:05-3:15	3:40-4:00		1:25-2:40	1:20-2:15	2:25-4:00	1:40-2:40		
2010-11 ET Test Results											2:30-4:00	
2011-12 HOT Table Values	1:00-1:45	1:05-1:45	1:30-2:45	2:05-3:15	3:40-4:00		1:25-2:40	1:20-2:15	2:25-4:00	1:40-2:40	2:30-4:00	
2011-12 ET Test Results												
2012-13 HOT Table Values	1:00-1:45	1:05-1:45	1:30-2:45	2:05-3:15	3:40-4:00		1:25-2:40	1:20-2:15	2:25-4:00	1:40-2:40	2:30-4:00	
2012-13 ET Test Results												3:55-4:00
2013-14 HOT Table Values	1:05-1:45	1:05-1:45	1:30-2:45		3:40-4:00		1:25-2:40	1:20-2:15	2:25-4:00	1:40-2:40	2:30-4:00	3:55-4:00

Table 6.20: Type IV 50/50 Fluid, Freezing Fog, -3°C and Above

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A/D-49	CR-PG	CR-PGA	C-L+
1996-97 Test Results and Table Values used in 97-98	0:20-0:45											
1997-98 ET Test Results												
1998-99 HOT Table Values	0:20-0:45											
1998-99 ETTest Results		~~0:20-0:35~~										
1999-00 HOT Table Values	0:20-0:35	0:20-0:35	0:20-0:35									
1999-00 ET Test Results			0:30-0:45									
2000-01 HOT Table Values	0:15-0:35	0:20-0:35	0:30-0:45									
2000-01 ET Test Results				~~0:55-1:45~~								
2001-02 HOT Table Values	0:15-0:35	0:20-0:35	0:30-0:45									
2002-03 ET Test Results												
2003-04 HOT Table Values	0:15-0:35	0:20-0:35	0:30-0:45									
2003-04 ET Test Results												
2004-05 HOT Table Values	0:15-0:35	0:20-0:35	0:30-0:45	0:55-1:45								
2004-05 ET Test Results												
2005-06 HOT Table Values	0:15-0:35	0:20-0:35	0:30-0:45	0:55-1:45								
2005-06 ET Test Results					1:25-2:45		~~0:20-0:40~~					
2006-07 HOT Table Values	0:15-0:35	0:20-0:35	0:30-0:45	0:55-1:45	1:25-2:45		0:20-0:40					
2006-07 ET Test Results							0:30-0:55	0:35-0:45				
2007-08 HOT Table Values	0:15-0:35	0:20-0:35	0:30-0:45	0:55-1:45	1:25-2:45		0:30-0:55	0:35-0:45				
2007-08 ET Test Results												
2008-09 HOT Table Values	0:15-0:35	0:20-0:35	0:30-0:45	0:55-1:45	1:25-2:45		0:30-0:55	0:35-0:45				
2008-09 ET Test Results									0:25-0:50			
2009-10 HOT Table Values	0:15-0:35	0:20-0:35	0:30-0:45	0:55-1:45	1:25-2:45		0:30-0:55	0:35-0:45	0:25-0:50			
2009-10 ET Test Results										0:25-0:40		
2010-11 HOT Table Values	0:15-0:35	0:20-0:35	0:30-0:45	0:55-1:45	1:25-2:45		0:30-0:55	0:35-0:45	0:25-0:50	0:25-0:40		
2010-11 ET Test Results											0:50-1:25	
2011-12 HOT Table Values	0:15-0:35	0:20-0:35	0:30-0:45	0:55-1:45	1:25-2:45		0:30-0:55	0:35-0:45	0:25-0:50	0:25-0:40	0:50-1:25	
2011-12 ET Test Results												
2012-13 HOT Table Values	0:20-0:35	0:20-0:35	0:30-0:45	0:55-1:45	1:25-2:45		0:30-0:55	0:35-0:45	0:25-0:50	0:25-0:40	0:50-1:25	
2012-13 ET Test Results												1:15-1:50
2013-14 HOT Table Values	0:20-0:35	0:20-0:35	0:30-0:45		1:25-2:45		0:30-0:55	0:35-0:45	0:25-0:50	0:25-0:40	0:50-1:25	1:15-1:50

Table 6.21: Type IV Neat Fluid, Freezing Fog, Below -3°C to -14°C

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A/D-49	CR-PG	CR-PGA	C-L+
1996-97 Test Results and Table Values used in 97-98	0:40-3:00											
1997-98 ET Test Results												
1998-99 HOT Table Values	0:40-3:00											
1998-99 ETTest Results		0:45-2:05										
1999-00 HOT Table Values	0:40-1:30	0:45-2:05	0:40-1:30									
1999-00 ET Test Results			~~0:20-1:20~~									
2000-01 HOT Table Values	0:20-1:20	0:45-2:05	0:20-1:20									
2000-01 ET Test Results				0:50-2:30								
2001-02 HOT Table Values	0:20-1:20	0:45-2:05	0:20-1:20									
2002-03 ET Test Results												
2003-04 HOT Table Values	0:20-1:20	0:45-2:05	0:20-1:20									
2003-04 ET Test Results												
2004-05 HOT Table Values	0:20-1:20	0:45-2:05	0:20-1:20	0:50-2:30								
2004-05 ET Test Results												
2005-06 HOT Table Values	0:20-1:20	0:45-2:05	0:20-1:20	0:50-2:30								
2005-06 ET Test Results					1:00-1:55	1:50-3:20	~~0:40-1:25~~					
2006-07 HOT Table Values	0:20-1:20	0:45-2:05	0:20-1:20	0:50-2:30	1:00-1:55	1:50-3:20	0:40-1:25					
2006-07 ET Test Results							0:55-3:30	1:00-2:25				
2007-08 HOT Table Values	0:20-1:20	0:45-2:05	0:20-1:20	0:50-2:30	1:00-1:55	1:50-3:20	0:55-3:30	1:00-2:25				
2007-08 ET Test Results												
2008-09 HOT Table Values	0:20-1:20	0:45-2:05	0:20-1:20	0:50-2:30	1:00-1:55	1:50-3:20	0:55-3:30	1:00-2:25				
2008-09 ET Test Results									~~0:20~~-1:35			
2009-10 HOT Table Values	0:20-1:20	0:45-2:05	0:20-1:20	0:50-2:30	1:00-1:55	1:50-3:20	0:55-3:30	1:00-2:25	0:20-1:35			
2009-10 ET Test Results										0:45-1:45		
2010-11 HOT Table Values	0:20-1:20	0:45-2:05	0:20-1:20	0:50-2:30	1:00-1:55	1:50-3:20	0:55-3:30	1:00-2:25	0:20-1:35	0:45-1:45		
2010-11 ET Test Results											0:55-2:30	
2011-12 HOT Table Values	0:20-1:20	0:45-2:05	0:20-1:20	0:50-2:30	1:00-1:55	1:50-3:20	0:55-3:30	1:00-2:25	0:20-1:35	0:45-1:45	0:55-2:30	
2011-12 ET Test Results												
2012-13 HOT Table Values	0:20-1:20	0:45-2:05	0:20-1:20	0:50-2:30	1:00-1:55	1:50-3:20	0:55-3:30	1:00-2:25	0:20-1:35	0:45-1:45	0:55-2:30	
2012-13 ET Test Results												0:55-2:15
2013-14 HOT Table Values	0:20-1:20	0:45-2:05	0:20-1:20	0:50-2:30	1:00-1:55	1:50-3:20	0:55-3:30	1:00-2:25	0:20-1:35	0:45-1:45	0:55-2:30	0:55-2:15

Table 6.22: Type IV 75/25 Fluid, Freezing Fog, Below -3°C to -14°C

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A/D-49	CR-PG	CR-PGA	C-L+
1996-97 Test Results and Table Values used in 97-98	0:35-2:00											
1997-98 ET Test Results												
1998-99 HOT Table Values	0:30-2:00											
1998-99 ETTest Results		~~0:25~~-1:00										
1999-00 HOT Table Values	0:25-1:00	0:25-1:00	0:25-1:00									
1999-00 ET Test Results			~~0:25~~-0:50									
2000-01 HOT Table Values	0:25-0:50	0:25-1:00	0:25-0:50									
2000-01 ET Test Results				~~0:30-1:05~~								
2001-02 HOT Table Values	0:25-0:50	0:25-1:00	0:25-0:50									
2002-03 ET Test Results												
2003-04 HOT Table Values	0:25-0:50	0:25-1:00	0:25-0:50									
2003-04 ET Test Results												
2004-05 HOT Table Values	0:25-0:50	0:25-1:00	0:25-0:50	0:30-1:05								
2004-05 ET Test Results												
2005-06 HOT Table Values	0:25-0:50	0:25-1:00	0:25-0:50	0:30-1:05								
2005-06 ET Test Results					0:40-1:20		~~0:40-1:15~~					
2006-07 HOT Table Values	0:25-0:50	0:25-1:00	0:25-0:50	0:30-1:05	0:40-1:20		0:40-1:15					
2006-07 ET Test Results							0:45-1:50	0:50-1:45				
2007-08 HOT Table Values	0:25-0:50	0:25-1:00	0:25-0:50	0:30-1:05	0:40-1:20		0:45-1:50	0:50-1:45				
2007-08 ET Test Results												
2008-09 HOT Table Values	0:25-0:50	0:25-1:00	0:25-0:50	0:30-1:05	0:40-1:20		0:45-1:50	0:50-1:45				
2008-09 ET Test Results									0:30-1:10			
2009-10 HOT Table Values	0:25-0:50	0:25-1:00	0:25-0:50	0:30-1:05	0:40-1:20		0:45-1:50	0:50-1:45	0:30-1:10			
2009-10 ET Test Results										0:35-1:30		
2010-11 HOT Table Values	0:25-0:50	0:25-1:00	0:25-0:50	0:30-1:05	0:40-1:20		0:45-1:50	0:50-1:45	0:30-1:10	0:35-1:30		
2010-11 ET Test Results											0:40-1:30	
2011-12 HOT Table Values	0:25-0:50	0:25-1:00	0:25-0:50	0:30-1:05	0:40-1:20		0:45-1:50	0:50-1:45	0:30-1:10	0:35-1:30	0:40-1:30	
2011-12 ET Test Results												
2012-13 HOT Table Values	0:25-0:50	0:25-1:00	0:25-0:50	0:30-1:05	0:40-1:20		0:45-1:50	0:50-1:45	0:30-1:10	0:35-1:30	0:40-1:30	
2012-13 ET Test Results												0:40-2:00
2013-14 HOT Table Values	0:25-0:50	0:25-1:00	0:25-0:50		0:40-1:20		0:45-1:50	0:50-1:45	0:30-1:10	0:35-1:30	0:40-1:30	0:40-2:00

Table 6.23: Type IV Neat Fluid, Freezing Fog, Below -14ºC to -25ºC

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A/D-49	CR-PG	CR-PGA	C-L+
1996-97 Test Results and Table Values used in 97-98	0:20-2:00											
1997-98 ET Test Results												
1998-99 HOT Table Values	0:20-2:00											
1998-99 ETTest Results		0:20-0:40										
1999-00 HOT Table Values	0:20-0:40	0:20-0:40	0:20-0:40									
1999-00 ET Test Results			0:15-0:40									
2000-01 HOT Table Values	0:15-0:40	0:20-0:40	0:15-0:40									
2000-01 ET Test Results				0:20-0:45								
2001-02 HOT Table Values	0:15-0:40	0:20-0:40	0:15-0:40									
2002-03 ET Test Results												
2003-04 HOT Table Values	0:15-0:40	0:20-0:40	0:15-0:40									
2003-04 ET Test Results												
2004-05 HOT Table Values	0:15-0:40	0:20-0:40	0:15-0:40	0:20-0:45								
2004-05 ET Test Results												
2005-06 HOT Table Values	0:15-0:40	0:20-0:40	0:15-0:40	0:20-0:45								
2005-06 ET Test Results					0:30-0:50	0:30-1:05	~~0:20-0:45~~					
2006-07 HOT Table Values	0:15-0:40	0:20-0:40	0:15-0:40	0:20-0:45	0:30-0:50	0:30-1:05	0:20-0:45					
2006-07 ET Test Results							0:40-1:00	0:25-0:45				
2007-08 HOT Table Values	0:15-0:40	0:20-0:40	0:15-0:40	0:20-0:45	0:30-0:50	0:30-1:05	0:40-1:00	0:25-0:45				
2007-08 ET Test Results												
2008-09 HOT Table Values	0:15-0:40	0:20-0:40	0:15-0:40	0:20-0:45	0:30-0:50	0:30-1:05	0:40-1:00	0:25-0:45				
2008-09 ET Test Results									0:25-0:40			
2009-10 HOT Table Values	0:15-0:40	0:20-0:40	0:15-0:40	0:20-0:45	0:30-0:50	0:30-1:05	0:40-1:00	0:25-0:45	0:25-0:40			
2009-10 ET Test Results										0:20-0:40		
2010-11 HOT Table Values	0:15-0:40	0:20-0:40	0:15-0:40	0:20-0:45	0:30-0:50	0:30-1:05	0:40-1:00	0:25-0:45	0:25-0:40	0:20-0:40		
2010-11 ET Test Results											0:25-0:50	
2011-12 HOT Table Values	0:15-0:40	0:20-0:40	0:15-0:40	0:20-0:45	0:30-0:50	0:30-1:05	0:40-1:00	0:25-0:45	0:25-0:40	0:20-0:40	0:25-0:50	
2011-12 ET Test Results												
2012-13 HOT Table Values	0:15-0:40	0:20-0:40	0:15-0:40	0:20-0:45	0:30-0:50	0:30-1:05	0:40-1:00	0:25-0:45	0:25-0:40	0:20-0:40	0:25-0:50	
2012-13 ET Test Results												0:25-0:50
2013-14 HOT Table Values	0:15-0:40	0:20-0:40	0:15-0:40	0:20-0:45	0:30-0:50	0:30-1:05	0:40-1:00	0:25-0:45	0:25-0:40	0:20-0:40	0:25-0:50	0:25-0:50

Table 6.24: Type IV Neat Fluid, Rain on a Cold-Soaked Wing, Above 0°C

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A/D-49	CR-PG	CR-PGA	C-L+
1996-97 Test Results and Table Values used in 97-98	~~0:10-0:50~~											
1997-98 ET Test Results		0:20-1:15										
1998-99 HOT Table Values	0:10-0:50											
1998-99 ETTest Results		~~0:30-2:00~~										
1999-00 HOT Table Values	0:10-0:50	0:20-1:15	0:10-0:50									
1999-00 ET Test Results			0:15-1:35									
2000-01 HOT Table Values	0:10-0:50	0:20-1:15	0:15-1:35									
2000-01 ET Test Results				0:20-2:00								
2001-02 HOT Table Values	0:10-0:50	0:20-1:15	0:15-1:35									
2002-03 ET Test Results												
2003-04 HOT Table Values	0:10-0:50	0:20-1:15	0:15-1:35									
2003-04 ET Test Results												
2004-05 HOT Table Values	0:10-0:50	0:20-1:15	0:15-1:35	0:20-2:00								
2004-05 ET Test Results												
2005-06 HOT Table Values	0:10-0:50	0:20-1:15	0:15-1:35	0:20-2:00								
2005-06 ET Test Results					0:15-1:40	0:20-2:00	~~0:15-1:40~~					
2006-07 HOT Table Values	0:10-0:50	0:20-1:15	0:15-1:35	0:20-2:00	0:15-1:40	0:20-2:00	0:15-1:40					
2006-07 ET Test Results							0:25-2:00	0:15-1:25				
2007-08 HOT Table Values	0:10-0:50	0:20-1:15	0:15-1:35	0:20-2:00	0:15-1:40	0:20-2:00	0:25-2:00	0:15-1:25				
2007-08 ET Test Results												
2008-09 HOT Table Values	0:10-1:05	0:20-1:15	0:15-1:35	0:20-2:00	0:15-1:40	0:20-2:00	0:25-2:00	0:15-1:25				
2008-09 ET Test Results									0:10-1:55			
2009-10 HOT Table Values	0:10-1:05	0:20-1:15	0:15-1:35	0:20-2:00	0:15-1:40	0:20-2:00	0:25-2:00	0:15-1:25	0:10-1:55			
2009-10 ET Test Results										0:15-1:25		
2010-11 HOT Table Values	0:10-1:05	0:20-1:15	0:15-1:35	0:20-2:00	0:15-1:40	0:20-2:00	0:25-2:00	0:15-1:25	0:10-1:55	0:15-1:25		
2010-11 ET Test Results											0:15-2:00	
2011-12 HOT Table Values	0:10-1:15	0:20-1:15	0:15-1:35	0:20-2:00	0:15-1:40	0:20-2:00	0:25-2:00	0:15-1:25	0:10-1:55	0:15-1:25	0:15-2:00	
2011-12 ET Test Results												
2012-13 HOT Table Values	0:10-1:15	0:20-1:15	0:15-1:35	0:20-2:00	0:15-1:40	0:20-2:00	0:25-2:00	0:15-1:25	0:10-1:55	0:15-1:25	0:15-2:00	
2012-13 ET Test Results												0:20-2:00
2013-14 HOT Table Values	0:10-1:15	0:20-1:15	0:15-1:35	0:20-2:00	0:15-1:40	0:20-2:00	0:25-2:00	0:15-1:25	0:10-1:55	0:15-1:25	0:15-2:00	0:20-2:00

Table 6.25: Type IV 75/25 Fluid, Rain on a Cold-Soaked Wing, Above 0°C

	GENERIC	K-ABCS	A/D-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A/D-49	CR-PG	CR-PGA	C-L+
1996-97 Test Results and Table Values used in 97-98	~~0:05-0:35~~											
1997-98 ET Test Results		0:100:50										
1998-99 HOT Table Values	0:05-0:35											
1998-99 ETTest Results		~~0:10-1:15~~										
1999-00 HOT Table Values	0:05-0:35	0:10-0:50	0:05-0:35									
1999-00 ET Test Results			0:10-1:15									
2000-01 HOT Table Values	0:05-0:35	0:10-0:50	0:10-1:15									
2000-01 ET Test Results				~~0:20-2:00~~								
2001-02 HOT Table Values	0:05-0:35	0:10-0:50	0:10-1:15									
2002-03 ET Test Results												
2003-04 HOT Table Values	0:05-0:35	0:10-0:50	0:10-1:15									
2003-04 ET Test Results												
2004-05 HOT Table Values	0:05-0:35	0:10-0:50	0:10-1:15	0:20-2:00								
2004-05 ET Test Results												
2005-06 HOT Table Values	0:05-0:35	0:10-0:50	0:10-1:15	0:20-2:00								
2005-06 ET Test Results					0:10-1:45		~~0:05-1:00~~					
2006-07 HOT Table Values	0:05-0:35	0:10-0:50	0:10-1:15	0:20-2:00	0:10-1:45		0:05-1:00					
2006-07 ET Test Results							0:10-1:20	0:09-1:20				
2007-08 HOT Table Values	0:05-0:35	0:10-0:50	0:10-1:15	0:20-2:00	0:10-1:45		0:10-1:20	0:05-1:20				
2007-08 ET Test Results												
2008-09 HOT Table Values	0:05-0:40	0:10-0:50	0:10-1:15	0:20-2:00	0:10-1:45		0:10-1:20	0:05-1:20				
2008-09 ET Test Results									0:10-1:40			
2009-10 HOT Table Values	0:05-0:40	0:10-0:50	0:10-1:15	0:20-2:00	0:10-1:45		0:10-1:20	0:05-1:20	0:10-1:40			
2009-10 ET Test Results										0:10-1:15		
2010-11 HOT Table Values	0:05-0:40	0:10-0:50	0:10-1:15	0:20-2:00	0:10-1:45		0:10-1:20	0:05-1:20	0:10-1:40	0:10-1:15		
2010-11 ET Test Results											0:09-1:40	
2011-12 HOT Table Values	0:09-0:50	0:10-0:50	0:10-1:15	0:20-2:00	0:10-1:45		0:10-1:20	0:09-1:20	0:10-1:40	0:10-1:15	0:09-1:40	
2011-12 ET Test Results												
2012-13 HOT Table Values	0:09-0:50	0:10-0:50	0:10-1:15	0:20-2:00	0:10-1:45		0:10-1:20	0:09-1:20	0:10-1:40	0:10-1:15	0:09-1:40	
2012-13 ET Test Results												0:20-1:50
2013-14 HOT Table Values	0:09-0:50	0:10-0:50	0:10-1:15		0:10-1:45		0:10-1:20	0:09-1:20	0:10-1:40	0:10-1:15	0:09-1:40	0:20-1:50

7. SUPPLEMENTAL TESTING: LIGHT/VERY LIGHT SNOW HOLDOVER TIMES FOR TYPE II/IV FLUIDS

Testing and additional analysis was completed in the winter of 2012-13 to finalize light and very light snow holdover times for select Type II and Type IV fluids. This work, the culmination of a multi-year research project, is described in this chapter.

7.1 Background

Through the forum of the SAE G-12 Holdover Time Committee, the aircraft ground deicing industry expressed the need for increased operational flexibility in lighter snow conditions. Specifically, a motion was passed at the May 2011 SAE G-12 Holdover Time Committee meeting in San Francisco requesting that Transport Canada and the FAA add light and very light snow columns to the Type II and Type IV HOT tables. As the holdover times in the existing snow column are based on moderate snowfall intensity rates, these columns would provide longer holdover times in lighter snow conditions.

The light snow and very light snow columns are already in use in the Type I and Type III HOT tables. Therefore, the snowfall intensity rates which define them already exist. The rates are as follows:

- Very Light Snow: 3 and 4 g/dm^2/h (FAA), 4 g/dm^2/h (Transport Canada);
- Light Snow: 4 and 10 g/dm^2/h; and
- Moderate Snow: 10 and 25 g/dm^2/h.

A project plan was subsequently developed to address the industry request. The project plan phases are described below. The phases were completed over several years due to funding availability/limitations.

- Phase 0: Conduct a feasibility analysis.
- Phase 1: Determine a minimum acceptable precipitation rate input for Holdover Time Determination Systems (HOTDS) and Liquid Water Equivalent Systems (LWES).
- Phase 2: Evaluate robustness of Type II, III and IV snow data sets at light and very light rates of precipitation and identify non-robust data sets.
- Phase 3: Collect and evaluate new data for non-robust data sets and use this data to validate existing regression coefficients or determine appropriate new regression coefficients for these data sets.
- Phase 4: Incorporate light and very light snow holdover times for Type II and Type IV fluids into the HOT guidelines.

7.2 Previous Work

Preliminary work was conducted in summer 2011 to evaluate the feasibility of developing light and very light snow holdover times for Type II and Type IV fluids using the existing endurance time data and standard regression analysis methodology (Phase 0 of the project plan). It was determined that sufficient data existed for many, but not all, Type II/IV fluids and that further analysis was needed to determine which fluids had sufficient data and which did not. This work is documented in the Transport Canada report, TP15158E, *Aircraft Ground Icing General Research Activities During the 2010-11 Winter* (9).

In the winter of 2011-12, a detailed analysis was completed to evaluate the robustness of existing snow data sets at light and very light rates of precipitation. This research identified the fluids/data sets with sufficient data to provide light and very light snow holdover times; and those which required more data for light and very light snow holdover times to be provided (Phase 2 of the project plan). The analysis also resulted in the publication of a table of lowest usable precipitation rates (LUPRs) in snow for use with HOTDS and LWES (Phase 1 of the project plan). The winter 2011-12 work is documented in the Transport Canada report, TP 15202E, *Aircraft Ground Icing General Research Activities During the 2011-12 Winter* (10).

7.3 Objective

The objective for winter 2012-13 was to complete Phases 3 and 4 of the project plan. This involved the following:

- Communicate with fluid manufacturers to determine which fluids to include in the project;
- Collect and evaluate additional data for fluids with non-robust data sets;
- Determine light and very light snow holdover times for all fluids/dilutions included in the project; and
- Incorporate the new holdover times into the HOT guidelines.

7.4 Fluids/Data Sets Included in the Project

Transport Canada and the FAA determined the 2012-13 work would be funded by the fluid manufacturers. Fluid manufacturers were given the option to obtain light and very light snow holdover times for each of their Type II/IV fluids for a fee, which was collected by Transport Canada. APS prepared a letter for this purpose, distributed it to the fluid manufacturers, and followed up to obtain responses. In total, fluid manufacturers requested that ten fluids be included.

Type IV:

- ABAX Ecowing AD-49
- Dow UCAR™ FlightGuard AD-49
- Clariant Safewing MP IV Launch
- Clariant Max Flight 04
- Cryotech Polar Guard Advance
- Kilfrost ABC-S Plus
- Dow UCAR Endurance EG106

Type II:

- ABAX Ecowing 26
- Clariant Safewing MP II Flight
- Cryotech Polar Guard II

With the exception of Dow UCAR Endurance EG106, for which holdover times are not published for diluted fluids, 3 data sets were involved for each fluid: 100/0, 75/25 and 50/50.

Two fluids in the project are duplicates of other fluids: Cryotech Polar Guard II is Cryotech Polar Guard Advance and Dow FlightGuard AD-49 is ABAX Ecowing AD-49. As such, separate data sets did not need to be included for these fluids.

The list of data sets required for the project is shown in Table 7.1. Twenty-two data sets were required in total.

Table 7.1: Data Sets Included in Project

Fluid Name	# Data Sets	Data Sets
ABAX AD-49 / Dow AD-49	3	100/0, 75/25, 50/50
ABAX Ecowing 26	3	100/0, 75/25, 50/50
Clariant Max-Flight 04	3	100/0, 75/25, 50/50
Clariant Safewing MP II Flight	3	100/0, 75/25, 50/50
Clariant Safewing MP IV Launch	3	100/0, 75/25, 50/50
Cryotech Polar Guard Advance / II	3	100/0, 75/25, 50/50
Dow UCAR Endurance EG106	1	100/0
Kilfrost ABC-S Plus	3	100/0, 75/25, 50/50
Total	**22**	

7.5 Collection/Evaluation of Additional Data

Phase 2 of the project evaluated the robustness of all Type II/IV fluid data sets. Those identified as robust at the lower precipitation rate boundary for very light snow (3 g/dm²/h) can be used as is to obtain light and very light snow holdover times for Transport Canada and the FAA without further data/analysis. Those identified as non-robust at 3 g/dm²/h require further data/analysis to provide light and very light snow holdover times. The details of the Phase 2 analysis are documented in TP 15202E (10).

The robustness of each data set included in the project (see Table 7.1) is listed in Table 7.2. This data was obtained from TP 15202E (10). As the data sets were coded in that report, both the fluid name and fluid code used in TP 15202E (10) are included in Table 7.2. In total, 14 data sets were identified as non-robust / requiring additional data/analysis.

Table 7.2: Robustness of Project Data Sets

Fluid Name	Fluid Code	Dilution	Robust at 3 g/dm²/h?	Require Additional Data?
ABAX AD-49 / Dow AD-49	Fluid A	100/0	No	Yes
		75/25	No	Yes
		50/50	No	Yes
ABAX Ecowing 26	Fluid B	100/0	Yes	No
		75/25	No	Yes
		50/50	Yes	No
Clariant Max-Flight 04	Fluid S	100/0	Yes	No
		75/25	Yes	No
		50/50	No	Yes
Clariant Safewing MP II Flight	Fluid E	100/0	Yes	No
		75/25	No	Yes
		50/50	Yes	No
Clariant Safewing MP IV Launch	Fluid G	100/0	No	Yes
		75/25	No	Yes
		50/50	No	Yes
Cryotech Polar Guard Advance / Cryotech Polar Guard II	Fluid I	100/0	No	Yes
		75/25	No	Yes
		50/50	No	Yes
Dow Endurance EG106	Fluid J	100/0	Yes	No
Kilfrost ABC-S Plus	Fluid P	100/0	No	Yes
		75/25	No	Yes
		50/50	Yes	No

Two types of additional data were collected: new test data and historical did not fail (HDNF) data. The two types of data are described below, followed by a summary of the data and a log with detailed information on each data point collected.

7.5.1 New Test Data

Manufacturers submitted low viscosity fluid samples to APS in late 2012 / early 2013. Samples were accepted as long as their viscosity was not more than 20 percent above their published lowest on-wing viscosity (LOWV). Viscosities were measured using the Aerospace Information Report (AIR) 9968 method. All samples submitted met this criterion (see Table 7.3).

Tests were conducted with the fluid samples in light and very light snow conditions over the winter of 2012-13 at the APS test site using standard endurance time testing procedures (see Subsection 2.1).

Table 7.3: Fluid Sample Viscosities

Fluid	Dilution	LOWV (mPa.s)	Sample Viscosity (mPa.s)	Viscosity Difference
ABAX/Dow AD-49	100/0	11,000	10,750	-2%
ABAX/Dow AD-49	75/25	32,350	28,700	-11%
ABAX/Dow AD-49	50/50	21,150	21,200	0%
ABAX Ecowing 26	75/25	2,200	2,100	-5%
Clariant Max-Flight 04	50/50	5,200	5,150	-1%
Clariant MP II Flight	75/25	12,900	14,300	+11%
Clariant MP IV Launch	100/0	7,550	7,300	-3%
Clariant MP IV Launch	75/25	18,000	15,300	-15%
Clariant MP IV Launch	50/50	17,800	14,750	-17%
Cryotech Polar Guard Advance	100/0	4,050	3,750	-7%
Cryotech Polar Guard Advance	75/25	9,750	6,550	-33%
Cryotech Polar Guard Advance	50/50	80	60	-25%
Kilfrost ABC-S Plus	100/0	17,900	18,200	+2%
Kilfrost ABC-S Plus	75/25	18,300	17,500	-4%

7.5.2 Historical "Did Not Fail" (HDNF) Data

Endurance time tests are sometimes not completed because snow stops midway through the test. The information for these tests, including the time the tests were ended, is nevertheless recorded and archived.

The tests are not valid for regression, but can be used to validate curves at low precipitation rates. Two acceptance criteria were put in place to determine which tests could be used for this purpose:

a) Precipitation rate < 10 g/dm²/h (light/very light snow); and

b) Test duration at least 85 percent of expected holdover time.

Test logs from previous winters were examined to find HDNF tests conducted with the project fluids that met these criteria.

7.5.3 Summary of Additional Data Collected

A summary of the additional data points collected is given in Table 7.4. In total 63 additional data points were collected, including 18 HDNF points and 45 new test points.

Table 7.4: Summary of Additional Data Points Collected

Fluid Name	Dilution	Additional Data Points		
		HDNF	**New**	**Total**
ABAX / Dow AD-49	100/0	4	3	7
ABAX / Dow AD-49	75/25	3	2	5
ABAX / Dow AD-49	50/50	0	2	2
ABAX Ecowing 26	75/25	0	4	4
Clariant Max Flight 04	50/50	0	5	5
Clariant Safewing MP II Flight	75/25	2	1	3
Clariant Safewing MP IV Launch	100/0	0	5	5
Clariant Safewing MP IV Launch	75/25	0	3	3
Clariant Safewing MP IV Launch	50/50	2	0	2
Cryotech Polar Guard Advance / II	100/0	3	3	6
Cryotech Polar Guard Advance / II	75/25	2	5	7
Cryotech Polar Guard Advance / II	50/50	0	6	6
Kilfrost ABC-S Plus	100/0	2	3	5
Kilfrost ABC-S Plus	75/25	0	3	3
All		**18**	**45**	**63**

7.5.4 Log of Additional Data Collected

A log of the additional data points collected is given in Table 7.5. The log includes: test date, fluid name, fluid dilution, precipitation rate, test temperature, endurance time, the regression calculated holdover time (calculated using the original data set regression equation and the test temperature and precipitation rate), and the test type.

Table 7.5: Log of Additional Data

Date	Fluid Name	Fluid Dil.	Precip. Rate (g/dm²/h)	Temp (°C)	Endurance Time* (min.)	Regression HOT (min.)	Endurance Time* / Regression HOT	Test Type
27-Feb-11	Polar Guard Advance	100%	2.94	-10.2	144.7*	127.9	113%	HDNF
06-Mar-11	Polar Guard Advance	100%	5.25	-2.2	136.8*	146.8	93%	HDNF
06-Mar-11	Polar Guard Advance	100%	6.16	-2.2	166.5*	138.6	120%	HDNF
25-Feb-11	Polar Guard Advance	75%	4.6	-3.8	113.2*	125.8	90%	HDNF
21-Mar-11	Polar Guard Advance	75%	8.6	0.7	140.3*	128.2	109%	HDNF
14-Feb-07	ABC-S Plus	100%	8.9	-13.4	94.9*	111.0	86%	HDNF
02-Mar-07	ABC-S Plus	100%	8.22	-1.8	147.3*	146.6	100%	HDNF
20-Feb-09	AD-49	100%	3.78	-7.7	286.5*	172.5	166%	HDNF
07-Apr-09	AD-49	100%	7.24	-0.9	109.7*	126.7	87%	HDNF
22-Feb-09	AD-49	100%	6.59	-3.6	166.8*	132.5	126%	HDNF
09-Mar-09	AD-49	100%	3.96	-3.2	221.0*	168.7	131%	HDNF
20-Feb-09	AD-49	75%	3.23	-7.7	237.5*	133.0	179%	HDNF
09-Mar-09	AD-49	75%	3.57	-3.2	207.5*	129.6	160%	HDNF
07-Apr-09	AD-49	75%	1.32	-1.0	201.5*	167.5	120%	HDNF
21-Feb-06	Flight	75%	2.3	-2.8	383.5*	237.0	162%	HDNF
16-Feb-06	Flight	75%	6.69	-8.5	63.2*	71.1	89%	HDNF
02-Mar-07	Launch	50%	8.58	-1.6	53.3*	51.9	103%	HDNF
19-Mar-07	Launch	50%	0.7	-0.2	284.3*	303.1	94%	HDNF
20-Feb-13	ABC-S Plus	100%	5.6	-5.4	175.0	164.1	107%	New
23-Feb-13	ABC-S Plus	100%	3.5	0.3	354.3	276.8	128%	New
02-Mar-13	ABC-S Plus	100%	4.9	-4.4	288.8	182.1	159%	New
20-Feb-13	ABC-S Plus	75%	4.7	-4.9	114.0	107.2	106%	New
23-Feb-13	ABC-S Plus	75%	5.8	0.0	120.5	115.8	104%	New
02-Mar-13	ABC-S Plus	75%	4.8	-3.9	95.3	108.6	88%	New
16-Dec-12	AD-49	100%	3.9	-7.6	163.3	126.7	129%	New
29-Dec-12	AD-49	100%	8.7	-8.6	82.0	116.1	71%	New
29-Dec-12	AD-49	100%	2.4	-9.4	210.4	214.0	98%	New
29-Nov-12	AD-49	75%	0.7	-2.8	248.0*	197.9	125%	New

**Fluid failure did not occur; endurance time is duration between start time and time test stopped*

Table 7.5: Log of Additional Data (cont'd)

Date	Fluid Name	Fluid Dil.	Precip. Rate (g/dm²/h)	Temp (°C)	Endurance Time* (min.)	Regression HOT (min.)	Endurance Time* / Regression HOT	Test Type
16-Dec-12	AD-49	75%	3.6	-7.8	127.8	176.5	72%	New
15-Feb-13	AD-49	50%	3.4	-0.8	136.6	46.3	295%	New
19-Feb-13	AD-49	50%	5.2	-3.3	104.8	33.9	309%	New
29-Nov-12	Ecowing 26	75%	0.7	-2.8	248.7*	236.8	105%	New
16-Dec-12	Ecowing 26	75%	2.1	-7.9	58.2	112.4	52%	New
16-Dec-12	Ecowing 26	75%	3.7	-7.8	47.4	80.0	59%	New
29-Dec-12	Ecowing 26	75%	7.5	-8.5	27.0	51.9	52%	New
16-Dec-12	Flight	75%	4.2	-7.4	258.1	104.3	247%	New
16-Dec-12	Launch	100%	4.5	-7.6	214.6	137.1	156%	New
29-Dec-12	Launch	100%	8.8	-8.6	108.0	93.6	115%	New
29-Dec-12	Launch	100%	2.8	-9.5	238.0	169.1	141%	New
03-Jan-13	Launch	100%	2.1	-13.6	175.3	183.1	96%	New
06-Jan-13	Launch	100%	4.0	-10.3	97.2	137.5	71%	New
16-Dec-12	Launch	75%	4.4	-7.6	204.3	141.2	145%	New
29-Dec-12	Launch	75%	8.8	-8.6	106.5	89.8	119%	New
29-Dec-12	Launch	75%	2.8	-9.5	235.7	178.8	132%	New
15-Feb-13	Max Flight 04	50%	3.9	-0.9	55.3	307.3	18%	New
15-Feb-13	Max Flight 04	50%	4.3	-0.7	37.6	280.0	13%	New
19-Feb-13	Max Flight 04	50%	2.5	-2.6	45.7	416.4	11%	New
23-Feb-13	Max Flight 04	50%	4.5	-0.1	92.9	303.0	31%	New
27-Feb-13	Max Flight 04	50%	51.1	0.2	7.7	18.8	41%	New
16-Dec-12	Polar Guard Advance	100%	4.1	-7.6	177.6	122.7	145%	New
29-Dec-12	Polar Guard Advance	100%	8.8	-8.6	122.5	90.3	136%	New
29-Dec-12	Polar Guard Advance	100%	2.8	-9.5	236.8	143.5	165%	New
16-Dec-12	Polar Guard Advance	75%	3.9	-7.6	165.1	122.1	135%	New
29-Dec-12	Polar Guard Advance	75%	8.8	-8.6	94.0	70.9	133%	New
29-Dec-12	Polar Guard Advance	75%	2.5	-9.4	216.3	154.5	140%	New
03-Jan-13	Polar Guard Advance	75%	1.8	-13.6	140.8	174.7	81%	New
06-Jan-13	Polar Guard Advance	75%	3.7	-10.1	277.6	118.5	234%	New
15-Feb-13	Polar Guard Advance	50%	3.9	-0.9	87.5	88.3	99%	New
15-Feb-13	Polar Guard Advance	50%	5.9	-0.7	57.0	63.3	90%	New
19-Feb-13	Polar Guard Advance	50%	4.2	-3.3	78.7	77.4	102%	New
23-Feb-13	Polar Guard Advance	50%	4.5	-0.1	91.4	83.2	110%	New
15-Mar-13	Polar Guard Advance	50%	2.1	-3.1	96.2	138.9	69%	New
12-Apr-13	Polar Guard Advance	50%	40.1	-0.2	10.1	13.0	78%	New

**Fluid failure did not occur; endurance time is duration between start time and time test stopped*

7.6 Analysis of Additional Data

The analysis completed with the additional data collected is described in this section. Tables 7.10 and 7.11 at the end of the section provide the detailed calculations and statistics described in the text.

7.6.1 Evaluation of Robustness of Updated Data Sets

The analysis methodology used to evaluate the robustness of the updated data sets was first developed during Phase 2 of the project. It is a five-factor weighted analysis. The five factors and their weights are given in Table 7.6. The factor rating system is shown in Table 7.7. The steps taken to analyse the robustness of a data set are as follows:

1. Determine the factor statistics for each of the five factors;
2. Determine the factor rating that applies to each of the factor statistics;
3. Multiply the factor rating for each factor by the factor weight;
4. Combine the weighted factor ratings to determine the overall score; and
5. Compare the overall score to the applicable minimum acceptance score – if the overall score is equal or above the minimum acceptance score, the data set is considered robust for the precipitation rate being evaluated.

The minimum acceptance scores were selected based on careful examination of the data, with input from APS, Transport Canada and the FAA. The score for 50/50 fluids is lower than for 100/0 and 75/25 fluids due to the absence of data collection below -3°C. The minimum acceptance scores are:

- 100/0 fluids = 28;
- 75/25 fluids = 28; and
- 50/50 fluids = 19.

This analysis methodology is used to evaluate the robustness of data sets at specific precipitation rates (inputs for factor #4 will vary depending on the precipitation rate being evaluated).

For this task, the objective was to collect sufficient data to create data sets robust at the lowest precipitation rate limit for very light snow (3 g/dm²/h, see Subsection 7.1). As additional data was collected, the original data sets were updated and the robustness at 3 g/dm²/h was re-evaluated. Data collection stopped when the data set met the requirements to be considered robust at 3 g/dm²/h.

The supporting statistics for the robustness analysis are given in Table 7.10.

Table 7.6: Factor Descriptions and Weights

Factor Description	Factor Weight
1. Total number of data points	5%
2. Number of data points with air temperatures below -3°C	20%
3. Number of data points with precipitation rates below 10 g/dm²/h	20%
4. Number of data points with precipitation rates less than or equal to 0.5 g/dm²/h above the precipitation rate being examined	40%
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)	15%

Table 7.7: Factor Rating System

Factor #1: Total Data Points	
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	
Rating = 40	≥15 data points -3 to -14°C
Rating = 30	12-14 data points -3 to -14°C
Rating = 20	9-11 data points -3 to -14°C
Rating = 10	6-8 data points -3 to -14°C
Rating = 0	<6 data points -3 to -14°C

Factor #3: Data Points Below 10 g/dm²/h	
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	
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	
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%

7.6.2 Update to Lowest Usable Precipitation Rates

The lowest precipitation rate at which the data set meets the minimum acceptance score is the lowest usable precipitation rate (LUPR). This is the lowest precipitation rate that can be used by HOTDS and LWES.

The addition of data to the data sets necessitated that the LUPRs for the 14 updated data sets be recalculated. To this end, data robustness was also evaluated at 2 g/dm²/h. In all 14 cases the LUPRs were reduced: some to 3 g/dm²/h and some to 2 g/dm²/h. The updated LUPRs were published in the Transport Canada and FAA regression publications for winter 2013-14.

The supporting calculations for the updated LUPR values are given in Table 7.10.

7.6.3 Conformance Analysis

In addition to the robustness analyses, a conformance analysis was completed on the updated data sets. The objective of the conformance analysis was to confirm that the additional data collected was not significantly below the original data regression curve. The analysis included the following steps:

- Regression analysis was performed on each updated data set (original historical data + additional data collected in 2012-13);
- The regression analysis was used to calculate holdover times at the snow precipitation rate and temperature boundaries (3, 4, 10, 25 g/dm²/h; -3 and -14°C); and
- The calculated holdover times were compared to those calculated with the original data set regression analysis.

If the holdover times calculated from the updated regression curve were more than 10 percent below the historical regression curve holdover times, the additional data did not conform to the historical regression curve. In this case the original regression curves were not used to generate light and very light snow holdover times (see Subsection 7.7).

All but two of the data sets passed the conformance analysis: ABAX Ecowing 26 75/25 and Clariant Max Flight 04 50/50. ABAX Ecowing 26 75/25 is discussed in more detail in Subsection 7.6.4; Max Flight 04 50/50 is discussed in more detail in Subsection 7.6.5.

The conformance analysis statistics are given in Table 7.11.

7.6.4 ABAX Ecowing 26 75/25

Tests run with the ABAX Ecowing 26 75/25 sample submitted for testing yielded slightly shorter endurance times than expected. The historic and new data are plotted in Figure 7.1, along with the historic regression curves and the new regression curves calculated from the updated data set.

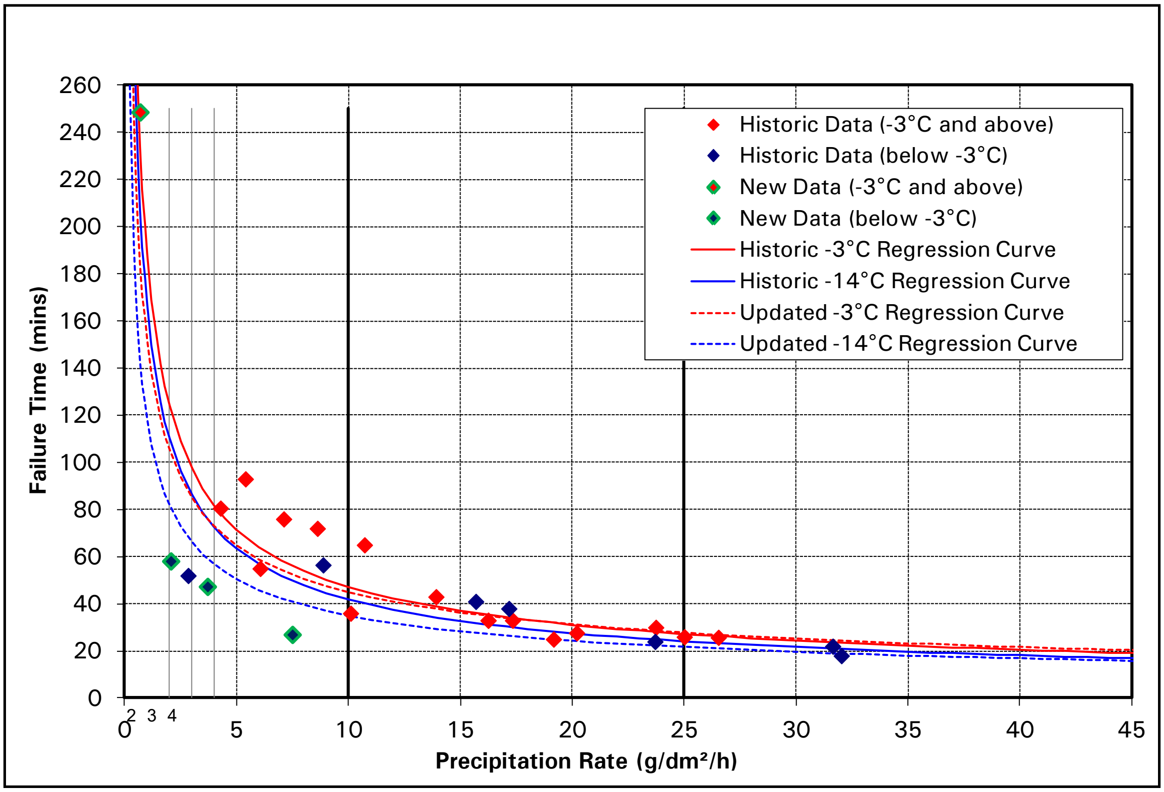

Figure 7.1: ABAX Ecowing 26 75/25 Snow Test Results

The regression curves produced holdover times which were in some cases more than 10 percent below the historic regression curves (see Table 7.11 for exact numbers).

As a result, the original ABAX Ecowing 26 75/25 regression curves were not used to generate light and very light snow holdover times for the data set. The alternate approach to producing light and very light snow holdover times for this data set is described in Subsection 7.7.

7.6.5 Clariant Max Flight 04 Dilutions

Tests run with the Clariant Max Flight 04 50/50 sample submitted for testing yielded significantly shorter endurance times than expected (see Figure 7.2).

These results were brought to the attention of the fluid manufacturer, Transport Canada and the FAA. As a result, new 50/50 and 75/25 samples, and a 100/0 sample were submitted for further testing. The further testing was conducted in simulated freezing precipitation conditions with the objective of determining whether the holdover times currently published for Max Flight 04 are valid for samples currently being produced.

The results of the freezing precipitation testing confirmed the lower holdover times measured in snow with the 50/50 fluid and raised concerns with the 75/25 fluid (some of the 75/25 endurance times measured were significantly longer than the current holdover times and others were significantly shorter than the current holdover times). The 100/0 fluid performed as expected. The results are summarized in Table 7.8.

As a result of this testing, Transport Canada and the FAA requested that the manufacturer remove the dilutions of this fluid from the HOT guidelines. The manufacturer agreed. For this reason, the results of Max Flight 04 50/50 were removed from the project and thus are not included in Table 7.10 or Table 7.11.

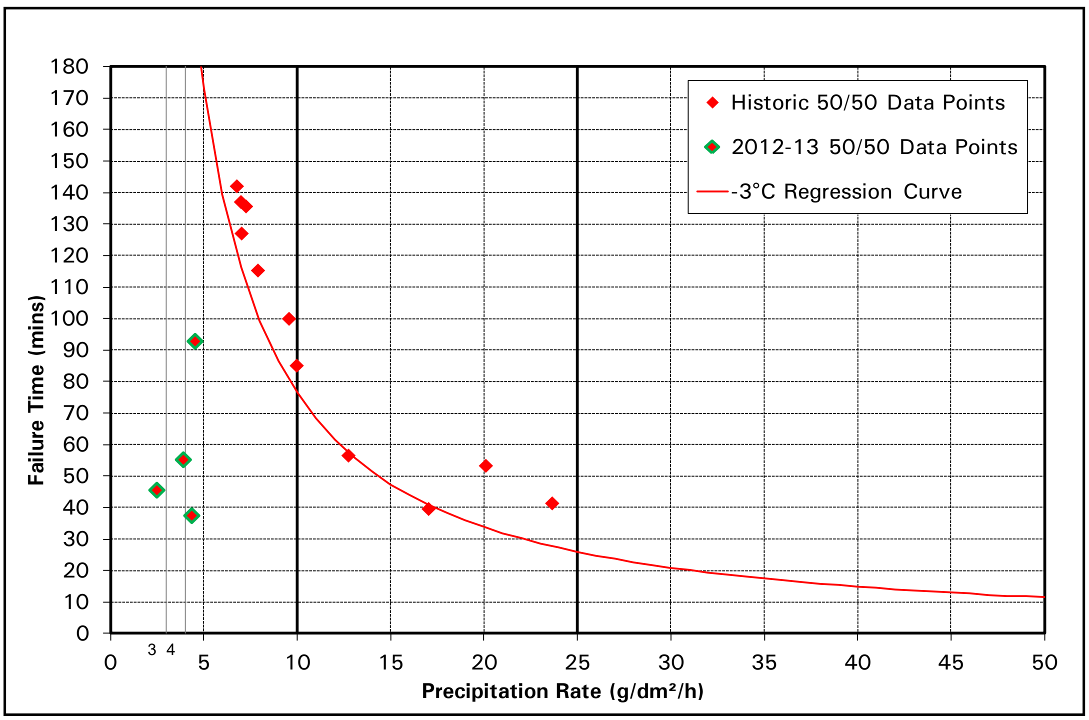

Figure 7.2: Max Flight 04 50/50 Snow Test Results

Table 7.8: Max Flight 04 Freezing Precipitation Test Results

Test #	Fluid Name	Fluid Dil.	Condition	Fail Time (min)	Current HOT (min)	Dif.	Avg. Dif.
MF01	Clariant MF-04 B2	100	Freezing Drizzle, -3°C, 5 g	>120	>120	0%	35%
MF02	Clariant MF-04 B2	100	Freezing Drizzle, -3°C, 13 g	>120	>120	0%	
MF03	Clariant MF-04 B2	100	Light Freezing Rain, -3°C, 13 g	>120	90	33%	
MF04	Clariant MF-04 B2	100	Light Freezing Rain, -3°C, 25 g	60	70	-14%	
MF05	Clariant MF-04 B2	100	Light Freezing Rain, -10°C, 13 g	38	40	-5%	
MF06	Clariant MF-04 B2	100	Light Freezing Rain, -10°C, 25 g	60	20	198%	
MF07	Clariant MF-04 B2	75	Freezing Drizzle, -3°C, 5 g	>120	>120	0%	8%
MF08	Clariant MF-04 B2	75	Freezing Drizzle, -3°C, 13 g	100	110	-9%	
MF09	Clariant MF-04 B2	75	Light Freezing Rain, -3°C, 13 g	54	80	-32%	
MF10	Clariant MF-04 B2	75	Light Freezing Rain, -3°C, 25 g	38	60	-37%	
MF11	Clariant MF-04 B2	75	Light Freezing Rain, -10°C, 13 g	44	30	46%	
MF12	Clariant MF-04 B2	75	Light Freezing Rain, -10°C, 25 g	27	15	83%	
MF13	Clariant MF-04 B2	50	Freezing Drizzle, -3°C, 5 g	20	70	-71%	-68%
MF14	Clariant MF-04 B2	50	Freezing Drizzle, -3°C, 13 g	8	35	-77%	
MF15	Clariant MF-04 B2	50	Light Freezing Rain, -3°C, 13 g	9	35	-73%	
MF16	Clariant MF-04 B2	50	Light Freezing Rain, -3°C, 25 g	6	25	-76%	
MF18	Clariant MF-04 B2	50	Freezing Fog, -3°C, 5 g	31	55	-44%	
MF19	Clariant MF-04 B1	50	Freezing Drizzle, -3°C, 5 g	20	70	-71%	-66%
MF20	Clariant MF-04 B1	50	Freezing Drizzle, -3°C, 13 g	10	35	-72%	
MF21	Clariant MF-04 B1	50	Light Freezing Rain, -3°C, 13 g	12	35	-67%	
MF22	Clariant MF-04 B1	50	Light Freezing Rain, -3°C, 25 g	5	25	-79%	
MF23	Clariant MF-04 B1	50	Freezing Fog, -3°C, 2 g	37	105	-65%	
MF24	Clariant MF-04 B1	50	Freezing Fog, -3°C, 5 g	31	55	-44%	

7.6.6 2012-13 New Fluids/Data

Following the completion of Phase 2, regulators decided that starting in the winter of 2012-13, any new Type II or Type IV fluid submitted for endurance time testing would undergo the necessary testing to obtain light and very light snow holdover times. The long-term goal is to have light and very light snow columns in all Type II/IV fluid HOT tables.

Clariant Safewing MP IV Launch Plus was submitted for endurance time testing in winter 2012-13. Analysis was completed to ensure sufficient data was collected at low precipitation rates to have data sets that were robust at light and very light snow precipitation rates. Calculations were also completed to determine the LUPR for each data set. Four "did not fail" tests were included in the analysis. Details of these tests are shown in Table 7.9.

The calculations and statistics to support the development of light and very light snow holdover times for Clariant Safewing Launch Plus are included in Table 7.10.

Table 7.9: Clariant Launch Plus "Did Not Fail" Data Points

Date	Fluid Name	Fluid Dil.	Precip. Rate ($g/dm^2/h$)	Temp (°C)	Endurance Time* (min.)	Regression HOT (min.)	Endurance Time* / Regression HOT	Test Type
02-Mar-13	Launch Plus	100%	3.2	-4.6	275.9*	318.7	87%	DNF
21-Feb-13	Launch Plus	100%	7.2	-10.8	119.3*	123.3	97%	DNF
02-Mar-13	Launch Plus	75%	3.2	-4.6	274.7*	307.7	89%	DNF
21-Feb-13	Launch Plus	75%	7.2	-10.8	119.0*	109.1	109%	DNF

**Fluid failure did not occur; endurance time is duration between start time and time test stopped*

Table 7.10: Statistics for Robustness and LUPR Analyses

Fluid Name	Dil.	Factor Statistics						Factor Scores						Total Score		LUPR (g/dm²/h)
		Total Data Points	Data Points -3 to -14°C	Data Points <10 g	Data Points ≤3.5 g	Data Points ≤2.5 g	Scatter 0-10 g	Total Data Points	Data Points -3 to -14°C	Data Points <10 g	Data Points ≤3.5 g	Data Points ≤2.5 g	Scatter 0-10 g	3 g/dm²/h	2 g/dm²/h	
ABAX / Dow AD-49	100/0	19	13	12	2	1	19%	30	30	40	30	20	20	31	27	3
ABAX / Dow AD-49	75/25	18	11	9	3	2	28%	30	20	30	40	30	20	31	27	3
ABAX / Dow AD-49	50/50	14	n/a	7	2	0	68%	20	0	30	30	0	0	19	7	3
ABAX Ecowing 26	75/25	27	10	11	3	2	30%	40	20	40	40	30	10	32	28	2
Clariant Flight	75/25	30	16	14	1	1	28%	40	40	40	20	20	20	29	29	2
Clariant Launch	100/0	25	20	8	2	1	27%	40	40	30	30	20	20	31	27	3
Clariant Launch	75/25	25	20	7	1	0	18%	40	40	30	20	0	30	29	21	3
Clariant Launch	50/50	13	n/a	4	2	2	3%	20	0	10	30	30	40	21	21	2
Clariant Launch Plus	100/0	21	13	9	2	0	12%	40	30	30	30	0	30	31	19	3
Clariant Launch Plus	75/25	21	12	9	2	0	19%	40	30	30	30	0	30	31	19	3
Clariant Launch Plus	50/50	12	2	6	3	1	6%	20	0	20	40	20	40	27	19	2
Cryotech PG	100/0	23	12	13	2	0	21%	40	30	40	30	0	20	31	19	3
Cryotech PG	75/25	28	15	14	2	2	30%	40	40	40	30	30	10	32	32	2
Cryotech PG	50/50	20	n/a	6	1	1	11%	40	0	20	20	20	30	19	19	2
Kilfrost ABC-S Plus	100/0	24	17	8	1	0	17%	40	40	30	20	0	30	29	21	3
Kilfrost ABC-S Plus	75/25	22	15	8	2	0	18%	40	40	30	30	0	30	33	21	3

Table 7.11: Conformance Analysis Statistics

Fluid Name	Dil.	Endurance Time	-3°C, 3 g	-3°C, 4 g	-3°C, 10 g	-3°C, 25 g	-14°C, 3 g	-14°C, 4 g	-14°C, 10 g	-14°C, 25 g	Pass/ Fail
ABAX / Dow AD-49	100/0	historic	192	168	109	70	192	168	109	70	pass
		updated	213	181	108	64	213	181	108	64	
		difference	11%	8%	-1%	-8%	11%	8%	-1%	-8%	
ABAX / Dow AD-49	75/25	historic	136	126	99	79	136	126	99	79	pass
		updated	158	143	104	76	158	143	104	76	
		difference	16%	13%	4%	-4%	16%	13%	4%	-4%	
ABAX / Dow AD-49	50/50	historic	45	39	25	15	n/a	n/a	n/a	n/a	pass
		updated	75	59	29	14	n/a	n/a	n/a	n/a	
		difference	64%	51%	16%	-11%	n/a	n/a	n/a	n/a	
ABAX Ecowing 26	75/25	historic	97	82	47	27	86	73	42	24	fail
		updated	85	73	45	28	66	57	35	22	
		difference	-13%	-11%	-5%	2%	-23%	-22%	-16%	-10%	
Clariant Flight	75/25	historic	191	156	81	42	100	81	42	22	pass
		updated	232	183	86	40	119	93	44	20	
		difference	21%	17%	6%	-5%	19%	15%	4%	-6%	
Clariant Launch	100/0	historic	199	171	105	64	151	129	79	49	pass
		updated	218	186	110	66	161	137	81	48	
		difference	10%	9%	5%	2%	7%	6%	3%	0%	
Clariant Launch	75/25	historic	222	186	105	60	175	147	83	47	pass
		updated	252	209	116	64	185	154	85	47	
		difference	14%	13%	10%	7%	6%	5%	2%	-1%	
Clariant Launch	50/50	historic	102	84	45	25	n/a	n/a	n/a	n/a	pass
		updated	101	83	45	25	n/a	n/a	n/a	n/a	
		difference	-1%	-1%	0%	1%	n/a	n/a	n/a	n/a	
Clariant Launch Plus	100/0	historic	365	282	125	55	249	193	85	38	pass
		updated	356	276	124	55	242	188	84	38	
		difference	-2%	-2%	-1%	0%	-3%	-3%	-1%	0%	
Clariant Launch Plus	75/25	historic	359	273	114	48	229	174	73	31	pass
		updated	352	269	114	48	230	175	74	32	
		difference	-2%	-2%	0%	1%	0%	1%	2%	3%	
Clariant Launch Plus	50/50	historic	122	95	44	20	n/a	n/a	n/a	n/a	n/a
		updated	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
		difference	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Cryotech PG Advance/II	100/0	historic	170	153	110	79	116	105	75	54	pass
		updated	203	177	115	74	146	127	82	53	
		difference	20%	16%	4%	-6%	25%	21%	9%	-2%	
Cryotech PG Advance/II	75/25	historic	173	144	80	45	125	104	58	33	pass
		updated	193	158	84	45	145	119	63	34	
		difference	12%	10%	5%	0%	16%	14%	9%	4%	
Cryotech PG Advance/II	50/50	historic	103	81	37	17	n/a	n/a	n/a	n/a	pass
		updated	96	76	35	17	n/a	n/a	n/a	n/a	
		difference	-7%	-6%	-5%	-4%	n/a	n/a	n/a	n/a	
Kilfrost ABC-S Plus	100/0	historic	254	214	125	73	210	177	103	60	pass
		updated	295	245	136	75	229	190	106	59	
		difference	16%	14%	9%	3%	9%	8%	2%	-3%	
Kilfrost ABC-S Plus	75/25	historic	147	124	73	43	121	103	60	35	pass
		updated	146	124	73	43	120	102	60	35	
		difference	0%	0%	0%	0%	-1%	-1%	-1%	0%	

7.7 Determination of Light and Very Light Snow Holdover Times

Light and very light snow holdover times were calculated for all fluids in the project using the standard holdover time regression analysis methodology, using the temperature boundaries in the Type II/IV HOT tables and the snow precipitation rate boundaries used in the Type I/III HOT tables.

Temperatures:

- -3°C and above: -3°C
- below -3 to -14°C: -14°C
- below -14°C to LOUT: see Subsection 7.7.1

Precipitation Rates:

- Light snow: 4 and 10 g/dm²/h
- Very light snow (Transport Canada): 4 g/dm²/h
- Very light snow (FAA): 3 and 4 g/dm²/h

The original regression curves were used to calculate light and very light snow holdover times for:

a) data sets for which additional data was not collected; and
b) data sets for which additional data was collected and which passed the conformance analysis (see Subsection 7.6.3).

The updated regression curves (those derived from the updated data sets, which include the additional data collected) were used to calculate light and very light snow holdover times for:

c) data sets for which additional data was collected which did not pass the conformance analysis (see Subsection 7.6.3).

Item (c) applied to one data set only: ABAX Ecowing 26 75/25.

The regression coefficients used to derive the light and very light snow holdover times are provided in Table 7.12. Table 7.12 also provides the resulting raw endurance times and applicable FAA and Transport Canada holdover times (holdover times are the endurance times rounded and capped).

Table 7.12: Regression Derived Light and Very Light Snow Holdover Times

Fluid	Dil.	Regression Coefficients*				Endurance Times (mins)				FAA HOTs (hh:mm)				TC HOTs (hh:mm)	
		Type	I	a	b	-3°C		-14°C		-3°C		-14°C		-3°C	-14°C
						3 g/dm²/h	4 g/dm²/h	3 g/dm²/h	4 g/dm²/h	3 g/dm²/h	4 g/dm²/h	3 g/dm²/h	4 g/dm²/h	4 g/dm²/h	4 g/dm²/h
ABAX / Dow AD-49	100/0	historic	2.5108	-0.4746	0.0000	192	168	192	168	3:00	2:50	3:00	2:50	2:00	2:00
	75/25	historic	2.2550	-0.2574	0.0000	136	126	136	126	2:15	2:05	2:15	2:05	2:00	2:00
	50/50	historic	2.0082	-0.5107	-0.1529	45	39	38	33	0:45	0:40	n/a	n/a	0:40	n/a
ABAX Ecowing 26	100/0	historic	2.3598	-0.5098	-0.0978	112	96	100	86	1:50	1:35	1:40	1:25	1:35	1:25
	75/25	updated	2.3334	-0.5288	-0.2160	85	73	66	57	1:25	1:15	1:05	0:55	1:15	0:55
	50/50	historic	2.0178	-0.6943	0.0298	51	42	53	43	0:50	0:40	n/a	n/a	0:40	n/a
Clariant Max-Flight 04	100/0	historic	3.4634	-0.7407	-0.7275	399	323	171	139	3:00	3:00	2:50	2:20	2:00	2:00
Clariant Safewing MP II Flight	100/0	historic	2.7425	-0.5435	-0.3120	184	157	128	110	3:00	2:35	2:10	1:50	2:00	1:50
	75/25	historic	3.0163	-0.7162	-0.5615	191	156	100	81	3:00	2:35	1:40	1:20	2:00	1:20
	50/50	historic	2.2879	-0.7080	-0.2971	55	45	39	32	0:55	0:45	n/a	n/a	0:45	n/a
Clariant Safewing MP IV Launch	100/0	historic	2.7218	-0.5330	-0.2408	199	171	151	129	3:00	2:50	2:30	2:10	2:00	2:00
	75/25	historic	2.7841	-0.6180	-0.2044	222	186	175	147	3:00	3:00	2:55	2:25	2:00	2:00
	50/50	historic	2.3978	-0.6703	-0.1021	102	84	90	74	1:40	1:25	n/a	n/a	1:25	n/a
Clariant Safewing MP IV Launch Plus	100/0	new	3.2161	-0.8902	-0.3284	365	282	249	193	3:00	3:00	3:00	3:00	2:00	2:00
	75/25	new	3.2776	-0.9501	-0.3856	359	273	229	174	3:00	3:00	3:00	2:55	2:00	2:00
	50/50	new	2.6868	-0.8488	-0.2819	122	95	88	69	2:00	1:35	n/a	n/a	1:35	n/a
Cryotech Polar Guard Advance / Polar Guard II	100/0	historic	2.6278	-0.3591	-0.3246	170	153	116	105	2:50	2:35	1:55	1:45	2:00	1:45
	75/25	historic	2.7318	-0.6352	-0.2744	173	144	125	104	2:55	2:25	2:05	1:45	2:00	1:45
	50/50	historic	2.5102	-0.8406	-0.1391	103	81	87	69	1:45	1:20	n/a	n/a	1:20	n/a
Dow Endurance EG106	100/0	historic	2.8358	-0.7951	-0.1996	207	165	164	131	3:00	2:45	2:45	2:10	2:00	2:00
Kilfrost ABC-S Plus	100/0	historic	2.7997	-0.5886	-0.1639	254	214	210	177	3:00	3:00	3:00	2:55	2:00	2:00
	75/25	historic	2.5586	-0.5815	-0.1638	147	124	121	103	2:25	2:05	2:00	1:45	2:00	1:45
	50/50	historic	2.1742	-0.6668	0.0000	72	59	72	59	1:10	1:00	n/a	n/a	1:00	n/a

* *Regression equation:* $t = 10^{I} R^{A} (2-T)^{B}$*, where t = endurance time, R = precipitation rate, T = air temperature*

7.7.1 Holdover Times for Below -14°C to LOUT Cells

Currently, all Type II/IV fluids are assigned generic holdover times in the coldest snow temperature band (below -14°C to LOUT). This is because it is difficult to collect natural snow data at very cold temperatures. The current "generic" snow holdover time (15 to 30 minutes) is based on snow machine testing with many Type II/IV fluids.

It was determined that generic holdover times will also be used for the new light and very light snow holdover times in the coldest temperature band. To obtain appropriate values, snow machine tests were conducted with six Type II/IV fluids at light / very light precipitation rates (3, 4 g/dm²/h) at -25°C. The results are shown in Table 7.13.

Table 7.13: Tests Conducted at -25°C

Fluid	Fluid Type	Endurance Time (minutes)	
		4 g/dm²/h	3 g/dm²/h
Fluid A	Type IV	38	56
Fluid B	Type II	41	48
Fluid C	Type IV	42	49
Fluid D	Type IV	44	57
Fluid E	Type IV	54	64
Fluid F	Type IV	65	74
Minimum Endurance Time		**38**	**48**

The standard protocol for determining generic holdover times was used: the minimum holdover time measured in each condition was used. As per standard protocol, the minimum endurance times were rounded to the nearest whole 5 minutes, resulting in times of 40 minutes (4 g/dm²/h) and 50 minutes (3 g/dm²/h).

7.8 Integration of New Holdover Times into HOT Publications

The new light and very light snow holdover times were integrated into the FAA and Transport Canada HOT guidelines for winter 2013-14. This was done by:

- renaming the "snow" column "moderate snow"; and
- adding new "light snow" and "very light snow" columns.

These changes were made only to the HOT tables for the ten fluids included in the project (see Subsection 7.4) and the new Type IV fluid (see Subsection 7.6.6). The HOT tables for those Type II/IV fluids which were not part of the project retained the standard Type II/IV HOT table format, which has a single snow column based on moderate snow precipitation rates.

It should be noted that the FAA decided to increase its cap on snow holdover times from 2 hours to 3 hours. This decision was made to gain further operational flexibility with the light and very light snow holdover times. As Transport Canada elected to retain the original 2 hour cap, this change introduced several differences to the FAA and Transport Canada Type II/IV holdover times.

Copies of the FAA and Transport Canada HOT guidelines documents are included in Appendix F.

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8. CONCLUSIONS

Endurance time testing was carried out with eight de/anti-icing fluids in the winter of 2012-13. The results of this testing, plus the results of supplemental testing, resulted in several changes being made to the HOT guidelines. The changes are described below.

8.1 Type I Fluids

No changes were made to the Type I fluid HOT guideline values for the winter of 2013-14. The freezing fog column in the Type I HOT tables was modified to include ice crystals.

8.2 Type II Fluids

Several changes were made to the Type II fluid HOT guidelines for the winter of 2013-14:

1. A fluid-specific HOT table was added for the new fluid Cryotech Polar Guard II;
2. LNT Solutions P250 was removed from the HOT guidelines at the request of the manufacturer;
3. Changes were made to the Clariant Safewing MP II Flight Plus 100/0 and 75/25 snow holdover times as the result of supplemental testing;
4. Light and very light snow holdover times were added to many of the Type II fluid-specific HOT tables and the “snow” column in these tables was renamed “moderate snow”; and
5. Ice crystals were added to all freezing fog columns in the Type II HOT tables.

These changes did not affect the generic Type II fluid holdover times.

8.3 Type III Fluids

No changes were made to the Type III fluid HOT guideline values for the winter of 2013-14. The freezing fog column in the Type III HOT table was modified to include ice crystals.

8.4 Type IV Fluids

Several changes were made to the Type IV fluid HOT guidelines for the winter of 2013-14:

1. A fluid-specific HOT table was added for the new fluid Clariant Safewing MP IV Launch Plus;
2. Kilfrost ABC-4^{sustain} was removed from the HOT guidelines at the request of the manufacturer;
3. Clariant Max Flight 04 75/25 and 50/50 dilutions were removed from the HOT guidelines at the request of the manufacturer;
4. Light and very light snow holdover times were added to many of the Type IV fluid-specific HOT tables and the "snow" column in these tables was renamed "moderate snow";
5. The FAA increased its cap on snow holdover times from 2 to 3 hours resulting in increases to two Type IV fluid-specific snow holdover times;
6. Nine increases were made to the Type IV generic HOT guidelines as a result of the removed fluids/data; and
7. Ice crystals were added to the freezing fog column of all Type IV HOT tables.

8.5 Other HOT Guidelines Changes

In addition to the changes to the Type I, II, III and IV fluids noted above, several other changes were made to the HOT guidelines for winter 2013-14. These changes are described below.

It should be noted that no changes were made to the frost HOT table for winter 2013-14.

8.5.1 Visibility Table

New guidance was added to the visibility table and TP 14052E (2) to clarify proper use of the table. This guidance includes operational examples with METARs, addresses improper use of RVR to determine visibility, and addresses the obscuration of visibility by freezing fog.

8.5.2 LOWV Table

Several changes were made to the table of LOWV values:

- Container size was added to the viscosity measurement method variables; and
- Viscosity measurement methods were moved from footnotes to a separate table and sorted by similarity rather than order of appearance in the table.

8.5.3 LOUT Table

The table of LOUT values was updated with new information provided by the fluid manufacturers.

8.5.4 Ice Pellets Allowance Times Table

Several notes/cautions were added to the ice pellets allowance times table to harmonize it with the HOT tables.

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9. RECOMMENDATIONS

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

It is also recommended that fluid-specific and fluid application temperature specific HOT guidelines for Type III fluids be developed in the winter of 2013-14 and that further research be conducted to evaluate endurance times of Type III fluids applied heated to composite surfaces.

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APPENDIX A

TRANSPORTATION DEVELOPMENT CENTRE WORK STATEMENT EXCERPT – AIRCRAFT & ANTI-ICING FLUID WINTER TESTING 2012-13

TRANSPORTATION DEVELOPMENT CENTRE
WORK STATEMENT EXCERPT –
AIRCRAFT & ANTI-ICING FLUID
WINTER TESTING 2012-13

4.4 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.

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);

   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 annual meeting.

4.5 Development of Heated Type III Fluid Holdover Times

NOTE: This activity is for testing using "heated" protocol for newly submitted Type III fluids. If no new fluids are submitted, consider testing with a "grandfathered" Type III fluid.

a) Conduct testing with newly submitted Type III fluids using the Type I test protocol (heated fluid) in addition to the Type II/IV test protocol (ambient fluid) with aluminum and composite surfaces. Testing shall be conducted in:

   i. Natural snow and frost at the P.E.T test site; and in

   ii. Simulated freezing precipitation at the NRC Climatic Environment Facility (CEF);

b) Analyze data and results;

c) Develop proposed changes to ARP5485 and ARP5718;

d) Consult with the fluid manufacturer and SAE G-12 HOT working group regarding integration of results into the holdover time guidelines; and

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

4.33 S- & S-- Phase 3: Collection and Evaluation of Data for Non-Robust Data Sets

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 (ten are anticipated) submitted for testing.

a) Preparation of tests (plan, labels, etc...) and measurement of viscosity;

b) Conduct endurance time testing in natural snow conditions or snowmaker with fluids/dilutions identified in Phase 2 as having non-robust data sets;

c) Conduct preliminary analysis from any new data during the course of the winter;

d) Incorporate new data into existing data sets and/or use analysis methodology to validate existing regression coefficients or determine appropriate new holdover times for these data sets; and

e) Develop HOT tables and provide a brief report for fluid manufacturer.

4.34 S- & S-- Phase 4: Implementation of S- & S-- HOTs

a) Meet with Transport Canada and FAA to determine how to incorporate new HOTs and how to address current outstanding issues (capping rules, operational concerns, HOTs for -25°C temperature band, TC/FAA harmonization, etc.);

b) Update HOT guidelines and recommended practices accordingly; and

c) Report the findings and present, as required, the results at the industry meetings.

4.35 S- & S-- Phase 5: Testing with Snowmaker at -25°C for Generic HOTs

a) Upgrade snowmaker machine with repairs and equipment proposed by NCAR;

b) Conduct testing to validate that the snowmaker machine results are consistent with NCAR snow machine prior to starting the -25°C tests. A total of 6 tests are proposed, based on previous similar intra-laboratory tests;

c) Develop procedure and coordinate tests;

d) Conduct testing at -25°C with the snowmaker to develop guidance for the lowest temperature band;

e) Update HOT guidelines and regression coefficients document accordingly; and

f) Report the findings and present, as required, the results at the industry meetings.

4.50 Infrastructure for FAA/TC HOT Guideline Development

This program element does not include the actual endurance time testing of newly submitted fluids; the description of the fluid endurance time testing has been included in a previous section of this document and will be funded by the fluid manufacturers.

Preparation and Setup for Natural Snow Testing at Trudeau International Airport

a) Prepare the P.E.T. test site at Trudeau International Airport (YUL) for conducting tests in the winter of 2012-13;

b) Upgrade test site infrastructure (i.e.: trailer, shed) to ensure personnel safety and adhere to environmental guidelines;

c) Prepare an updated procedure for testing fluids outdoors during snow events;

d) Evaluate current methods for measuring snowfall intensity or holdover times; and

e) Develop improved, more efficient methods to measure snowfall intensity or holdover times, if appropriate.

Preparation and Setup for Simulated Precipitation Testing at NRC

a) Prepare a test plan to coordinate all simulated precipitation required by the winter 2012-13 research program. Testing will be conducted at the NRC Climatic Environment Facility (CEF) in U89 at Uplands, Ottawa.

   Note: The NRC facility costs associated with testing at U89 are not included in this task and are dealt with directly with TC through a M.O.U. agreement with NRC;

b) Coordinate scheduling and test plans with NRC CEF personnel;

c) Prepare a test procedure for the conduct of endurance time tests in simulated precipitation at the NRC CEF;

d) Conduct calibration to attain appropriate test conditions for each weather condition represented in the holdover time tables; and

e) As the cost for this activity is highly weighted on calibration of precipitation rates, evaluate and, if possible, develop an improved, more efficient method to measure intensity of precipitation.

General Activities

a) Analyze individual fluid HOT data for in order to develop generic table HOTs;

b) Maintain data to ensure continuity;

c) Present material and data at SAE G-12 meeting; and

d) Prepare report.

APPENDIX B

PROCEDURES FOR HOLDOVER TIME TESTING

- Test Requirements for Natural Precipitation Flat Plate Testing
- Determination of Endurance Times of Type I Fluids Under Natural Snow Precipitation at Dorval
- Test Requirements for Simulated Freezing Precipitation Flat Plate Testing
- Overall Program of Tests at NRC, April 2013
- Overall Program of Tests at NRC, September 2013
  (Special Testing for Baltic Ground Services Defrosol ADF)

TEST REQUIREMENTS
FOR NATURAL PRECIPITATION FLAT PLATE TESTING

CM1892.001

TEST REQUIREMENTS FOR NATURAL PRECIPITATION FLAT PLATE TESTING

Winter 2004-05

Prepared for

Transportation Development Centre
Transport Canada

Prepared by: Nicoara Moc

Reviewed by: John D'Avirro

APS Aviation Inc.

December 23, 2004
Version 1.0

TEST REQUIREMENTS FOR NATURAL PRECIPITATION FLAT PLATE TESTING

2004-05

This document provides a brief summary of the test requirements and data forms needed for natural precipitation flat plate tests in the 2004-05 winter season. The procedure containing a detailed description of the test parameters, snow measurement methods, testing procedure and test equipment for conducting endurance time tests for SAE Type II, III and IV de/anti-icing fluids is stored on APS's local network and can be found at the following location: M:\Groups\CM1892 (TC-Deicing 03-04)\Procedures\AS5485\

This document is based on the aforementioned procedure, and was developed for documentation purposes, to be inserted in the final report after the completion of endurance time testing, and to provide the latest data forms.

Also included in this document there is a list of steps required for testing (see Attachment 1).

1. TEST PLAN

The test plan, shown in Table 1.1 provides the temperature and requirements for fluid type testing. Test will be conducted at the Dorval test site located adjacent to the Meteorological Services of Canada. These tests shall be conducted during natural snow conditions.

Table 1.1: Natural Snow Precipitation Test Plan New Fluids

Temperature Range	Type II/IV Neat	Type II/IV 75/25	Type II/IV 50/50	Type III
>0°C	Yes	Yes	Yes	Yes
0 to -3°C	Yes	Yes	Yes	Yes
-3 to -14°C	Yes	Yes	No	Yes
-14 to -25°C	Yes	No	No	Yes
Below -25°C	Yes	No	No	Yes

2. DATA FORMS

The data forms are included in Tables 2.1 to 2.4. Table 2.1 represents the data form developed for the end-condition tester. Table 2.2 shows the data form for the meteo/video tester. Table 2.3 and Table 2.4 present two data forms to be filled in each testing session and winter season, respectively.

Table 2.1: End Condition Data Form for 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 2°C OF AIR TEMP)						
Initial Fluid Temperature (°C) (NEEDS TO BE WITHIN 2°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 2°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: ______

Table 2.2: Meteorological and Precipitation Rate Data Form

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 [illegible] (g/dm²/h)	WIND SPEED** (km/h)	WIND DIR*** (°)

* [illegible]
** [illegible]
*** [illegible]

METEO OBSERVATIONS ***

TIME (h:min)	TYPE (Table 1) [illegible]	CLASSIF. ([illegible])	if SNOW, WET or DRY

*** [illegible]

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:		

Table 2.3: General Form for Each Testing Session – Natural Snow

LOCATION: APS TEST SITE DATE:

Angle of the Test Stands (°):
(the angle shall be within 10° ± 0.2)

PLATE 1	PLATE 6	PLATE 7	PLATE 12
☐	☐	☐	☐

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: ______________

Table 2.4: General Form for Each Winter Season – Natural Snow

LOCATION: APS TEST SITE 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: ______________

ATTACHMENT 1
SUMMARY OF STEPS TO CONDUCT TESTS

The following are the major steps required to conduct flat plate tests at Dorval.

Upon Entering Trailer

a) Turn on lights (outside and inside) and sign-in;
b) Determine tests to be conducted and fluids (Type II, III, IV to be placed outdoors);
c) Remove snow and clear access to stands; and
d) Synchronize all clocks and stop watches, if used.

For Each Test

a) Fill in general material on Table 2.3, and prepare plate pans for start of test;
b) Place fluids by stand;
c) Ensure stand is into wind;
d) Record end condition times of all panels (care to be taken for the 5th crosshair of each panel);
e) Measure plate pan weights over the course of the test;
f) Video record start of test, progression of failures, and when the end condition (5 of 15 crosshairs) is being called on each panel (OPTIONAL);
g) Ensure forms are properly completed and signed; and
h) Start a new test.

To Close Trailer

a) Replenish fluids;
b) Log and document date, times, test #'s, etc. on all media;
c) After major events (more than 10 tests), start new tapes for next occasion;
d) Place all media and test forms in large envelope for delivery to office;
e) Clean trailer and all garbage;
f) Ensure outdoor is left clean and presentable; and
g) Close lights and sign-out.

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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 1	ColdSoak BOX 2	ColdSoak BOX 3	ColdSoak BOX 4	ColdSoak BOX 5

OTHER COMMENTS (Fluid Batch, etc):

____

____

____

____

____

____

____

	PRINT	SIGN
FAILURES CALLED BY :	__________	__________

***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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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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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

TEST REQUIREMENTS
FOR SIMULATED FREEZING PRECIPITATION FLAT PLATE TESTING

CM1892.001

TEST REQUIREMENTS FOR SIMULATED FREEZING PRECIPITATION FLAT PLATE TESTING

- Freezing Fog
- Freezing Drizzle and Light Freezing Rain
- Rain on a Cold-Soaked Surface

Winter 2003-04

Prepared for

Transportation Development Centre
Transport Canada

Prepared by: Richard Campbell

Reviewed by: John D'Avirro

APS Aviation Inc.

January 15, 2004
Version 1.0

TEST REQUIREMENTS FOR SIMULATED FREEZING PRECIPITATION FLAT PLATE TESTING

Winter 2003-04

This document provides a brief summary of the test requirements and data forms needed for the conduct of simulated freezing fog, freezing drizzle, light freezing rain and rain on a cold-soaked surface holdover time tests. The list of tests and schedule of tests are described in the separate document "Overall Program of Tests at NRC, April, 2004". These tests will be conducted at NRC's Climatic Engineering Facility (CEF) in Ottawa. The procedure containing a detailed description of the test parameters, precipitation measurement methods, testing procedure and test equipment for conducting endurance time tests for SAE Type II, III and IV de/anti-icing fluids is stored on APS's local network and can be found at the following location: M:\Groups\CM1892 (TC-Deicing 03-04)\Procedures\AS5485\

This document is based on the aforementioned procedure, and was developed for documentation purposes, to be inserted in the final report after the completion of endurance time testing, and to provide the latest data forms.

1. CHARACTERISTICS OF SIMULATED PRECIPITATION PRODUCED

The following is a point-form summary of the set of test conditions under which data for freezing drizzle, light freezing rain, rain on a cold-soaked surface, and freezing fog are collected:

1. Freezing Drizzle:
   High precipitation rate: 13 g/dm²/h;
   Droplet median volume diameter: 350 μm;
   Air temperature: -3 and -10°C.

   Low Precipitation rate: 5 g/dm²/h;
   Droplet median volume diameter: 250 μm;
   Air temperature: -3 and -10°C.

2. Light Freezing Rain:
   High precipitation rate: 25 g/dm²/h;
   Droplet median volume diameter: 1 000 μm;
   Air temperature: -3 and -10°C.

   Low precipitation rate: 13 g/dm²/h;
   Droplet median volume diameter: 1 000 μm;
   Air temperature: -3 and -10°C.

3. Drizzle on Cold-Soaked Surface:
   Precipitation rate: 5 $g/dm^2/h$;
   Droplet median volume diameter: 250 μm;
   Air temperature: +1°C.

4. Moderate Rain on Cold-Soaked Surface:
   Precipitation rate: 75 $g/dm^2/h$;
   Droplet median volume diameter: 1 400 μm;
   Air temperature: +1°C.

5. Freezing Fog:
   Precipitation rate: 2 and 5 $g/dm^2/h$;
   Droplet median volume diameter: 30 μm; and
   Air temperature: -3°C, -14°C and -25°C.

2. DATA FORMS

The data forms used for tests conducted in simulated conditions are as follows:

Figure 2.1: Test Stand Location for Each Condition at NRC;

Figure 2.2: General Form for Each Session at NRC;

Figure 2.3: General Form for Each Condition at NRC;

Figure 2.4: De/Anti-icing Data Form for Freezing Precipitation at NRC;

Figure 2.5: De/Anti-icing Data Form for Cold Soak Box;

Figure 2.6: Chamber Setting for Each Condition at NRC;

Figure 2.7: Rate Management Form at NRC, and;

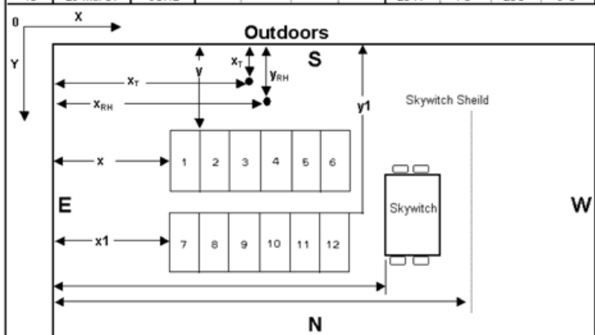
Table 2.1: Condition Checklist

TEST REQUIREMENTS FOR SIMULATED FREEZING PRECIPITATION FLAT PLATE TESTING

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	04-Apr-01	ZR3H					24' 2"	7'	22' 7"	9' 10"				Very Good		Top Stand 19' from snow fence
2	04-Apr-01	ZR3L					24' 2"	7'	22' 7"	9' 10"				Very Good		Top Stand 19' from snow fence
3	02/04/2001	ZR10H					24'	6' 9"	24' 5"	9' 6"				Very Good		Top stand is 20 ft. from snow fence
4	02-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	02-Apr-01	ZD10H					24'	7'11"	25' 3"	9' 6"				Very Good		
8	02-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	09-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	09-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	06-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	06-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						

Figure 2.1: Test Stand Location for Each Condition 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)

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: ____________

Figure 2.2: General Form for Each Session at NRC

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Version 1.0, January 04

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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)

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: ____________

Figure 2.3: General Form for Each Condition 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:

Figure 2.4: 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)

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

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:

Figure 2.5: De/Anti-icing Data Form for Cold Soak Box

TEST REQUIREMENTS FOR SIMULATED FREEZING PRECIPITATION FLAT PLATE TESTING

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						MT'S on						Last Date
													1	2	3	4	5	6	1	2	3	4	5	6	
ZR 3 L	**2x20**	**1 GPM**	**60**	**12.5**	**78**	**2**	**75**	**full**	**low**	**full**	**high**		**y**	**y**					**y**	**y**	**y**				**04-Apr-01**
ZR 10 L	2x20	1 GPM	60	12.5	82	2.5	75	full	low	full	high			y					y	y	y				03-Apr-01
ZR 3 H	**2x20**	**1 GPM**	**60**	**12.5**	**61**	**2**	**75**	**partial**	**low**	**full**	**high**								**y**	**y**	**y**				**04-Apr-01**
ZR 10 H	2x20	1 GPM	60	12.5	78	2.5	73	partial	low	full	high			y					y	y	y				03-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				05-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										06-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				09-Apr-01
FOG 25 H	1 x 20/50/120	75	40	73	-	73.2	73	full	low	full	low	144	y	y	y										06-Apr-01
CSW 1 H	2x17	1 GPM	60	13.5	75	2	85	part	low	full	high										y	y		y	04-Jun-01
CSW 1 L	2 x 24	1 GPM	60	12.5	30	2.5	89	full	low	full	high										y	y			04-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				09-Apr-01
FOG 10 L	1 X 20/50	55	40	-	-	-	-	full	low	full	low	144							y	y	y				09-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										04-Apr-00
ZR3H-2	2X20	1GPM	60	12.5	90	1.5	-	partial	low	full	high								y	y	y				06-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						MT'S on						Date
													1	2	3	4	5	6	1	2	3	4	5	6	

COMPUTER TECHNICIAN:____________________ LEADER: ____________________

Figure 2.6: Chamber Setting for Each Condition at NRC

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Version 1.0, January 04

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TEST REQUIREMENTS FOR SIMULATED FREEZING PRECIPITATION FLAT PLATE TESTING

RATE MANAGEMENT FORM AT NRC

CONDITION: ____________

DATE: ___________ WEIGH SCALE TECHNICIAN: ____________

PAN #	TIME OUT	1^{st} or 2^{nd} 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)

Figure 2.7: Rate Management Form at NRC

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Table 2.1: Condition Checklist

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	

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

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OVERALL PROGRAM OF TESTS AT NRC, APRIL 2013

CM2265.002 (12-13)

OVERALL PROGRAM OF TESTS AT NRC, APRIL 2013

Winter 2012-13

Prepared for

Transportation Development Centre
Transport Canada

Prepared by: Stephanie Bendickson

Reviewed by: John D'Avirro

April 2, 2013
Final Version 1.0

OVERALL PROGRAM OF TESTS AT NRC, APRIL 2013

Winter 2012-13

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 April 4-11, 2013.

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 April 2013 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 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. This program will be used. A guide to the rate management program is available to help with training of any new rate station managers.

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 III and Type IV tests, as described below.

Type III Tests: Tests will be conducted with a commercial Type III fluid, Clariant Safewing MP III 2031 ECO, using the Type I test protocol. The main difference in this protocol and the Type II/III/IV protocol (which was used in the original tests with this fluid) is that fluids are applied at 20°C rather than at ambient air temperature. Tests will be conducted over the entire range of freezing precipitation conditions encompassed by the Type III HOT table.

Type III Supplemental Tests: Several sets of supplemental Type III endurance times will be conducted with the Type III fluid:

- Composite Surface Tests: Limited tests (6) will be conducted on composite surfaces to gather preliminary data to determine if heated Type III endurance times are reduced on composite surfaces.
- Ambient Fluid Application Temperature Tests: Limited tests (6) will be conducted with fluid applied at ambient temperature to compare endurance times of the 2013 fluid sample to those obtained with the original endurance time testing sample (tested in 2004).

Type IV Tests: One new Type IV fluid, Clariant Safewing MP IV Launch Plus, will be tested over the entire range of freezing precipitation conditions encompassed by the Type IV HOT tables.

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 the new fluid endurance time tests is given in Table 1. All tests will be conducted on the main test stand.

2.2 Supplemental Testing of Commercial Type IV Fluid (Commercial)

Supplemental testing will be conducted with a commercialized Type IV fluid as a result of abnormal results obtained during outdoor testing with the fluid for a separate project. Limited tests will be conducted with neat fluid and 75/25 and 50/50 dilutions. The test plan for the supplemental commercial fluid tests is given in Table 2.

2.3 Thickness of New Fluids (Fluid Thickness)

The objective of these tests is to measure the thickness 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. It should be noted that Type III tests will be conducted with fluid at 20°C and Type IV tests will be conducted with fluid at ambient temperature (-3°C).

The test plan for Fluid Thickness tests is given in Table 3. The tests will be conducted at the small end of the chamber outside of the spray area.

2.4 Inspection Immediately Prior to Takeoff (5 Minute Rule)

Current guidance stipulates aircraft surfaces must be inspected within five minutes of beginning the takeoff roll. If it is not possible to take-off within five minutes, the aircraft return and be re-treated. The objective of this project is to evaluate the appropriateness of this guidance by evaluating the condition of test plates five minutes after fluid failure is called. Initial tests were completed in March 2012; the objective of the April 2013 testing is to collect additional data.

This project will be carried out by conducting additional observations on tests being conducted for other projects. Tests with Type III and IV fluids will be piggybacked on the new fluid endurance time tests (see Section 2.1). Type I tests will be piggybacked on the ice phobic endurance time tests (see Section 2.6) and the deployed flaps tests (see Section 2.7). Several independent Type I tests will be conducted to complete the testing.

There is no formal procedure for this project, however, the following points are of importance:

- After fluid failure is recorded for the selected tests, the test plates will be left under the freezing precipitation spray for five minutes. At the five minute mark the percentage of the plate covered with fluid failure will be recorded (using the ET data form).
- Testing will be conducted in the following conditions:
  - Freezing Rain, -3°C, 13 and 25 g/dm^2/h (Type III/IV only);
  - Freezing Rain, -10°C, 13 and 25 g/dm^2/h;
  - Freezing Drizzle, -3°C, 5 g/dm^2/h;
  - Freezing Drizzle, -3°C, 13 g/dm^2/h (Type I only);
  - Freezing Drizzle, -10°C, 5 g/dm^2/h (Type I only); and
  - Freezing Fog, -3°C, 2 g/dm^2/h.

The test plan for the 5 minute rule tests is given in Table 4.

2.5 NCAR Snowmaker Testing (Snowmaker)

Testing is being conducted with the NCAR snowmaker in the winter of 2012-13 to meet several objectives, as listed below. The snowmaker will be brought to the NRC test session to work on these objectives.

1. **Light Snow / Very Light Snow Calibration:** The purpose of these tests is to validate that the snowmaker can reproduce results obtained in outdoor light snow / very light snow conditions. The conditions of select outdoor light snow / very light data points will be reproduced in controlled laboratory conditions. Tests will be conducted with three fluids. The procedure for the conduct of these tests is provided in the document *Endurance Time Test Requirements for Simulated Snow Flat Plate Testing, Type II, III, and IV Fluids* (4). The test plan is given in Table 5.

2. **Heavy Snow**: The objective of this activity is to try to determine why differences are seen between endurance times measured in natural snow and with the snowmaker. The conditions in which three select natural snow tests were conducted will be reproduced in controlled laboratory conditions using the NCAR snow machine. Each of the three tests will be reproduced three times. The procedure for the conduct of these tests is provided in the document *Endurance Time Testing with Heavy Snow with the Snowmaker in Comparison with Natural Snow* (5). These tests require Brix and thickness measurements and photos to enable correlation with the outdoor endurance times. The test plan for the snowmaker tests is given in Table 6.

3. **Light Snow / Very Light Snow**: Testing with the NCAR snowmaker is planned for the week of April 22 at the PMG Technologies cold chamber in Blainville, Quebec. The objective of the testing is to measure endurance times in light and very light snow at -25°C. Preliminary testing for this project will be conducted at the NRC test session to ensure feasibility of the project test plan. The procedure for the conduct of these tests is provided in the document *Endurance Time Test Requirements for Simulated Snow Flat Plate Testing, Type II, III, and IV Fluids* (4). The test plan is given in Table 7.

4. **Rate Distribution:** Rate distribution on the snowmaker test plate will be evaluated using the protocol provided in ARP 5485. A limited number of tests will be conducted in advance of testing, typically on a daily basis close to the expected temperatures and precipitation rates of that particular day's testing.

The snowmaker will be set up in the small end of the chamber away from the freezing precipitation sprayer. A calendar is included (see Figure 3) to identify which snowmaker tests will be conducted during each cold chamber condition.

2.6 Evaluation of Ice Phobic Products (Ice Phobic)

The objective of this project is to continue the evaluation of newly developed ice phobic products. The project has five sub-objectives as described below.

1. **Endurance Times:** Evaluation of impact of ice phobic products on fluid endurance times. Tests will be conducted with five coatings and seven fluids. The procedure for the conduct of these tests is provided in the document *Effect of Ice Phobic Products on HOTs* (6). The test plan is given in Table 8.

2. **Thickness:** Evaluation of ice phobic products on fluid thickness. The standard procedure for measuring fluid thickness will be used (see Subsection 2.3). Notably, thickness (Type II fluid) or percent wetted (Type I fluid) will be measured at 15 cm line at time of application and 2, 5, 15, and 30 minutes after. The test plan is given in Table 9. Tests will be conducted at the small end of the chamber outside of the spray area.

3. **Adhesion:** Evaluation of impact of ice phobic products on fluid adhesion. These tests will be conducted without fluid. The test plan is given in Table 10.

4. **High vs. Low Viscosity:** Evaluation of the endurance times of high and low viscosity fluids when applied to ice phobic coated surfaces; this is being done in support of the fluid selection process for AIR 6232 (in development). Testing will be done in conjunction with the ice phobic endurance times testing to minimize the number of tests required. The tests are included in the endurance time test plan provided in Table 8.

5. **Hot Water:** Evaluate the potential for using only hot water as a deicer for end of runway or deicing only type applications. Some coatings may delay the onset of adherence of precipitation and therefore may result in equal or longer protection times than a Type I fluid. The test plan is given in Table 11.

Except where noted, tests will be conducted on the main and/or side stand.

2.7 Endurance Times on Flaps/Slats (Flaps)

The objective of this project is to continue the evaluation of endurance time performance of anti-icing fluids on wing surfaces with deployed flaps. Limited testing with Type I fluids is being carried out at this test session to supplement previously collected data.

The procedure for the conduct of these tests is provided in the document *Evaluation of Endurance Times on Deployed Flaps* (7). The procedure was written for testing in outdoor conditions; changes to the procedure required for indoor testing and the indoor test plan are provided herein.

Tests will be conducted using standard holdover time testing procedures. Each comparative test will include a baseline test (conducted on plate inclined to a 10° slope) and two non-nested flap tests (conducted on plates inclined to a 20° and 35° slope). Tests with nested plates will also be done to demonstrate that nesting does not have an impact. In addition to failure time, fluid thickness and Brix will be taken as detailed in the test plan.

The test plan for Deployed Flaps tests is given in Table 12. The tests will be conducted on the main and/or side stand. Tests requiring plates oriented to 20° or 35° must be positioned on the lower main stand or on the side stand.

2.7.1 Supplemental Flap/Slat Extension Tests

Supplemental tests will be conducted to investigate the effects of extending a flap or slat during the holdover time. This will be achieved by overlapping two plates in either a flap or slat configuration and fully separating them midway during the expected holdover time. Particular attention will be given to investigating how the bare areas on the plates behave with the precipitation. The test plan for the flap/slat extension tests is provided in Table 13.

2.8 ROGIDS

The manufacturer of the only know remote on-ground ice detection system (ROGIDS) will be invited to participate at the April 2013 NRC tests session on a non-obtrusive basis.

3. PERSONNEL REQUIREMENTS/RESPONSIBILITIES

The personnel responsibilities are listed below.

1. New Fluid ETs/Commercial:
    - Manager: JD (pours fluids, calls failures)
    - Assistant: VZ (preps fluids/data forms)
    - Rates Team: SB, YOW1
2. Fluid Thickness:
    - Manager: MR (runs tests, takes measurements)
    - Assistant: YOW2 (records measurements)
3. 5 Minute Rule:
    - Manager: VZ (tracks timing, records measurements)
    - Failure Calls: JD/MR (depending on piggybacked project)
    - Rates Team: SB, YOW1
4. Snowmaker:
    - Manager: DY (runs tests, takes measurements)
5. Ice Phobic ETs:
    - Manager: MR (runs tests, takes measurements)
    - Assistant: YOW2 (records measurements, assists as needed)
    - Rates Team: SB, YOW1
6. Flaps/Slats:
    - Manager: MR (runs tests, takes measurements)
    - Assistant: YOW2 (records measurements)
    - Rates Team: SB, YOW1

The Rates Team will consist of:

- Rate Manager: SB (runs rate station)
- Rate Assistant: YOW1 (runs pans, refills fluids)

In the condition of Cold Soak Wing, additional personnel will be required:

- Box Prep Manager: MR
- Box Prep Assistants: DY, YOW2

In addition, personnel will be designated responsible for:

- Equipment: MR/DY
- Pre-test Setup: MR/DY
- Data Form Manager: VZ
- HOT Data Management: SB

- Fluid Management: SB/VZ
- Photographer: BG

4. FLUIDS

The required fluids and fluid quantities are shown in Table 14. Type I fluids will be diluted prior to testing using the dilution tables provided in Table 15.

5. EQUIPMENT

Table 16 provides a list of the general equipment required. A supplemental equipment list for snowmaker testing is provided in Table 17.

6. DATA FORMS

The data forms required for each project are listed below.

1. New Fluid ETs:
   - Freezing Precipitation Endurance Time Data Form (Figure 4)
   - Rate Management Form (Figure 5)
2. Fluid Thickness:
   - Fluid Thickness Data Form (Figure 6)
3. 5 Minute Rule:
   - No data forms required; observations recorded on endurance time data forms.
4. Snowmaker
   - Snowmaker End Condition Data Form (Figure 7)
   - Fluid Brix and Thickness Data Form (Figure 8)
5. Ice Phobic ETs:
   - Ice Phobic End Condition Data Form (Figure 9)
   - Ice Phobic Thickness Data Form (Figure 10)
6. Flaps/Slats:
   - Freezing Precipitation Endurance Time Data Form (Figure 4)

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 (MR)
2. ~~Check rate pans: check quantity, check for holes, and check all pans are properly labelled~~
3. Ensure plates and boxes are equipped with operational and verified thermistors or smart buttons (MR)
4. ~~Prepare labels for pour containers (VZ)~~
5. Ensure fluids are prepared in advance according to Table 14 (DP)
6. Clean and label 1 litre pour containers (DP)
7. ~~Check laptops (2) work for rate station (MR)~~
8. ~~Rent cube van (VZ)~~
9. ~~Book hotel (VZ)~~
10. ~~Update and print chamber settings file (EA)~~
11. Print data forms and procedures (EA)
12. Print chamber condition sheets (SB/VZ)
13. Contact Medhat (DY)
    - confirm availability of NRC camera system for rates
    - distilled water for ice cores
    - waste tote
14. Figure out logging intervals of smart buttons (MR/DY)
15. Inventory at test site (MR/DY)
    - Latex gloves
    - Whiteboard
16. Get yellow fluid carrying case from GTCA (MR/DY)
17. Order two inclinometers (AE/VZ)
18. Speak to BG re testing schedule (VZ)

19. Leave 1 camera bag (old Canon camera) at site (DY)
20. Back up MTL drive (Projects and General folders) (AE/VZ)
21. Install Trendreader on all laptops (MR/VZ)
22. Pack snowmaker (DY)
23. Talk to Ben re rate station observation (SB)

The following items should be purchased prior to arrival at the NRC:

1. Scrapers x5
2. IKEA cart, Purchase 2 (VZ)

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:

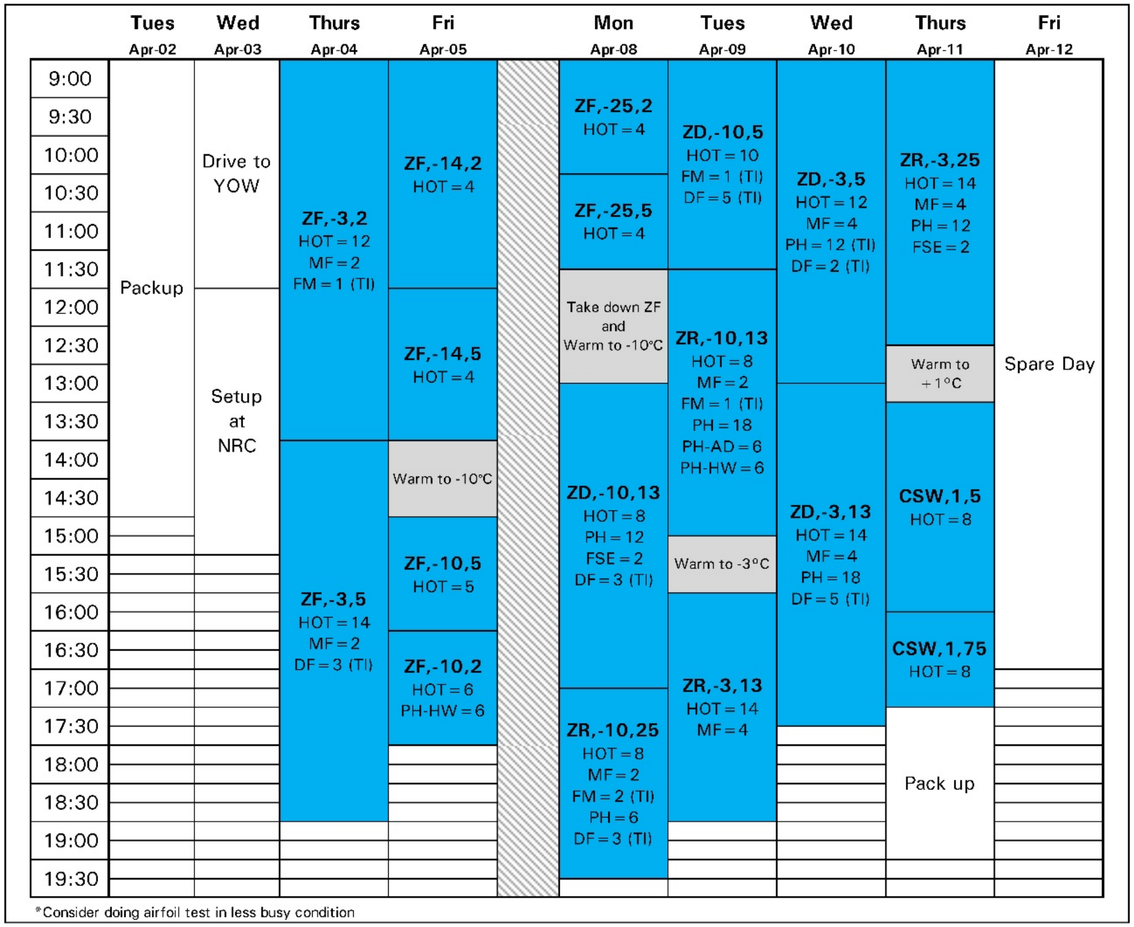
1. Fluid MSDS sheets are available for review.
2. Waterproof clothing and gloves are available.
3. Rubber mats must be properly placed in and around the test area and cleaned as necessary.
4. Care should be taken when circulating near the test stand due to slipperiness.
5. First aid kit, water and fire extinguisher are available.
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 2004.
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. Endurance Time Test Requirements for Simulated Snow Flat Plate Testing, Type II, III, and IV Fluids, Final Version 1.2, January 23, 2008.
5. Endurance Time Testing with Heavy Snow with the Snowmaker in Comparison with Natural Snow, Final Version 1.0, January 2, 2009.
6. Effect of Ice Phobic Products on Holdover Times, Final Version 1.0, December 24, 2009.
7. Evaluation of Endurance Times on Deployed Flaps, Final Version 1.0, January 25, 2012.

OVERALL PROGRAM OF TESTS AT NRC, APRIL 2013

FIGURE 1: TEST SCHEDULE



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Final Version 1.0, March 13

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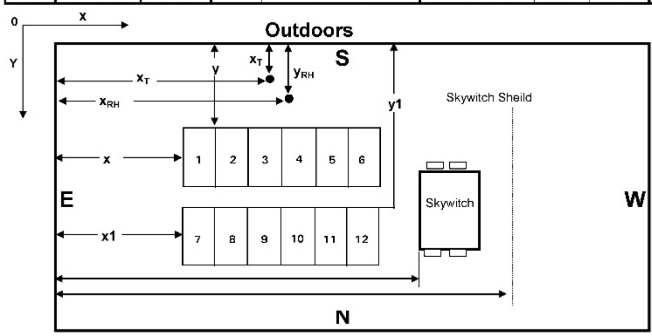
FIGURE 2: TEST STAND LOCATION MEASUREMENTS

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	04-Apr-01	ZR3H					24' 2"	7'	22' 7"	9' 10"				Very Good		Top Stand 19' from snow fence
2	04-Apr-01	ZR3L					24' 2"	7'	22' 7"	9' 10"				Very Good		Top Stand 19' from snow fence
3	02/04/2001	ZR10H					24'	6' 9"	24' 5"	9' 6"				Very Good		Top stand is 20 ft. from snow fence
4	02-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	02-Apr-01	ZD10H					24'	7'11"	25' 3"	9' 6"				Very Good		
8	02-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	09-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	09-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	06-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	06-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: ____________

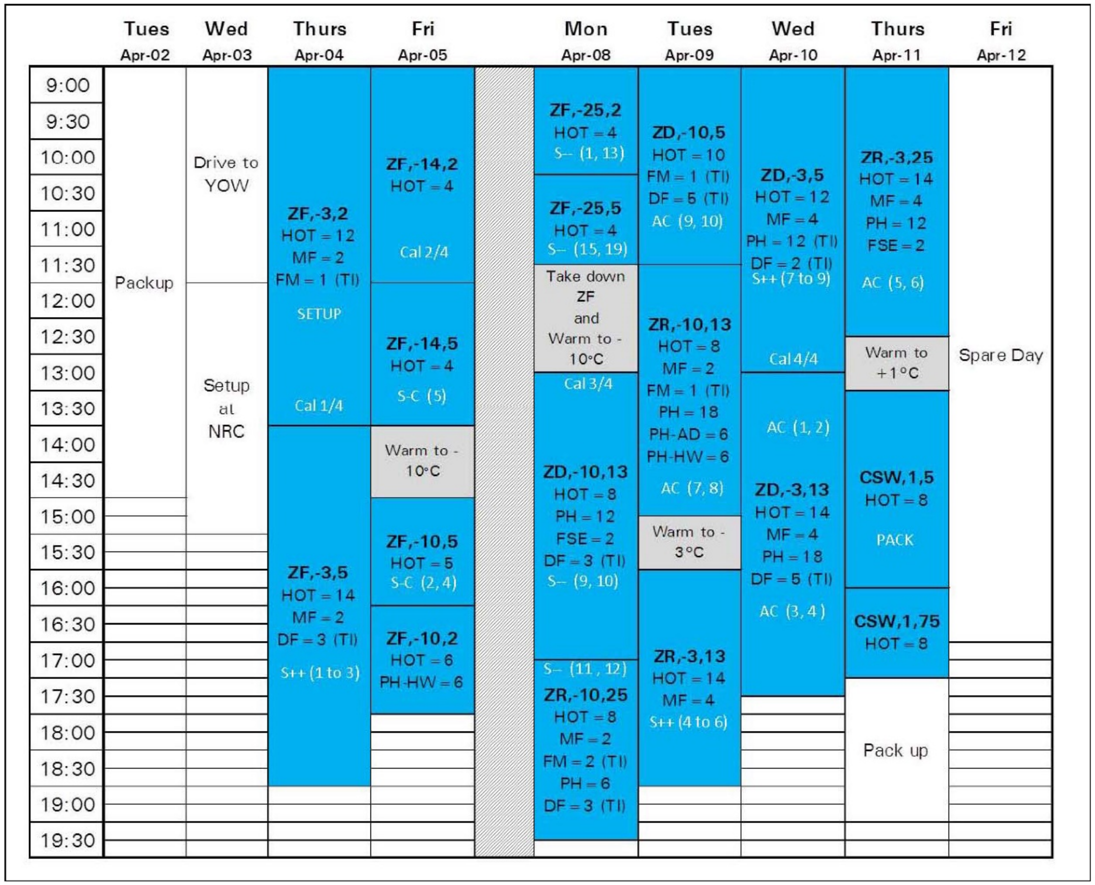
LEADER: ____________

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						

OVERALL PROGRAM OF TESTS AT NRC, APRIL 2013

FIGURE 3: SNOWMAKER TEST CALENDAR



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).

TABLE 1: ENDURANCE TIME TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Fluid Dilution (%)	Test Surface	Comments
1	Freezing Fog	-3	2	Clariant Launch Plus	100	Al. Plate	5 min failure
2	Freezing Fog	-3	2	Clariant Launch Plus	100	Al. Plate	
3	Freezing Fog	-3	2	Clariant Launch Plus	75	Al. Plate	5 min failure
4	Freezing Fog	-3	2	Clariant Launch Plus	75	Al. Plate	
5	Freezing Fog	-3	2	Clariant Launch Plus	50	Al. Plate	5 min failure
6	Freezing Fog	-3	2	Clariant Launch Plus	50	Al. Plate	
7	Freezing Fog	-3	2	Clariant MP III 2031	100	Al. Plate	5 min failure
8	Freezing Fog	-3	2	Clariant MP III 2031	100	Al. Plate	
9	Freezing Fog	-3	2	Clariant MP III 2031	75	Al. Plate	5 min failure
10	Freezing Fog	-3	2	Clariant MP III 2031	75	Al. Plate	
11	Freezing Fog	-3	2	Clariant MP III 2031	50	Al. Plate	5 min failure
12	Freezing Fog	-3	2	Clariant MP III 2031	50	Al. Plate	
13	Freezing Fog	-3	5	Clariant Launch Plus	100	Al. Plate	
14	Freezing Fog	-3	5	Clariant Launch Plus	100	Al. Plate	
15	Freezing Fog	-3	5	Clariant Launch Plus	75	Al. Plate	
16	Freezing Fog	-3	5	Clariant Launch Plus	75	Al. Plate	
17	Freezing Fog	-3	5	Clariant Launch Plus	50	Al. Plate	
18	Freezing Fog	-3	5	Clariant Launch Plus	50	Al. Plate	
19	Freezing Fog	-3	5	Clariant MP III 2031	100	Al. Plate	
20	Freezing Fog	-3	5	Clariant MP III 2031	100	Al. Plate	
21	Freezing Fog	-3	5	Clariant MP III 2031	75	Al. Plate	
22	Freezing Fog	-3	5	Clariant MP III 2031	75	Al. Plate	
23	Freezing Fog	-3	5	Clariant MP III 2031	50	Al. Plate	
24	Freezing Fog	-3	5	Clariant MP III 2031	50	Al. Plate	
CD24	Freezing Fog	-3	5	Clariant MP III 2031 COLD	50	Al. Plate	Fluid @ OAT
CP24	Freezing Fog	-3	5	Clariant MP III 2031	50	Comp. Plate	
25	Freezing Fog	-10	2	Clariant MP III 2031	100	Al. Plate	
26	Freezing Fog	-10	2	Clariant MP III 2031	100	Al. Plate	
27	Freezing Fog	-10	2	Clariant MP III 2031	75	Al. Plate	
28	Freezing Fog	-10	2	Clariant MP III 2031	75	Al. Plate	
CD28	Freezing Fog	-10	2	Clariant MP III 2031 COLD	75	Al. Plate	Fluid @ OAT
CP28	Freezing Fog	-10	2	Clariant MP III 2031	75	Comp. Plate	
29	Freezing Fog	-10	5	Clariant MP III 2031	100	Al. Plate	
30	Freezing Fog	-10	5	Clariant MP III 2031	100	Al. Plate	
31	Freezing Fog	-10	5	Clariant MP III 2031	75	Al. Plate	
32	Freezing Fog	-10	5	Clariant MP III 2031	75	Al. Plate	
33	Freezing Fog	-14	2	Clariant Launch Plus	100	Al. Plate	
34	Freezing Fog	-14	2	Clariant Launch Plus	100	Al. Plate	
35	Freezing Fog	-14	2	Clariant Launch Plus	75	Al. Plate	
36	Freezing Fog	-14	2	Clariant Launch Plus	75	Al. Plate	
37	Freezing Fog	-14	5	Clariant Launch Plus	100	Al. Plate	
38	Freezing Fog	-14	5	Clariant Launch Plus	100	Al. Plate	
39	Freezing Fog	-14	5	Clariant Launch Plus	75	Al. Plate	
40	Freezing Fog	-14	5	Clariant Launch Plus	75	Al. Plate	
41	Freezing Fog	-25	2	Clariant Launch Plus	100	Al. Plate	
42	Freezing Fog	-25	2	Clariant Launch Plus	100	Al. Plate	
43	Freezing Fog	-25	2	Clariant MP III 2031	100	Al. Plate	

TABLE 1: ENDURANCE TIME TEST PLAN (CONT'D)

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Fluid Dilution (%)	Test Surface	Comments
44	Freezing Fog	-25	2	Clariant MP III 2031	100	Al. Plate	
45	Freezing Fog	-25	5	Clariant Launch Plus	100	Al. Plate	
46	Freezing Fog	-25	5	Clariant Launch Plus	100	Al. Plate	
47	Freezing Fog	-25	5	Clariant MP III 2031	100	Al. Plate	
48	Freezing Fog	-25	5	Clariant MP III 2031	100	Al. Plate	
49	Light Freezing Rain	-3	13	Clariant Launch Plus	100	Al. Plate	5 min failure
50	Light Freezing Rain	-3	13	Clariant Launch Plus	100	Al. Plate	
51	Light Freezing Rain	-3	13	Clariant Launch Plus	75	Al. Plate	5 min failure
52	Light Freezing Rain	-3	13	Clariant Launch Plus	75	Al. Plate	
53	Light Freezing Rain	-3	13	Clariant Launch Plus	50	Al. Plate	5 min failure
54	Light Freezing Rain	-3	13	Clariant Launch Plus	50	Al. Plate	
55	Light Freezing Rain	-3	13	Clariant MP III 2031	100	Al. Plate	5 min failure
56	Light Freezing Rain	-3	13	Clariant MP III 2031	100	Al. Plate	
57	Light Freezing Rain	-3	13	Clariant MP III 2031	75	Al. Plate	5 min failure
58	Light Freezing Rain	-3	13	Clariant MP III 2031	75	Al. Plate	
CD58	Light Freezing Rain	-3	13	Clariant MP III 2031 COLD	75	Al. Plate	Fluid @ OAT
CP58	Light Freezing Rain	-3	13	Clariant MP III 2031	75	Comp. Plate	
59	Light Freezing Rain	-3	13	Clariant MP III 2031	50	Al. Plate	5 min failure
60	Light Freezing Rain	-3	13	Clariant MP III 2031	50	Al. Plate	
61	Light Freezing Rain	-3	25	Clariant Launch Plus	100	Al. Plate	5 min failure
62	Light Freezing Rain	-3	25	Clariant Launch Plus	100	Al. Plate	
63	Light Freezing Rain	-3	25	Clariant Launch Plus	75	Al. Plate	
64	Light Freezing Rain	-3	25	Clariant Launch Plus	75	Al. Plate	5 min failure
65	Light Freezing Rain	-3	25	Clariant Launch Plus	50	Al. Plate	5 min failure
66	Light Freezing Rain	-3	25	Clariant Launch Plus	50	Al. Plate	
67	Light Freezing Rain	-3	25	Clariant MP III 2031	100	Al. Plate	5 min failure
68	Light Freezing Rain	-3	25	Clariant MP III 2031	100	Al. Plate	
CD68	Light Freezing Rain	-3	25	Clariant MP III 2031 COLD	100	Al. Plate	Fluid @ OAT
CP68	Light Freezing Rain	-3	25	Clariant MP III 2031	100	Comp. Plate	
69	Light Freezing Rain	-3	25	Clariant MP III 2031	75	Al. Plate	5 min failure
70	Light Freezing Rain	-3	25	Clariant MP III 2031	75	Al. Plate	
71	Light Freezing Rain	-3	25	Clariant MP III 2031	50	Al. Plate	5 min failure
72	Light Freezing Rain	-3	25	Clariant MP III 2031	50	Al. Plate	
73	Light Freezing Rain	-10	13	Clariant Launch Plus	100	Al. Plate	5 min failure
74	Light Freezing Rain	-10	13	Clariant Launch Plus	100	Al. Plate	
75	Light Freezing Rain	-10	13	Clariant Launch Plus	75	Al. Plate	5 min failure
76	Light Freezing Rain	-10	13	Clariant Launch Plus	75	Al. Plate	
77	Light Freezing Rain	-10	13	Clariant MP III 2031	100	Al. Plate	5 min failure
78	Light Freezing Rain	-10	13	Clariant MP III 2031	100	Al. Plate	
79	Light Freezing Rain	-10	13	Clariant MP III 2031	75	Al. Plate	5 min failure
80	Light Freezing Rain	-10	13	Clariant MP III 2031	75	Al. Plate	
81	Light Freezing Rain	-10	25	Clariant Launch Plus	100	Al. Plate	5 min failure
82	Light Freezing Rain	-10	25	Clariant Launch Plus	100	Al. Plate	
83	Light Freezing Rain	-10	25	Clariant Launch Plus	75	Al. Plate	5 min failure
84	Light Freezing Rain	-10	25	Clariant Launch Plus	75	Al. Plate	
85	Light Freezing Rain	-10	25	Clariant MP III 2031	100	Al. Plate	5 min failure
86	Light Freezing Rain	-10	25	Clariant MP III 2031	100	Al. Plate	
87	Light Freezing Rain	-10	25	Clariant MP III 2031	75	Al. Plate	5 min failure

OVERALL PROGRAM OF TESTS AT NRC, APRIL 2013

TABLE 1: ENDURANCE TIME TEST PLAN (CONT'D)

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Fluid Dilution (%)	Test Surface	Comments
88	Light Freezing Rain	-10	25	Clariant MP III 2031	75	Al. Plate	
89	Freezing Drizzle	-3	5	Clariant Launch Plus	100	Al. Plate	5 min failure
90	Freezing Drizzle	-3	5	Clariant Launch Plus	100	Al. Plate	
91	Freezing Drizzle	-3	5	Clariant Launch Plus	75	Al. Plate	5 min failure
92	Freezing Drizzle	-3	5	Clariant Launch Plus	75	Al. Plate	
93	Freezing Drizzle	-3	5	Clariant Launch Plus	50	Al. Plate	5 min failure
94	Freezing Drizzle	-3	5	Clariant Launch Plus	50	Al. Plate	
95	Freezing Drizzle	-3	5	Clariant MP III 2031	100	Al. Plate	5 min failure
96	Freezing Drizzle	-3	5	Clariant MP III 2031	100	Al. Plate	
97	Freezing Drizzle	-3	5	Clariant MP III 2031	75	Al. Plate	5 min failure
98	Freezing Drizzle	-3	5	Clariant MP III 2031	75	Al. Plate	
99	Freezing Drizzle	-3	5	Clariant MP III 2031	50	Al. Plate	5 min failure
100	Freezing Drizzle	-3	5	Clariant MP III 2031	50	Al. Plate	
101	Freezing Drizzle	-3	13	Clariant Launch Plus	100	Al. Plate	
102	Freezing Drizzle	-3	13	Clariant Launch Plus	100	Al. Plate	
103	Freezing Drizzle	-3	13	Clariant Launch Plus	75	Al. Plate	
104	Freezing Drizzle	-3	13	Clariant Launch Plus	75	Al. Plate	
105	Freezing Drizzle	-3	13	Clariant Launch Plus	50	Al. Plate	
106	Freezing Drizzle	-3	13	Clariant Launch Plus	50	Al. Plate	
107	Freezing Drizzle	-3	13	Clariant MP III 2031	100	Al. Plate	
108	Freezing Drizzle	-3	13	Clariant MP III 2031	100	Al. Plate	
109	Freezing Drizzle	-3	13	Clariant MP III 2031	75	Al. Plate	
110	Freezing Drizzle	-3	13	Clariant MP III 2031	75	Al. Plate	
111	Freezing Drizzle	-3	13	Clariant MP III 2031	50	Al. Plate	
112	Freezing Drizzle	-3	13	Clariant MP III 2031	50	Al. Plate	
CD112	Freezing Drizzle	-3	13	Clariant MP III 2031 COLD	50	Al. Plate	Fluid @ OAT
CP112	Freezing Drizzle	-3	13	Clariant MP III 2031	50	Comp. Plate	
113	Freezing Drizzle	-10	5	Clariant Launch Plus	100	Al. Plate	
114	Freezing Drizzle	-10	5	Clariant Launch Plus	100	Al. Plate	
115	Freezing Drizzle	-10	5	Clariant Launch Plus	75	Al. Plate	
116	Freezing Drizzle	-10	5	Clariant Launch Plus	75	Al. Plate	
117	Freezing Drizzle	-10	5	Clariant MP III 2031	100	Al. Plate	
118	Freezing Drizzle	-10	5	Clariant MP III 2031	100	Al. Plate	
CD118	Freezing Drizzle	-10	5	Clariant MP III 2031 COLD	100	Al. Plate	Fluid @ OAT
CP118	Freezing Drizzle	-10	5	Clariant MP III 2031	100	Comp. Plate	
119	Freezing Drizzle	-10	5	Clariant MP III 2031	75	Al. Plate	
120	Freezing Drizzle	-10	5	Clariant MP III 2031	75	Al. Plate	
121	Freezing Drizzle	-10	13	Clariant Launch Plus	100	Al. Plate	
122	Freezing Drizzle	-10	13	Clariant Launch Plus	100	Al. Plate	
123	Freezing Drizzle	-10	13	Clariant Launch Plus	75	Al. Plate	
124	Freezing Drizzle	-10	13	Clariant Launch Plus	75	Al. Plate	
125	Freezing Drizzle	-10	13	Clariant MP III 2031	100	Al. Plate	
126	Freezing Drizzle	-10	13	Clariant MP III 2031	100	Al. Plate	
127	Freezing Drizzle	-10	13	Clariant MP III 2031	75	Al. Plate	
128	Freezing Drizzle	-10	13	Clariant MP III 2031	75	Al. Plate	
129	Cold Soak Box	1	5	Clariant Launch Plus	100	Box	
130	Cold Soak Box	1	5	Clariant Launch Plus	100	Box	
131	Cold Soak Box	1	5	Clariant Launch Plus	75	Box	

TABLE 1: ENDURANCE TIME TEST PLAN (CONT'D)

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Fluid Dilution (%)	Test Surface	Comments
132	Cold Soak Box	1	5	Clariant Launch Plus	75	Box	
133	Cold Soak Box	1	5	Clariant MP III 2031	100	Al. Box	
134	Cold Soak Box	1	5	Clariant MP III 2031	100	Al. Box	
135	Cold Soak Box	1	5	Clariant MP III 2031	75	Al. Box	
136	Cold Soak Box	1	5	Clariant MP III 2031	75	Al. Box	
137	Cold Soak Box	1	75	Clariant Launch Plus	100	Box	
138	Cold Soak Box	1	75	Clariant Launch Plus	100	Box	
139	Cold Soak Box	1	75	Clariant Launch Plus	75	Box	
140	Cold Soak Box	1	75	Clariant Launch Plus	75	Box	
141	Cold Soak Box	1	75	Clariant MP III 2031	100	Al. Box	
142	Cold Soak Box	1	75	Clariant MP III 2031	100	Al. Box	
143	Cold Soak Box	1	75	Clariant MP III 2031	75	Al. Box	
144	Cold Soak Box	1	75	Clariant MP III 2031	75	Al. Box	
132	Cold Soak Box	1	5	Clariant Launch Plus	75	Box	
133	Cold Soak Box	1	5	Clariant MP III 2031	100	Al. Box	
134	Cold Soak Box	1	5	Clariant MP III 2031	100	Al. Box	
135	Cold Soak Box	1	5	Clariant MP III 2031	75	Al. Box	
136	Cold Soak Box	1	5	Clariant MP III 2031	75	Al. Box	
137	Cold Soak Box	1	75	Clariant Launch Plus	100	Box	
138	Cold Soak Box	1	75	Clariant Launch Plus	100	Box	
139	Cold Soak Box	1	75	Clariant Launch Plus	75	Box	
140	Cold Soak Box	1	75	Clariant Launch Plus	75	Box	
141	Cold Soak Box	1	75	Clariant MP III 2031	100	Al. Box	
142	Cold Soak Box	1	75	Clariant MP III 2031	100	Al. Box	
143	Cold Soak Box	1	75	Clariant MP III 2031	75	Al. Box	
144	Cold Soak Box	1	75	Clariant MP III 2031	75	Al. Box	

TABLE 2: SUPPLEMENTAL COMMERCIAL FLUID TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Fluid Dilution (%)	Test Surface
MF1	Freezing Drizzle	-3	5	MF04-2	100	Al. Plate
MF2	Freezing Drizzle	-3	13	MF04-2	100	Al. Plate
MF3	Light Freezing Rain	-3	13	MF04-2	100	Al. Plate
MF4	Light Freezing Rain	-3	25	MF04-2	100	Al. Plate
MF5	Light Freezing Rain	-10	13	MF04-2	100	Al. Plate
MF6	Light Freezing Rain	-10	25	MF04-2	100	Al. Plate
MF7	Freezing Drizzle	-3	5	MF04-2	75	Al. Plate
MF8	Freezing Drizzle	-3	13	MF04-2	75	Al. Plate
MF9	Light Freezing Rain	-3	13	MF04-2	75	Al. Plate
MF10	Light Freezing Rain	-3	25	MF04-2	75	Al. Plate
MF11	Light Freezing Rain	-10	13	MF04-2	75	Al. Plate
MF12	Light Freezing Rain	-10	25	MF04-2	75	Al. Plate
MF13	Freezing Drizzle	-3	5	MF04-2	50	Al. Plate
MF14	Freezing Drizzle	-3	13	MF04-2	50	Al. Plate
MF15	Light Freezing Rain	-3	13	MF04-2	50	Al. Plate
MF16	Light Freezing Rain	-3	25	MF04-2	50	Al. Plate
MF17	Freezing Fog	-3	2	MF04-2	50	Al. Plate
MF18	Freezing Fog	-3	5	MF04-2	50	Al. Plate
MF19	Freezing Drizzle	-3	5	MF04-1	50	Al. Plate
MF20	Freezing Drizzle	-3	13	MF04-1	50	Al. Plate
MF21	Light Freezing Rain	-3	13	MF04-1	50	Al. Plate
MF22	Light Freezing Rain	-3	25	MF04-1	50	Al. Plate
MF23	Freezing Fog	-3	2	MF04-1	50	Al. Plate
MF24	Freezing Fog	-3	5	MF04-1	50	Al. Plate

TABLE 3: FLUID THICKNESS TEST PLAN

Test #	Fluid	Fluid Dilution	Fluid Temp	Test Surface	Ambient Air Temp
TH1	Cryotech X	100/0	-3°C	Al. Plate	-3°C
TH2	Cryotech X	100/0	-3°C	Al. Plate	-3°C
TH3	Cryotech X	75/25	-3°C	Al. Plate	-3°C
TH4	Cryotech X	75/25	-3°C	Al. Plate	-3°C
TH5	Cryotech X	50/50	-3°C	Al. Plate	-3°C
TH6	Cryotech X	50/50	-3°C	Al. Plate	-3°C
TH7	Clariant 2031	100/0	20°C	Al. Plate	-3°C
TH8	Clariant 2031	100/0	20°C	Al. Plate	-3°C
TH9	Clariant 2031	75/25	20°C	Al. Plate	-3°C
TH10	Clariant 2031	75/25	20°C	Al. Plate	-3°C
TH11	Clariant 2031	50/50	20°C	Al. Plate	-3°C
TH12	Clariant 2031	50/50	20°C	Al. Plate	-3°C
TH13	Clariant Launch Plus	100/0	-3°C	Al. Plate	-3°C
TH14	Clariant Launch Plus	100/0	-3°C	Al. Plate	-3°C
TH15	Clariant Launch Plus	75/25	-3°C	Al. Plate	-3°C
TH16	Clariant Launch Plus	75/25	-3°C	Al. Plate	-3°C
TH17	Clariant Launch Plus	50/50	-3°C	Al. Plate	-3°C
TH18	Clariant Launch Plus	50/50	-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

TABLE 4: FIVE MINUTE RULE TEST PLAN

Test #	Piggyback Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Fluid Dilution (%)	Test Surface
TYPE I TESTS							
FM1	DF12	Freezing Fog	-3	2	Dow UCAR ADF (EG)	10°B (B=17.6)	Al. Plate
FM2	n/a	Freezing Fog	-3	2	Octagon Octaflo EF	10°B (B=21.25)	Al. Plate
FM3	n/a	Light Freezing Rain	-10	13	Dow UCAR ADF (EG)	10°B (B=22.9)	Al. Plate
FM4	PH1	Light Freezing Rain	-10	13	Octagon Octaflo EF	10°B (B=27.0)	Al. Plate
FM5	n/a	Light Freezing Rain	-10	25	Dow UCAR ADF (EG)	10°B (B=22.9)	Al. Plate
FM6	n/a	Light Freezing Rain	-10	25	Octagon Octaflo EF	10°B (B=27.0)	Al. Plate
FM7	PH25	Freezing Drizzle	-3	5	Dow UCAR ADF (EG)	10°B (B=17.6)	Al. Plate
FM8	DF1/PH31	Freezing Drizzle	-3	5	Octagon Octaflo EF	10°B (B=21.25)	Al. Plate
FM9	PH49	Freezing Drizzle	-3	13	Dow UCAR ADF (EG)	10°B (B=17.6)	Al. Plate
FM10	DF15	Freezing Drizzle	-3	13	Octagon Octaflo EF	10°B (B=21.25)	Al. Plate
FM11	n/a	Freezing Drizzle	-10	5	Dow UCAR ADF (EG)	10°B (B=22.9)	Al. Plate
FM12	DF4	Freezing Drizzle	-10	5	Octagon Octaflo EF	10°B (B=27.0)	Al. Plate
TYPE II, III, IV TESTS							
FM13	1	Freezing Fog	-3	2	Clariant Launch Plus	100	Al. Plate
FM14	3	Freezing Fog	-3	2	Clariant Launch Plus	75	Al. Plate
FM15	5	Freezing Fog	-3	2	Clariant Launch Plus	50	Al. Plate
FM16	7	Freezing Fog	-3	2	Clariant 2031 WARM	100	Al. Plate
FM17	9	Freezing Fog	-3	2	Clariant 2031 WARM	75	Al. Plate
FM18	11	Freezing Fog	-3	2	Clariant 2031 WARM	50	Al. Plate
FM19	49	Light Freezing Rain	-3	13	Clariant Launch Plus	100	Al. Plate
FM20	51	Light Freezing Rain	-3	13	Clariant Launch Plus	75	Al. Plate
FM21	53	Light Freezing Rain	-3	13	Clariant Launch Plus	50	Al. Plate
FM22	55	Light Freezing Rain	-3	13	Clariant 2031 WARM	100	Al. Plate
FM23	57	Light Freezing Rain	-3	13	Clariant 2031 WARM	75	Al. Plate
FM24	59	Light Freezing Rain	-3	13	Clariant 2031 WARM	50	Al. Plate
FM25	61	Light Freezing Rain	-3	25	Clariant Launch Plus	100	Al. Plate
FM26	64	Light Freezing Rain	-3	25	Clariant Launch Plus	75	Al. Plate
FM27	65	Light Freezing Rain	-3	25	Clariant Launch Plus	50	Al. Plate
FM28	67	Light Freezing Rain	-3	25	Clariant 2031 WARM	100	Al. Plate
FM29	69	Light Freezing Rain	-3	25	Clariant 2031 WARM	75	Al. Plate
FM30	71	Light Freezing Rain	-3	25	Clariant 2031 WARM	50	Al. Plate
FM31	73	Light Freezing Rain	-10	13	Clariant Launch Plus	100	Al. Plate
FM32	75	Light Freezing Rain	-10	13	Clariant Launch Plus	75	Al. Plate
FM33	77	Light Freezing Rain	-10	13	Clariant 2031 WARM	100	Al. Plate
FM34	79	Light Freezing Rain	-10	13	Clariant 2031 WARM	75	Al. Plate
FM35	81	Light Freezing Rain	-10	25	Clariant Launch Plus	100	Al. Plate
FM36	83	Light Freezing Rain	-10	25	Clariant Launch Plus	75	Al. Plate
FM37	85	Light Freezing Rain	-10	25	Clariant 2031 WARM	100	Al. Plate
FM38	87	Light Freezing Rain	-10	25	Clariant 2031 WARM	75	Al. Plate
FM39	89	Freezing Drizzle	-3	5	Clariant Launch Plus	100	Al. Plate
FM40	91	Freezing Drizzle	-3	5	Clariant Launch Plus	75	Al. Plate
FM41	93	Freezing Drizzle	-3	5	Clariant Launch Plus	50	Al. Plate
FM42	95	Freezing Drizzle	-3	5	Clariant 2031 WARM	100	Al. Plate
FM43	97	Freezing Drizzle	-3	5	Clariant 2031 WARM	75	Al. Plate
FM44	99	Freezing Drizzle	-3	5	Clariant 2031 WARM	50	Al. Plate

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TABLE 5: LIGHT SNOW / VERY LIGHT SNOW CALIBRATION TEST PLAN

Test #	Fluid Name	Fluid Dilution	Fluid Type	Endurance Time (mins)	Rate [g/dm²/h]	Temp [°C]	Plate Temp [°C]
~~1~~	~~ABAX Ecowing 26~~	~~75%~~	~~II~~	~~27.0~~	~~7.5~~	~~-8.5~~	~~-9.5~~
2	ABAX Ecowing 26	75%	II	47.4	3.7	-7.8	-8.5
~~3~~	~~ABAX AD 49~~	~~100%~~	~~IV~~	~~82.0~~	~~8.7~~	~~-8.6~~	~~-9.7~~
4	Cryotech Polar Guard Advance	75%	IV	94.0	8.8	-8.6	-9.7
5	Clariant Launch	100%	IV	97.2	4.0	-10.3	-11.1

Tests listed with a strikethrough do not need to be conducted as they have already been completed at the APS test site in March 2013.

TABLE 6: HEAVY SNOW TEST PLAN

Test #	Fluid Name	Fluid Dilution	Batch No.	Fluid Type	Endurance Time (mins)	Rate [g/dm²/h]	Temp [°C]	Plate Temp
1	Kilfrost ABC-S Plus	100%	WT 10-11	IV	33.9	65.0	-5.5	-10.2
2	Kilfrost ABC-S Plus	100%	WT 10-11	IV	33.9	65.0	-5.5	-10.2
3	Kilfrost ABC-S Plus	100%	WT 10-11	IV	33.9	65.0	-5.5	-10.2
4	Dow EG106	100%	WT 10-11	IV	25.2	63.9	-5.5	-10.2
5	Dow EG106	100%	WT 10-11	IV	25.2	63.9	-5.5	-10.2
6	Dow EG106	100%	WT 10-11	IV	25.2	63.9	-5.5	-10.2
7	Clariant Launch	100%	WT 10-11	IV	29.4	65.0	-5.5	-10.2
8	Clariant Launch	100%	WT 10-11	IV	29.4	65.0	-5.5	-10.2
9	Clariant Launch	100%	WT 10-11	IV	29.4	65.0	-5.5	-10.2

TABLE 7: LIGHT SNOW / VERY LIGHT SNOW TEST PLAN

Test #	Fluid	Type	Dilution	Fluid Qty (L)	Condition Temp. (°C)	Precip. Rate (g/dm²/h)	Plate Set Temp (°C)	Priority	Generic HOT (mins)	Predicted HOT (mins)
1	Clariant MP II Flight Plus	II	100	1	-25.0	3.0	-25.7	1	75	185
2	Clariant MP II Flight Plus	II	100	1	-25.0	4.0	-25.8	1	60	145
3	LNT P250	II	100	1	-25.0	3.0	-25.7	1	75	200
4	LNT P250	II	100	1	-25.0	4.0	-25.8	1	60	170
5	Clariant MP III 2031 ECO[10]	III	100	0.5	-25.0	3.0	-25.7	1	37	37
6	Clariant MP III 2031 ECO[10]	III	100	0.5	-25.0	4.0	-25.8	1	30	30
7	Clariant MP III 2031 ECO[10]	III	100	0.5	-25.0	10.0	-26.2	1	16	16
8	Clariant MP III 2031 ECO[10]	III	100	0.5	-25.0	25.0	-27.1	1	9	9
9	Clariant MP III 2031 ECO[10]	III	100	0.5	-10.0	3.0	-25.7	1	42	42
10	Clariant MP III 2031 ECO[10]	III	100	0.5	-10.0	4.0	-25.8	1	35	35
11	Clariant MP III 2031 ECO[10]	III	100	0.5	-10.0	10.0	-26.2	1	18	18
12	Clariant MP III 2031 ECO[10]	III	100	0.5	-10.0	25.0	-27.1	1	10	10
13	ABAX FlightGuard AD-49	IV	100	1	-25.0	3.0	-25.7	1	75	190
14	ABAX FlightGuard AD-49	IV	100	1	-25.0	4.0	-25.8	1	60	170
15	Kilfrost ABC-S Plus	IV	100	1	-25.0	3.0	-25.7	1	75	190
16	Kilfrost ABC-S Plus	IV	100	1	-25.0	4.0	-25.8	1	60	160
17	Kilfrost ABC-S Plus	IV	100	1	-25.0	10.0	-26.2	1	30	95
18	Kilfrost ABC-S Plus	IV	100	1	-25.0	25.0	-27.1	1	15	55
19	Clariant Launch	IV	100	1	-25.0	3.0	-25.7	1	75	135
20	Clariant Launch	IV	100	1	-25.0	4.0	-25.8	1	60	115
21	Clariant Launch	IV	100	1	-25.0	10.0	-26.2	1	30	70
22	Clariant Launch	IV	100	1	-25.0	25.0	-27.1	1	15	43
23	Clariant Launch Plus	IV	100	1	-25.0	3.0	-25.7	2	75	250
24	Clariant Launch Plus	IV	100	1	-25.0	4.0	-25.8	2	60	190
25	Clariant Max-Flight 04	IV	100	1	-25.0	3.0	-25.7	1	75	115
26	Clariant Max-Flight 04	IV	100	1	-25.0	4.0	-25.8	1	60	95
27	Cryotech Polar Guard	IV	100	1	-25.0	3.0	-25.7	1	75	100
28	Cryotech Polar Guard	IV	100	1	-25.0	4.0	-25.8	1	60	90

NOTES:

1. Objective: Develop generic holdover times for very light snow and light snow at -25°C.
2. Standard ARP5485 procedure shall be used to conduct tests.
3. Testing shall be conducted with LOWV fluid samples.
4. The fluid temperature is within 3°C of the enclosure temperature.
5. The enclosure temperature is typically 2°C below the plate temperature (no tolerance specified).
6. The plate temperature shall be within ±0.5 (°C)
7. Measurement of Brix at 15 cm line is required at time of failure.
8. Photo should be taken at time of failure. Position camera at an angle of 30 degrees facing the plate and capturing the whole plate + 20%.
9. See TP 14376E for historical -25°C data collected.
10. Type III fluid must be applied at 60°C.

OVERALL PROGRAM OF TESTS AT NRC, APRIL 2013

TABLE 8: ICE PHOBIC ENDURANCE TIME TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid Name	Fluid Dilution	Test Surface	Comments	Fluid Req'd (L)	Priority
PH1	Light Freezing Rain	-10	13 (25)	Octagon Octaflo EF	10°B (B=27.0)	Baseline	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	1
PH2	Light Freezing Rain	-10	13 (25)	Octagon Octaflo EF	10°B (B=27.0)	B12	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	1
PH3	Light Freezing Rain	-10	13 (25)	Octagon Octaflo EF	10°B (B=27.0)	B13	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	1
PH4	Light Freezing Rain	-10	13 (25)	Octagon Octaflo EF	10°B (B=27.0)	C3	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	1
PH5	Light Freezing Rain	-10	13 (25)	Octagon Octaflo EF	10°B (B=27.0)	D1	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	1
PH6	Light Freezing Rain	-10	13 (25)	Octagon Octaflo EF	10°B (B=27.0)	D2	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	1
PH7	Light Freezing Rain	-10	13 (25)	AD-49 (WT)	75/25	Baseline	Thick @ 5 mins, Brix at fail	1	1
PH8	Light Freezing Rain	-10	13 (25)	AD-49 (WT)	75/25	B12	Thick @ 5 mins, Brix at fail	1	1
PH9	Light Freezing Rain	-10	13 (25)	AD-49 (WT)	75/25	B13	Thick @ 5 mins, Brix at fail	1	1
PH10	Light Freezing Rain	-10	13 (25)	AD-49 (WT)	75/25	C3	Thick @ 5 mins, Brix at fail	1	1
PH11	Light Freezing Rain	-10	13 (25)	AD-49 (WT)	75/25	D1	Thick @ 5 mins, Brix at fail	1	1
PH12	Light Freezing Rain	-10	13 (25)	AD-49 (WT)	75/25	D2	Thick @ 5 mins, Brix at fail	1	1
PH-V1	Light Freezing Rain	-10	13 (25)	AD-49 (WT LOWV)	75/25	Baseline	Thick @ 5 mins, Brix at fail	1	1
PH-V2	Light Freezing Rain	-10	13 (25)	AD-49 (WT LOWV)	75/25	B12	Thick @ 5 mins, Brix at fail	1	1
PH-V3	Light Freezing Rain	-10	13 (25)	AD-49 (WT LOWV)	75/25	B13	Thick @ 5 mins, Brix at fail	1	1
PH-V4	Light Freezing Rain	-10	13 (25)	AD-49 (WT LOWV)	75/25	C3	Thick @ 5 mins, Brix at fail	1	1
PH-V5	Light Freezing Rain	-10	13 (25)	AD-49 (WT LOWV)	75/25	D1	Thick @ 5 mins, Brix at fail	1	1
PH-V6	Light Freezing Rain	-10	13 (25)	AD-49 (WT LOWV)	75/25	D2	Thick @ 5 mins, Brix at fail	1	1
PH13	Freezing Drizzle	-10	13 (5)	Polar Guard Advance (WT)	100/0	Baseline	Thick @ 5 mins, Brix at fail	1	1
PH14	Freezing Drizzle	-10	13 (5)	Polar Guard Advance (WT)	100/0	B12	Thick @ 5 mins, Brix at fail	1	1
PH15	Freezing Drizzle	-10	13 (5)	Polar Guard Advance (WT)	100/0	B13	Thick @ 5 mins, Brix at fail	1	1
PH16	Freezing Drizzle	-10	13 (5)	Polar Guard Advance (WT)	100/0	C3	Thick @ 5 mins, Brix at fail	1	1
PH17	Freezing Drizzle	-10	13 (5)	Polar Guard Advance (WT)	100/0	D1	Thick @ 5 mins, Brix at fail	1	1
PH18	Freezing Drizzle	-10	13 (5)	Polar Guard Advance (WT)	100/0	D2	Thick @ 5 mins, Brix at fail	1	1
PH-V7	Freezing Drizzle	-10	13 (5)	Polar Guard Advance (WT LOWV)	100/0	Baseline	Thick @ 5 mins, Brix at fail	1	1
PH-V8	Freezing Drizzle	-10	13 (5)	Polar Guard Advance (WT LOWV)	100/0	B12	Thick @ 5 mins, Brix at fail	1	1
PH-V9	Freezing Drizzle	-10	13 (5)	Polar Guard Advance (WT LOWV)	100/0	B13	Thick @ 5 mins, Brix at fail	1	1
PH-V10	Freezing Drizzle	-10	13 (5)	Polar Guard Advance (WT LOWV)	100/0	C3	Thick @ 5 mins, Brix at fail	1	1
PH-V11	Freezing Drizzle	-10	13 (5)	Polar Guard Advance (WT LOWV)	100/0	D1	Thick @ 5 mins, Brix at fail	1	1
PH-V12	Freezing Drizzle	-10	13 (5)	Polar Guard Advance (WT LOWV)	100/0	D2	Thick @ 5 mins, Brix at fail	1	1

Note: LOWV should be done at same time as comaprative tests (with extra set of plates), or back-to back on same plates

TABLE 8: ICE PHOBIC ENDURANCE TIME TEST PLAN (CONT'D)

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid Name	Fluid Dilution	Test Surface	Comments	Fluid Req'd (L)	Priority
PH19	Light Freezing Rain	-10	25 (13)	Dow UCAR EG106	100/0	Baseline	Thick @ 5 mins, Brix at fail	1	1
PH20	Light Freezing Rain	-10	25 (13)	Dow UCAR EG106	100/0	B12	Thick @ 5 mins, Brix at fail	1	1
PH21	Light Freezing Rain	-10	25 (13)	Dow UCAR EG106	100/0	B13	Thick @ 5 mins, Brix at fail	1	1
PH22	Light Freezing Rain	-10	25 (13)	Dow UCAR EG106	100/0	C3	Thick @ 5 mins, Brix at fail	1	1
PH23	Light Freezing Rain	-10	25 (13)	Dow UCAR EG106	100/0	D1	Thick @ 5 mins, Brix at fail	1	1
PH24	Light Freezing Rain	-10	25 (13)	Dow UCAR EG106	100/0	D2	Thick @ 5 mins, Brix at fail	1	1
PH25	Freezing Drizzle	-3	5 (13)	Dow UCAR ADF (EG)	10°B (B=17.6)	Baseline	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	1
PH26	Freezing Drizzle	-3	5 (13)	Dow UCAR ADF (EG)	10°B (B=17.6)	B12	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	1
PH27	Freezing Drizzle	-3	5 (13)	Dow UCAR ADF (EG)	10°B (B=17.6)	B13	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	1
PH28	Freezing Drizzle	-3	5 (13)	Dow UCAR ADF (EG)	10°B (B=17.6)	C3	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	1
PH29	Freezing Drizzle	-3	5 (13)	Dow UCAR ADF (EG)	10°B (B=17.6)	D1	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	1
PH30	Freezing Drizzle	-3	5 (13)	Dow UCAR ADF (EG)	10°B (B=17.6)	D2	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	1
PH31	Freezing Drizzle	-3	5 (13)	Octagon Octaflo EF	10°B (B=21.25)	Baseline	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	1
PH32	Freezing Drizzle	-3	5 (13)	Octagon Octaflo EF	10°B (B=21.25)	B12	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	1
PH33	Freezing Drizzle	-3	5 (13)	Octagon Octaflo EF	10°B (B=21.25)	B13	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	1
PH34	Freezing Drizzle	-3	5 (13)	Octagon Octaflo EF	10°B (B=21.25)	C3	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	1
PH35	Freezing Drizzle	-3	5 (13)	Octagon Octaflo EF	10°B (B=21.25)	D1	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	1
PH36	Freezing Drizzle	-3	5 (13)	Octagon Octaflo EF	10°B (B=21.25)	D2	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	1
PH37	Freezing Drizzle	-3	13 (5)	ABAX AD-49 (WT)	50/50	Baseline	Thick @ 5 mins, Brix at fail	1	1
PH38	Freezing Drizzle	-3	13 (5)	ABAX AD-49 (WT)	50/50	B12	Thick @ 5 mins, Brix at fail	1	1
PH39	Freezing Drizzle	-3	13 (5)	ABAX AD-49 (WT)	50/50	B13	Thick @ 5 mins, Brix at fail	1	1
PH40	Freezing Drizzle	-3	13 (5)	ABAX AD-49 (WT)	50/50	C3	Thick @ 5 mins, Brix at fail	1	1
PH41	Freezing Drizzle	-3	13 (5)	ABAX AD-49 (WT)	50/50	D1	Thick @ 5 mins, Brix at fail	1	1
PH42	Freezing Drizzle	-3	13 (5)	ABAX AD-49 (WT)	50/50	D2	Thick @ 5 mins, Brix at fail	1	1
PH-V13	Freezing Drizzle	-3	13 (5)	ABAX AD-49 (WT LOWV)	50/50	Baseline	Thick @ 5 mins, Brix at fail	1	1
PH-V14	Freezing Drizzle	-3	13 (5)	ABAX AD-49 (WT LOWV)	50/50	B12	Thick @ 5 mins, Brix at fail	1	1
PH-V15	Freezing Drizzle	-3	13 (5)	ABAX AD-49 (WT LOWV)	50/50	B13	Thick @ 5 mins, Brix at fail	1	1
PH-V16	Freezing Drizzle	-3	13 (5)	ABAX AD-49 (WT LOWV)	50/50	C3	Thick @ 5 mins, Brix at fail	1	1
PH-V17	Freezing Drizzle	-3	13 (5)	ABAX AD-49 (WT LOWV)	50/50	D1	Thick @ 5 mins, Brix at fail	1	1
PH-V18	Freezing Drizzle	-3	13 (5)	ABAX AD-49 (WT LOWV)	50/50	D2	Thick @ 5 mins, Brix at fail	1	1

Note: LOWV should be done at same time as comaprative tests (with extra set of plates), or back-to back on same plates

TABLE 8: ICE PHOBIC ENDURANCE TIME TEST PLAN (CONT'D)

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid Name	Fluid Dilution	Test Surface	Comments	Fluid Req'd (L)	Priority
PH43	Light Freezing Rain	-3	25 (13)	ABC-S Plus (WT)	75/25	Baseline	Thick @ 5 mins, Brix at fail	1	2
PH44	Light Freezing Rain	-3	25 (13)	ABC-S Plus (WT)	75/25	B12	Thick @ 5 mins, Brix at fail	1	2
PH45	Light Freezing Rain	-3	25 (13)	ABC-S Plus (WT)	75/25	B13	Thick @ 5 mins, Brix at fail	1	2
PH46	Light Freezing Rain	-3	25 (13)	ABC-S Plus (WT)	75/25	C3	Thick @ 5 mins, Brix at fail	1	2
PH47	Light Freezing Rain	-3	25 (13)	ABC-S Plus (WT)	75/25	D1	Thick @ 5 mins, Brix at fail	1	2
PH48	Light Freezing Rain	-3	25 (13)	ABC-S Plus (WT)	75/25	D2	Thick @ 5 mins, Brix at fail	1	2
PH-V19	Light Freezing Rain	-3	25 (13)	ABC-S Plus (WT LOWV)	75/25	Baseline	Thick @ 5 mins, Brix at fail	1	2
PH-V20	Light Freezing Rain	-3	25 (13)	ABC-S Plus (WT LOWV)	75/25	B12	Thick @ 5 mins, Brix at fail	1	2
PH-V21	Light Freezing Rain	-3	25 (13)	ABC-S Plus (WT LOWV)	75/25	B13	Thick @ 5 mins, Brix at fail	1	2
PH-V22	Light Freezing Rain	-3	25 (13)	ABC-S Plus (WT LOWV)	75/25	C3	Thick @ 5 mins, Brix at fail	1	2
PH-V23	Light Freezing Rain	-3	25 (13)	ABC-S Plus (WT LOWV)	75/25	D1	Thick @ 5 mins, Brix at fail	1	2
PH-V24	Light Freezing Rain	-3	25 (13)	ABC-S Plus (WT LOWV)	75/25	D2	Thick @ 5 mins, Brix at fail	1	2
PH49	Freezing Drizzle	-3	13 (5)	Dow UCAR ADF (EG)	10°B (B=17.6)	Baseline	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	2
PH50	Freezing Drizzle	-3	13 (5)	Dow UCAR ADF (EG)	10°B (B=17.6)	B12	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	2
PH51	Freezing Drizzle	-3	13 (5)	Dow UCAR ADF (EG)	10°B (B=17.6)	B13	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	2
PH52	Freezing Drizzle	-3	13 (5)	Dow UCAR ADF (EG)	10°B (B=17.6)	C3	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	2
PH53	Freezing Drizzle	-3	13 (5)	Dow UCAR ADF (EG)	10°B (B=17.6)	D1	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	2
PH54	Freezing Drizzle	-3	13 (5)	Dow UCAR ADF (EG)	10°B (B=17.6)	D2	1 L at 20°C, Thick @ 5 mins, Brix at fail	1	2

Note: LOWV should be done at same time as comparative tests (with extra set of plates), or back-to back on same plates

TABLE 9: ICE PHOBIC THICKNESS TEST PLAN

Test #	Priority	Fluid Name	Fluid Type	Fluid Dilution	Test Surface Treatment*	Ambient Air Temperature
PH-TH1	1	Dow UCAR ADF (EG)	Type I EG	10°B (B=17.6)	Baseline	-3°C
PH-TH2	1	Dow UCAR ADF (EG)	Type I EG	10°B (B=17.6)	B12	-3°C
PH-TH3	1	Dow UCAR ADF (EG)	Type I EG	10°B (B=17.6)	B13	-3°C
PH-TH4	1	Dow UCAR ADF (EG)	Type I EG	10°B (B=17.6)	C3	-3°C
PH-TH5	1	Dow UCAR ADF (EG)	Type I EG	10°B (B=17.6)	D1	-3°C
PH-TH6	1	Dow UCAR ADF (EG)	Type I EG	10°B (B=17.6)	D2	-3°C
PH-TH7	2	Dow UCAR ADF (EG)	Type I EG	FFP=-35°C (B=30.5)	Baseline	-3°C
PH-TH8	2	Dow UCAR ADF (EG)	Type I EG	FFP=-35°C (B=30.5)	B12	-3°C
PH-TH9	2	Dow UCAR ADF (EG)	Type I EG	FFP=-35°C (B=30.5)	B13	-3°C
PH-TH10	2	Dow UCAR ADF (EG)	Type I EG	FFP=-35°C (B=30.5)	C3	-3°C
PH-TH11	2	Dow UCAR ADF (EG)	Type I EG	FFP=-35°C (B=30.5)	D1	-3°C
PH-TH12	2	Dow UCAR ADF (EG)	Type I EG	FFP=-35°C (B=30.5)	D2	-3°C
PH-TH13	1	Cryotech 13552	Type II PG	100/0	Baseline	-3°C
PH-TH14	1	Cryotech 13552	Type II PG	100/0	B12	-3°C
PH-TH15	1	Cryotech 13552	Type II PG	100/0	B13	-3°C
PH-TH16	1	Cryotech 13552	Type II PG	100/0	C3	-3°C
PH-TH17	1	Cryotech 13552	Type II PG	100/0	D1	-3°C
PH-TH18	1	Cryotech 13552	Type II PG	100/0	D2	-3°C

Procedure: Measure thickness (TII) at 15 cm line or % wetted (TI) at application and 2, 5, 15, and 30 minutes after pouring

TABLE 10: ICE PHOBIC ADHERENCE TEST PLAN

Test #	Priority	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Fluid Dilution	Test Surface	Comments
PH-AD1	1	Light Freezing Rain	-10	13	No fluid	n/a	Baseline	Measure time of adherence
PH-AD2	1	Light Freezing Rain	-10	13	No fluid	n/a	B12	Measure time of adherence
PH-AD3	1	Light Freezing Rain	-10	13	No fluid	n/a	B13	Measure time of adherence
PH-AD4	1	Light Freezing Rain	-10	13	No fluid	n/a	C3	Measure time of adherence
PH-AD5	1	Light Freezing Rain	-10	13	No fluid	n/a	D1	Measure time of adherence
PH-AD6	1	Light Freezing Rain	-10	13	No fluid	n/a	D2	Measure time of adherence

NOTE: Can be done a few a time, or all at once by moving 6pos stand into spray area. Can consider other conditions with large spray area

TABLE 11: ICE PHOBIC HOT WATER TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid Name	Fluid Dilution (%)	Test Surface	Comments	Fluid Required (L)	Priority
PH-HW1	Freezing Fog	-10	2	Octagon Octaflo EF	10°C Buff	Baseline	Measure time of adherence	1	1
PH-HW2	Freezing Fog	-10	2	Hot Water (1L @ 20°C)	n/a	B12	Measure time of adherence	1	1
PH-HW3	Freezing Fog	-10	2	Hot Water (1L @ 20°C)	n/a	B13	Measure time of adherence	1	1
PH-HW4	Freezing Fog	-10	2	Hot Water (1L @ 20°C)	n/a	C3	Measure time of adherence	1	1
PH-HW5	Freezing Fog	-10	2	Hot Water (1L @ 20°C)	n/a	D1	Measure time of adherence	1	1
PH-HW6	Freezing Fog	-10	2	Hot Water (1L @ 20°C)	n/a	D2	Measure time of adherence	1	1
PH-HW7	Light Freezing Rain	-10	13	Octagon Octaflo EF	10°C Buff	Baseline	Measure time of adherence	1	1
PH-HW8	Light Freezing Rain	-10	13	Hot Water (1L @ 20°C)	n/a	B12	Measure time of adherence	1	1
PH-HW9	Light Freezing Rain	-10	13	Hot Water (1L @ 20°C)	n/a	B13	Measure time of adherence	1	1
PH-HW10	Light Freezing Rain	-10	13	Hot Water (1L @ 20°C)	n/a	C3	Measure time of adherence	1	1
PH-HW11	Light Freezing Rain	-10	13	Hot Water (1L @ 20°C)	n/a	D1	Measure time of adherence	1	1
PH-HW12	Light Freezing Rain	-10	13	Hot Water (1L @ 20°C)	n/a	D2	Measure time of adherence	1	1

NOTE: This could be done outside the spray area

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TABLE 12: DEPLOYED FLAPS TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid Name	Fluid Dilution (%)	Test Surface*	Comments	Fluid Req'd (L)	Priority
DF1	Freezing Drizzle	-3	5	Octagon Octaflo EF	10° Buff	Plate (10°)	Thickness at 5 mins, Brix at failure	1	1
DF2	Freezing Drizzle	-3	5	Octagon Octaflo EF	10° Buff	Plate (20°)	Thickness at 5 mins, Brix at failure	1	1
DF3	Freezing Drizzle	-3	5	Octagon Octaflo EF	10° Buff	Plate (35°)	Thickness at 5 mins, Brix at failure	1	1
DF4	Freezing Drizzle	-10	5	Octagon Octaflo EF	10° Buff	Plate (10°)	Thickness at 5 mins, Brix at failure	1	1
DF5	Freezing Drizzle	-10	5	Octagon Octaflo EF	10° Buff	Plate (20°)	Thickness at 5 mins, Brix at failure	1	1
DF6	Freezing Drizzle	-10	5	Octagon Octaflo EF	10° Buff	Plate (35°)	Thickness at 5 mins, Brix at failure	1	1
DF7	Freezing Drizzle	-10	5	Octagon Octaflo EF	10° Buff	Plate (20°) Nested	Thickness at 5 mins, Brix at failure	2	1
DF8	Freezing Drizzle	-10	5	Octagon Octaflo EF	10° Buff	Plate (35°) Nested	Thickness at 5 mins, Brix at failure	2	1
DF9	Freezing Drizzle	-10	13	Octagon Octaflo EF	10° Buff	Plate (10°)	Thickness at 5 mins, Brix at failure	1	2
DF10	Freezing Drizzle	-10	13	Octagon Octaflo EF	10° Buff	Plate (20°)	Thickness at 5 mins, Brix at failure	1	2
DF11	Freezing Drizzle	-10	13	Octagon Octaflo EF	10° Buff	Plate (35°)	Thickness at 5 mins, Brix at failure	1	2
DF12	Freezing Fog	-3	5	Dow UCAR ADF (EG)	10° Buff	Plate (10°)	Thickness at 5 mins, Brix at failure	1	1
DF13	Freezing Fog	-3	5	Dow UCAR ADF (EG)	10° Buff	Plate (20°)	Thickness at 5 mins, Brix at failure	1	1
DF14	Freezing Fog	-3	5	Dow UCAR ADF (EG)	10° Buff	Plate (35°)	Thickness at 5 mins, Brix at failure	1	1
DF15	Freezing Drizzle	-3	13	Octagon Octaflo EF	10° Buff	Plate (10°)	Thickness at 5 mins, Brix at failure	1	1
DF16	Freezing Drizzle	-3	13	Octagon Octaflo EF	10° Buff	Plate (20°)	Thickness at 5 mins, Brix at failure	1	1
DF17	Freezing Drizzle	-3	13	Octagon Octaflo EF	10° Buff	Plate (35°)	Thickness at 5 mins, Brix at failure	1	1
DF18	Freezing Drizzle	-3	13	Octagon Octaflo EF	10° Buff	Plate (20°) Nested	Thickness at 5 mins, Brix at failure	2	2
DF19	Freezing Drizzle	-3	13	Octagon Octaflo EF	10° Buff	Plate (35°) Nested	Thickness at 5 mins, Brix at failure	2	2
DF20	Light Freezing Rain	-10	25	Dow UCAR ADF (EG)	10° Buff	Plate (10°)	Thickness at 5 mins, Brix at failure	1	2
DF21	Light Freezing Rain	-10	25	Dow UCAR ADF (EG)	10° Buff	Plate (20°)	Thickness at 5 mins, Brix at failure	1	2
DF22	Light Freezing Rain	-10	25	Dow UCAR ADF (EG)	10° Buff	Plate (35°)	Thickness at 5 mins, Brix at failure	1	2

*NOTE: 20° and 35° plates need to be positioned on bottom HOT stand (pos 7-12) or on side stand (1s-3s)

TABLE 13: FLAPS SLATS EXTENSION TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid	Fluid Dil. (%)	Test Surface	Comments	Fluid Required (L)	Priority
FSE1	Freezing Drizzle	-10	13	Clariant Launch Plus	100/0	Plate (10°)	Thickness at 5 mins, Brix at failure	1	1
FSE2	Freezing Drizzle	-10	13	Clariant Launch Plus	100/0	2 Plates (20°) Slat	Extend after 5-10min. Thickness at 5 mins, Brix at fail	1.5	1
FSE3	Freezing Drizzle	-10	13	Clariant Launch Plus	100/0	2 Plates (20°) Flap	Extend after 5-10min. Thickness at 5 mins, Brix at fail	1.5	1
FSE4	Light Freezing Rain	-3	25	Clariant Launch Plus	75/25	Plate (10°)	Thickness at 5 mins, Brix at failure	1	2
FSE5	Light Freezing Rain	-3	25	Clariant Launch Plus	75/25	2 Plates (35°) Slat	Extend after 5-10min. Thickness at 5 mins, Brix at fail	1.5	2
FSE6	Light Freezing Rain	-3	25	Clariant Launch Plus	75/25	2 Plates (35°) Flap	Extend after 5-10min. Thickness at 5 mins, Brix at fail	1.5	2

NOTE: 2 plates used. 1 on top of other at 10° to start (with overlap), then split into 10° and 20/35°

OVERALL PROGRAM OF TESTS AT NRC, APRIL 2013

TABLE 14: LIST OF FLUIDS

Fluid	Batch #	Fluid Temp	Fluid Dil or Brix (FFP)	Litres Required per Project													Total Litres	Pour Bottles	Notes
				ET	TH	CML	5-MIN	AS-CAL	AS-VLS	AS-HS	PH-ET	PH-TH	PH-AD	PH-HW	FSE	DF			
Type II, II, IV (HOT)																			
Clariant Safewing 2031 WARM	USHA035838	20°C	100	34	2	-	-	-	8	-	-	-	-	-	-	-	44	8*	3 x 20L jugs****
Clariant Safewing 2031 WARM	USHA035838	20°C	75	30	2	-	-	-	-	-	-	-	-	-	-	-	32	8*	2 x 20L jugs****
Clariant Safewing 2031 WARM	USHA035838	20°C	50	14	2	-	-	-	-	-	-	-	-	-	-	-	16	8*	1 x 50L jug****
Clariant Safewing 2031 COLD	USHA035838	OAT	100	2	-	-	-	-	-	-	-	-	-	-	-	-	2	2	** and ****
Clariant Safewing 2031 COLD	USHA035838	OAT	75	2	-	-	-	-	-	-	-	-	-	-	-	-	2	2	
Clariant Safewing 2031 COLD	USHA035838	OAT	50	2	-	-	-	-	-	-	-	-	-	-	-	-	2	2	
Clariant Launch Plus	TV 523	OAT	100	32	2	-	-	-	2	-	-	-	-	-	3	-	39	8*	3 x 20L jugs****
Clariant Launch Plus	TV 523	OAT	75	28	2	-	-	-	-	-	-	-	-	-	3	-	33	8*	2 x 20L jugs****
Clariant Launch Plus	TV 523	OAT	50	12	2	-	-	-	-	-	-	-	-	-	-	-	14	8*	1 x 20L jugs****
Type II, II, IV (R&D)																			
Cryotech 13552	13552	OAT	100	-	-	-	-	-	-	-	-	6	-	-	-	-	6	6	**
Clariant Max-Flight 04 B1	U 49 E 001966	OAT	50	-	-	6	-	-	-	-	-	-	-	-	-	-	6	6	**
Clariant Max-Flight 04 B2	U 49 E 002061	OAT	100	-	-	6	-	-	2	-	-	-	-	-	-	-	8	3	prepare pour containers, bring empty***
Clariant Max-Flight 04 B2	U 49 E 002061	OAT	75	-	-	6	-	-	-	-	-	-	-	-	-	-	6	3	
Clariant Max-Flight 04 B2	U 49 E 002061	OAT	50	-	-	6	-	-	-	-	-	-	-	-	-	-	6	3	
Type II, III, IV (SNOWMAKER)																			
ABAX Ecowing 26	L12-321	OAT	75	-	-	-	-	1	-	-	-	-	-	-	-	-	1	1	fill pour containers plus bring 1 larger container as spare if available
Clariant Launch	WT 10-11	OAT	100	-	-	-	-	-	-	3	-	-	-	-	-	-	3	3	
Clariant Launch	DEG4 146164	OAT	100	-	-	-	-	1	4	-	-	-	-	-	-	-	5	3	
Cryotech Polar Guard Advance	13102	OAT	100	-	-	-	-	-	2	-	-	-	-	-	-	-	2	2	
Cryotech Polar Guard Advance	13102	OAT	75	-	-	-	-	1	-	-	-	-	-	-	-	-	1	1	
Dow EG106	WT 10-11	OAT	100	-	-	-	-	-	-	3	-	-	-	-	-	-	3	3	
ABAX FlightGuard AD-49	L12-318	OAT	100	-	-	-	-	-	2	-	-	-	-	-	-	-	2	2	
Kilfrost ABC-S Plus	WT 10-11	OAT	100	-	-	-	-	-	-	3	-	-	-	-	-	-	3	3	
Kilfrost ABC-S Plus	B/50/11/12 (P2549)	OAT	100	-	-	-	-	-	4	-	-	-	-	-	-	-	4	4	
LNT P250	53563-40	OAT	100	-	-	-	-	-	2	-	-	-	-	-	-	-	2	2	
MP II Flight Plus	TV513	OAT	100	-	-	-	-	-	2	-	-	-	-	-	-	-	2	2	
Type II, III, IV (WT FLUIDS)																			
ABAX AD-49 (WT)	L-12-328	OAT	75	-	-	-	-	-	-	-	10	-	-	-	-	-	10	nil	bring fluid in 10L containers, do not fill or label any pour containers, pack 12 empty no label pour containers
ABAX AD-49 (LOWV)	L-12-331	OAT	75	-	-	-	-	-	-	-	10	-	-	-	-	-	10	nil	
ABAX AD-49 (WT)	L-12-328	OAT	50	-	-	-	-	-	-	-	10	-	-	-	-	-	10	nil	
ABAX AD-49 (LOWV)	L-12-331	OAT	50	-	-	-	-	-	-	-	10	-	-	-	-	-	10	nil	
Kilfrost ABC-S+ (WT)	WT.12.13.ABC-S+	OAT	75	-	-	-	-	-	-	-	10	-	-	-	-	-	10	nil	
Kilfrost ABC-S+ (LOWV)	WT.12.13.ABC-S+	OAT	75	-	-	-	-	-	-	-	10	-	-	-	-	-	10	nil	
Cryotech Polar Guard Advance (WT)	13342	OAT	100	-	-	-	-	-	-	-	10	-	-	-	-	-	10	nil	
Cryotech Polar Guard Advance (LOWV)	13102	OAT	100	-	-	-	-	-	-	-	10	-	-	-	-	-	10	nil	
Dow UCAR EG106 (WT)	1J0201GKDR	OAT	100	-	-	-	-	-	-	-	10	-	-	-	-	-	10	nil	
Type I																			
Octagon Octaflo EF	?	20°C	21.25 (-13°C)	-	-	-	1	-	-	-	6	-	-	-	-	10	17	6	Bring amount required plus extra container of undiluted fluid (one Octaflo, one Dow ADF)
Octagon Octaflo EF	?	20°C	27.0 (-20°C)	-	-	-	1	-	-	-	6	-	-	2	-	10	19	6	
Dow UCAR ADF (EG)	?	20°C	17.6 (-13°C)	-	-	-	-	-	-	-	12	6	-	-	-	6	24	6	
Dow UCAR ADF (EG)	?	20°C	22.9 (-20°C)	-	-	-	3	-	-	-	-	-	-	-	-	-	3	3	
Dow UCAR ADF (EG)	?	20°C	30.5 (-35°C)	-	-	-	-	-	-	-	-	6	-	-	-	-	6	6	
All Fluids				156	12	24	5	3	28	9	114	18	0	2	6	26	403	160	

Notes

* pour bottles already exist at site, pack them

**Fluid requirements met by fluid brought in pour containers, no large containers need to be brought

***Fluid will be shipped directly to NRC

****WARM / COLD labels go on all pour / large 2031 containers

Warm Storage Fluid

Cold Storage Fluid

TABLE 15: TYPE I DILUTION TABLES

Octagon Octaflo EF (PG)					
FFP (°C)	Test Temp (10°B)	% Fluid	Brix	Glycol for 4 L	Water for 4 L
-13	-3	32.0	21.25	1.3	2.7
-20	-10	43.0	27.0	1.7	2.3
-24	-14	47.0	29.50	1.9	2.1
-35	-25	56.0	34.50	2.2	1.8

Dow UCAR ADF (EG)					
FFP (°C)	Test Temp (10°B)	% Fluid	Brix	Glycol for 4 L	Water for 4 L
-13	-3	27.4	17.6	1.1	2.9
-20	-10	36.3	22.9	1.5	2.5
-35	-25	50.3	30.5	2.0	2.0

TABLE 16: GENERAL EQUIPMENT LIST

HOT, 5 MIN, PH-ET,THICKNESS AND PH-TH PROJECTS

EQUIPMENT	LOCATION
10L & 20L aqua packs jug for PH-ET tests	Site
1L Pour containers (see separate list)	Site
Barrel Opener	Site
Boards for cold-soak test x 15	Site
Brixometer x 4	Site
Calculators x 3	Site
Close circuit TV camera for rates	Site
Cold-soak boxes x 15	Site
Collection pans for stands (one per stand)	Site
Composite Boxes x 2	Site
Composite Plates x 2	Site
Electrical Extension Cords x 4	Site
Empty 20 L cont. for -30C CSW fluid x 4	Site
Falling Ball Viscometer	Site
Flashlights x 2	Site
Fluids (see Table 14)	Site
Funnels x 4 (big and small)	Site
Gloves - black and yellow	Site
Gloves - cotton (1 box)	Site
Gloves - latex (2 boxes)	Site
Half plates x all	Site
Hard water chemicals x 3 premixes	Site
Ice Phobic Plates x 10	Site
Inclinometer (yellow level) x 2	Site
Isopropyl x 15	Site
Large digital clock x 2	Site
Marker for Waste x 2	Site
Measuring Cups x 10	Site
Mixing bins for CSW fluid x 5 (rubbermaids)	Site
Nuts to separate plates x 100 (full box)	Site
Outdoor Rate Pan x1	Site
Paper Towels (4 packs)	Site
Plate covers x 16	Site
Plates: 12 w/smart buttons & 15 without	Site
Power bars x 5	Site
Precipitation Rate Pans x 100	Site
Printer & Ink Cartridge	Site
Protective clothing (all) and personel clothin	Site
Rubber Mats	Site
Rubber squeegees x 10	Site
Scrapers x 10	Site
Shelving unit x 1 (black one)	Site
Shop Vac + Sump Pump + Tubing	Site
Small folding table x 1	Site
Smart button kits x 2 + extension wire	Site
Speed tape x 1 and electrical tape x 5	Site
Tape measure (yellow + small)	Site
Temperature probes: immersion x 3	Site
Temperature probes: surface x 3	Site
Temperature readers x 2	Site
Test Stand Shims (poker chips) x 1 box	Site
Test Stands: 2 x 6 position (for small end)	Site
IKEA cart x2	Site

EQUIPMENT	LOCATION
Sample bottles x6 for MF04 viscosity tests	Site
Test Stands: 2 x 6-position (main stand)	Site
Test Stands: 3 position (side stand) (2 + 1)	Site
Thickness Gauges (8 x small 4 x large)	Site
Vise grip (large) + rubber opener for containers	Site
Walkie Talkies x 4	Site
Washers x 1 box	Site
Waste containers (use 20 L pails) x 3	Site
Water (1 x 18L) for hard water	Site
Weigh Scale x 2 (sartorius) + wiring	Site
White boards for water run-off	Site
Yellow Carrying Cases x2	Site
Yellow Ice Pic	Site
Thermistors (for Type III ZR -25 tests	Site
Black computer (for Type III ZR -25 tests)	Site
Cold-soak box filling stand	NRC
Cold-soak fluid pump	NRC
Copper tubing insulation (for passing wires)	NRC
Fluid for cold-soak boxes (barrel)	NRC
Rubber Mats	NRC
Tie wraps	NRC
Tools	NRC
Tote for Waste Fluid	NRC
Accordian Folder	Office
Camera Suitcase Pack (2 suitcases +backpack)	Office
Chamber Settings + Stand settings	Office
Clipboards x 10	Office
Data Forms (on water phobic paper)	Office
Envelopes (9x12) x box	Office
Go pro camera	Office
Hard Drive with Current Project folder	Office
iPads x 3	Office
Laptop for rates x2	Office
Laptop for smart button (MR)	Office
Mouse for Rate Station and keypad	Office
Paper for printer (1 pack)	Office
Pencils (sharpened) + pens + markers	Office
Test Procedures x 2 (1 sided)	Office
Waterproof paper (100 sheets)	Office
Watmans paper	Office

PH-ADHERENCE PROJECT

EQUIPMENT	LOCATION
Adhesion probe	Site

DEPLOYED FLAPS PROJECT

EQUIPMENT	LOCATION
20° Stand x 2 with plates	Site
35° Stand x 2 with plates	Site
Drilled plates x 2	Site

TABLE 17: SNOWMAKER EQUIPMENT LIST

EQUIPMENT	LOCATION
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
Stryofoam 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 litre 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
Additonal PVC Wizz Pad Aparatus	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

FIGURE 4: 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)

	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. 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

	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. 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 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: 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**

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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 7: SNOWMAKER END CONDITION DATA FORM

Version 1.0 Winter 2009-10

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)

Final Brix (o)

B2	C1	C2	C3	D2	E2

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Final Version 1.0, March 13

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FIGURE 8: FLUID BRIX / THICKNESS DATA FORM

FLUID BRIX/THICKNESS DATA FORM

DATE: ______________ PERFORMED BY: ________________

RUN #: ______________ WRITTEN BY: ________________

STAND: ______________ LOCATION: ________________

Plate/BOX: Fluid:			Plate/BOX: Fluid:			Plate/BOX: Fluid:			Plate/BOX: Fluid:		
TIME	Brix at 15 cm Line	Thick. at 15 cm Line	TIME	Brix at 15 cm Line	Thick. at 15 cm Line	TIME	Brix at 15 cm Line	Thick. at 15 cm Line	TIME	Brix at 15 cm Line	Thick. at 15 cm Line

FIGURE 9: ICE PHOBIC END CONDITION DATA FORM

LOCATION: NRC	DATE:	RUN #:	STAND #:

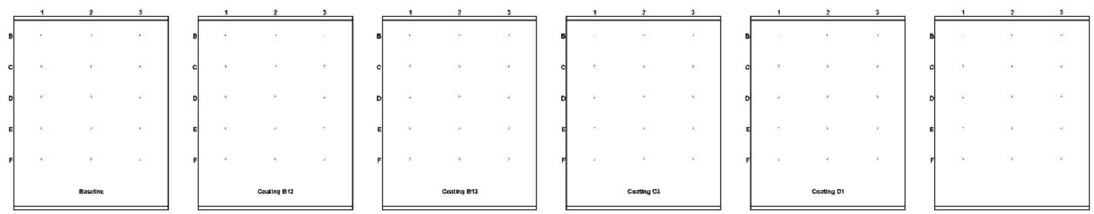
		Plate 1 Baseline	Plate 2 Coating B12	Plate 3 Coating B13	Plate 4 Coating C3	Plate 5 Coating D1	Plate 6 Coating D2
FLUID / DILUTION		______	______	______	______	______	______
DESCRIBED ADHESION AND DRAW FAILURE AT TIME OF PLATE 1 FAILURE		1 2 3 / B C D E F	1 2 3 / B C D E F	1 2 3 / B C D E F	1 2 3 / B C D E F	1 2 3 / B C D E F	1 2 3 / B C D E F
TIME OF FLUID APPLICATION		______	______	______	______	______	______
TIME OF FLUID FAILURE		______	______	______	______	______	______
FAILURE TIME (MIN)							
BRIX MEASUREMENTS TIME / BRIX	5 MIN	/	/	/	/	/	/
	END	/	/	/	/	/	/
	AT P1 FAIL		/	/	/	/	/
THICKNESS MEAS. TIME / THICKNESS	5 MIN	/	/	/	/	/	/
	END	/	/	/	/	/	/
	AT P1 FAIL		/	/	/	/	/

FAILURES CALLED BY: ______________

FIGURE 10: ICE PHOBIC THICKNESS DATA FORM

LOCATION: NRC CONDITION: DATE: RUN#: STAND#:

PLATE #						
SURFACE	Baseline	Coating B12	Coating B13	Coating C3	Coating D1	Coating D2
FLUID/DIL.						
TIME OF FLUID APP.						



THICKNESS MEASUREMENTS (mil)

Time	6" LINE	Time	6" LINE	Time	6" LINE	Time	6" LINE	Time	6" LINE	Time	6" LINE

PERFORMED BY: ____________ WRITTEN BY: ____________

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OVERALL PROGRAM OF TESTS AT NRC, SEPTEMBER 2013
(SPECIAL TESTING FOR BALTIC GROUND SERVICES DEFROSOL ADF)

CM2265.002 (12-13)

OVERALL PROGRAM OF TESTS AT NRC, SEPTEMBER 2013 (SPECIAL TESTING FOR BALTIC GROUND SERVICES DEFROSOL ADF)

Fall 2013

Prepared for

Transportation Development Centre
Transport Canada

Prepared by: Victoria Zoitakis, John D'Avirro

Reviewed by: John D'Avirro

September 13, 2013
Final Version 1.0

OVERALL PROGRAM OF TESTS AT NRC, SEPTEMBER 2013 (SPECIAL TESTING FOR BALTIC GROUND SERVICES DEFROSOL ADF)

Winter 2012-13

1. INTRODUCTION

The primary objective of the test session is to measure the endurance times of one new Type I fluid from September 17 to September 19, 2013 at the NRC. Several other research projects will also be carried out. 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 September 2013 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 5945.
- There will be two test stands positioned under the sprayer (main stand with two 6-position stands) 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. This program will be used. A guide to the rate management program is available to help with training of any new rate station managers.

2.1 Endurance Times of New and Existing Fluids (New Fluid ETs)

The objective of this project is to measure endurance times of a new fluid.

- **Type I:** Tests will be conducted with a new non-glycol Type I fluid over the entire range of freezing precipitation conditions encompassed by the Type I HOT table.

- **Type III Tests:** In April 2013, tests were conducted with a commercial Type III fluid, Clariant Safewing MP III 2031 ECO using the Type I test protocol. A select number of tests will be completed at -6C in freezing rain as this is the more appropriate protocol. Tests will be conducted in two of the freezing precipitation conditions encompassed by the Type III HOT table, as follows:

  - Freezing Rain: -6°C, 13 $g/dm^2/h$ 100/0
  - Freezing Rain: -6°C, 13 $g/dm^2/h$ 75/25
  - Freezing Rain: -6°C, 13 $g/dm^2/h$ 50/50
  - Freezing Rain: -6°C, 25 $g/dm^2/h$ 100/0
  - Freezing Rain: -6°C, 25 $g/dm^2/h$ 75/25
  - Freezing Rain: -6°C, 13 $g/dm^2/h$ 50/50

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 the new fluid endurance time tests is given in Table 1. All tests will be conducted on the main test stand.

2.2 Thickness of New Fluids (Fluid Thickness)

The objective of these tests is to measure the thickness of the Type I non-glycol fluid 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* (2) and can be found in Transport Canada Report TP 13991E, Appendix I.

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.

2.3 NCAR Snowmaker Testing (Snowmaker)

Testing will be conducted with the NCAR snowmaker to verify the snow HOTs. Additional testing will be completed over the winter of 2013-14 in outdoor snow. The snowmaker testing will be completed in Montreal at the APS test site at the same time as the freezing precipitation testing is being conducted in Ottawa.

APS developed a specific procedure for testing in artificial snow based on the requirements outlined in ARP5485 (currently ARP5945 does not provide a procedure for artificial snow testing). Key details of the procedure include:

- Tests are conducted on a standard plate with insulated tray;
- Fluid is diluted to a freeze point 10°C below ambient temperature using information provided by the fluid manufacturer;
- Fluid is applied at a temperature of 60°C;
- 0.5 L of fluid is applied to the test surface with a 12-hole spreader; and
- For each test with a new Type I fluid, a test with a Type I reference fluid is conducted also. The reference fluid is a Type I fluid that was used in the determination of the current Type I generic holdover times.

2.4 Calibration of Replacement Ice Pellet Dispenser

It has recently become known that the seed spreaders, historically modified and used for applying ice pellets during wind tunnel and flat plate testing, are no longer available as the manufacturer has stopped production of the model. A new replacement seed spreader system has been found which is similar (but not identical), and may be a suitable replacement (with necessary modifications), however some calibration work needs to be done to demonstrate an equivalency in the two systems: the historical system versus the new replacement system. Calibration work will be performed using simulated ice pellets dispensed over a know area to demonstrate the equivalency of the two systems. A footprint area of approximately 60″ x 60″ using 15 plastic 12″x20″ rate pans has been selected; the original work was done using an area of 66″ x 66″ using 121 plastic 6″x6″ pans, however this level of detail is not necessary at this time. A test plan has not been issued as the exact test plan will be determined on an ad-hoc basis depending on visual evaluations of the performance of the new system early on in the evaluation; however at a minimum testing will require 1KG of ice pellets to be dispensed by each of the two systems over the 15 pans in the 60″ x 60″ area. No data from is necessary as the NRC electronic rate file will be used and modified as necessary.

3. PERSONNEL REQUIREMENTS/RESPONSIBILITIES

The personnel responsibilities are listed below.

1. New Fluid ETs:
   - Manager: JD (pours fluids, calls failures)
   - Assistant: YOW1 (preps fluids/data forms)
   - Rates Team: VZ, YOW2
2. Fluid Thickness:
   - Manager: JD (runs tests, takes measurements)
   - Assistant: YOW1 (records measurements)
3. Snowmaker:
   - Manager: DY (runs tests, takes measurements)
4. The Rates Team will consist of:
   - Rate Manager: VZ (runs rate station)
   - Rate Assistant: YOW2 (runs pans, refills fluids)
5. In addition, personnel will be designated responsible for:
   - Equipment: JD/VZ/YOW1
   - Pre-test Setup: JD/VZ
   - Data Form Manager: VZ
   - HOT Data Management: VZ
   - Fluid Management: VZ
6. Calibration of Replacement Ice Pellet Dispenser
   - Manage project: MR
   - Support: YOW3

4. FLUIDS

The required fluids and fluid quantities are shown in Table 3.

5. EQUIPMENT

Table 4 provides a list of the general equipment required.

6. DATA FORMS

The data forms required for each project are listed below.

1. New Fluid ETs:
   - Freezing Precipitation Endurance Time Data Form (Figure 3)
   - Rate Management Form (Figure 4)
2. Fluid Thickness:
   - Fluid Thickness Data Form (Figure 5)
3. Snowmaker:
   - Snowmaker End Condition Data Form (Figure 6)

7. PRE–TEST SET–UP ACTIVITIES

The following activities need to be completed prior to arrival at the NRC:

1. Prepare labels for pour containers (VZ)
2. Clean and label 1 litre pour containers (VZ)
3. Check laptops (2) work for rate station (VZ)
4. Rent cube van or moving company (VZ)
5. Book hotel (VZ)
6. Update and print chamber settings file (EA)
7. Print data forms and procedures (EA)
8. Print chamber condition sheets (VZ)
9. Back up MTL drive (Projects and General folders) (EA)
10. Adapt and modify new dispenser system (MR)

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.
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 2004.
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. SAE Aerospace Recommended Practice 5945, Endurance Time Tests for Aircraft Deicing/Anti-icing Fluids: SAE Type I, October 2005.

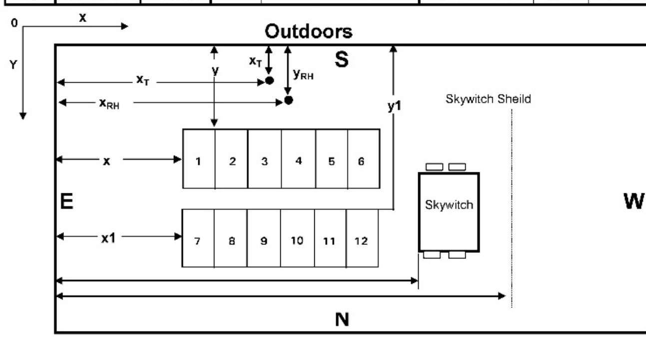
FIGURE 1: TEST SCHEDULE

	Mon Sep 16	Tues Sep 17	Wed Sep 18	Thurs Sep 19	Fri Sep 20
8:00		Unpackup and setup	**ZF,-25,2** HOT=4		
8:30					
9:00			**ZF,-25,5** HOT=4		
9:30					
10:00		**ZD,-3,5** HOT=4	Warm to -10	Drive to YUL	
10:30			**ZF,-10,5** HOT=4		
11:00		**ZD,-3,13** HOT=4			
11:30			**ZF,-10,2** HOT=4		
12:00					
12:30		Cool to -6	Cool to -6		
13:00	Packup Drive to YOW	**ZD,-6,13** HOT=4	**ZF,-6,2** HOT=4		
13:30					
14:00		**ZD,-6,5** HOT=4	**ZF,-6,5** HOT=4		
14:30					
15:00					
15:30		**ZR,-6,13** HOT=4 TYPE III = 6			
16:00			**ZF,-3,5** HOT=4		
16:30		**ZR,-6,25** HOT=4 TYPE III = 6			
17:00			**ZF,-3,2** HOT=4		
17:30		Cool to -10			
18:00		**ZR,-10,25** HOT=4	Warm to +1		
18:30			**CSW,1,5** HOT=4		
19:00		**ZR,-10,13** HOT=4			
19:30			**CSW,1,75** HOT=4		
20:00					
20:30		**ZD,-10,13** HOT=4	Packup		
21:00					
21:30		**ZD,-10,5** HOT=4			
22:00					
22:30					
23:00					

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	04-Apr-01	ZR3H					24' 2"	7'	22' 7"	9' 10"				Very Good		Top Stand 19' from snow fence
2	04-Apr-01	ZR3L					24' 2"	7'	22' 7"	9' 10"				Very Good		Top Stand 19' from snow fence
3	02/04/2001	ZR10H					24'	6' 9"	24' 5"	9' 6"				Very Good		Top stand is 20 ft. from snow fence
4	02-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	02-Apr-01	ZD10H					24'	7'11"	25' 3"	9' 6"				Very Good		
8	02-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	09-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	09-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	06-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	06-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						

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, SEPTEMBER 2013

TABLE 1: ENDURANCE TIME TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid Name	Fluid Dilution (%)	Test Surface	Comments
1	Freezing Fog	-3	2	BGS DEFROSOL ADF	10°B (B=24.0)	Al. Plate	
2	Freezing Fog	-3	2	BGS DEFROSOL ADF	10°B (B=24.0)	Al. Plate	
3	Freezing Fog	-3	2	BGS DEFROSOL ADF	10°B (B=24.0)	Comp. Plate	
4	Freezing Fog	-3	2	BGS DEFROSOL ADF	10°B (B=24.0)	Comp. Plate	
5	Freezing Fog	-3	5	BGS DEFROSOL ADF	10°B (B=24.0)	Al. Plate	
6	Freezing Fog	-3	5	BGS DEFROSOL ADF	10°B (B=24.0)	Al. Plate	
7	Freezing Fog	-3	5	BGS DEFROSOL ADF	10°B (B=24.0)	Comp. Plate	
8	Freezing Fog	-3	5	BGS DEFROSOL ADF	10°B (B=24.0)	Comp. Plate	
9	Freezing Fog	-6	2	BGS DEFROSOL ADF	10°B (B=27.25)	Al. Plate	
10	Freezing Fog	-6	2	BGS DEFROSOL ADF	10°B (B=27.25)	Al. Plate	
11	Freezing Fog	-6	2	BGS DEFROSOL ADF	10°B (B=27.25)	Comp. Plate	
12	Freezing Fog	-6	2	BGS DEFROSOL ADF	10°B (B=27.25)	Comp. Plate	
13	Freezing Fog	-6	5	BGS DEFROSOL ADF	10°B (B=27.25)	Al. Plate	
14	Freezing Fog	-6	5	BGS DEFROSOL ADF	10°B (B=27.25)	Al. Plate	
15	Freezing Fog	-6	5	BGS DEFROSOL ADF	10°B (B=27.25)	Comp. Plate	
16	Freezing Fog	-6	5	BGS DEFROSOL ADF	10°B (B=27.25)	Comp. Plate	
17	Freezing Fog	-10	2	BGS DEFROSOL ADF	10°B (B=31.25)	Al. Plate	
18	Freezing Fog	-10	2	BGS DEFROSOL ADF	10°B (B=31.25)	Al. Plate	
19	Freezing Fog	-10	2	BGS DEFROSOL ADF	10°B (B=31.25)	Comp. Plate	
20	Freezing Fog	-10	2	BGS DEFROSOL ADF	10°B (B=31.25)	Comp. Plate	
21	Freezing Fog	-10	5	BGS DEFROSOL ADF	10°B (B=31.25)	Al. Plate	
22	Freezing Fog	-10	5	BGS DEFROSOL ADF	10°B (B=31.25)	Al. Plate	
23	Freezing Fog	-10	5	BGS DEFROSOL ADF	10°B (B=31.25)	Comp. Plate	
24	Freezing Fog	-10	5	BGS DEFROSOL ADF	10°B (B=31.25)	Comp. Plate	
25	Freezing Fog	-25	2	BGS DEFROSOL ADF	10°B (B=41.0)	Al. Plate	
26	Freezing Fog	-25	2	BGS DEFROSOL ADF	10°B (B=41.0)	Al. Plate	
27	Freezing Fog	-25	2	BGS DEFROSOL ADF	10°B (B=41.0)	Comp. Plate	
28	Freezing Fog	-25	2	BGS DEFROSOL ADF	10°B (B=41.0)	Comp. Plate	
29	Freezing Fog	-25	5	BGS DEFROSOL ADF	10°B (B=41.0)	Al. Plate	
30	Freezing Fog	-25	5	BGS DEFROSOL ADF	10°B (B=41.0)	Al. Plate	
31	Freezing Fog	-25	5	BGS DEFROSOL ADF	10°B (B=41.0)	Comp. Plate	
32	Freezing Fog	-25	5	BGS DEFROSOL ADF	10°B (B=41.0)	Comp. Plate	
33	Light Freezing Rain	-6	13	BGS DEFROSOL ADF	10°B (B=27.25)	Al. Plate	
34	Light Freezing Rain	-6	13	BGS DEFROSOL ADF	10°B (B=27.25)	Al. Plate	
35	Light Freezing Rain	-6	13	BGS DEFROSOL ADF	10°B (B=27.25)	Comp. Plate	
36	Light Freezing Rain	-6	13	BGS DEFROSOL ADF	10°B (B=27.25)	Comp. Plate	
37	Light Freezing Rain	-6	25	BGS DEFROSOL ADF	10°B (B=27.25)	Al. Plate	
38	Light Freezing Rain	-6	25	BGS DEFROSOL ADF	10°B (B=27.25)	Al. Plate	
39	Light Freezing Rain	-6	25	BGS DEFROSOL ADF	10°B (B=27.25)	Comp. Plate	
40	Light Freezing Rain	-6	25	BGS DEFROSOL ADF	10°B (B=27.25)	Comp. Plate	
41	Light Freezing Rain	-10	13	BGS DEFROSOL ADF	10°B (B=31.25)	Al. Plate	
42	Light Freezing Rain	-10	13	BGS DEFROSOL ADF	10°B (B=31.25)	Al. Plate	
43	Light Freezing Rain	-10	13	BGS DEFROSOL ADF	10°B (B=31.25)	Comp. Plate	
44	Light Freezing Rain	-10	13	BGS DEFROSOL ADF	10°B (B=31.25)	Comp. Plate	
45	Light Freezing Rain	-10	25	BGS DEFROSOL ADF	10°B (B=31.25)	Al. Plate	
46	Light Freezing Rain	-10	25	BGS DEFROSOL ADF	10°B (B=31.25)	Al. Plate	
47	Light Freezing Rain	-10	25	BGS DEFROSOL ADF	10°B (B=31.25)	Comp. Plate	
48	Light Freezing Rain	-10	25	BGS DEFROSOL ADF	10°B (B=31.25)	Comp. Plate	
49	Freezing Drizzle	-3	5	BGS DEFROSOL ADF	10°B (B=24.0)	Al. Plate	

TABLE 1: ENDURANCE TIME TEST PLAN (CONT'D)

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid Name	Fluid Dilution (%)	Test Surface	Comments
50	Freezing Drizzle	-3	5	BGS DEFROSOL ADF	10°B (B=24.0)	Al. Plate	
51	Freezing Drizzle	-3	5	BGS DEFROSOL ADF	10°B (B=24.0)	Comp. Plate	
52	Freezing Drizzle	-3	5	BGS DEFROSOL ADF	10°B (B=24.0)	Comp. Plate	
53	Freezing Drizzle	-3	13	BGS DEFROSOL ADF	10°B (B=24.0)	Al. Plate	
54	Freezing Drizzle	-3	13	BGS DEFROSOL ADF	10°B (B=24.0)	Al. Plate	
55	Freezing Drizzle	-3	13	BGS DEFROSOL ADF	10°B (B=24.0)	Comp. Plate	
56	Freezing Drizzle	-3	13	BGS DEFROSOL ADF	10°B (B=24.0)	Comp. Plate	
57	Freezing Drizzle	-6	5	BGS DEFROSOL ADF	10°B (B=27.25)	Al. Plate	
58	Freezing Drizzle	-6	5	BGS DEFROSOL ADF	10°B (B=27.25)	Al. Plate	
59	Freezing Drizzle	-6	5	BGS DEFROSOL ADF	10°B (B=27.25)	Comp. Plate	
60	Freezing Drizzle	-6	5	BGS DEFROSOL ADF	10°B (B=27.25)	Comp. Plate	
61	Freezing Drizzle	-6	13	BGS DEFROSOL ADF	10°B (B=27.25)	Al. Plate	
62	Freezing Drizzle	-6	13	BGS DEFROSOL ADF	10°B (B=27.25)	Al. Plate	
63	Freezing Drizzle	-6	13	BGS DEFROSOL ADF	10°B (B=27.25)	Comp. Plate	
64	Freezing Drizzle	-6	13	BGS DEFROSOL ADF	10°B (B=27.25)	Comp. Plate	
65	Freezing Drizzle	-10	5	BGS DEFROSOL ADF	10°B (B=31.25)	Al. Plate	
66	Freezing Drizzle	-10	5	BGS DEFROSOL ADF	10°B (B=31.25)	Al. Plate	
67	Freezing Drizzle	-10	5	BGS DEFROSOL ADF	10°B (B=31.25)	Comp. Plate	
68	Freezing Drizzle	-10	5	BGS DEFROSOL ADF	10°B (B=31.25)	Comp. Plate	
69	Freezing Drizzle	-10	13	BGS DEFROSOL ADF	10°B (B=31.25)	Al. Plate	
70	Freezing Drizzle	-10	13	BGS DEFROSOL ADF	10°B (B=31.25)	Al. Plate	
71	Freezing Drizzle	-10	13	BGS DEFROSOL ADF	10°B (B=31.25)	Comp. Plate	
72	Freezing Drizzle	-10	13	BGS DEFROSOL ADF	10°B (B=31.25)	Comp. Plate	
73	Cold Soak Box	1	5	BGS DEFROSOL ADF	10°B (B=19.0)	Al. Box	
74	Cold Soak Box	1	5	BGS DEFROSOL ADF	10°B (B=19.0)	Al. Box	
75	Cold Soak Box	1	5	BGS DEFROSOL ADF	10°B (B=19.0)	Comp. Box	
76	Cold Soak Box	1	5	BGS DEFROSOL ADF	10°B (B=19.0)	Comp. Box	
77	Cold Soak Box	1	75	BGS DEFROSOL ADF	10°B (B=19.0)	Al. Box	
78	Cold Soak Box	1	75	BGS DEFROSOL ADF	10°B (B=19.0)	Al. Box	
79	Cold Soak Box	1	75	BGS DEFROSOL ADF	10°B (B=19.0)	Comp. Box	
80	Cold Soak Box	1	75	BGS DEFROSOL ADF	10°B (B=19.0)	Comp. Box	

TABLE 2: FLUID THICKNESS TEST PLAN

Test #	Fluid Code	Fluid Dilution	Test Surface	Ambient Air Temperature
TH1	BGS	10°B (B=24.0)	Al. Plate	-3°C
TH2	BGS	10°B (B=24.0)	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

TABLE 4: BGS DEFROSOL ADF SIMULATED SNOW TEST PLAN

Test #	Fluid	Dilution	Condition Temperature (°C)	Precipitation Rate (g/dm²/h)	Plate Set Temp ±0.5 (°C)	Generic HOT (mins)
1	BGS Defrosol ADF	10° Buffer (Brix =24.00)	-3	25	-5.1	3
2	Octagon Octoflo EF	10° Buffer (Brix =21.25)	-3	25	-5.1	3
3	BGS Defrosol ADF	10° Buffer (Brix =24.00)	-3	4	-3.8	12
4	Octagon Octoflo EF	10° Buffer (Brix =21.25)	-3	4	-3.8	12
5	BGS Defrosol ADF	10° Buffer (Brix =24.00)	-3	10	-4.2	6
6	Octagon Octoflo EF	10° Buffer (Brix =21.25)	-3	10	-4.2	6

1. The fluid temperature is within 3°C of the enclosure temperature.
2. The enclosure temperature is typically 2°C below the plate temperature (no tolerance specified).
3. The plate temperature shall be within ±0.5 (°C)
4. Measurement of Brix at 15 cm line is required at time of failure.
5. Photo should be taken at time of failure. Position camera at an angle of 30 degrees facing the plate and capturing the whole plate + 20%.

TABLE 3: LIST OF FLUIDS

TYPE I									
Fluid Name/Code	Batch #	Test Temp	FFP	Brix	Litres Required per Project				Pour Bottles
					ET	TH	SNMK	ALL	
BGD Defrosol ADF	56-130619	1	-9	19	8	-	-	**8**	**8***
BGD Defrosol ADF	56-130619	-3	-13	24	16	2	3	**21**	**8**
BGD Defrosol ADF	56-130619	-6	-16	27.25	24	-	-	**24**	**8**
BGD Defrosol ADF	56-130619	-10	-20	31.25	24	-	-	**24**	**8**
BGD Defrosol ADF	56-130619	-25	-35	41	8	-	-	**8**	**8***
Octagon Octaflo EF	WL102009	-3	-13	21.25	-	-	3	**3**	**2**
ALL					**80**	**2**	**6**	**88**	**42**

*No other containers needed (for Type Is bring some extra concentrate)

TABLE 4: GENERAL EQUIPMENT LIST

EQUIPMENT	LOCATION
1L Pour containers (see separate list)	Site
Boards for cold-soak test x 4	Site
Camera x 1	Site
Brixometer x 3	Site
Cold-soak boxes x 4 (2x alum + 2 x comp)	Site
Collection pans for stands (one per stand)	Site
Electrical Extension Cords x 4	Site
Empty 20 L cont. for -30C CSW fluid x 2	Site
Flashlights x 2	Site
Fluids (see separate Table 14)	Site
Funnels x 1 (small)	Site
Gloves - black and yellow	Site
Gloves - cotton (5 packs)	Site
Gloves - latex (1 boxes)	Site
Hard water chemicals x1	Site
Inclinometer (yellow level) x 2	Site
Isopropyl x 6	Site
Large digital clock x 1	Site
Marker for Waste x 1	Site
Mixing bins for CSW fluid x 2 (rubbermaids)	Site
Paper Towels (2 packs)	Site
Plate covers x 12	Site
Plates: 12 w/smart buttons	Site
Precipitation Rate Pans (whole set)	Site
Printer & Ink Cartridge	Site
Protective clothing x 2 and personel clothing	Site
Rubber squeegees x 2	Site
Scrapers x 4	Site
Shelving unit x 1 (black one)	Site
Shop Vac + Sump Pump + Tubing	Site
Smart button connector + extension wire	Site
Speed tape x 1	Site
Temperature probes: immersion x 2	Site
Temperature probes: surface x 2	Site

EQUIPMENT	LOCATION
Ice pellets Styrofoam containers x10	Site
Ice bags (to be delivered to NRC)	Site
Blenders x3	Site
Ice pellets sieves (pan, 1.4mm, and 4mm)	Site
Large folding table x1	Site
1L Measuring cups x 3	Site
Wooden Spoons x2	Site
Rubber Mats x 4	Site
NCAR Scale x1	Site
Ice pellets dispersers x4 (2 new and 2 old)	Site
Stands for ice pellets dispensing devices x2	Site
Ice Pellet control wires and boxes (all)	Site
RPM gauge with reflective stickers	Site
15 plastic rate pans numbered 1-12 and 1s-3s	Site
Rate station (Sartorius scale, laptop, and wiring) *Could consider using HOT station.*	Site

EQUIPMENT	LOCATION
Temperature readers x 2	Site
Test Stand Shims (poker chips) x 1 box	Site
Test Stands: 2 x 6-position (main stand)	Site
Test Stands: 2 position stand (thickness stand)	Site
Thickness Gauges (1 x small 1 x large)	Site
Walkie Talkies x 4	Site
Waste containers (use 20 L pails) x 2	Site
Weigh Scale x 2 (sartorius) + wiring	Site
Cold-soak box filling stand	NRC
Cold-soak fluid pump	NRC
Copper tubing insulation (for passing wires)	NRC
Fluid for cold-soak boxes (barrel)	NRC
Rubber Mats	NRC
Tie wraps	NRC
Tools	NRC
Tote for Waste Fluid	NRC
Accordian Folder	Office
Chamber Settings + Stand settings	Office
Clipboards x 4	Office
Data Forms (on water phobic paper)	Office
Envelopes (9x12) x box	Office
Hard Drive with Current Project folder	Office
iPads x 2	Office
Laptop for smart button (MR)	Office
Mouse for Rate Station and keypad	Office
Paper for printer (1 pack)	Office
Pencils (sharpened) + pens + markers	Office
Test Procedures x 2 (1 sided)	Office
Waterproof paper (100 sheets)	Office

FIGURE 3: 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)

	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. 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

	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. 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

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: ____________________

OVERALL PROGRAM OF TESTS AT NRC, SEPTEMBER 2013

FIGURE 4: 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

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Final Version 1.0, Sept 13

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FIGURE 5: 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**

OVERALL PROGRAM OF TESTS AT NRC, SEPTEMBER 2013

FIGURE 6: SNOWMAKER END CONDITION DATA FORM

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)

Final Brix (o)

B2	C1	C2	C3	D2	E2

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Final Version 1.0, Sept 13

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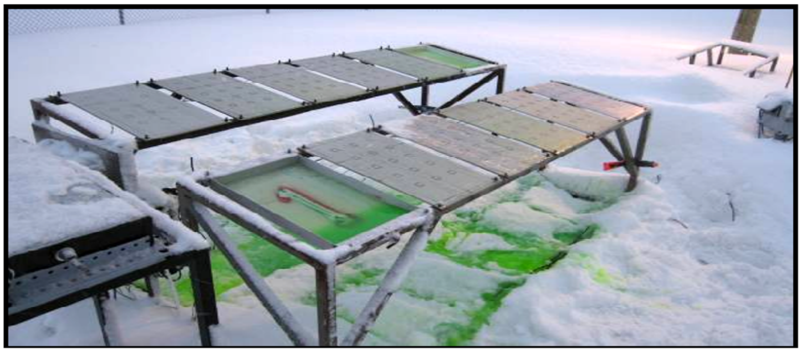
APPENDIX C

FLUID MANUFACTURER REPORT:
BALTIC GROUND SERVICES DEFROSOL ADF (TYPE I)

AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

Baltic Ground Services Defrosol ADF (Type I)



Prepared for

Baltic Ground Services

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.

September 2013
Version 1.0
Report No. BGS-D 2012-13

AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

Baltic Ground Services Defrosol ADF (Type I)

Prepared for

Baltic Ground Services

Prepared by:

Sept. 24, 2013

Stephanie Bendickson
Project Analyst

Date

Reviewed by:

Sept. 24, 2013

John D'Avirro, Eng.
Program Manager

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.

September 2013
Version 1.0
Report No. BGS-D 2012-13

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FLUID IDENTIFICATION AND CHARACTERISTICS

Manufacturer:	Baltic Ground Services
Fluid Test Name:	Defrosol ADF
Fluid Commercial Name:	Defrosol ADF
Fluid Type / Colour:	Type I / Orange
Fluid Formulation:	Non-glycol (Propylene Glycol and Glycerin)
Batch #:	56-130619
Date of Receipt:	July 24, 2013
Brix (Measured):	Concentrate: > 50°
WSET (from AMIL):	5.0 minutes

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SUMMARY

The primary objective of this project was to measure the endurance time performance of Baltic Ground Services Defrosol ADF over the entire range of conditions encompassed by the Type I 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 and the Federal Aviation Administration (FAA).

Tests were carried out according to the protocol provided in Aerospace Recommended Practice (ARP) 5945. The test procedure consisted of pouring fluids onto clean aluminum and composite test surfaces inclined at 10°; the onset of failure was recorded as a function of time in simulated freezing fog, freezing drizzle, light freezing rain, rain on cold soaked wing and snow. Tests were performed at the National Research Council Canada (NRC) Climatic Engineering Facility (CEF) in Ottawa, Ontario and at the APS Aviation Inc. (APS) test facility located at the Pierre-Elliott-Trudeau International Airport in Montreal, Quebec.

The endurance times measured with this fluid are similar or superior to those of Type I fluids tested in past years. As a result, it was concluded that Baltic Ground Services Defrosol ADF can be used with the Type I generic HOT guidelines.

Natural snow tests will be carried out over the winter of 2013-14 to confirm the artificial snow results.

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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
LWC	Liquid Water Content
MVD	Median Volume Diameter
MANOBS	Manual of Surface Weather Observations
NCAR	National Center for Atmospheric Research
NRC	National Research Council Canada
TDC	Transportation Development Centre

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1. INTRODUCTION

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 de/anti-icing fluid holdover time (HOT) tables. 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.

Testing has shown that Type II and Type IV fluid endurance time performance varies considerably by fluid. As a result, endurance time testing is carried out with all Type II and Type IV fluids and fluid-specific HOT tables are developed for each Type II/IV fluid based on the results of the testing.

In contrast, a significant body of previous research and testing has indicated the endurance time performance of all Type I fluids formulated with glycol is similar. As a result, all Type I fluids are used with the Type I generic holdover times (no fluid-specific holdover times are provided) and regulators no longer require endurance time testing be conducted with Type I fluids formulated with propylene glycol, ethylene glycol or diethylene glycol. However, they do require the endurance time performance of fluids formulated with other glycol bases or with non-glycol bases be measured. This is to ensure the endurance time performance of these fluids is similar to the performance of the Type I fluids that were used to generate the current Type I generic holdover times.

This report provides a detailed account of the endurance time testing APS Aviation Inc. (APS) carried out with **Baltic Ground Services (BGS) Defrosol ADF**, a new Type I fluid formulated with a non-glycol base. It describes the test methodology used, endurance time data collected, and conclusions derived from the results.

This report has been created with the support of the fluid manufacturer, the Transport Development Centre (TDC) of Transport Canada and the Federal Aviation Administration (FAA).

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2

2. METHODOLOGY

SAE Aerospace Recommended Practice (ARP) 5945 provides the procedure and requirements for endurance time testing with Type I fluids under natural and simulated conditions. This chapter summarizes some of aspects of the test methodology included in ARP5945, and some aspects which are not included in ARP5945. The chapter includes sections for test sites, equipment, procedures, precipitation rates and ambient temperatures used in Type I endurance time testing, and freezing precipitation droplet sizes. The final subsection describes the analysis methodology used to evaluate Type I endurance time data.

2.1 Test Sites

Natural and artificial snow testing is 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. Photos 2.1 and 2.2 show the test site as seen from the test pads and main trailer, respectively.

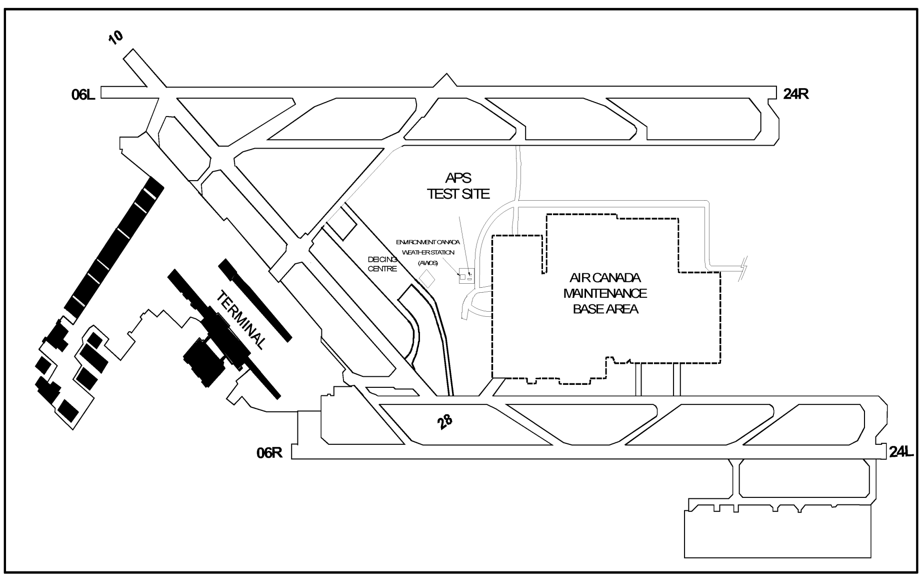

Figure 2.1: APS Test Site at Montréal-Pierre-Elliott-Trudeau International Airport

Tests under conditions of simulated freezing fog, freezing drizzle, light freezing rain and rain on cold soaked wing are conducted indoors at the National Research Council (NRC) Climatic Engineering Facility (CEF), where precipitation is 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.

2.2 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.

2.2.1 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.

2.2.2 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 ARP5945.

2.2.3 Test Surface Structures

The majority of endurance time testing is carried out on standard flat plates. A schematic of a standard flat plate is provided in Figure 2.2. 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 2.3.3) are achieved. Photo 2.5, taken outdoors at the APS test site, shows six test plates mounted on a test stand.

Figure 2.3 shows a schematic of the sealed boxes used for tests simulating a cold soaked wing and in natural snow testing with Type I fluids. The top of the box consists of a flat plate identical to the standard flat plate. A box shaped reservoir is welded to the bottom of the plate. Photo 2.6 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 and a leading edge thermal equivalent box when used empty for testing Type I fluids in natural snow conditions.

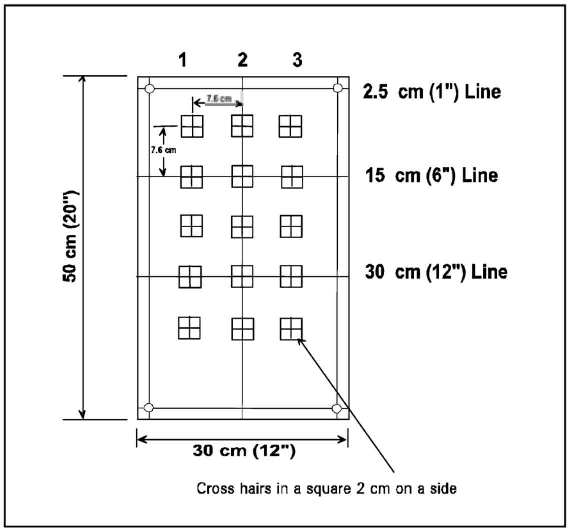

Figure 2.2: Standard Test Plate Schematic

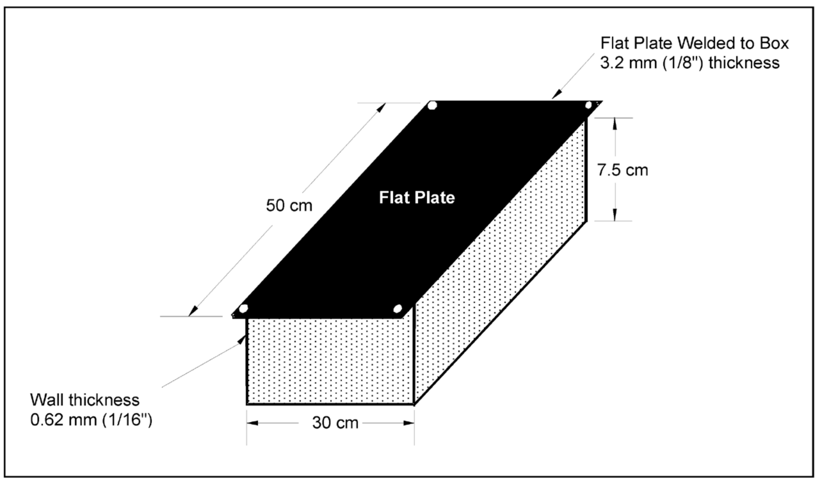

Figure 2.3: Cold Soak Box Schematic

2.2.4 Test Surface Materials

Research has shown endurance times of Type I fluids can be shorter on composite surfaces than on aluminum surfaces. For many years all test surfaces used in endurance time testing were constructed of aluminum. However, since Transport Canada and the FAA implemented new holdover times for composite surfaces in the winter of 2010-11, all Type I fluids evaluated for endurance time performance are tested on both aluminum and composite surfaces. The details of the test surface materials are as follows:

- Aluminum: Alclad 2024 T3 aluminum, 0.32 cm thick; and
- Composite: Carbon fibre cross weave fabric, 0.32 cm thick.

Previous research has shown this composite material produces endurance time results representative of many composite aircraft materials.

2.2.5 Test Stands

Figure 2.4 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. Photos 2.4 and 2.5 show the test stands set up for indoor and outdoor testing, respectively.

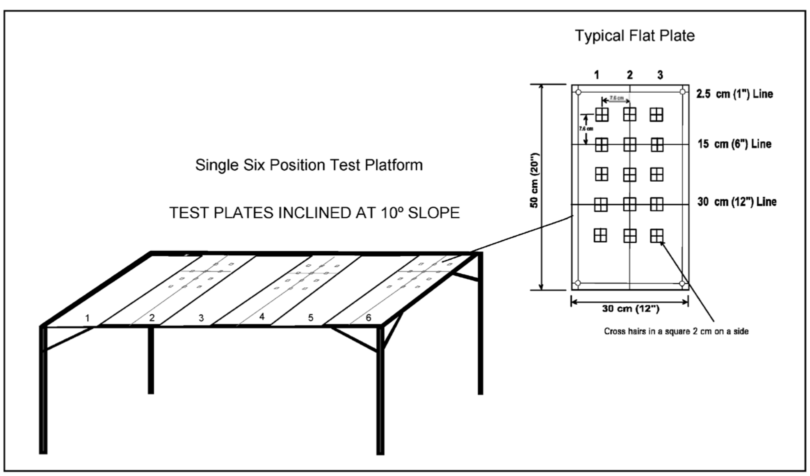

Figure 2.4: Test Stand Setup Schematic

2.2.6 Collection Pans

Figure 2.5 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 2.7 shows the collection pans used for measuring precipitation rates indoors at the NRC.

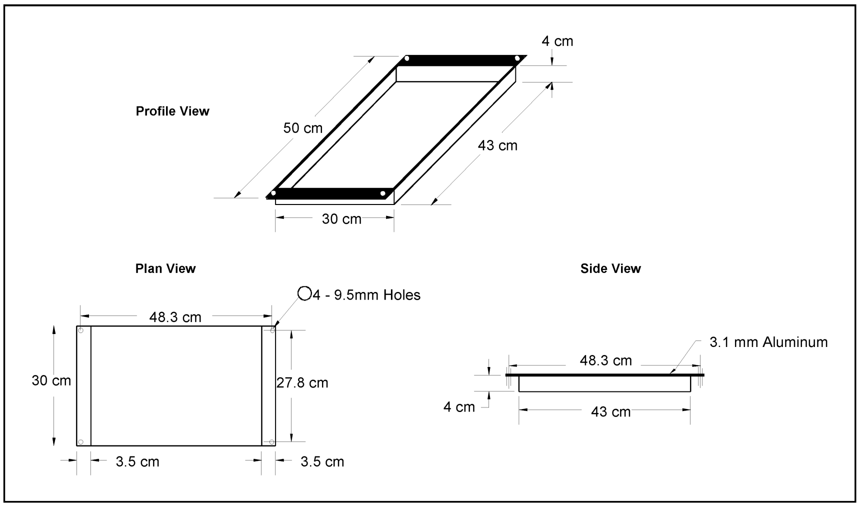

Figure 2.5: Schematic of Outdoor Precipitation Measurement Pan

2.2.7 NRC Sprayer Assembly

NRC developed an improved sprayer assembly, shown in Photos 2.8 and 2.9, 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 2.10.

2.2.8 Refractometer

Freeze points were measured using a hand-held Misco refractometer with a Brix scale (see Photo 2.11)

2.2.9 12-Hole Spreader

A 12-hole spreader is used to apply fluids during natural snow tests (see Photo 2.12).

2.2.10 Fluids

Testing was carried out using fluid diluted to a freeze point 10°C below the ambient temperature. Information provided by the manufacturer was used to develop the dilution table shown in Table 2.1, which was used to mix the fluid to the appropriate freeze point for each test.

Table 2.1: BGS Defrosol ADF Dilution Table

Test Temp. (°C)	**FFP** (°C)	**Fluid** %	**Brix** (°)	**Fluid for 4 L**	**Water for 4 L**
+1	-9	27.6	19.0	1.10	2.90
-3	-13	35.7	24.0	1.43	2.57
-6	-16	40.7	27.5	1.63	2.37
-10	-20	46.3	31.25	1.85	2.15
-25	-35	60.4	41.0	2.42	1.58

2.3 Test Procedures

ARP5945 provides the procedure for endurance time testing of Type I 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 2.3.3), when a specified degree of freezing occurs.

The following subsections provide summaries of the test procedures followed for testing in natural snow, artificial snow and simulated freezing precipitation.

2.3.1 Test Protocol – Natural Snow Tests

APS developed a specific procedure for Type I testing in natural snow based on the requirements outlined in ARP5945. Key details of the procedure include:

- Tests are conducted on empty leading edge thermal equivalent boxes (see Subsection 2.2.3);
- Fluid is applied at a temperature of 60ºC;
- 0.5 L of fluid is applied to the test surface with a 12-hole spreader; and
- For each test with a new Type I fluid, a test with a Type I reference fluid is conducted simultaneously. The reference fluid is a Type I fluid that was used in the determination of the current Type I generic holdover times.

2.3.2 Test Protocol – Simulated Precipitation Tests

APS developed a specific procedure for Type I testing in natural snow based on the requirements outlined in ARP5945. Key details of the procedure include:

- Freezing fog, freezing drizzle and light freezing rain tests are conducted on standard flat plates (see Section 2.2.3);
- Rain on cold-soaked surface tests are conducted on filled cold-soak boxes (see Section 2.2.3);
- Fluid is applied at a temperature of 20ºC; and
- 1 L of fluid is hand-poured on the test surface.

2.3.3 Test Protocol – Artificial Snow Tests

APS developed a specific procedure for Type I testing in artificial snow based on the requirements outlined in ARP5485 (ARP5945 does not currently include a procedure for artificial snow testing). Key details of the procedure include:

- Tests are conducted on a standard test plate with insulated tray (see Photo 2.13);
- Fluid is applied at a temperature of 60ºC;
- 0.5 L of fluid is applied to the test surface with a 12-hole spreader; and
- For each test with a new Type I fluid, a test with a Type I reference fluid is also conducted. The reference fluid is a Type I fluid that was used in the determination of the current Type I generic holdover times.

2.3.4 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.

2.3.5 Precipitation Rate Measurement Procedures

The procedures for measuring and determining precipitation rates during simulated precipitation and natural precipitation conditions are provided below.

2.3.5.1 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, 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.

2.3.5.2 Natural precipitation conditions

Two rate collection pans per test stand are 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 anti-icing 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 (see Figure 2.4) and are allowed to collect precipitation for 10-minute intervals in normal conditions and 5-minute intervals in periods of high precipitation rates and high winds. 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 has failed.

The rate for any HOT 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 this particular test.

An example of the rate calculation method for tests in natural snow conditions is displayed in Figure 2.6. Typically, two collections pans are used for each test. The start and end times of the test shown in Figure 206 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).

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 2.6, 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.

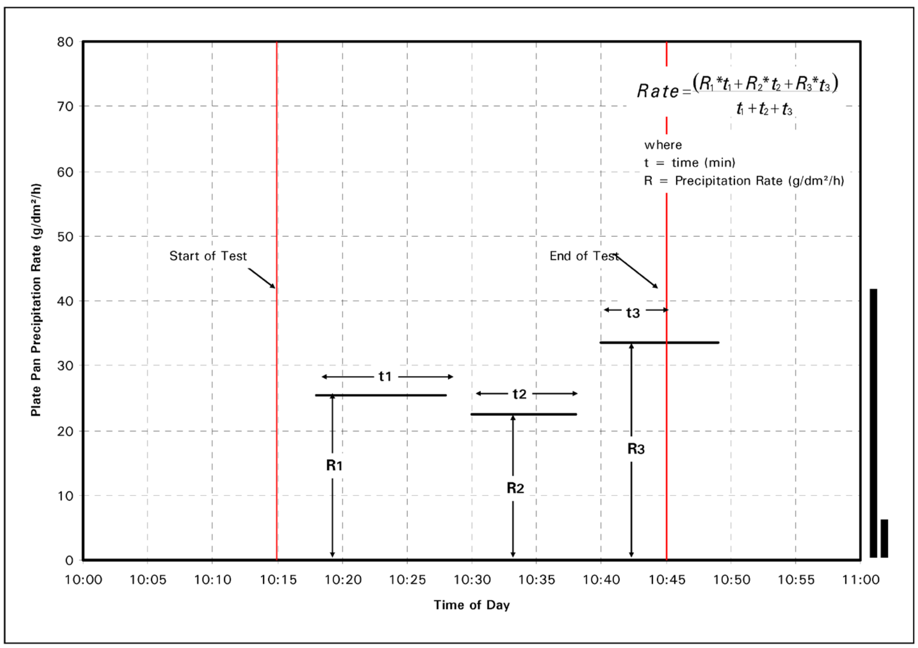

Figure 2.6: Calculation of Outdoor Precipitation Rate

2.4 Precipitation Rate Limits in Type I Endurance Time Testing

Upper and lower precipitation rate limits are an important part of the test methodology for measuring fluid endurance times. Table 2.2 provides the meteorologically accepted definitions of weather phenomenon / precipitation types. It also includes the criteria used to determine precipitation intensity. This table 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 I endurance time testing are provided in ARP5945 and represented graphically in Figure 2.7. Subsections 2.4.1 to 2.4.5 provide detailed definitions and explanations of the precipitation types and rate boundaries used in Type I 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 2.2.

Table 2.2: 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 <u>not</u> 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 <u>estimation</u> 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) gm/dm² = 0.01 cm = 0.1 mm = 0.0039 in
2) in = 2.54 cm = 25.4 mm = 254 gm/dm²

Compiled by Jeff Cole and Roy Rasmussen of NCAR/RAP Sept 8, 1999 (Updated for METAR codes)

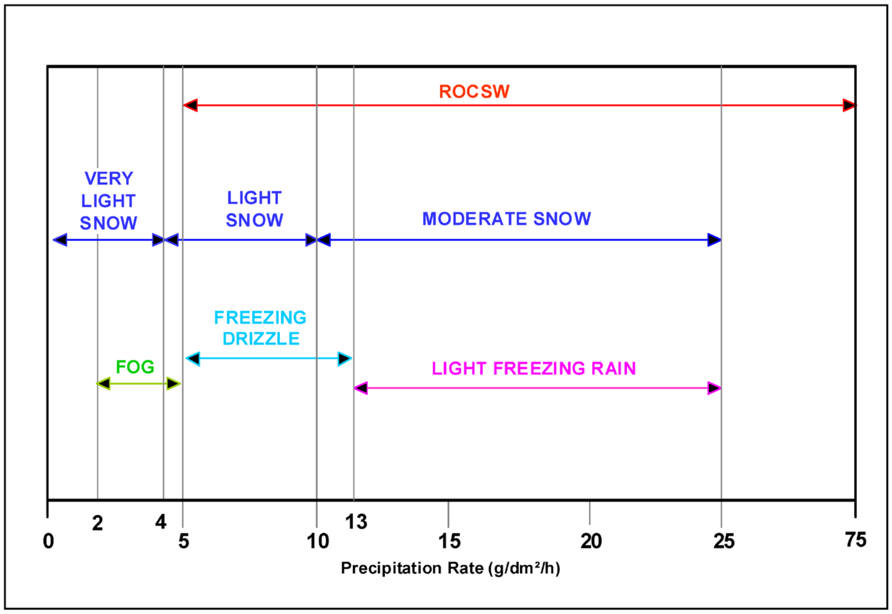

Figure 2.7: Precipitation Rate Limits Used in Endurance Time Testing

2.4.1 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.

2.4.2 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.

2.4.3 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.

2.4.4 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).

2.4.5 Snow

The precipitation rate limits used to determine snow holdover times are:

a) Very light snow: 3 and 4 g/dm^2/h;
b) Light snow: 4 and 10 g/dm^2/h; and
c) Moderate snow: 10 and 25 g/dm^2/h.

2.5 Ambient Temperatures in Type I Endurance Time Testing

The Type I generic holdover time tables provide holdover times for four temperature ranges:

- -3°C and above
- Below -3 to -6°C
- Below -6 to -10°C
- Below -10°C

In natural snow 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, -6°C, -10°C and -25°C
- Freezing Drizzle: -3°C, -6°C and -10°C
- Light Freezing Rain: -6°C and -10°C (see note below)
- Rain on Cold Soaked Surface: +1°C

Note: Testing is not carried out with Type I fluids in light freezing rain at -3°C as the latent heat of freezing in calm test conditions produces artificially long endurance times.

2.6 Freezing Precipitation Droplet Sizes

Research has shown that median volume diameter (MVD) of rain droplets is related to rate of precipitation as follows:

$MVD = (\text{precipitation rate}/10)^{0.23}$, 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 2.2 beside the experimental MVDs for each precipitation condition.

Table 2.3: 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

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 P.E.T. 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
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

2.7 Summary of Freezing Precipitation Test Conditions

The precipitation types/rates, ambient temperatures and droplet sizes for freezing precipitation testing with Type I fluids were described in the previous subsections. In summary, freezing precipitation tests are carried out under each of the 20 weather conditions listed in Table 2.4.

2.8 Analysis Methodology

The endurance time performance of Type I fluids is evaluated by comparing the data collected to the performance of historical Type I fluids (i.e. the Type I fluids the generic Type I holdover times are based on). In order for the endurance time performance of a new Type I fluid to be considered acceptable, the endurance time results need to be similar or superior to the historical fluid data.

Table 2.4: Summary of Freezing Precipitation Test Conditions (Type I Fluids)

Precipitation Type	Ambient Temperature	Precipitation Rate (Droplet Size)
Freezing Fog	-3°C	2 g/dm²/h (30 µm)
		5 g/dm²/h (30 µm)
	-6°C	2 g/dm²/h (30 µm)
		5 g/dm²/h (30 µm)
	-10°C	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)
	-6°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	-6°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)

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

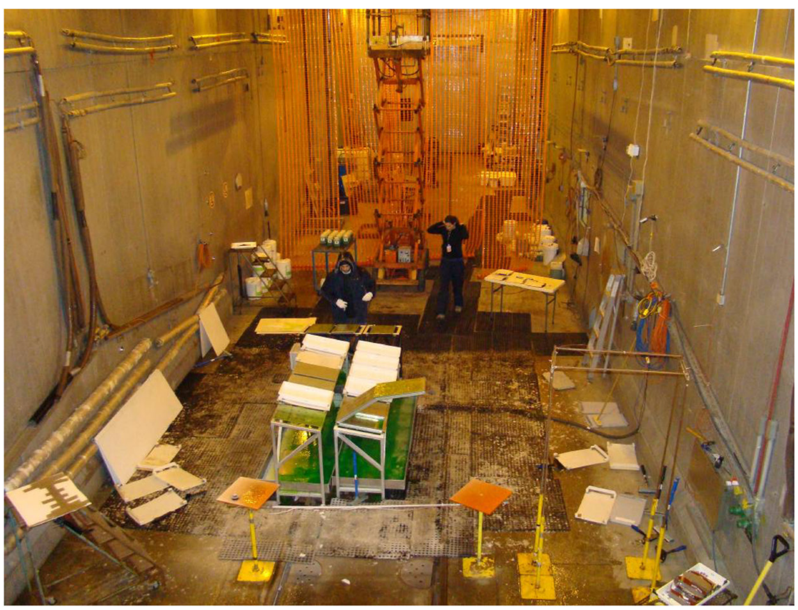

Photo 2.5: Test Plates Mounted on Stand

Photo 2.6: Cold-Soak / Leading Edge Thermal Equivalent Box

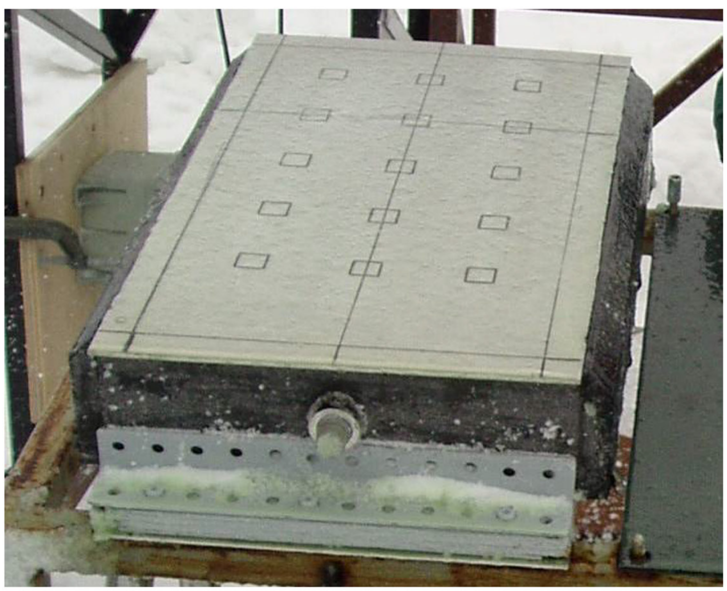

Photo 2.7: Collection Pans Used Indoors at the NRC

Photo 2.8: Sprayer Assembly

Photo 2.9: Sprayer Assembly in Use

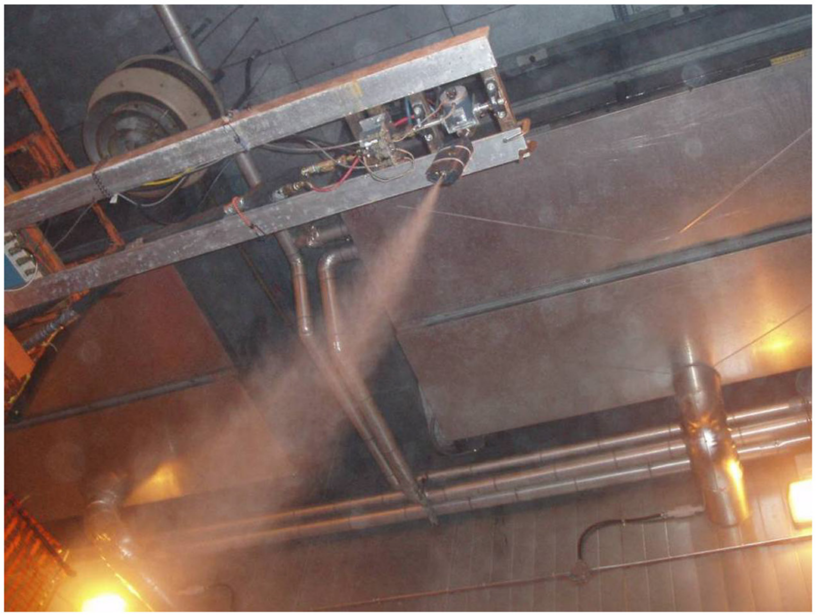

Photo 2.10: Sprayer Nozzle

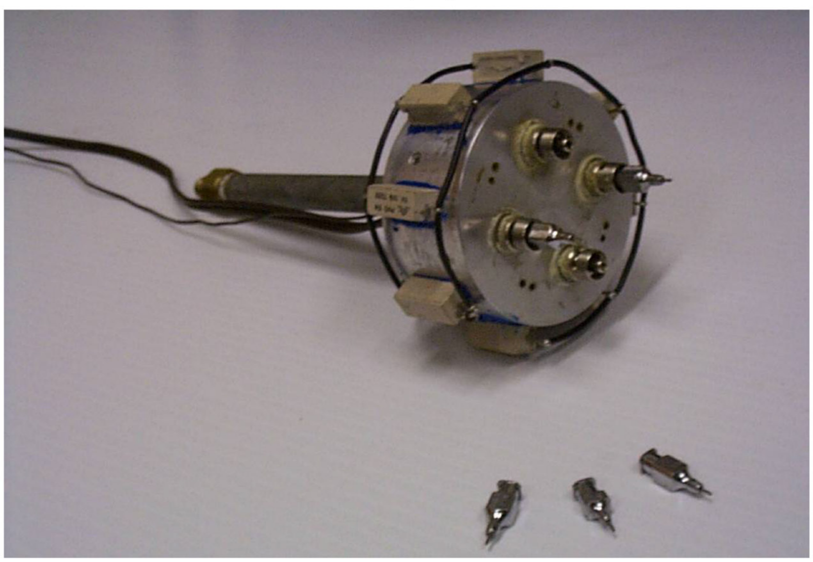

Photo 2.11: Hand Held Brixometer

Photo 2.12: Twelve Hole Spreader Used for Fluid Application

Photo 2.13: Standard Plate Setup for Type I Testing with Artificial Snowmaker

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3. DESCRIPTION OF DATA

This section provides a summary of the number of tests conducted. Breakdowns are provided for the quantity of tests performed by precipitation type, fluid dilution, test surface, and test temperature. A list of the tests conducted is provided in Section 3.7.

3.1 Natural Snow Tests

Natural snow tests will be completed over the winter of 2013-14. Results will be provided in a subsequent version of this report.

3.2 Artificial Snow Tests

Three tests were conducted with an artificial snowmaker at the APS test site. The tests were conducted on an aluminum surface at -3°C. For comparison purposes, the tests were repeated with a baseline historic Type I fluid.

Test Surface	-3°C	-6°C	-10°C	-25°C
Aluminum	3	0	0	0

3.3 Freezing Fog Tests

Thirty-two tests were conducted in freezing fog at the NRC CEF. The number of tests conducted is shown below by test surface and temperature.

Test Surface	-3°C	-6°C	-10°C	-25°C
Aluminum	4	4	4	4
Composite	4	4	4	4

3.4 Freezing Drizzle Tests

Twenty-four tests were conducted in freezing drizzle at the NRC CEF. The number of tests conducted is shown below by test surface and temperature.

Test Surface	-3°C	-6°C	-10°C
Aluminum	4	4	4
Composite	4	4	4

3.5 Light Freezing Rain Tests

Sixteen tests were conducted in light freezing rain at the NRC CEF. The number of tests conducted is shown below by test surface and temperature.

Test Surface	-3°C	-6°C	-10°C
Aluminum	0	4	4
Composite	0	4	4

It should be noted that Type I fluids are not tested in light freezing rain at -3°C because the latent heat of freezing in calm test conditions produces artificially long endurance times.

3.6 Rain on Cold-Soaked Surface Tests

Eight tests were conducted in rain on cold-soaked surface conditions at the NRC CEF. The number of tests conducted is shown below by test surface and temperature.

Test Surface	+ 1°C
Aluminum	4
Composite	4

3.7 Fluid Thickness Tests

Fluid thickness tests were conducted at the NRC CEF. The purpose of these tests was to measure the film thickness profile of BGS Defrosol ADF under dry conditions. Two tests were performed at an ambient temperature of -3°C. The measurements are displayed below.

Measurement	Time after Application (mins)	Thickness (mm)	
		Run 1	Run 2
1	5	0.1	0.1
2	30	0.1	0.1

For each test, one litre of fluid was poured onto a flat plate mounted at 10° to the horizontal. Film thickness measurements were taken at the 15-cm (6") line at pre-selected time intervals over a 30-minute interval. The thickness after 30 minutes was 0.1 mm.

3.8 Summary of Tests Performed

A summary of the tests performed is provided in Table 3.1. The table includes the following information for each test: test number, test date, fluid name, fluid dilution (Brix), precipitation type, test surface, air temperature, precipitation rate and endurance time.

Table 3.1: Summary of Tests Performed

Test No.	Date	Fluid Name	Fluid Dil.	Precipitation Type	Test Surface	Air Temp. (°C)	Precip. Rate (g/dm²/h)	Endurance Time (min)
1	19-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Fog	Al. Plate	-3.2	1.5	20.4
2	19-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Fog	Al. Plate	-3.2	1.7	20.8
3	19-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Fog	Comp. Plate	-3.3	1.6	17.8
4	19-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Fog	Comp. Plate	-3.3	1.7	19.1
5	19-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Fog	Al. Plate	-3.4	5.4	11.6
6	19-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Fog	Al. Plate	-3.4	4.7	11.7
7	19-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Fog	Comp. Plate	-3.4	5.0	11.3
8	19-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Fog	Comp. Plate	-3.4	5.0	10.0
9	19-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Fog	Al. Plate	-6.8	2.0	13.7
10	19-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Fog	Al. Plate	-6.9	2.3	12.9
11	19-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Fog	Comp. Plate	-6.9	2.2	10.3
12	19-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Fog	Comp. Plate	-6.9	2.4	10.0
13	19-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Fog	Al. Plate	-6.1	4.8	9.4
14	19-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Fog	Al. Plate	-6.2	5.4	9.7
15	19-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Fog	Comp. Plate	-6.1	5.1	8.1
16	19-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Fog	Comp. Plate	-6.2	4.5	7.8
17	19-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Fog	Al. Plate	-10.1	2.8	10.5
18	19-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Fog	Al. Plate	-10.1	2.7	10.2
19	19-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Fog	Comp. Plate	-10.1	2.6	8.5
20	19-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Fog	Comp. Plate	-10.1	2.7	8.1
21	19-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Fog	Al. Plate	-10.4	5.1	6.5
22	19-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Fog	Al. Plate	-10.3	5.4	6.3
23	19-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Fog	Comp. Plate	-10.4	4.8	6.0
24	19-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Fog	Comp. Plate	-10.4	5.2	5.3
25	19-Sep-13	BGS Defrosol ADF	10°B (B=41.0)	Freezing Fog	Al. Plate	-24.7	2.1	13.3
26	19-Sep-13	BGS Defrosol ADF	10°B (B=41.0)	Freezing Fog	Al. Plate	-24.8	2.4	11.8
27	19-Sep-13	BGS Defrosol ADF	10°B (B=41.0)	Freezing Fog	Comp. Plate	-24.7	2.4	8.4
28	19-Sep-13	BGS Defrosol ADF	10°B (B=41.0)	Freezing Fog	Comp. Plate	-24.8	2.0	9.1

Table 3.1 (cont'd): Summary of Tests Performed

Test No.	Date	Fluid Name	Fluid Dil.	Precipitation Type	Test Surface	Air Temp. (°C)	Precip. Rate (g/dm²/h)	Endurance Time (min)
29	19-Sep-13	BGS Defrosol ADF	10°B (B=41.0)	Freezing Fog	Al. Plate	-24.2	5.6	7.0
30	19-Sep-13	BGS Defrosol ADF	10°B (B=41.0)	Freezing Fog	Al. Plate	-24.2	5.0	6.1
31	19-Sep-13	BGS Defrosol ADF	10°B (B=41.0)	Freezing Fog	Comp. Plate	-24.2	5.3	5.5
32	19-Sep-13	BGS Defrosol ADF	10°B (B=41.0)	Freezing Fog	Comp. Plate	-24.2	4.9	5.3
33	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Light Freezing Rain	Al. Plate	-6.3	13.0	7.2
34	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Light Freezing Rain	Al. Plate	-6.3	12.6	7.8
35	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Light Freezing Rain	Comp. Plate	-6.1	13.0	7.5
36	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Light Freezing Rain	Comp. Plate	-6.2	12.9	7.8
37	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Light Freezing Rain	Al. Plate	-6.3	25.3	7.6
38	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Light Freezing Rain	Al. Plate	-6.3	25.3	6.3
39	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Light Freezing Rain	Comp. Plate	-6.1	25.2	5.4
40	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Light Freezing Rain	Comp. Plate	-6.1	25.1	5.5
41	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Light Freezing Rain	Al. Plate	-10.1	12.6	6.3
42	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Light Freezing Rain	Al. Plate	-10.1	12.3	6.2
43	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Light Freezing Rain	Comp. Plate	-10.1	13.0	5.6
44	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Light Freezing Rain	Comp. Plate	-10.1	12.9	5.5
45	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Light Freezing Rain	Al. Plate	-9.5	25.4	5.3
46	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Light Freezing Rain	Al. Plate	-9.5	24.9	5.4
47	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Light Freezing Rain	Comp. Plate	-9.5	25.4	4.2
48	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Light Freezing Rain	Comp. Plate	-9.6	25.8	4.6
49	18-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Drizzle	Al. Plate	-3.4	5.3	17.8
50	18-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Drizzle	Al. Plate	-3.4	4.5	13.4
51	18-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Drizzle	Comp. Plate	-3.4	5.4	17.7
52	18-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Drizzle	Comp. Plate	-3.4	5.2	15.2
53	18-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Drizzle	Al. Plate	-3.3	13.1	10.2
54	18-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Drizzle	Al. Plate	-3.3	13.5	10.0
55	18-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Drizzle	Comp. Plate	-3.3	13.4	11.2
56	18-Sep-13	BGS Defrosol ADF	10°B (B=24.0)	Freezing Drizzle	Comp. Plate	-3.3	13.1	9.6

Table 3.1 (cont'd): Summary of Tests Performed

Test No.	Date	Fluid Name	Fluid Dil.	Precipitation Type	Test Surface	Air Temp. (°C)	Precip. Rate (g/dm²/h)	Endurance Time (min)
57	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Drizzle	Al. Plate	-6.2	4.7	12.2
58	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Drizzle	Al. Plate	-6.0	4.7	12.7
59	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Drizzle	Comp. Plate	-6.0	5.0	12.0
60	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Drizzle	Comp. Plate	-6.2	5.6	10.9
61	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Drizzle	Al. Plate	-5.6	13.6	7.9
62	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Drizzle	Al. Plate	-5.6	13.0	7.3
63	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Drizzle	Comp. Plate	-5.6	13.2	8.1
64	18-Sep-13	BGS Defrosol ADF	10°B (B=27.25)	Freezing Drizzle	Comp. Plate	-5.6	13.2	7.2
65	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Drizzle	Al. Plate	-10.2	5.4	8.4
66	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Drizzle	Al. Plate	-10.2	5.2	7.9
67	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Drizzle	Comp. Plate	-10.3	5.6	8.7
68	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Drizzle	Comp. Plate	-10.2	5.1	8.3
69	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Drizzle	Al. Plate	-10.0	13.1	5.8
70	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Drizzle	Al. Plate	-10.1	13.2	5.4
71	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Drizzle	Comp. Plate	-10.0	13.0	5.2
72	18-Sep-13	BGS Defrosol ADF	10°B (B=31.25)	Freezing Drizzle	Comp. Plate	-10.1	13.3	5.6
73	19-Sep-13	BGS Defrosol ADF	10°B (B=19.0)	Cold Soak Box	Al. Box	0.1	5.1	4.7
74	19-Sep-13	BGS Defrosol ADF	10°B (B=19.0)	Cold Soak Box	Al. Box	0.9	5.1	5.0
75	19-Sep-13	BGS Defrosol ADF	10°B (B=19.0)	Cold Soak Box	Comp. Box	0.3	5.1	7.6
76	19-Sep-13	BGS Defrosol ADF	10°B (B=19.0)	Cold Soak Box	Comp. Box	0.9	5.1	7.7
77	19-Sep-13	BGS Defrosol ADF	10°B (B=19.0)	Cold Soak Box	Al. Box	1.2	72.4	2.0
78	19-Sep-13	BGS Defrosol ADF	10°B (B=19.0)	Cold Soak Box	Al. Box	1.2	72.5	2.3
79	19-Sep-13	BGS Defrosol ADF	10°B (B=19.0)	Cold Soak Box	Comp. Box	1.2	72.5	2.0
80	19-Sep-13	BGS Defrosol ADF	10°B (B=19.0)	Cold Soak Box	Comp. Box	1.2	72.4	2.2

4. RESULTS AND DISCUSSION

The endurance time test results of BGS Defrosol ADF are presented in this section. To assess the performance of the fluid, the endurance time results are compared to historic Type I fluid endurance times.

4.1 Results

Figures 4.1 to 4.20 show the results of testing in simulated freezing precipitation. There is one chart for each freezing precipitation cell in the Type I generic holdover time tables, with the exception of the "-3°C and above" light freezing rain cells (see note in Subsection 2.5). Each chart contains the BGS Defrosol ADF endurance times (represented with solid diamonds), the endurance times of other Type I fluids (represented with hollow diamonds) and the current Type I generic holdover times (represented by solid squares).

Figure 4.21 shows the results of testing in artificial snow. There is one chart showing the results collected at a temperature of -3°C. For each precipitation rate under which tests were conducted, there is a bar showing the endurance time of BGS Defrosol ADF and a bar showing the endurance time of the historic Type I fluid tested.

4.2 Discussion

The data collected shows the endurance times of BGS Defrosol ADF are similar or superior to the endurance times of Type I fluids tested in past years and to the current Type I generic holdover times. These results indicate this non-glycol based fluid performs similar to glycol based Type I fluids from an endurance time perspective and therefore can be used with the generic Type I HOT guidelines.

Testing under natural snow conditions will be carried out over the winter of 2013-14. The purpose of this testing is to confirm the artificial snow results. When the testing is completed, an updated version of this report will be provided.

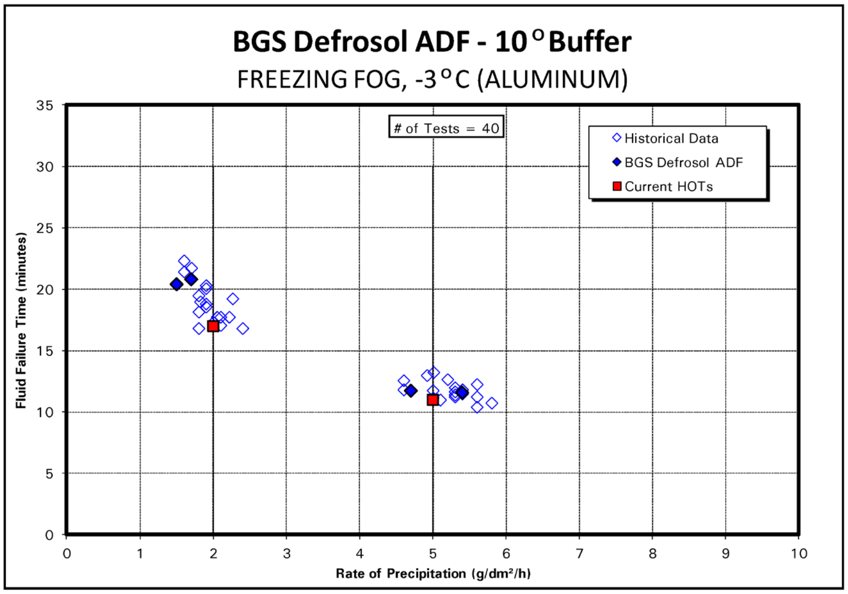


Figure 4.1: Freezing Fog, -3°C and Above, Aluminum Surface

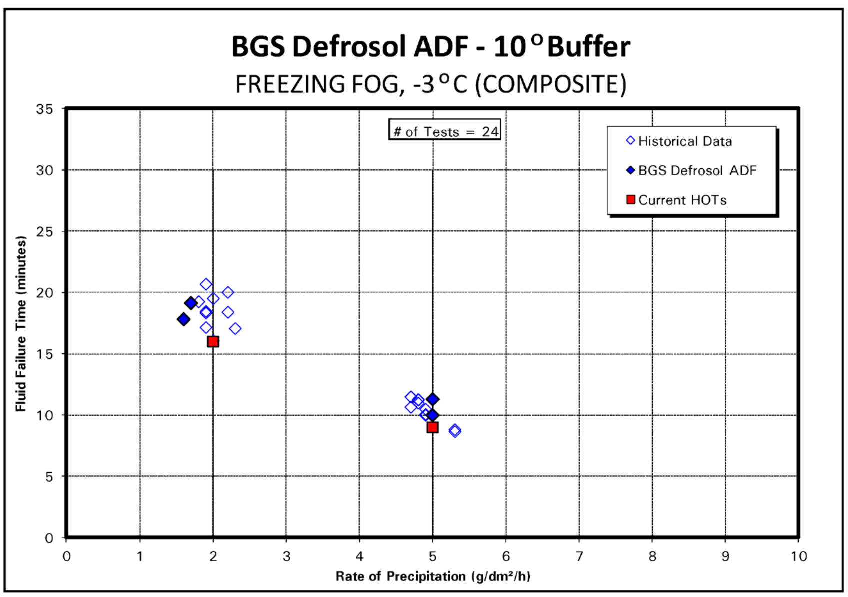


Figure 4.2: Freezing Fog, -3°C and Above, Composite Surface

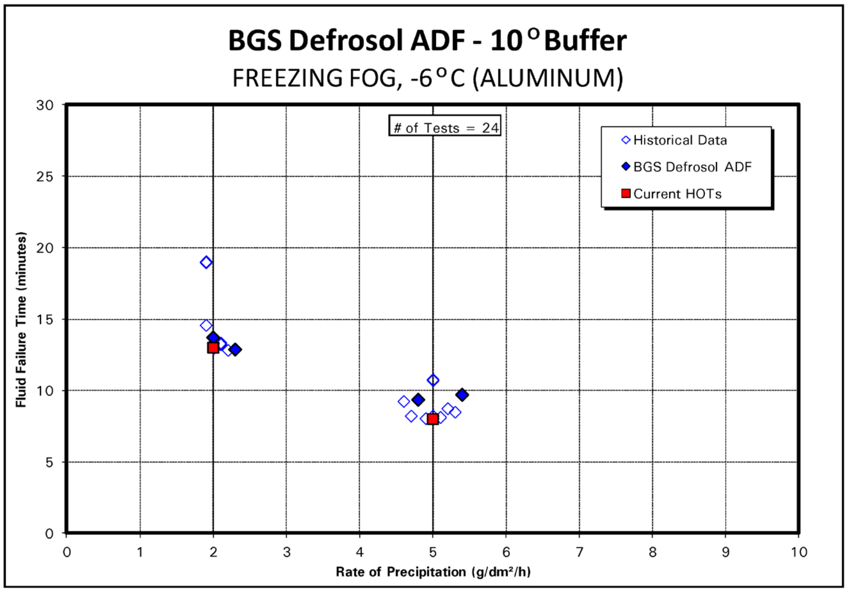


Figure 4.3: Freezing Fog, Below -3 to -6°C, Aluminum Surface

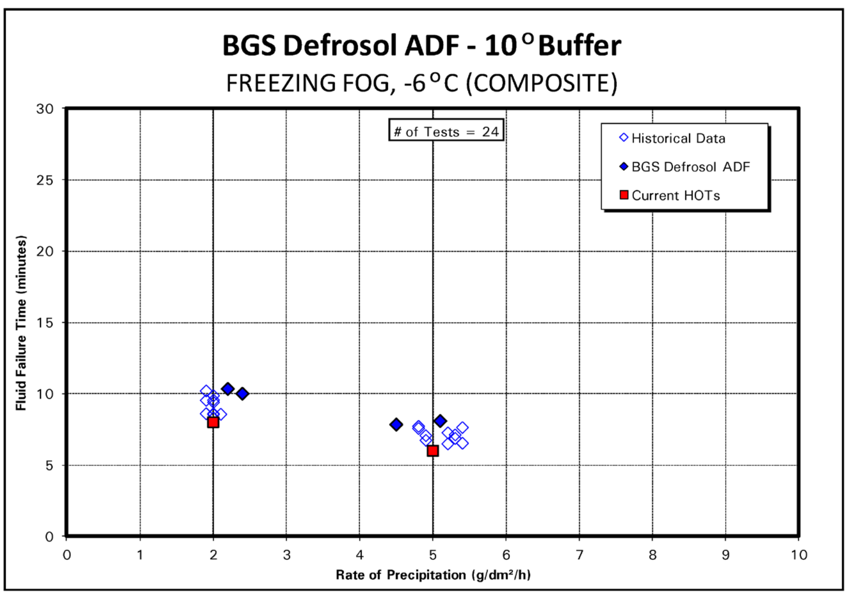


Figure 4.4: Freezing Fog, Below -3 to -6°C, Composite Surface

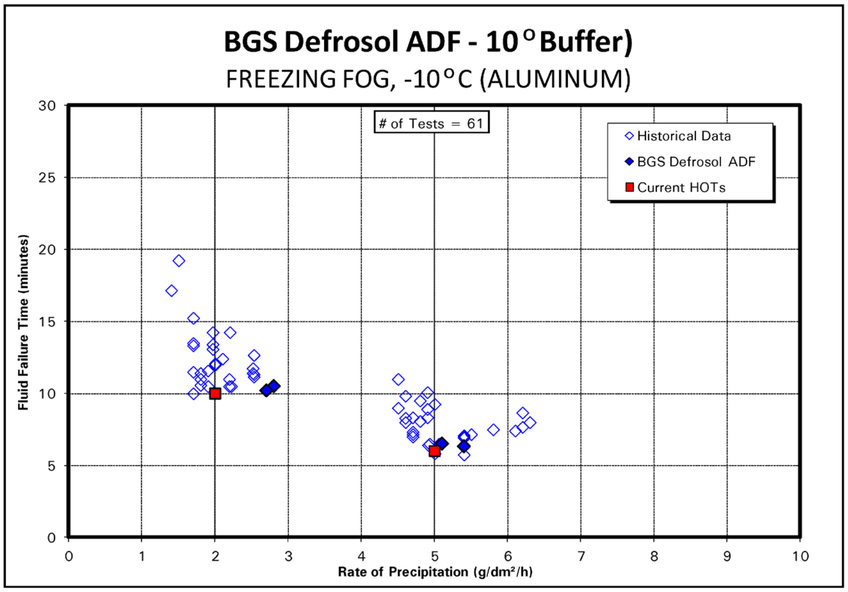


Figure 4.5: Freezing Fog, Below -6 to -10°C, Aluminum Surface

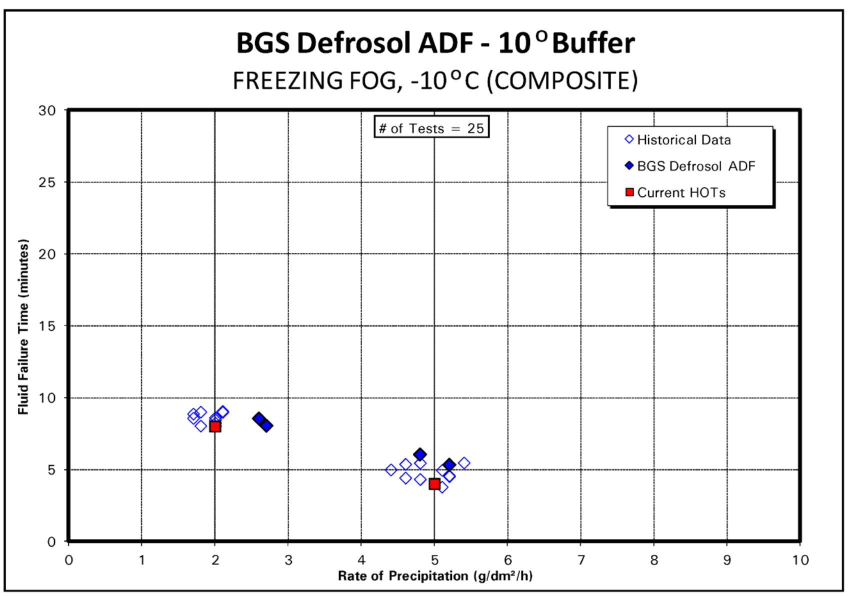


Figure 4.6: Freezing Fog, Below -6 to -10°C, Composite Surface

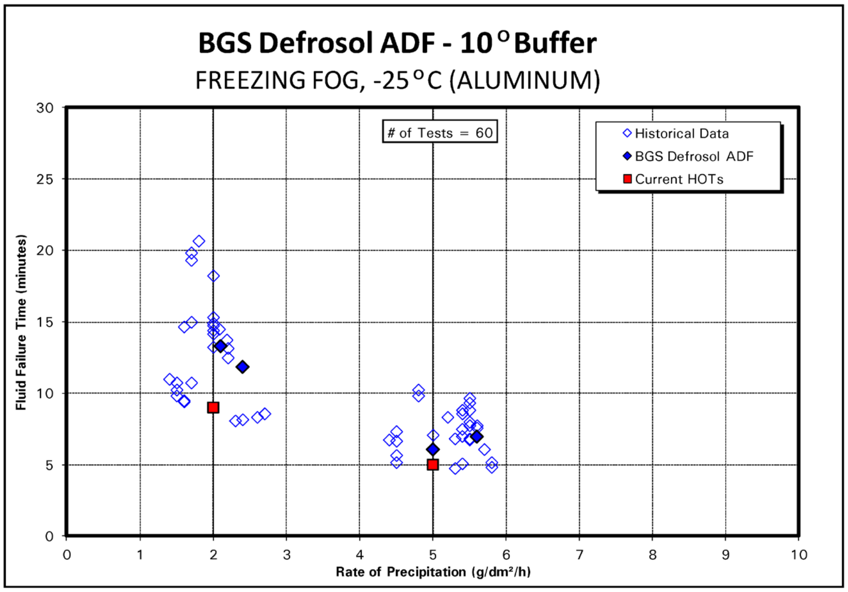


Figure 4.7: Freezing Fog, Below -10°C, Aluminum Surface

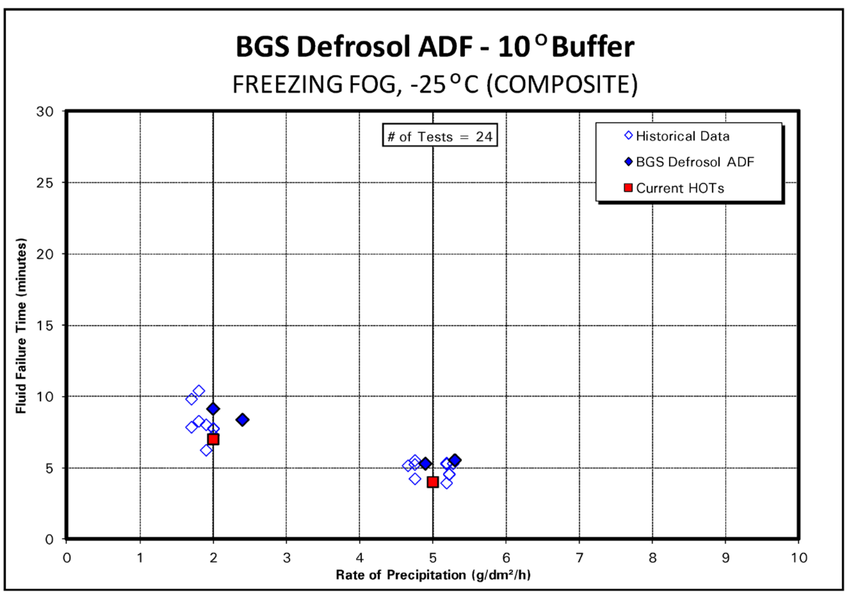


Figure 4.8: Freezing Fog, Below -10°C, Composite Surface

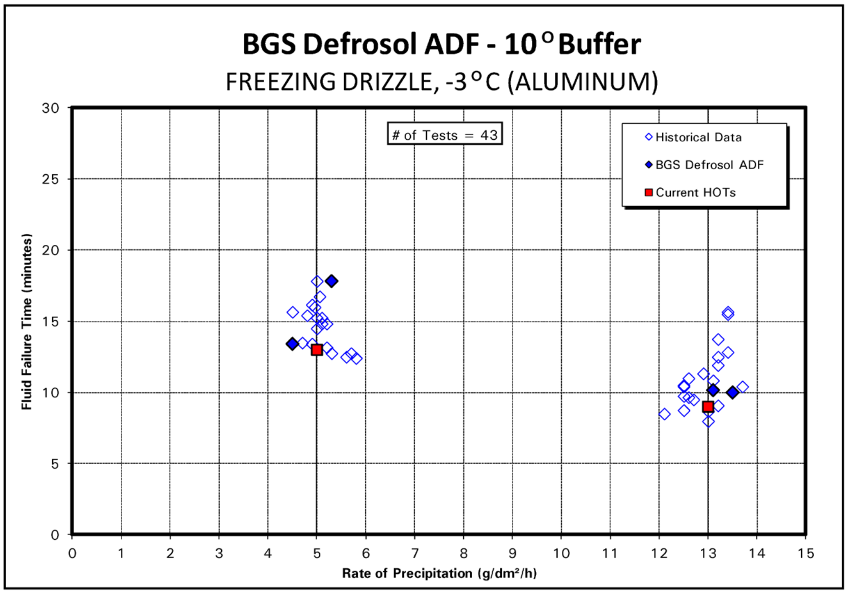


Figure 4.9: Freezing Drizzle, -3°C and Above, Aluminum Surface

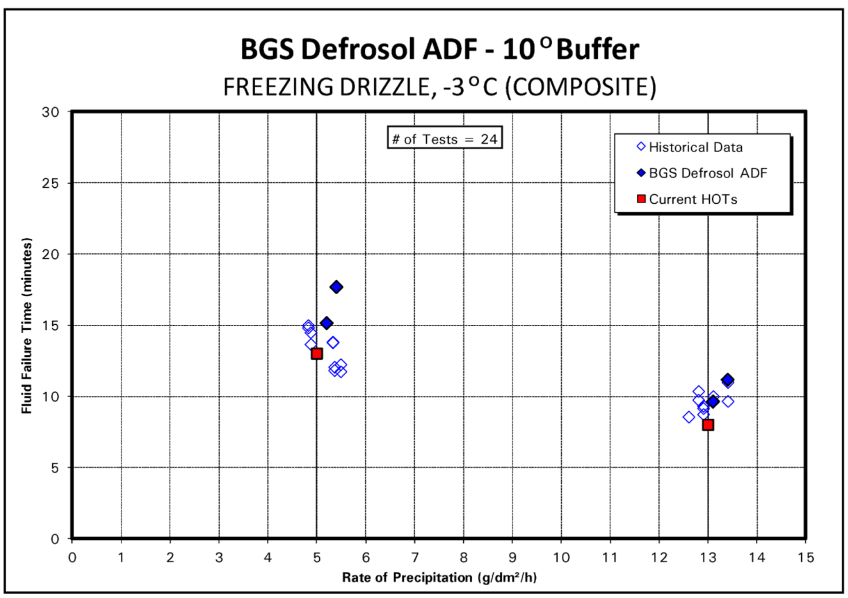


Figure 4.10: Freezing Drizzle, -3°C and Above, Composite Surface

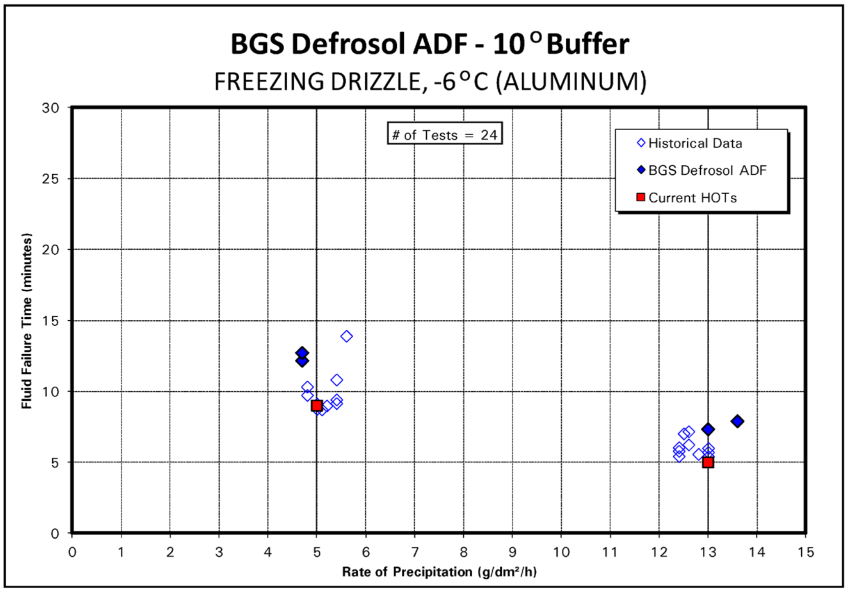


Figure 4.11: Freezing Drizzle, Below -3 to -6°C, Aluminum Surface

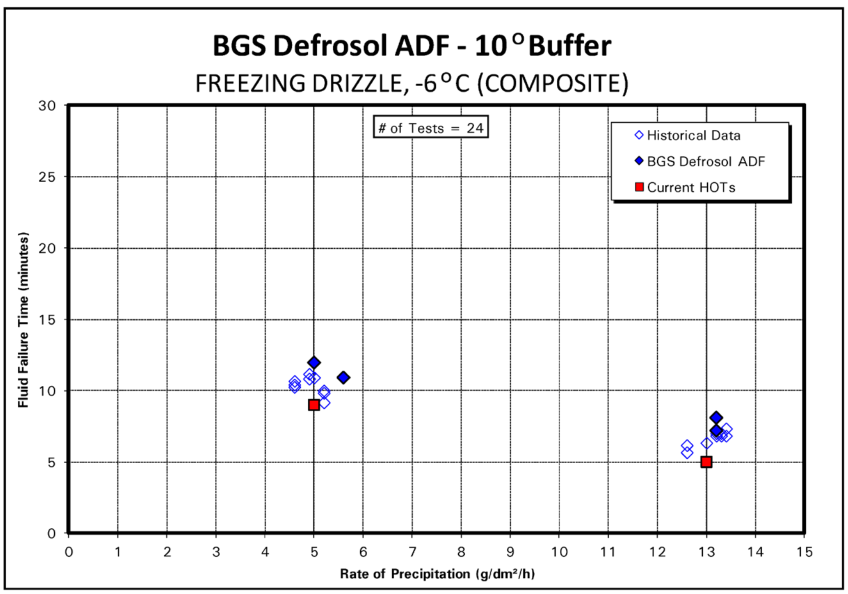


Figure 4.12: Freezing Drizzle, Below -3 to -6°C, Composite Surface

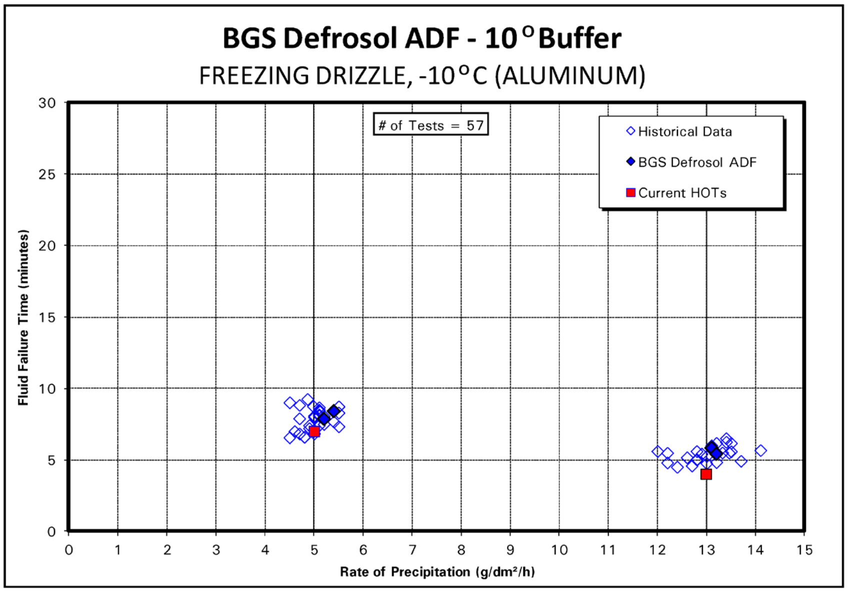


Figure 4.13: Freezing Drizzle, Below -6 to -10°C, Aluminum Surface

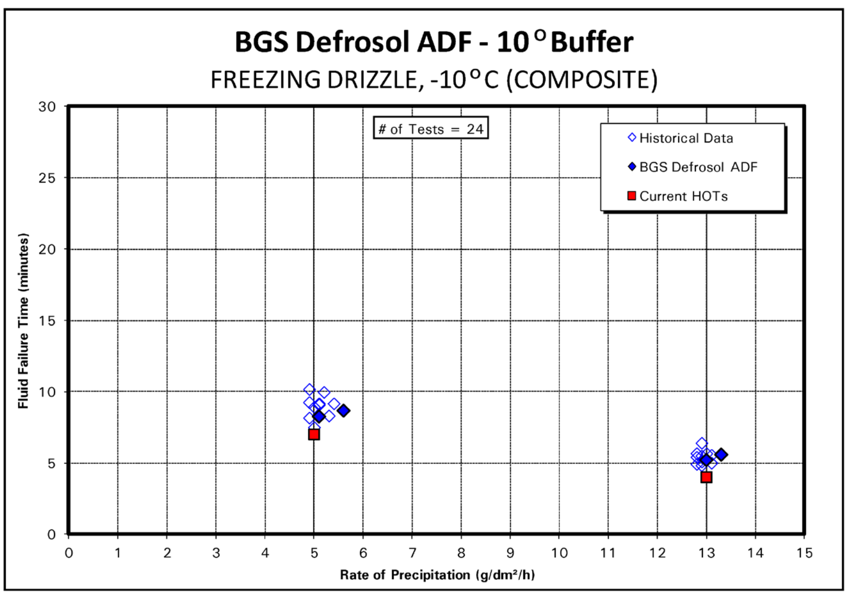


Figure 4.14: Freezing Drizzle, Below -6 to -10°C, Composite Surface

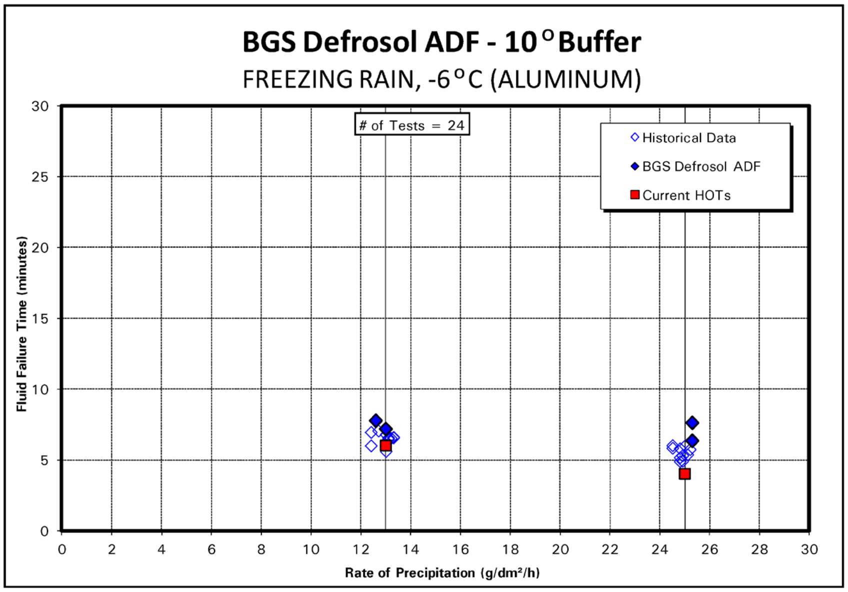


Figure 4.15: Light Freezing Rain, Below -3 to -6°C, Aluminum Surface

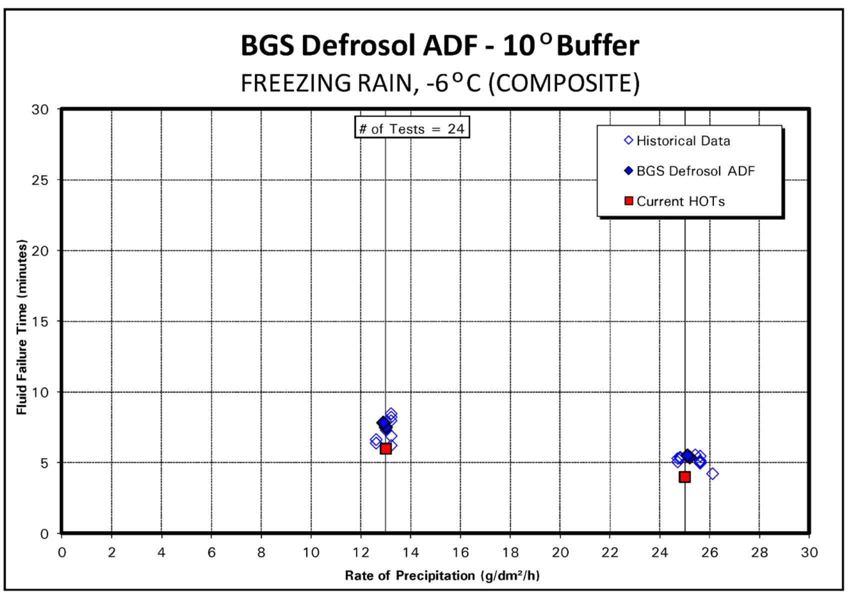


Figure 4.16: Light Freezing Rain, Below -3 to -6°C, Composite Surface

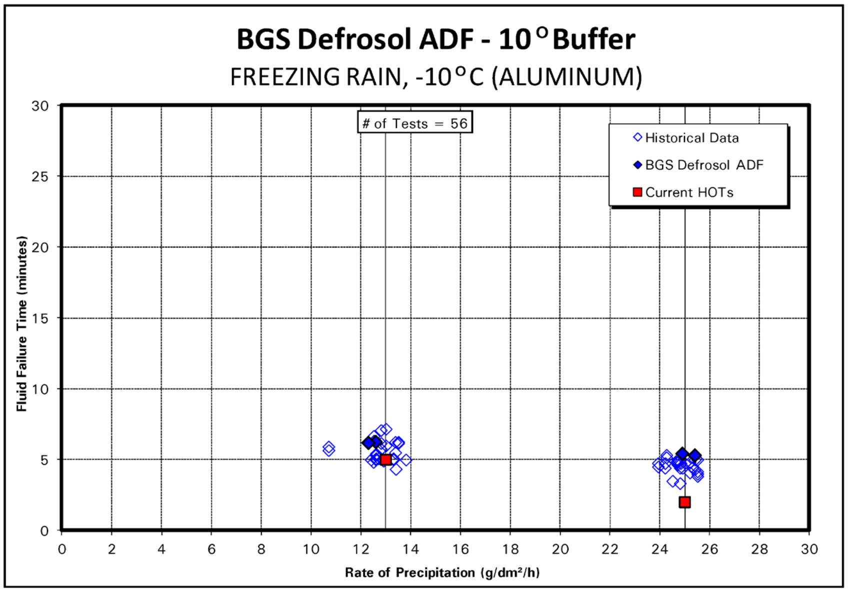


Figure 4.17: Light Freezing Rain, Below -6 to -10°C, Aluminum Surface

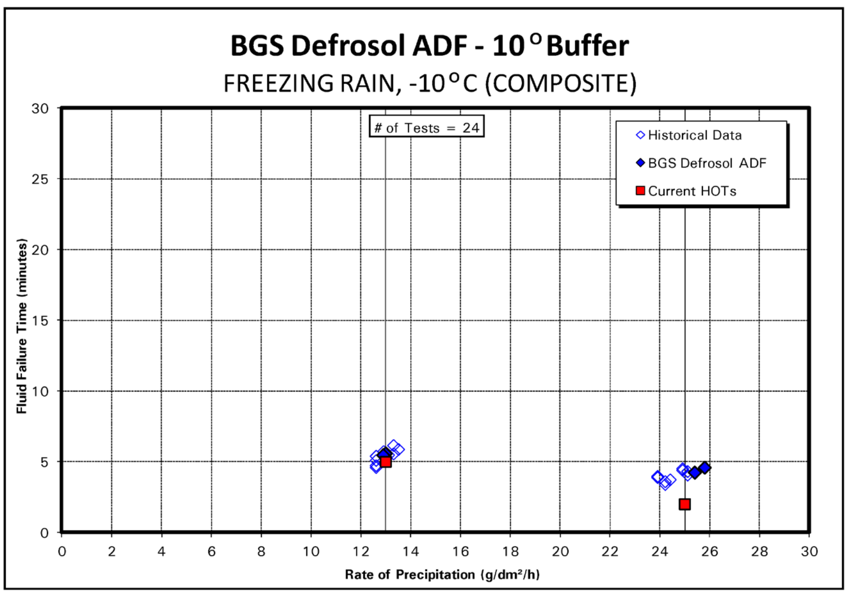


Figure 4.18: Light Freezing Rain, Below -6 to -10°C, Composite Surface

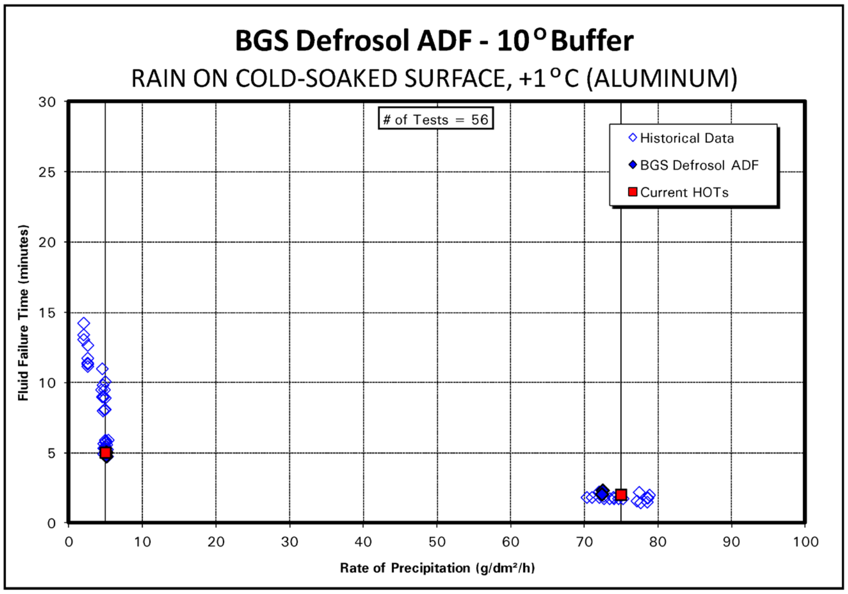


Figure 4.19: Rain on Cold-Soaked Surface, -3°C and Above, Aluminum Surface

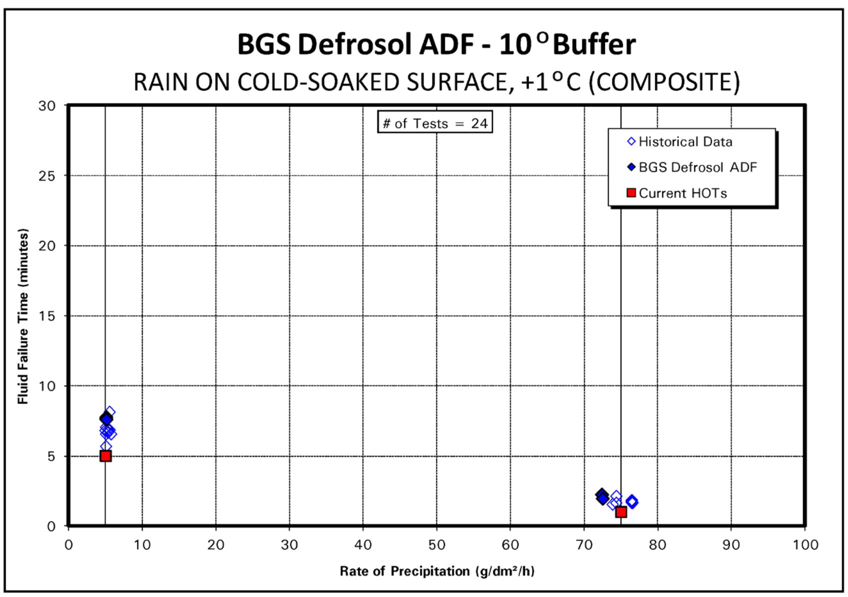


Figure 4.20: Rain on Cold-Soaked Surface, -3°C and Above, Composite Surface

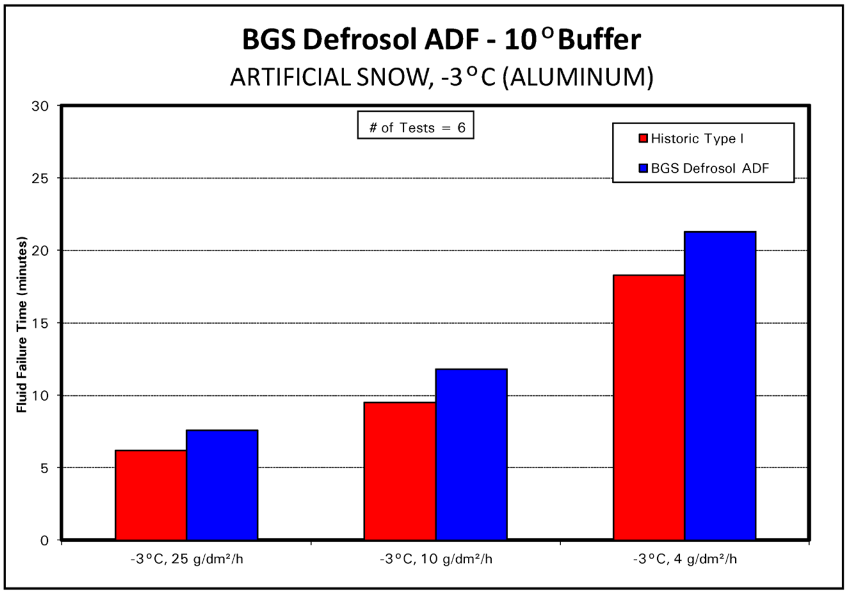


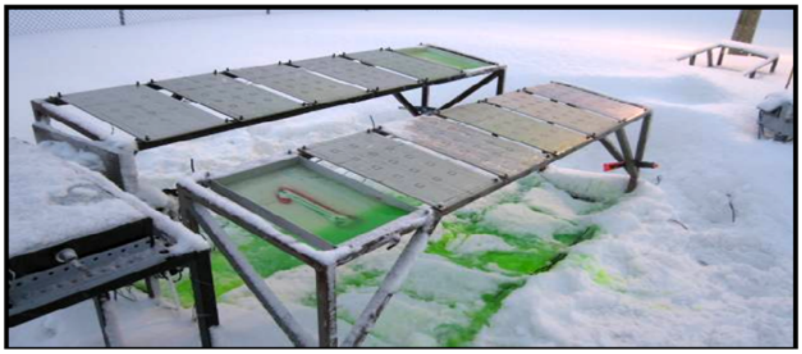
Figure 4.21: Artificial Snow, -3°C and Above, Aluminum Surface

APPENDIX D

FLUID MANUFACTURER REPORT: CLARIANT SAFEWING MP II FLIGHT PLUS (TYPE II)

AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

Clariant Safewing MP II FLIGHT PLUS (Type II)



Prepared for

Clariant 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 2013
Version 2.0
Report No. C-FP 2012-13

AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

Clariant Safewing MP II FLIGHT PLUS (Type II)

Prepared for

Clariant GmbH

Prepared by:

Victoria Zoitakis
Junior Technologist

August 27, 2013
Date

Reviewed by:

John D'Avirro, Eng.
Program Manager

August 27, 2013
Date

and by:

Stephanie Bendickson
Project Analyst

August 27, 2013
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 2013
Version 2.0
Report No. C-FP 2012-13

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FLUID IDENTIFICATION AND CHARACTERISTICS

Manufacturer:	Clariant GmbH		
Fluid Test Name:	Safewing MP II FLIGHT PLUS		
Fluid Commercial Name:	Safewing MP II FLIGHT PLUS		
Fluid Type / Base / Colour:	Type II / Propylene Glycol / Yellow		
Batch #:	TV 513		
Date of Receipt:	March 1, 2012		
Brix (Measured):	Neat fluid:	35.25°	
	75/25 dilution:	28.25°	
	50/50 dilution:	19.75°	
Freeze Point (Stated):	Neat fluid:	-36°C	
	75/25 dilution:	-21°C	
	50/50 dilution:	-10°C	
LOUT (Stated):	Neat fluid:	-29°C	
	75/25 dilution:	-14°C	
	50/50 dilution:	-3°C	
Viscosity:	**Mfr Method[1]**	**Stated**	**Measured**
	Neat fluid:	3,520 cP	3,650 cP
	75/25 dilution:	8,660 cP	12,400 cP
	50/50 dilution:	5,500 cP	7,800 cP
	AIR9968 Method[2]	**Stated**	**Measured**
	Neat fluid:	3,400 cP	3,100 cP
	75/25 dilution:	9,040 cP	10,450 cP
	50/50 dilution:	6,970 cP	7,050 cP
WSET (from AMIL):	Neat fluid:	62 minutes	

[1] Spindle LV1, big sample adapter, 50 mL of fluid, 20°C, 0.3 rpm, for 10 minutes 0 seconds
[2] Spindle LV1 with guard leg, 600 mL beaker, 500 mL of fluid, 20°C, 0.3 rpm, for 10 minutes 0 seconds

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SUMMARY

The primary objective of this project was to measure the endurance time performance of Clariant Safewing MP II FLIGHT PLUS 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, the National Research Council Canada (NRC) Climatic Engineering Facility (CEF) in Ottawa, and at several mobile test stations in Quebec and New Brunswick.

Due to the late submission of this fluid in winter 2011-12, sufficient data was not collected to determine fluid-specific holdover times for the below -3 to -14°C snow cells. Supplemental testing with an artificial snowmaker allowed the use of generic holdover times in these cells in the winter 2012-13 HOT guidelines. Additional natural snow tests conducted in the winter of 2012-13 completed the snow testing and produced new fluid-specific holdover times for the below -3 to -14°C and -3°C and above snow cells.

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.

Clariant Safewing MP II FLIGHT PLUS Type II Fluid Holdover Times

Outside Air Temperature		Type II Fluid Concentration Neat Fluid/Water (Vol %/Vol %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-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	0:35-0:55	CAUTION: No holdover time guidelines exist	
		75/25	0:30-1:45	0:55–1:40	0:25-1:10	0:30-0:45		
below -14 to -29	below 7 to -20.2	100/0	0:20-0:40	0:15–0:30				

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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
LOWV	Lowest On-Wing Viscosity
LWC	Liquid Water Content
MVD	Median Volume Diameter
MANOBS	Manual of Surface Weather Observations
NCAR	National Center for Atmospheric Research
NRC	National Research Council Canada
TC	Transport Canada
TDC	Transportation Development Centre

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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 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 all cells of the Type II/IV HOT tables using this protocol and are used to create a fluid-specific HOT table for each Type II/IV fluid tested.

This report provides a detailed account of the endurance time testing conducted by APS Aviation Inc. (APS) with **Clariant Safewing MP II FLIGHT PLUS**, 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.

Version 1.0 of this report documented the testing completed with this fluid in the winter of 2011-12 and the HOT table published for the winter of 2012-13. Version 2.0 of the report includes the additional natural snow testing conducted in the winter of 2012-13 and the resulting updated snow holdover times. These holdover times are expected to be published by regulators for use in the winter 2013-14 operating season. Version 2.0 also includes the results of natural frost testing, which substantiated use of the generic frost holdover times for MP II FLIGHT PLUS.

2. METHODOLOGY

SAE Aerospace Recommended Practice (ARP) 5485 provides the procedure and requirements for endurance time testing with Type II, III and IV fluids under natural and simulated conditions. This chapter summarizes some of aspects of the test methodology included in ARP5485, and some aspects which are not included in ARP5485. The chapter includes sections for test sites, equipment, procedures, precipitation rates and ambient temperatures used in Type II endurance time testing, and freezing precipitation droplet sizes. The final subsection describes the analysis methodology used to evaluate Type II endurance time data.

2.1 Test Sites

The test sites used to conduct natural snow and freezing precipitation tests are described in Subsections 2.1.1 and 2.1.2, respectively.

2.1.1 Natural Snow and Natural Frost

Natural snow and natural snow testing is typically 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. Photos 2.1 and 2.2 show the test site as seen from the test pads and main trailer, respectively.

Clariant Safewing MP II FLIGHT PLUS was submitted late in the test season. Due to a lack of suitable weather conditions in Montreal after the fluid was received, a mobile test station was assembled and dispatched to several locations. Locations were selected based on weather forecasts and suitability for testing. Test data was collected at four mobile locations: Edmundston, New Brunswick; Rimouski, Quebec; St-Jovite, Quebec; and Gaspésie National Park, Quebec (mapped in Figure 2.2). Photo 2.3 shows the mobile test site.

2.1.2 Artificial Snow

Artificial snow testing was also performed at the APS test site located at Montréal-Pierre-Elliott-Trudeau International Airport. The testing was performed inside the refrigerated trailer.

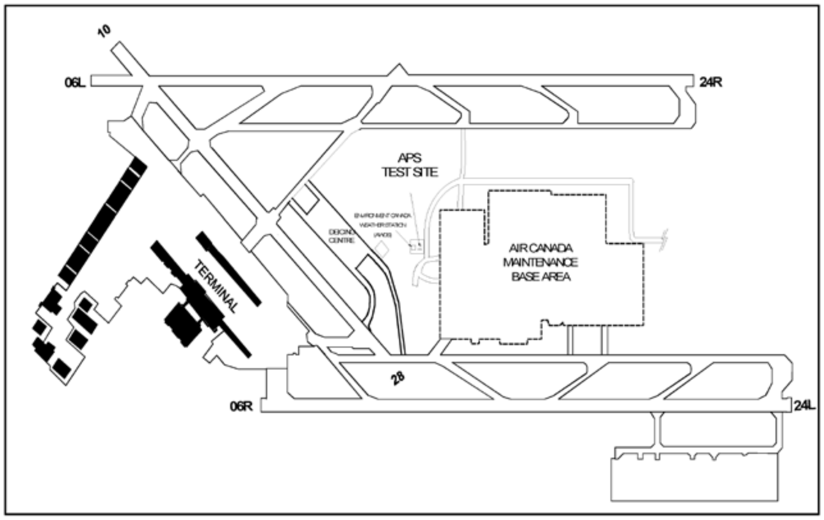

Figure 2.1: APS Test Site at Montréal-Pierre-Elliott-Trudeau International Airport

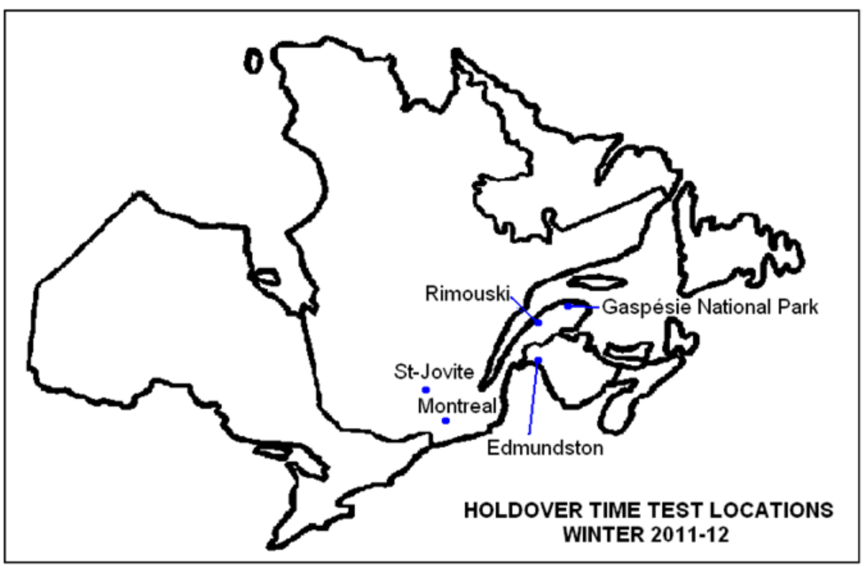

Figure 2.2: Snow Test Site Locations

2.1.3 Freezing Precipitation

Tests under conditions of freezing fog, rain on cold-soaked surface, freezing drizzle, and light freezing rain were conducted indoors at the NRC Climatic Engineering Facility (CEF), where precipitation was artificially produced.

Photo 2.4 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 2.5 provides an interior view of the CEF set up for endurance time testing. The lowest temperature achievable in the CEF is -46°C.

2.2 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.

2.2.1 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.

2.2.2 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.

2.2.3 Test Surface Structures

The majority of endurance time testing is carried out on standard flat plates. A schematic of a standard flat plate is provided in Figure 2.3. 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 2.3.5) are achieved. Photo 2.6, taken outdoors at the APS test site, shows six test plates mounted on a test stand.

Figure 2.4 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. A box shaped reservoir is welded to the bottom of the plate. Photo 2.7 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.

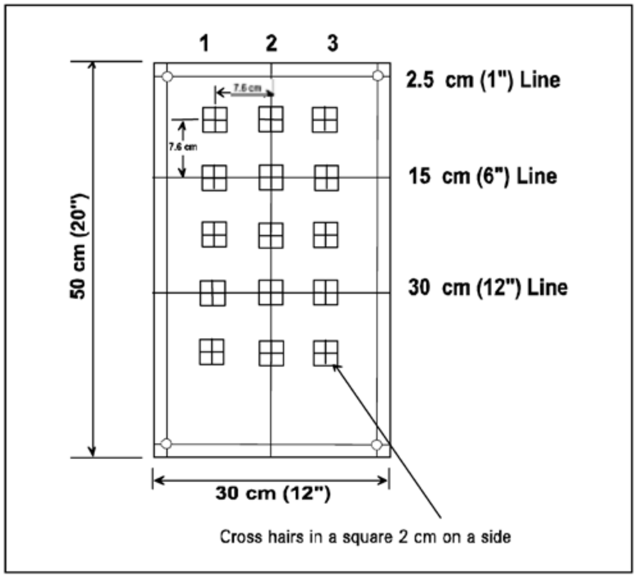

Figure 2.3: Standard Test Plate Schematic

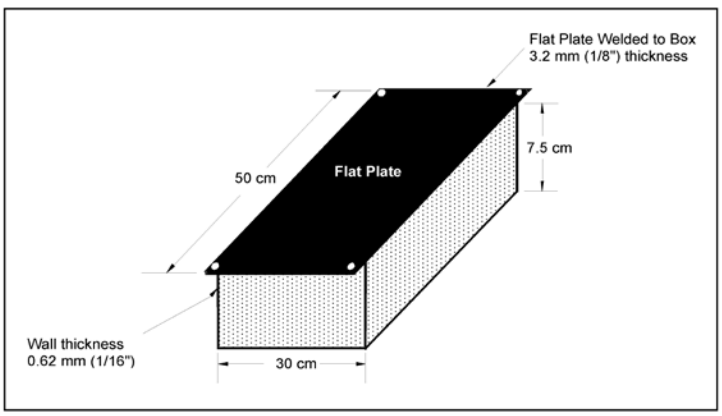

Figure 2.4: Cold Soak Box Schematic

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 2.8 shows a white-painted aluminum frosticator plate.

2.2.4 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.

2.2.5 Test Stands

Figure 2.5 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. Photos 2.5 and 2.6 show the test stands set up for indoor and outdoor testing, respectively.

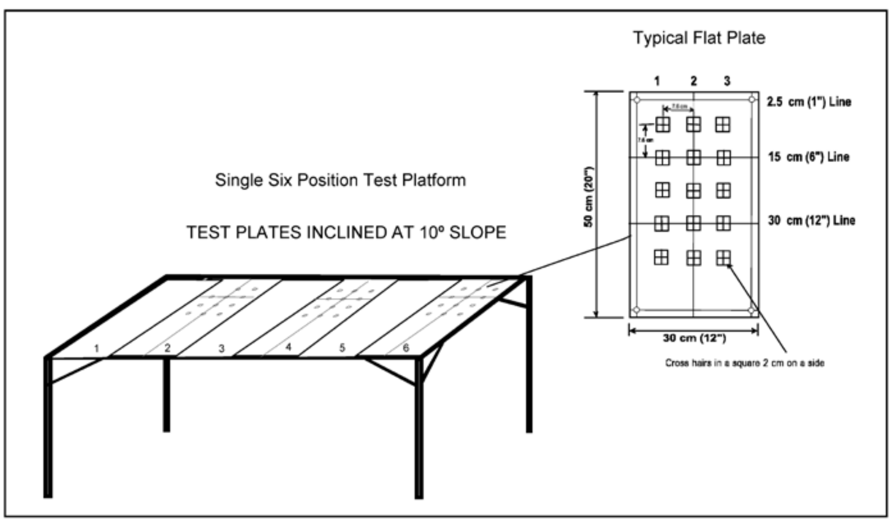

Figure 2.5: Test Stand Setup Schematic

2.2.6 Collection Pans

Figure 2.6 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 2.9 shows the collection pans used for measuring precipitation rates indoors at the NRC.

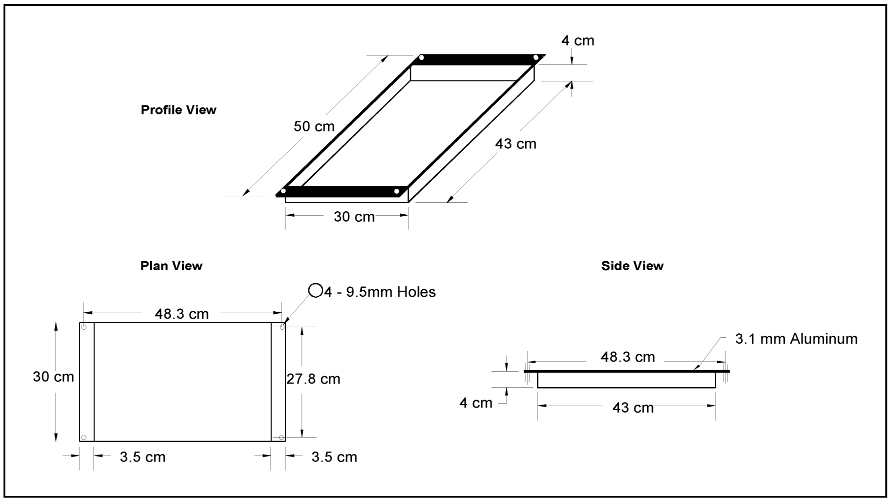

Figure 2.6: Schematic of Outdoor Precipitation Measurement Pan

2.2.7 NRC Sprayer Assembly

NRC developed an improved sprayer assembly, shown in Photos 2.10 and 2.11, 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 2.11.

2.2.8 Fluids

Testing was carried out with Clariant Safewing MP II FLIGHT PLUS in the standard Type II, III and IV fluid test dilutions: neat, 75/25 and 50/50. The fluid sample was diluted by the manufacturer.

2.3 Test Procedures

ARP5485 provides the 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 2.3.5), when a specified degree of freezing occurs. The following subsections provide summaries of the test procedures followed for natural snow, artificial snow and simulated freezing precipitation testing.

2.3.1 Test Protocol – 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 2.2.3);
- Fluid is applied at ambient temperature; and
- 1 L of fluid is hand-poured on the test surface.

2.3.2 Test Protocol – 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 with insulated tray (shown in Photo 2.13);
- Fluid is applied at ambient temperature; and
- 1 L of fluid is hand-poured on the test surface.

2.3.3 Test Protocol – 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 2.2.3);
- Rain on cold-soak surface tests are conducted on filled cold-soak boxes (see Section 2.2.3);
- Fluid is applied at ambient temperature; and
- 1 L of fluid is hand-poured on the test surface.

2.3.4 Test Protocol – 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 2.2.3);
- Fluid is applied at ambient temperature; and
- 1 L of fluid is hand-poured on the test surface.

2.3.5 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.

2.3.6 Precipitation Rate Measurement Procedures

The procedures for measuring and determining precipitation rates during simulated precipitation and natural precipitation conditions are provided below.

2.3.6.1 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. Prior to the start of the precipitation catch period, the exact time (hh:mm:ss) is recorded. 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 this 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.

2.3.6.2 Natural precipitation conditions

Two rate collection pans per test stand are 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 anti-icing 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) from the timepiece located near the rate station before leaving the trailer to place the pans on the test stand. The person responsible for collecting precipitation rate data take the time delay necessary to proceed outside from the rate station into consideration.

The pans are positioned in locations 6 and 7 (see Figure 2.5) and are allowed to collect precipitation for 10-minute intervals in normal conditions and 5-minute intervals in periods of high precipitation rates and high winds. 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 has failed.

The rate for any HOT 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 this particular test. To measure and document the rate of frost accretion, two test surfaces were weighed at half hour to one hour intervals depending on the frost accretion intensity.

An example of the rate calculation method for tests in natural snow conditions is displayed in Figure 2.7. Typically, two collections pans are used for each test. 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 t1, t2, and t3 (minutes). The calculated rates for each collection period are indicated by R1, R2, and R3 (g/dm²/h). In order to calculate the average rate for this pan, the following formula is then used:

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

In the example shown in Figure 2.7, 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.

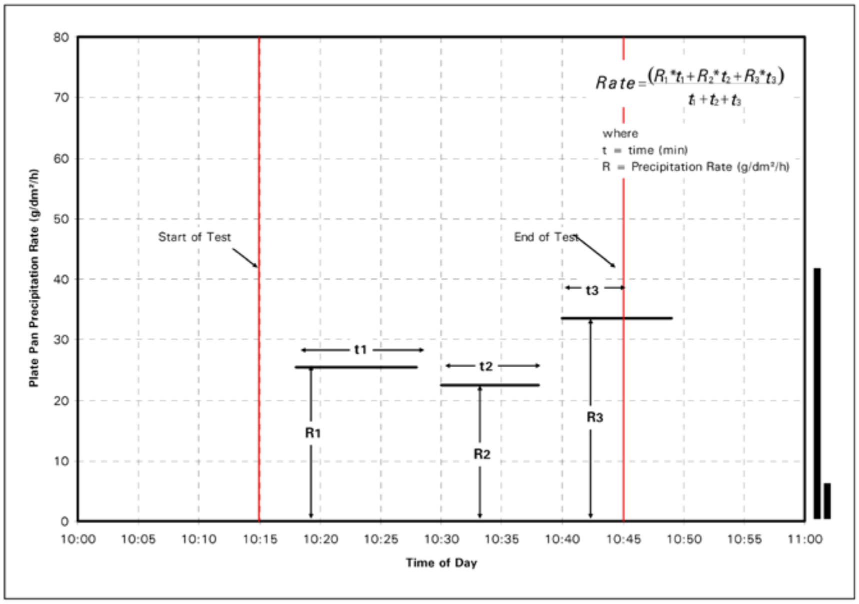

Figure 2.7: Calculation of Outdoor Precipitation Rate

2.4 Precipitation Rate Limits in Type II/IV Endurance Time Testing

Upper and lower precipitation rate limits are an important part of the test methodology for measuring fluid endurance times. Table 2.1 provides the meteorologically accepted definitions of weather phenomenon / precipitation types. It also includes the criteria used to determine precipitation intensity. This table 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/IV endurance time testing are provided in ARP5485 and represented graphically in Figure 2.8. Subsections 2.4.1 to 2.4.5 provide detailed definitions and explanations of the precipitation types and rate boundaries used in Type II/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 2.1.

Table 2.1: 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 visibility at the earth's surface to less than 1 km (5/8 mile).
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 (23°F), the crystals are generally agglomerated into snowflakes.
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 the ground or other exposed objects.
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 mm (0.02 in.) or smaller drops which, in contrast to drizzle, are widely separated.
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)	Precipitation of white and opaque grains of ice. These grains are spherical or sometimes conical; their diameter is about 2-5 mm (0.1-0.2 in.). Grains are brittle, easily crushed; they bounce and break on hard ground.
SNOW GRAINS (SG)	Precipitation of very small white and opaque grains of ice. These grains are fairly flat or elongated; their diameter is less than 1 mm (0.04 in.). When the grains hit hard ground, they do not bounce or shatter.
HAIL (GR)	Precipitation of small balls or pieces of ice with a diameter ranging from 5 to > 50 mm (0.2 to 2.0 in.) falling either separately or agglomerated.
ICE PELLETS (PE) Note: Includes Sleet and Small Hail	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.) or less. The pellets of ice usually bounce when hitting hard ground.

Intensity Criteria**

	Snow(SN),Pellets(GS),Grains(SG),Frz Drizzle(FZDZ)		Ice Pellets (PE)
Estimated Intensity	Horizontal Visibility (statute mile)	Liquid Equivalent Snow (S) Intensity***	Definition and Horizontal Visibility
Light (-)	If visibility is: ≥ 5/8 mi (≥ 1.0 km)	Trace to 0.05 in/hr (≤ 1.0 mm or 10.0 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 or 25.0 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 shown that visibility and precipitation intensity are not always directly correlated.

	Drizzle Intensity (FZDZ)
Light(-)	Trace to 0.01 in/hr (0.254 mm 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 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 exposed surface up to a condition where individual drops are easily seen.
Moderate	Measured Intensity	0.11 in to 0.30 in/hr (7.6 mm 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 pavement and other hard surfaces.
Heavy (+)	Measured Intensity	More than 0.30 in/hr (7.6 mm 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 spray to height of several inches is observed over hard surfaces.

* 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 Proposed Definition for Liquid Equivalent Snowfall Intensity

1) gm/dm² = 0.01 cm = 0.1 mm = 0.0039 in
2) in = 2.54 cm = 25.4 mm = 254 gm/dm²

Compiled by Jeff Cole and Roy Rasmussen of NCAR/RAP June 17, 1997 (Updated for METAR codes)

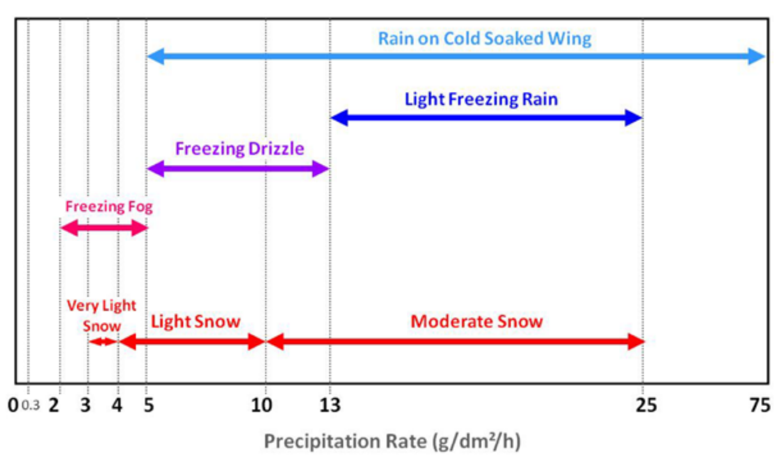

Figure 2.8: Precipitation Rate Limits Used in Endurance Time Testing

2.4.1 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.

2.4.2 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.

2.4.3 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.

2.4.4 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 $g/dm^2/h$).

2.4.5 Snow

The precipitation rate limits used to determine holdover times for Type II/IV fluids in snow are 3, 4, 10 and 25 $g/dm^2/h$. These rate limits encompass very light, light and moderate snow.

2.5 Ambient Temperatures in Type II/IV Endurance Time Testing

The Type II/IV holdover time tables provide holdover times for three temperature ranges:

- -3°C and above;
- Below -3 to -10°C (freezing drizzle, light freezing rain, cold soak wing) or Below -3 to -14°C (freezing fog, snow); and
- Below -14°C to LOUT

In natural snow testing, endurance time testing is carried out under a range of temperatures. In simulated freezing precipitation testing and artificial snow testing, endurance time testing is typically conducted at the lower limit of each temperature band.

- Freezing Fog: -3°C, -10°C and -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, -14 and/or -25°C

2.6 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 2.2 beside the experimental MVDs for each precipitation condition.

Table 2.2: 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

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 P.E.T. 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
   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

2.7 Summary of Freezing Precipitation Test Conditions

The precipitation types/rates, ambient temperatures and droplet sizes for freezing precipitation testing with Type II/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 2.3.

Table 2.3: Summary of Freezing Precipitation Test Conditions (Type II/IV Fluids)

Precipitation Type	Ambient Temperature	Precipitation Rate (Droplet Size)
Freezing Fog	-3°C	2 g/dm²/h (30 μm)
		5 g/dm²/h (30 μm)
	-10°C	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)

2.8 Analysis Methodology

A multi-variable regression procedure is used to derive fluid-specific holdover times for Type II/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 2.4. 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.

2.8.1 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 2.4).
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 2.8.3.

2.8.2 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 ($g/dm^2/h$)
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 2.8.3.

2.8.3 Natural Frost Tests

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 data under all temperatures encompassed by the frost HOT table.

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 current 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.

2.8.4 Rounding and Capping Protocols

Regression-generated holdover times are subject to rounding and capping protocols. For Type II/IV fluids they are as follows:

- Rounding Protocol: 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. In cases where the regression-generated holdover times are below 10 minutes, the numbers are rounded down to the nearest whole minute as a precautionary measure. For example, 9.6 minutes is rounded down to 9 minutes.

- Capping Protocol: Holdover time values are capped at 2 hours for all precipitation conditions except freezing fog values, which are capped at 4 hours.

2.8.5 Example

Sample plots of **Log t** versus **Log R** are shown in Figure 2.9. 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 2.10. 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/dm²/h and 35 minutes at 25 g/dm²/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.

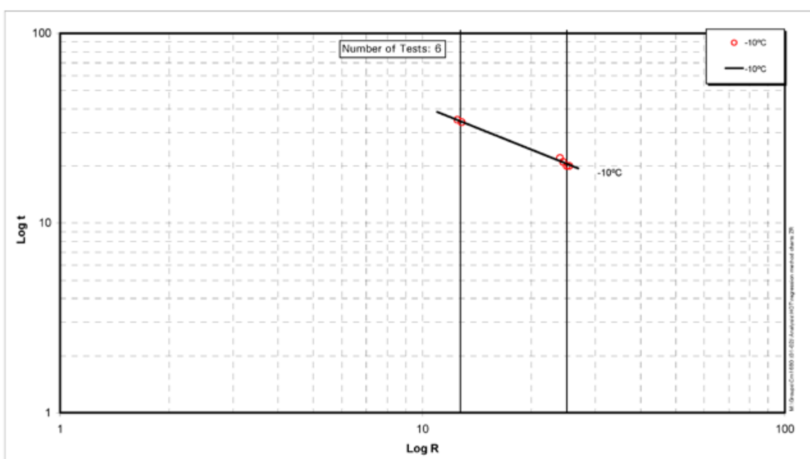

Figure 2.9: Regression Method on Log-Log Chart – Type IV Neat, Freezing Rain

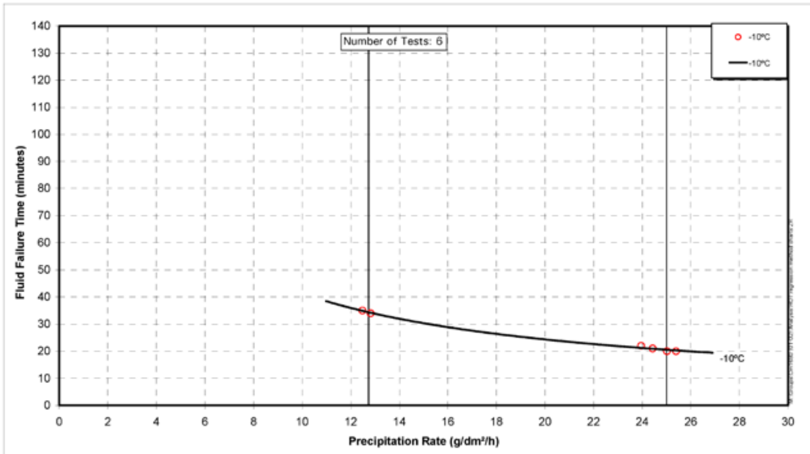

Figure 2.10: Regression Method on Standard Chart – Type IV Neat, Freezing Rain

Photo 2.1: APS Test Site - View from Test Pad

Photo 2.2: APS Test Site - View from Trailer

Photo 2.3: Mobile Test Site

Photo 2.4: Outdoor View of NRC Climatic Engineering Facility

Photo 2.5: Inside View of NRC Climatic Engineering Facility

Photo 2.6: Test Plates Mounted on Stand

Photo 2.7: Cold-Soak / Leading Edge Thermal Equivalent Box

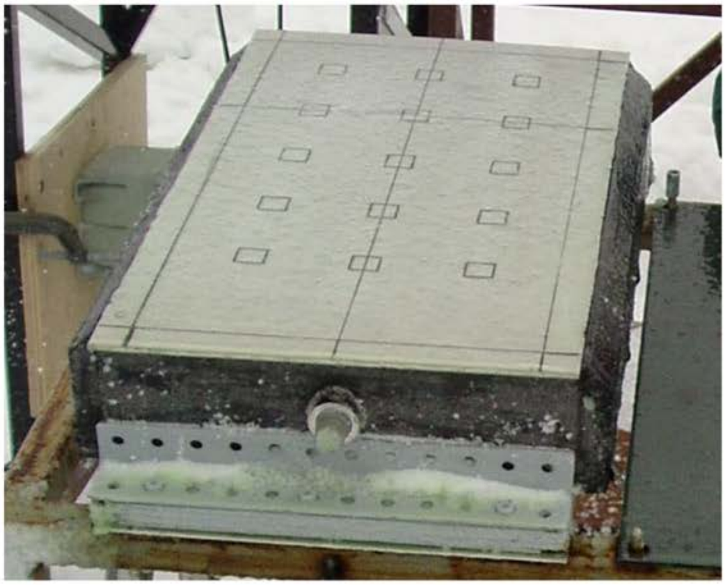

Photo 2.8: Frost Plate with Insulated Backing

Photo 2.9: Collection Pans Used Indoors at the NRC

Photo 2.10: Sprayer Assembly

Photo 2.11: Sprayer Assembly in Use

Photo 2.12: Sprayer Nozzle

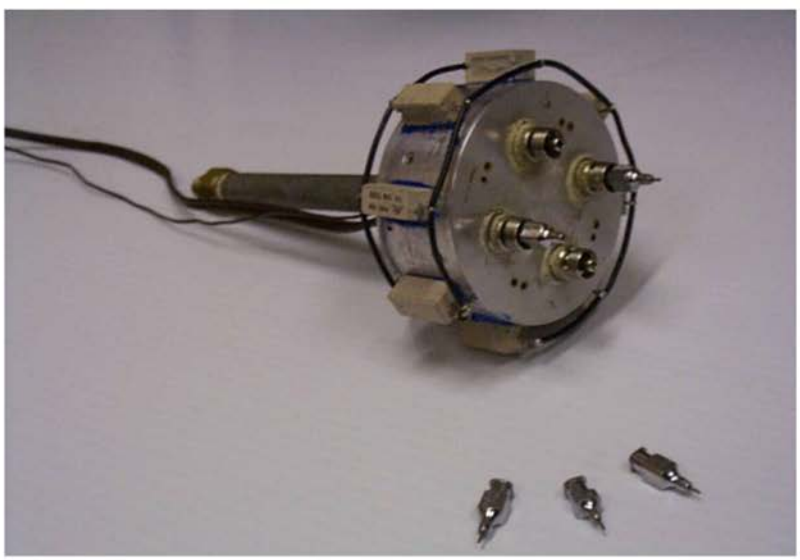

Photo 2.13: Standard Plate Setup for Type I Testing with Artificial Snowmaker

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3. DESCRIPTION OF DATA

This section provides a summary of the number of tests conducted in natural snow, artificial snow, light freezing rain, freezing drizzle, freezing fog and rain on cold soaked wing. Breakdowns are provided for the number of tests performed by fluid type and temperature.

A log of tests conducted in snow (Table 3.1), a log of tests conducted in freezing precipitation (Table 3.2) and a log of tests conducted in frost (Table 3.3) are provided at the end of this section. The logs provide details of each test conducted.

3.1 Freezing Fog Tests

Tests were conducted in freezing fog conditions at the NRC CEF. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

	-3°C	-14°C	-25°C
Neat	4	4	4
75/25	4	4	0
50/50	4	0	0

3.2 Freezing Drizzle and Light Freezing Rain Tests

Tests were conducted in freezing drizzle and light freezing rain conditions at the NRC CEF. The breakdown of tests conducted is summarized below by precipitation type, fluid dilution and temperature.

	Freezing Drizzle		Light Freezing Rain	
	-3°C	-10°C	-3°C	-10°C
Neat	4	4	4	4
75/25	4	4	4	4
50/50	4	0	4	0

3.3 Rain on Cold-Soaked Surface Tests

Tests were conducted in rain on cold-soaked surface conditions at the NRC CEF with Neat and 75/25 diluted fluids. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

	+1°C
Neat	4
75/25	4
50/50	0

3.4 Natural Snow Tests

Tests were conducted in natural snow conditions at the APS test site and at several mobile test sites (see Subsection 2.2.1). The breakdown of tests conducted is summarized below by fluid dilution and temperature.

	≥ -3°C	-3 to -14°C	<-14°C
Neat	14	12	0
75/25	16	14	0
50/50	19	0	0

3.5 Artificial Snow Tests

Supplemental tests were conducted in artificial snow at the APS test site with Neat and 75/25 dilutions at -14°C. The breakdown of tests conducted is summarized below by fluid dilution, temperature and rate of precipitation.

	-10°C	
	10 $g/dm^2/h$	25 $g/dm^2/h$
Neat	1	1
75/25	1	1
50/50	0	0

3.6 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.

	≥-1°C	<-1 to -3°C	<-3 to -10°C	<-10 to -14°C	<-14
Neat	1	1	3	1	0
75/25	1	2	3	1	0
50/50	1	1	0	0	0

3.7 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.

The film thickness profiles are displayed in Figure 3.1. The final fluid thicknesses are displayed in Figure 3.2.

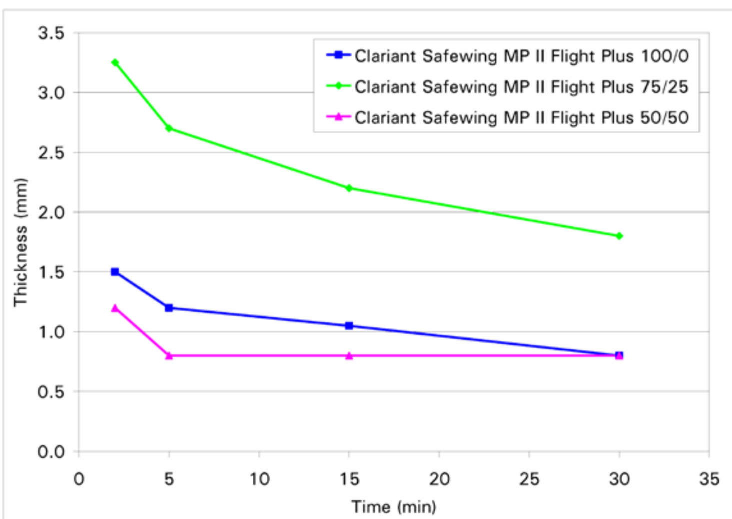

Figure 3.1: Fluid Thickness Profiles of Clariant Safewing MP II FLIGHT PLUS

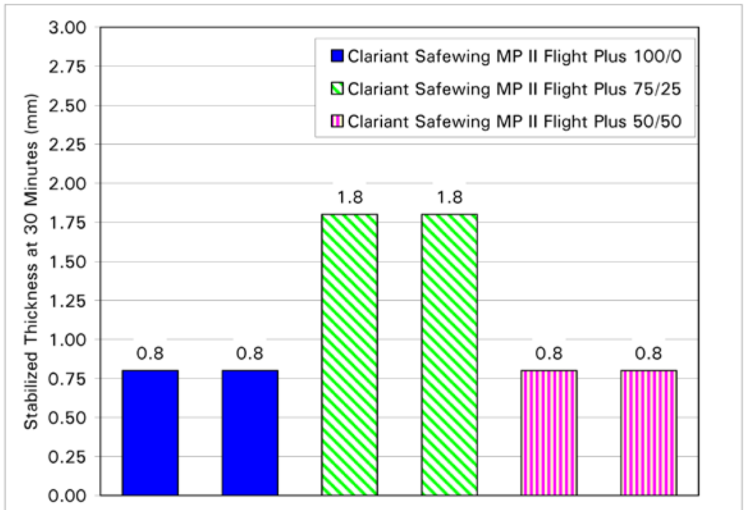

Figure 3.2: Final Fluid Thickness of Clariant Safewing MP II FLIGHT PLUS

Table 3.1: Summary of Tests Performed (Snow)

Test No.	Date	Snow Type	Test Location	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
Winter 2011-12 Tests								
92	3-Mar-12	Natural	Montreal	MP II Flight Plus	100/0	-0.5	22.9	84.4
93	3-Mar-12	Natural	Montreal	MP II Flight Plus	100/0	-0.1	18.8	86.0
94	3-Mar-12	Natural	Montreal	MP II Flight Plus	75/25	-0.1	18.8	84.3
95	3-Mar-12	Natural	Montreal	MP II Flight Plus	50/50	-0.3	15.4	33.5
102	3-Mar-12	Natural	Montreal	MP II Flight Plus	75/25	-0.5	23.0	84.3
103	3-Mar-12	Natural	Montreal	MP II Flight Plus	50/50	-0.6	20.5	26.3
108	3-Mar-12	Natural	Montreal	MP II Flight Plus	50/50	-0.3	25.6	27.6
109	3-Mar-12	Natural	Montreal	MP II Flight Plus	75/25	0.0	23.8	75.0
112	3-Mar-12	Natural	Montreal	MP II Flight Plus	50/50	-0.3	24.0	23.6
126	13-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	50/50	-1.4	20.0	23.0
129	13-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	100/0	-1.2	20.7	74.6
130	13-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	75/25	-1.2	21.5	78.0
131	13-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	50/50	-1.4	13.5	20.4
132	13-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	75/25	-1.2	25.2	56.2
133	13-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	100/0	-1.2	26.5	65.5
136	13-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	75/25	-1.7	15.9	105.5
137	13-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	50/50	-1.4	32.0	22.3
140	13-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	50/50	-1.7	5.4	61.4
142	14-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	75/25	-3.5	4.9	199.5
145	14-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	100/0	-3.9	5.0	232.4
146	14-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	75/25	-3.9	5.0	229.9
147	14-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	100/0	-3.5	5.6	209.5
148	14-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	75/25	-3.9	4.8	189.7
151	14-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	50/50	-2.8	11.4	29.8
154	14-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	100/0	-3.0	12.8	123.7
155	14-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	75/25	-2.8	12.8	112.1
156	14-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	100/0	-2.9	12.0	107.1
157	14-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	75/25	-2.9	12.1	108.4
158	14-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	100/0	-3.3	6.5	237.8
159	14-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	75/25	-3.4	6.1	216.5
160	14-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	50/50	-2.8	12.2	36.1
163	14-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	100/0	-3.0	11.8	117.6
164	14-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	75/25	-2.9	12.1	121.5
167	14-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	100/0	-3.2	12.7	113.5
168	14-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	75/25	-3.2	12.6	110.8
169	14-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	100/0	-3.2	12.4	107.0
170	14-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	75/25	-3.2	12.4	109.9

Table 3.1 (cont'd): Summary of Tests Performed (Snow)

Test No.	Date	Snow Type	Test Location	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
Winter 2011-12 Tests (cont'd)								
173	14-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	50/50	-3.2	15.0	17.1
183	27-Mar-12	Natural	St-Jovite, QC	MP II Flight Plus	100/0	-2.3	13.0	66.1
184	27-Mar-12	Natural	St-Jovite, QC	MP II Flight Plus	75/25	-2.3	13.1	66.6
185	27-Mar-12	Natural	St-Jovite, QC	MP II Flight Plus	50/50	-2.2	4.4	29.5
189	4-Apr-12	Natural	Rimouski, QC	MP II Flight Plus	75/25	-0.3	7.3	107.8
190	4-Apr-12	Natural	Rimouski, QC	MP II Flight Plus	50/50	-0.3	8.7	48.1
192	4-Apr-12	Natural	Rimouski, QC	MP II Flight Plus	50/50	-0.3	6.8	74.1
201	4-Apr-12	Natural	Rimouski, QC	MP II Flight Plus	50/50	-0.3	6.5	78.3
207	4-Apr-12	Natural	Rimouski, QC	MP II Flight Plus	50/50	-0.1	7.0	98.6
217	5-Apr-12	Natural	Gaspésie, QC	MP II Flight Plus	50/50	0.0	4.2	88.6
224	8-Apr-12	Natural	Gaspésie, QC	MP II Flight Plus	100/0	0.0	15.2	91.2
225	8-Apr-12	Natural	Gaspésie, QC	MP II Flight Plus	75/25	0.0	14.6	86.0
230	8-Apr-12	Natural	Gaspésie, QC	MP II Flight Plus	100/0	0.0	18.7	71.0
231	8-Apr-12	Natural	Gaspésie, QC	MP II Flight Plus	75/25	0.0	17.9	66.3
233	8-Apr-12	Natural	Gaspésie, QC	MP II Flight Plus	50/50	0.0	22.0	24.6
235	8-Apr-12	Natural	Gaspésie, QC	MP II Flight Plus	100/0	0.0	19.8	91.1
236	8-Apr-12	Natural	Gaspésie, QC	MP II Flight Plus	75/25	0.0	23.5	70.4
253	8-Apr-12	Natural	Gaspésie, QC	MP II Flight Plus	50/50	0.0	21.8	23.9
A1	24-Apr-12	Artificial	Montreal	MP II Flight Plus	100/0	-14	10	45
A2	24-Apr-12	Artificial	Montreal	MP II Flight Plus	100/0	-14	25	20
A3	24-Apr-12	Artificial	Montreal	MP II Flight Plus	75/25	-14	10	20
A4	24-Apr-12	Artificial	Montreal	MP II Flight Plus	75/25	-14	25	10
Winter 2012-13 Tests								
5	16-Dec-12	Natural	Montreal	MP II Flight Plus	100/0	-7.6	4.7	196.0
7	16-Dec-12	Natural	Montreal	MP II Flight Plus	75/25	-7.4	4.5	235.1
17	27-Dec-12	Natural	Montreal	MP II Flight Plus	100/0	-6.2	58.5	23.5
18	27-Dec-12	Natural	Montreal	MP II Flight Plus	75/25	-6.2	57.8	19.8
20	29-Dec-12	Natural	Montreal	MP II Flight Plus	75/25	-8.6	8.7	88.0
23	29-Dec-12	Natural	Montreal	MP II Flight Plus	100/0	-8.5	8.7	88.0
24	29-Dec-12	Natural	Montreal	MP II Flight Plus	75/25	-9.3	3.2	200.2
27	29-Dec-12	Natural	Montreal	MP II Flight Plus	100/0	-9.1	3.9	175.5
75	11-Feb-13	Natural	Montreal	MP II Flight Plus	100/0	-6.8	20.4	23.7
80	11-Feb-13	Natural	Montreal	MP II Flight Plus	75/25	-6.8	25.0	31.1
104	15-Feb-13	Natural	Montreal	MP II Flight Plus	100/0	-0.7	6.7	172.0
105	15-Feb-13	Natural	Montreal	MP II Flight Plus	75/25	-0.7	6.4	167.7
160	20-Feb-13	Natural	Montreal	MP II Flight Plus	100/0	-5.4	5.8	176.4
161	20-Feb-13	Natural	Montreal	MP II Flight Plus	75/25	-6.2	5.8	185.7

Table 3.1 (cont'd): Summary of Tests Performed (Snow)

Test No.	Date	Snow Type	Test Location	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
Winter 2012-13 Tests (cont'd)								
189	23-Feb-13	Natural	Montreal	MP II Flight Plus	100/0	0.0	7.0	137.8
193	23-Feb-13	Natural	Montreal	MP II Flight Plus	75/25	-0.1	4.4	93.1
285	15-Mar-13	Natural	Montreal	MP II Flight Plus	75/25	-3.1	2.2	105.0
300	19-Mar-13	Natural	Montreal	MP II Flight Plus	100/0	-3.8	9.4	76.1
304	19-Mar-13	Natural	Montreal	MP II Flight Plus	75/25	-3.7	9.8	118.8
317	19-Mar-13	Natural	Montreal	MP II Flight Plus	100/0	-2.8	14.2	53.2

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	26-Mar-12	Freezing Fog	MP II Flight Plus	100/0	-26.0	2.0	42.5
2	26-Mar-12	Freezing Fog	MP II Flight Plus	100/0	-26.0	2.0	41.6
11	26-Mar-12	Freezing Fog	MP II Flight Plus	100/0	-25.8	4.6	20.5
12	26-Mar-12	Freezing Fog	MP II Flight Plus	100/0	-25.8	4.6	20.0
21	26-Mar-12	Freezing Fog	MP II Flight Plus	100/0	-13.9	2.1	130.6
22	26-Mar-12	Freezing Fog	MP II Flight Plus	100/0	-13.9	2.1	129.7
25	26-Mar-12	Freezing Fog	MP II Flight Plus	75/25	-13.9	1.8	109.7
26	26-Mar-12	Freezing Fog	MP II Flight Plus	75/25	-13.9	2.1	108.6
29	26-Mar-12	Freezing Fog	MP II Flight Plus	100/0	-14.2	5.2	42.1
30	26-Mar-12	Freezing Fog	MP II Flight Plus	100/0	-14.3	4.6	44.0
33	26-Mar-12	Freezing Fog	MP II Flight Plus	75/25	-14.2	4.9	35.0
34	26-Mar-12	Freezing Fog	MP II Flight Plus	75/25	-14.3	4.8	31.2
61	27-Mar-12	Freezing Fog	MP II Flight Plus	100/0	-2.5	1.9	> 4 hrs
62	27-Mar-12	Freezing Fog	MP II Flight Plus	100/0	-2.5	1.7	> 4 hrs
65	27-Mar-12	Freezing Fog	MP II Flight Plus	75/25	-2.5	1.8	> 4 hrs
66	27-Mar-12	Freezing Fog	MP II Flight Plus	75/25	-2.5	2.0	> 4 hrs
69	27-Mar-12	Freezing Fog	MP II Flight Plus	50/50	-2.5	1.8	154.0
70	27-Mar-12	Freezing Fog	MP II Flight Plus	50/50	-2.5	1.8	153.3
83	28-Mar-12	Freezing Fog	MP II Flight Plus	100/0	-2.9	5.3	156.0
84	28-Mar-12	Freezing Fog	MP II Flight Plus	100/0	-2.9	5.4	151.7
87	28-Mar-12	Freezing Fog	MP II Flight Plus	75/25	-2.9	5.4	148.8
88	28-Mar-12	Freezing Fog	MP II Flight Plus	75/25	-2.9	5.4	144.8
91	28-Mar-12	Freezing Fog	MP II Flight Plus	50/50	-3.0	5.1	61.0
92	28-Mar-12	Freezing Fog	MP II Flight Plus	50/50	-3.0	5.1	62.2
105	21-Mar-12	Light Freezing Rain	MP II Flight Plus	100/0	-10.4	13.1	54.3
106	21-Mar-12	Light Freezing Rain	MP II Flight Plus	100/0	-10.4	12.8	53.8
109	21-Mar-12	Light Freezing Rain	MP II Flight Plus	75/25	-10.4	13.2	44.5
110	21-Mar-12	Light Freezing Rain	MP II Flight Plus	75/25	-10.4	12.8	41.5
121	21-Mar-12	Light Freezing Rain	MP II Flight Plus	100/0	-10.1	25.4	31.5
122	21-Mar-12	Light Freezing Rain	MP II Flight Plus	100/0	-10.1	24.9	34.4
125	21-Mar-12	Light Freezing Rain	MP II Flight Plus	75/25	-10.1	25.2	31.4
126	21-Mar-12	Light Freezing Rain	MP II Flight Plus	75/25	-10.1	25.0	32.7
145	23-Mar-12	Light Freezing Rain	MP II Flight Plus	100/0	-2.9	13.1	59.5
146	23-Mar-12	Light Freezing Rain	MP II Flight Plus	100/0	-2.9	12.9	64.6
149	23-Mar-12	Light Freezing Rain	MP II Flight Plus	75/25	-2.9	13.2	77.7
150	23-Mar-12	Light Freezing Rain	MP II Flight Plus	75/25	-2.9	12.9	73.0
153	23-Mar-12	Light Freezing Rain	MP II Flight Plus	50/50	-3.1	13.1	18.9
154	23-Mar-12	Light Freezing Rain	MP II Flight Plus	50/50	-3.0	12.8	20.0

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)
163	23-Mar-12	Light Freezing Rain	MP II Flight Plus	100/0	-2.9	24.8	48.3
164	23-Mar-12	Light Freezing Rain	MP II Flight Plus	100/0	-2.9	24.4	47.2
167	23-Mar-12	Light Freezing Rain	MP II Flight Plus	75/25	-2.9	25.7	47.4
168	23-Mar-12	Light Freezing Rain	MP II Flight Plus	75/25	-2.9	25.5	49.1
171	23-Mar-12	Light Freezing Rain	MP II Flight Plus	50/50	-2.9	25.1	13.3
172	23-Mar-12	Light Freezing Rain	MP II Flight Plus	50/50	-2.9	25.8	13.8
181	21-Mar-12	Freezing Drizzle	MP II Flight Plus	100/0	-10.3	5.0	89.0
182	21-Mar-12	Freezing Drizzle	MP II Flight Plus	100/0	-10.3	5.2	82.2
185	21-Mar-12	Freezing Drizzle	MP II Flight Plus	75/25	-10.3	4.8	74.6
186	21-Mar-12	Freezing Drizzle	MP II Flight Plus	75/25	-10.4	4.6	72.2
197	21-Mar-12	Freezing Drizzle	MP II Flight Plus	100/0	-10.5	13.5	33.4
198	21-Mar-12	Freezing Drizzle	MP II Flight Plus	100/0	-10.5	13.2	33.4
201	21-Mar-12	Freezing Drizzle	MP II Flight Plus	75/25	-10.5	13.4	25.4
202	21-Mar-12	Freezing Drizzle	MP II Flight Plus	75/25	-10.5	13.5	26.5
221	22-Mar-12	Freezing Drizzle	MP II Flight Plus	100/0	-2.5	5.2	> 2 hrs
222	22-Mar-12	Freezing Drizzle	MP II Flight Plus	100/0	-2.5	5.2	> 2 hrs
225	22-Mar-12	Freezing Drizzle	MP II Flight Plus	75/25	-2.5	5.4	> 2 hrs
226	22-Mar-12	Freezing Drizzle	MP II Flight Plus	75/25	-2.5	5.4	> 2 hrs
229	22-Mar-12	Freezing Drizzle	MP II Flight Plus	50/50	-2.5	5.4	55.4
230	22-Mar-12	Freezing Drizzle	MP II Flight Plus	50/50	-2.6	5.2	66.3
243	22-Mar-12	Freezing Drizzle	MP II Flight Plus	100/0	-2.5	13.4	84.0
244	22-Mar-12	Freezing Drizzle	MP II Flight Plus	100/0	-2.5	13.2	84.0
247	22-Mar-12	Freezing Drizzle	MP II Flight Plus	75/25	-2.6	13.1	97.2
248	22-Mar-12	Freezing Drizzle	MP II Flight Plus	75/25	-2.6	12.9	93.6
251	22-Mar-12	Freezing Drizzle	MP II Flight Plus	50/50	-2.5	13.3	29.1
252	22-Mar-12	Freezing Drizzle	MP II Flight Plus	50/50	-2.5	13.3	30.5
265	23-Mar-12	Cold Soak Box	MP II Flight Plus	100/0	1.1	5.0	> 2 hrs
266	23-Mar-12	Cold Soak Box	MP II Flight Plus	100/0	1.1	4.8	> 2 hrs
269	23-Mar-12	Cold Soak Box	MP II Flight Plus	75/25	1.2	5.2	79.9
270	23-Mar-12	Cold Soak Box	MP II Flight Plus	75/25	1.2	5.1	72.2
281	23-Mar-12	Cold Soak Box	MP II Flight Plus	100/0	0.8	77.8	13.3
282	23-Mar-12	Cold Soak Box	MP II Flight Plus	100/0	0.8	78.0	13.1
285	23-Mar-12	Cold Soak Box	MP II Flight Plus	75/25	0.8	76.5	14.9
286	23-Mar-12	Cold Soak Box	MP II Flight Plus	75/25	0.8	77.0	15.7

Table 3.3: Summary of Tests Performed (Natural Frost)

Test No.	Date	Precip. Type	Fluid Name	Fluid Dilution	Endurance Time (min.)	Average Rate (g/dm²/h)	Temp (°C)	Wind Speed (km/h)	Average RH (%)	Comments
1	25-Dec-12	Natural Frost	Flight Plus	100%	491.0	0.058	-12.1	5	87	not failed
3	25-Dec-12	Natural Frost	Flight Plus	75%	490.5	0.058	-12.0	5	87	not failed
8	13-Feb-13	Natural Frost	Flight Plus	100%	521.8	0.031	-1.3	4	86	not failed
13	13-Feb-13	Natural Frost	Flight Plus	75%	521.2	0.031	-1.3	4	86	not failed
18	18-Feb-13	Natural Frost	Flight Plus	100%	601.2	0.047	-9.3	6	60	not failed
23	18-Feb-13	Natural Frost	Flight Plus	75%	599.5	0.047	-9.3	6	60	not failed
28	21-Feb-13	Natural Frost	Flight Plus	100%	383.8	0.004	-5.9	9	78	not failed
33	21-Feb-13	Natural Frost	Flight Plus	75%	383.5	0.004	-5.9	9	78	not failed
39	8-Mar-13	Natural Frost	Flight Plus	75%	615.4	0.146	-3.5	4	79	not failed
48	8-Mar-13	Natural Frost	Flight Plus	100%	617.8	0.146	-3.5	4	79	not failed
56	9-Mar-13	Natural Frost	Flight Plus	75%	366.2	0.051	-1.1	4	84	not failed
58	9-Mar-13	Natural Frost	Flight Plus	50%	191.4	0.143	-3.2	5	78	failed
63	9-Mar-13	Natural Frost	Flight Plus	100%	349.6	0.051	-0.3	4	72	not failed
68	9-Mar-13	Natural Frost	Flight Plus	50%	338.0	0.051	-0.2	4	72	not failed
73	9-Mar-13	Natural Frost	Flight Plus	100%	623.9	0.146	-3.5	4	79	not failed

4. RESULTS AND DISCUSSION

The methods used to evaluate the test data were reviewed in Subsection 2.8. The holdover times and data used to generate holdover times for Clariant Safewing MP II FLIGHT PLUS are presented in this section.

4.1 Data

Figures 4.1 to 4.14 present the data collected in natural snow, 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.

Figures 4.15 and 4.16 present the supplemental data collected in artificial snow. The bar chart compares the endurance times measured with a snowmaker to the current generic Type II holdover times.

Table 4.1 illustrates the outputs from the multi-variable regression analyses performed on the natural snow, freezing fog, freezing drizzle, freezing rain and cold soak data. These outputs were used to derive fluid-specific holdover times for all cells in the fluid-specific HOT table, with the exception of the values in the “Below -3 to -14°C” and “Below -14°C to LOUT” snow cells.

The natural frost data was presented in Table 3.3. All completed (“failed”) tests surpassed the generic holdover times, as did most of the tests that were not completed (due to active frost ending before fluid failure could occur). Observations from the remaining tests indicated the generic frost holdover times would have been achieved had the tests been completed. Thus the data indicates the generic frost holdover times have been substantiated for Clariant Safewing MP II FLIGHT PLUS.

4.2 Holdover Time Table

A fluid-specific HOT table for Clariant Safewing MP II FLIGHT PLUS was produced for and published in the FAA and TC 2012-13 HOT guidelines. An updated HOT table was produced for the winter 2013-14 HOT guidelines. This table includes updated snow holdover times, which are the result of additional natural snow testing conducted in the winter of 2012-13. The table is shown in Table 4.2 (Transport Canada format). Most of the values in the table were derived from standard regression analysis of the endurance time data collected; exceptions are described below in Subsections 4.2.1 and 4.2.2.

It is expected the updated fluid-specific HOT table will be published by TC and FAA in their 2013-14 HOT guidelines.

4.2.1 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 snow data at temperatures below -14°C. As a result of this testing, the existing propylene Type II and Type IV fluids were given generic values in the "Below -14 to LOUT" snow cell. It was also decided that all new Type II and Type IV fluids would be given the generic values. Accordingly, Clariant Safewing MP II FLIGHT PLUS has been given generic values in the "Below -14°C to LOUT" snow cell.

4.2.2 Holdover Times in Frost

In May 2009, a decision was made by TC and the FAA 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 fluid-specific HOT table for Clariant Safewing MP II FLIGHT PLUS.

4.2.3 Fluid Viscosity

The viscosities of the fluid samples used in this testing were measured using both the AIR 9968 method and the manufacturer's designated method. The APS measured viscosities appear at the beginning of this document and will also be published in the HOT Guidelines 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 Discussion

Clariant indicated it would commercialize Safewing MP II FLIGHT PLUS in the winter of 2012-13; therefore, the original HOT table created for this fluid, as well as the LOWV and LOUT information, were published in the 2012-13 FAA and TC HOT guidelines. It is expected the updated HOT table, which includes updated snow holdover times developed using the new natural snow data collected in the winter of 2012-13, will be published in the 2013-14 FAA and TC HOT guidelines.

4. RESULTS AND DISCUSSION

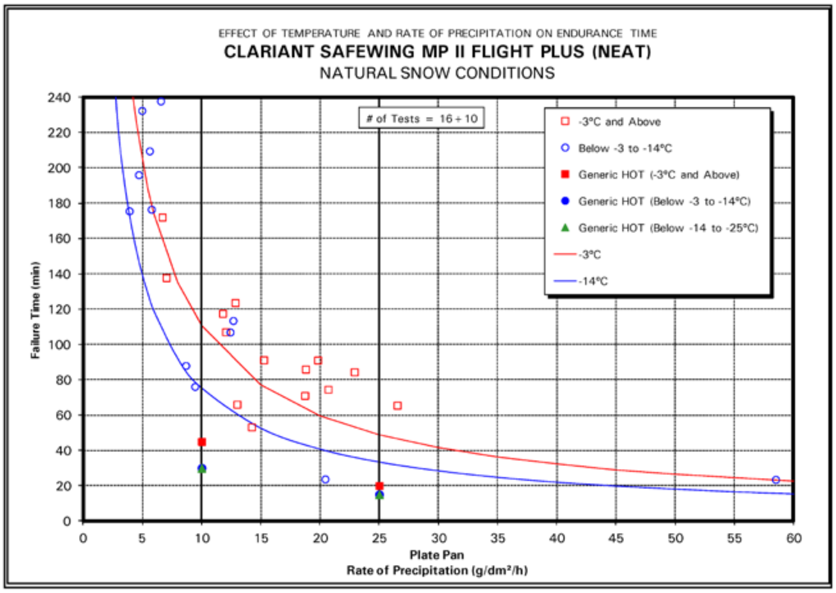

Figure 4.1: Type II Neat – Natural Snow

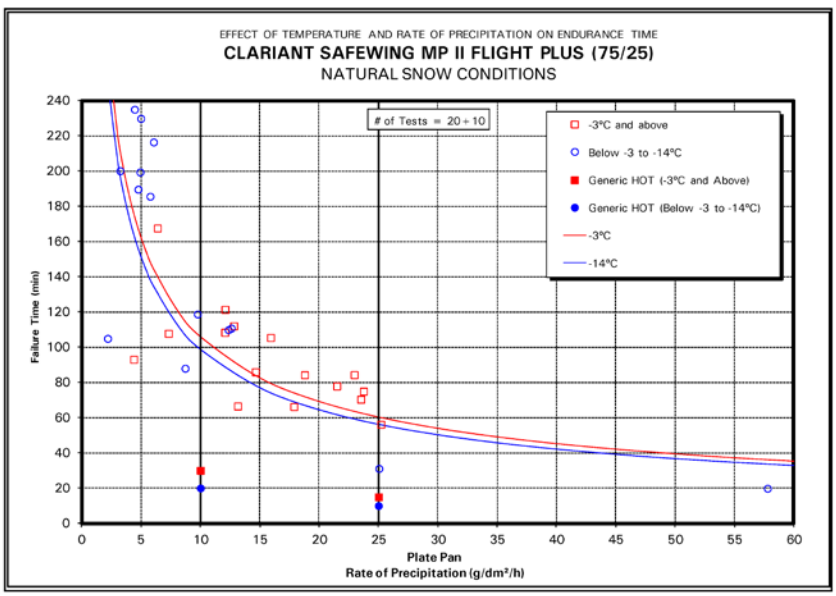

Figure 4.2: Type II 75/25 – Natural Snow

M:\Projects\PM2265.002 (TC Deicing 2012-13)\Reports\Fluid Manufacturer\Clariant MP II Flight Plus\Clariant Safewing MP II Flight Plus Version 2.0.docx
Version 2.0, August 13

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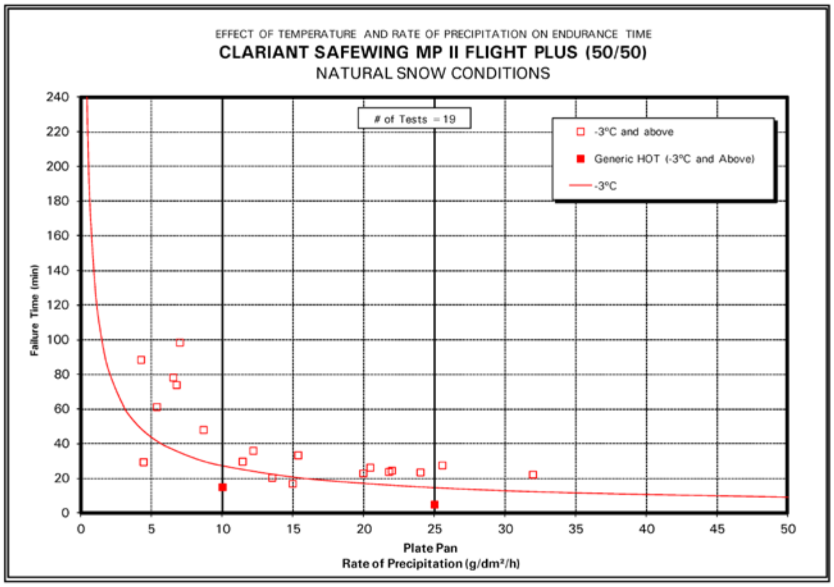


Figure 4.3: Type II 50/50 – Natural Snow

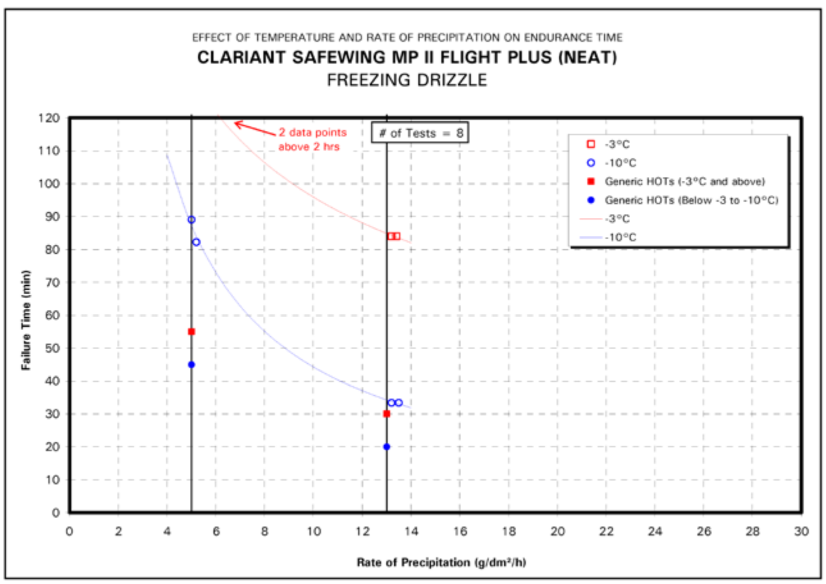


Figure 4.4: Type II Neat – Freezing Drizzle

4. RESULTS AND DISCUSSION

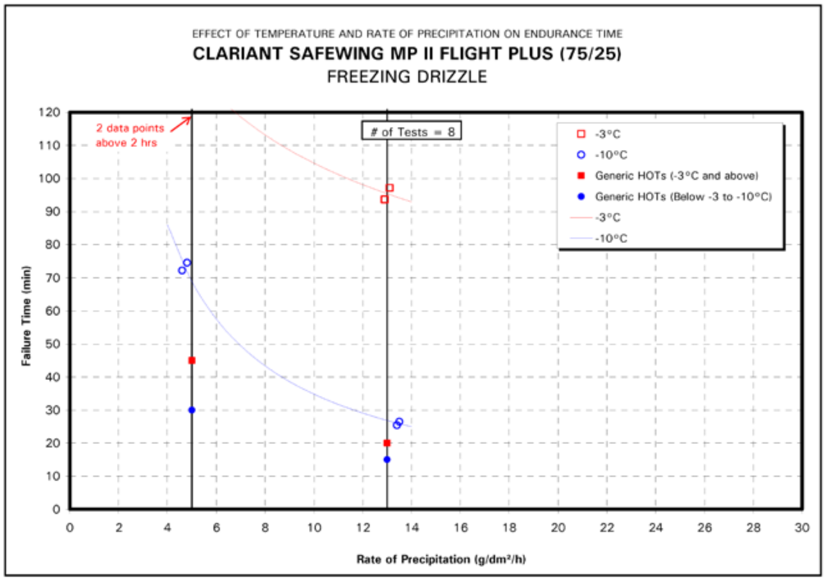


Figure 4.5: Type II 75/25 – Freezing Drizzle

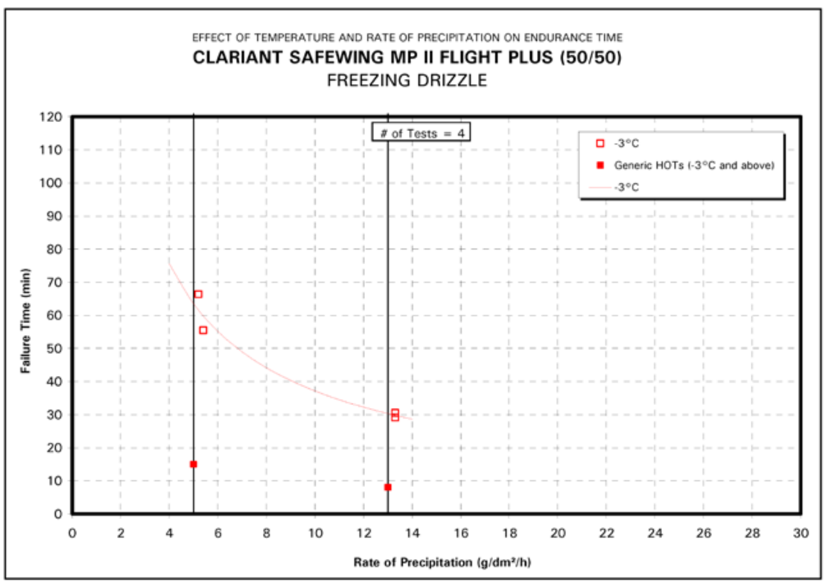


Figure 4.6: Type II 50/50 – Freezing Drizzle

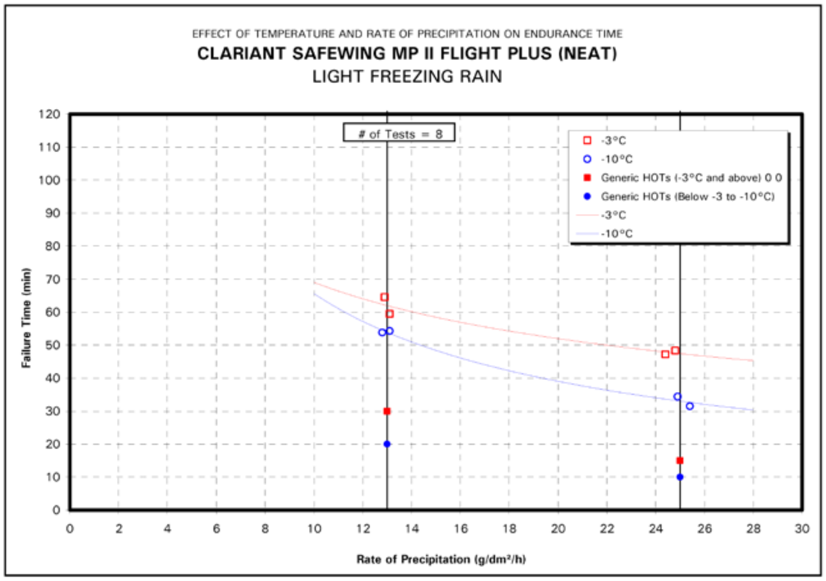


Figure 4.7: Type II Neat – Light Freezing Rain

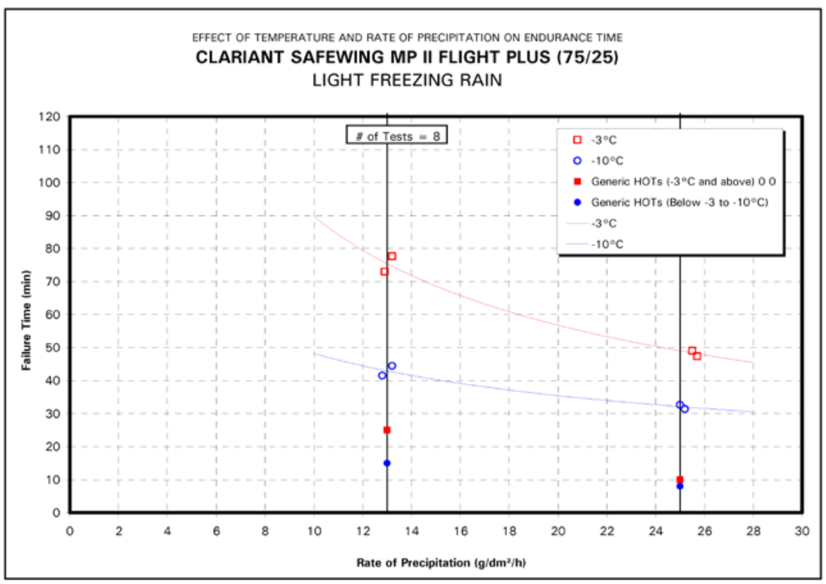


Figure 4.8: Type II 75/25 – Light Freezing Rain

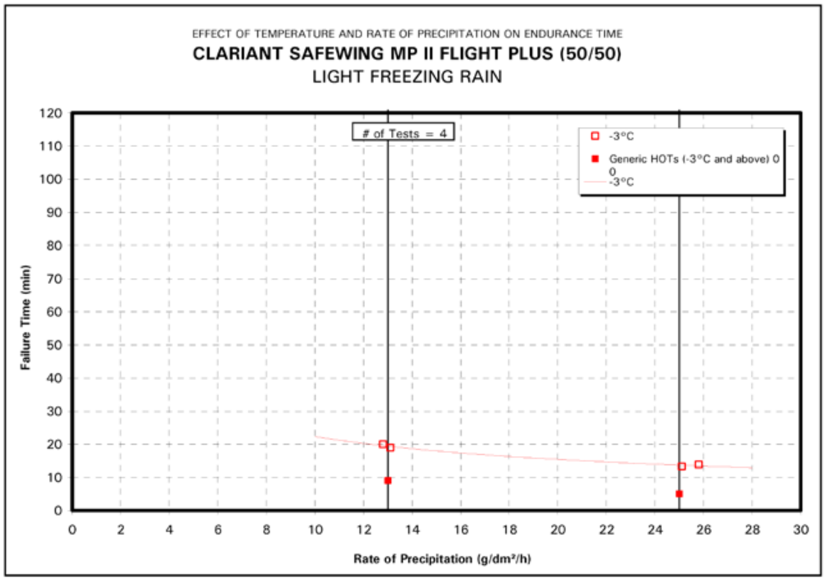


Figure 4.9: Type II 50/50 – Light Freezing Rain

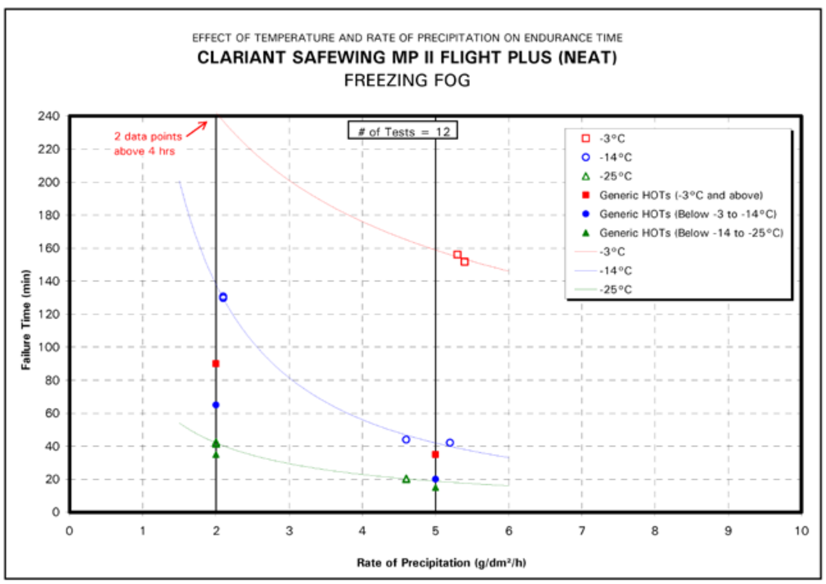


Figure 4.10: Type II Neat – Freezing Fog

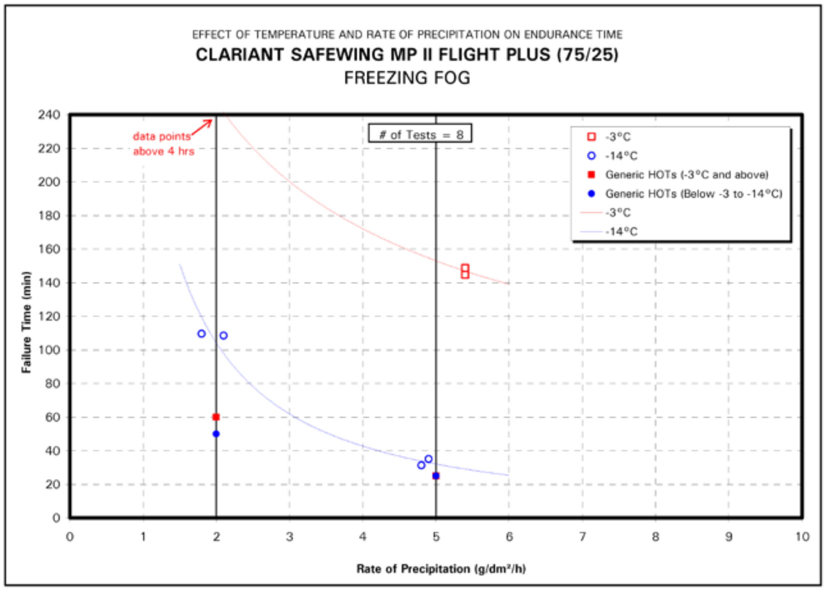


Figure 4.11: Type II 75/25 – Freezing Fog

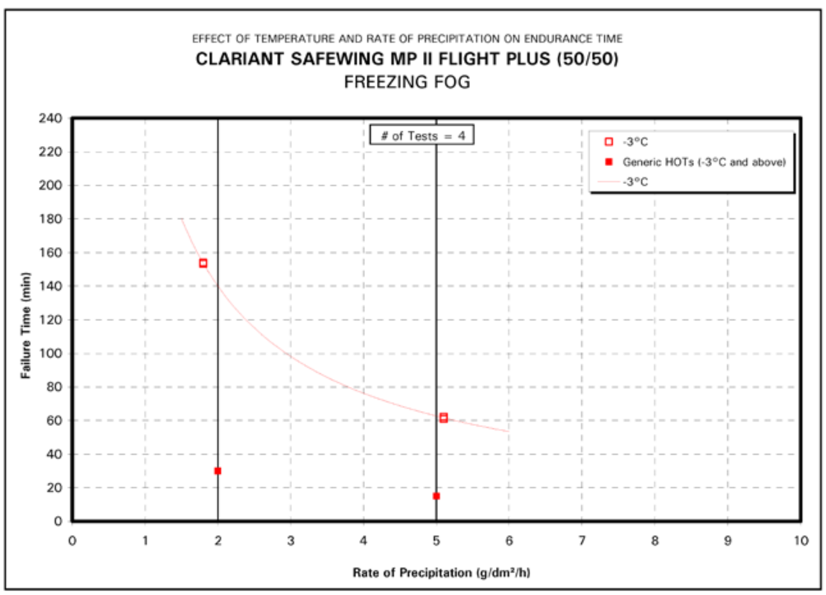


Figure 4.12: Type II 50/50 – Freezing Fog

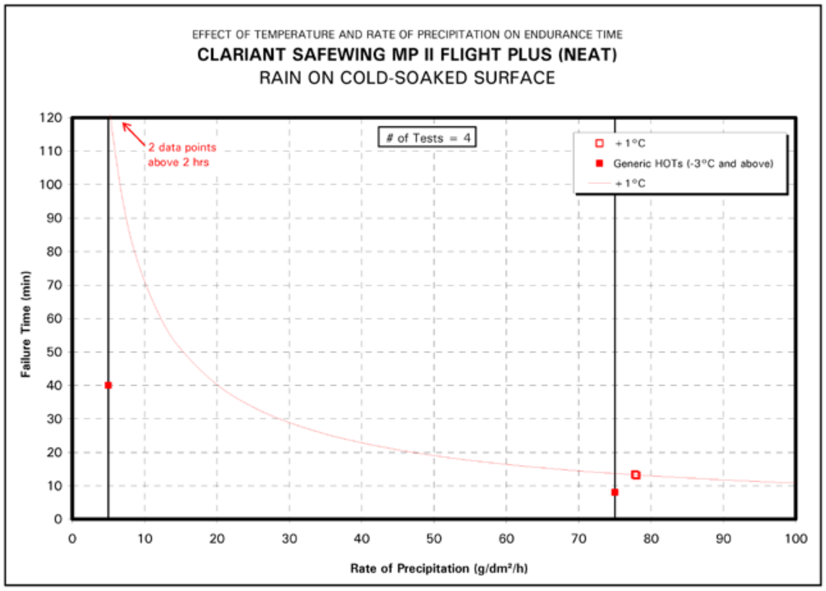


Figure 4.13: Type II Neat – Rain on Cold-Soaked Surface

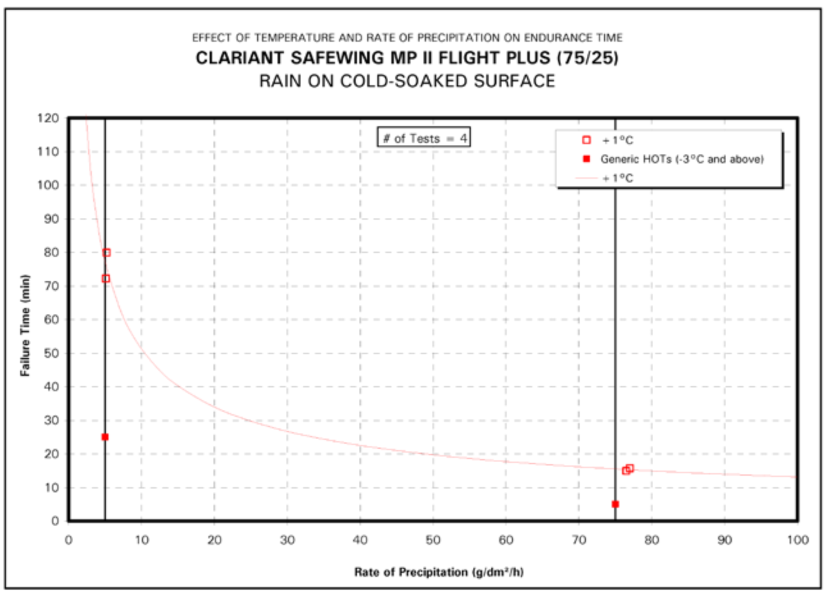


Figure 4.14: Type II 75/25 – Rain on Cold-Soaked Surface

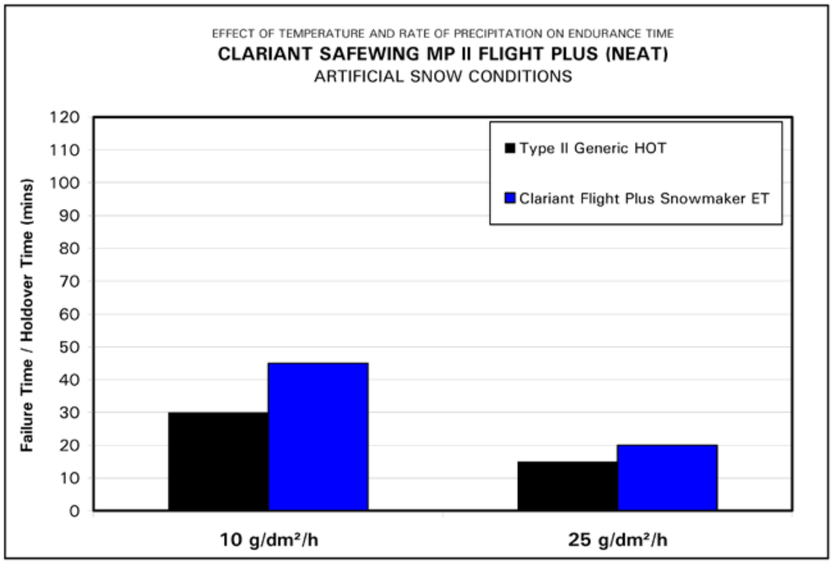


Figure 4.15: Type II Neat – Artificial Snow

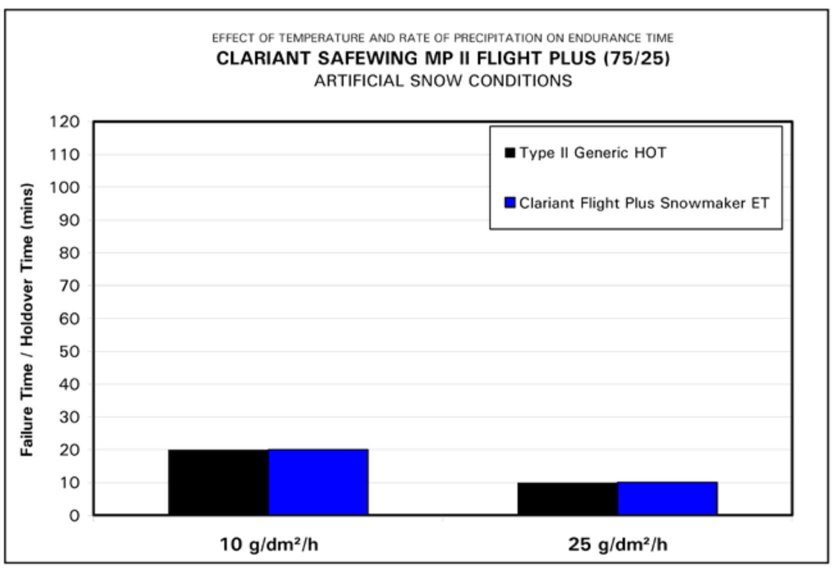


Figure 4.16: Type II 75/25 – Artificial Snow

Table 4.1: Regression Equation Coefficients for Clariant Safewing MP II FLIGHT PLUS

Natural Snow Conditions*

Fluid	Dil	R^2	Intercept (I)	Coeff. Rate (A)	Coeff. Tem (B)	Total Pts.
Clariant Safewing MP II Flight Plus	Neat	79%	3.1605	-0.8880	-0.3275	26
Clariant Safewing MP II Flight Plus	75/25	65%	2.6834	-0.6171	-0.0598	30
Clariant Safewing MP II Flight Plus	50/50	87%	2.6120	-0.6769	-0.7145	19

General Equation $t = 10^I R^A (2\text{-}T)^B$
*For use at -3°C and above only

Simulated Freezing Fog

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
Clariant Safewing MP II Flight Plus	Neat	-3°C	99%	2.5234	-0.4612	4
Clariant Safewing MP II Flight Plus	75/25	-3°C	99%	2.5521	-0.5255	4
Clariant Safewing MP II Flight Plus	50/50	-3°C	100%	2.4106	-0.8778	4
Clariant Safewing MP II Flight Plus	Neat	-14°C	99%	2.5312	-1.2991	4
Clariant Safewing MP II Flight Plus	75/25	-14°C	98%	2.4057	-1.2869	4
Clariant Safewing MP II Flight Plus	Neat	-25°C	100%	1.8877	-0.8771	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 MP II Flight Plus	Neat	-3°C	100%	2.4469	-0.4650	4
Clariant Safewing MP II Flight Plus	75/25	-3°C	99%	2.3720	-0.3524	4
Clariant Safewing MP II Flight Plus	50/50	-3°C	98%	2.3447	-0.7750	4
Clariant Safewing MP II Flight Plus	Neat	-10°C	100%	2.6242	-0.9778	4
Clariant Safewing MP II Flight Plus	75/25	-10°C	100%	2.5280	-0.9864	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 MP II Flight Plus	Neat	-3°C	95%	2.2484	-0.4093	4
Clariant Safewing MP II Flight Plus	75/25	-3°C	98%	2.6120	-0.6593	4
Clariant Safewing MP II Flight Plus	50/50	-3°C	98%	1.8799	-0.5318	4
Clariant Safewing MP II Flight Plus	Neat	-10°C	99%	2.5660	-0.7490	4
Clariant Safewing MP II Flight Plus	75/25	-10°C	95%	2.1271	-0.4438	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 MP II Flight Plus	Neat	+1°C	100%	2.6707	-0.8193	4
Clariant Safewing MP II Flight Plus	75/25	+1°C	100%	2.3026	-0.5932	4

General Equation $t = 10^I R^A$

Table 4.2: Fluid Specific Holdover Time Guidelines – Clariant Safewing MP II FLIGHT PLUS

TABLE 2-C-FLIGHT+

CLARIANT TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2013-2014[1]
SAFEWING MP II FLIGHT PLUS

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		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[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	CAUTION: No holdover time guidelines exist
		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]		
		75/25	0:30 – 1:45	0:55 – 1:40	0:25 – 1:10[7]	0:30 – 0:45[7]		
below -14 to -LOUT	below 7 to -20.2	100/0	0:20 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
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 guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

CAUTIONS

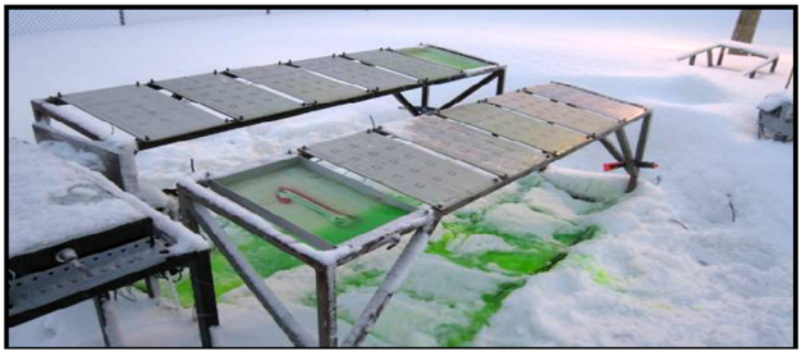
- **The only acceptable decision-making criterion, for takeoff without a pre-takeoff contamination inspection, is the shorter time within the applicable holdover time table cell.**
- **The time of protection will be shortened in heavy weather conditions, heavy precipitation rates, or high moisture content.**
- **High wind velocity or jet blast may reduce holdover time.**
- **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 E

FLUID MANUFACTURER REPORT: CLARIANT SAFEWING MP IV LAUNCH PLUS (TYPE IV)

AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

Clariant Safewing MP IV LAUNCH PLUS (Type IV)



Prepared for

Clariant 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 2013
Version 1.0
Report No. C-LP 2012-13

AIRCRAFT GROUND ANTI-ICING FLUID ENDURANCE TIME TEST RESULTS

Clariant Safewing MP IV LAUNCH PLUS (Type IV)

Prepared for

Clariant GmbH

Prepared by: Victoria Zoitakis, Junior Technologist — Date: August 27, 2013

Reviewed by: John D'Avirro, Eng., Program Manager — Date: August 27, 2013

and by: Stephanie Bendickson, Project Analyst — Date: August 27, 2013

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 2013
Version 1.0
Report No. C-LP 2012-13

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FLUID IDENTIFICATION AND CHARACTERISTICS

Manufacturer:	Clariant GmbH		
Fluid Test Name:	Safewing MP IV LAUNCH PLUS		
Fluid Commercial Name:	Safewing MP IV LAUNCH PLUS		
Fluid Type / Base / Colour:	Type IV / Propylene Glycol / Green		
Batch #:	TV 523		
Date of Receipt:	February 13, 2013		
Brix (Measured):	Neat fluid:	35.00°	
	75/25 dilution:	28.75°	
	50/50 dilution:	18.75°	
Freeze Point (Stated):	Neat fluid:	-36.0°C	
	75/25 dilution:	-20.8°C	
	50/50 dilution:	-10.7°C	
LOUT (Stated):	Neat fluid:	-29°C	
	75/25 dilution:	-14°C	
	50/50 dilution:	-3°C	
Viscosity:	**Mfr Method**	**Stated**	**Measured**
	Neat fluid:	8,400 cP[1]	8,700 cP[1]
	75/25 dilution:	17,400 cP[2]	18,800 cP[2]
	50/50 dilution:	15,200 cP[2]	9,700 cP[1]
	AIR 9968 Method	**Stated**	**Measured**
	Neat fluid:	8,300 cP[3]	8,450 cP[3]
	75/25 dilution:	19,100 cP[4]	17,200 cP[4]
	50/50 dilution:	14,100 cP[4]	12,150 cP[3]
WSET (from AMIL):	Neat fluid:	87 minutes	

[1] Spindle LV1, big sample adapter, 55 mL of fluid, 20°C, 0.3 rpm, for 10 minutes 0 seconds
[2] Spindle LV2-disc, big sample adapter, 60 mL of fluid, 20°C, 0.3 rpm, for 10 minutes 0 seconds
[3] Spindle LV1 with guard leg, 600 mL beaker, 500 mL of fluid, 20°C, 0.3 rpm, for 10 minutes 0 seconds
[4] Spindle LV2-disc with guard leg, 600 mL beaker, 500 mL of fluid, 20°C, 0.3 rpm, for 10 minutes 0 seconds

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SUMMARY

The primary objective of this project was to measure the endurance time performance of Clariant Safewing MP IV LAUNCH PLUS 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 in the tables on the next page. It is expected these holdover times will be published by regulators for use in the winter 2013-14 operating season.

Clariant Safewing MP IV LAUNCH PLUS Type IV Fluid Holdover Times (Transport Canada Format)

Outside Air Temperature		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: Very Light	Snow, Snow Grains or Snow Pellets: Light	Snow, Snow Grains or Snow Pellets: Moderate	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-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	
		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	CAUTION: No holdover time guidelines exist	
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	0:25–0:40		
		75/25	0:40–2:00	2:00	1:15–2:00	0:30–1:15	0:20–1:05	0:20–0:30		
below -14 to -29	below 7 to -20.2	100/0	0:25–0:50	0:40	0:40–0:30	0:15–0:30				

Clariant Safewing MP IV LAUNCH PLUS Type IV Fluid Holdover Times (FAA Format)

Outside Air Temperature		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: Very Light	Snow, Snow Grains or Snow Pellets: Light	Snow, Snow Grains or Snow Pellets: Moderate	Freezing Drizzle	Light Freezing Rain	Rain on Cold Soaked Wing	Other
-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	
		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	CAUTION: No holdover time guidelines exist	
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	0:25–0:40		
		75/25	0:40–2:00	2:55-3:00	1:15-2:55	0:30-1:15	0:20–1:05	0:20–0:30		
below -14 to -29	below 7 to -20.2	100/0	0:25–0:50	0:40-0:50	0:30-0:40	0:15-0:30				

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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
LOWV	Lowest On-Wing Viscosity
LWC	Liquid Water Content
MVD	Median Volume Diameter
MANOBS	Manual of Surface Weather Observations
NCAR	National Center for Atmospheric Research
NRC	National Research Council Canada
TC	Transport Canada
TDC	Transportation Development Centre

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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 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 all cells of the Type II/IV HOT tables using this protocol and are used to create a fluid-specific HOT table for each Type II/IV fluid tested.

This report provides a detailed account of the endurance time testing conducted by APS Aviation Inc. (APS) with **Clariant Safewing MP IV LAUNCH PLUS**, 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. These holdover times are expected to be published by regulators for use in the winter 2013-14 operating season.

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2

2. METHODOLOGY

SAE Aerospace Recommended Practice (ARP) 5485 provides the procedure and requirements for endurance time testing with Type II, III and IV fluids under natural and simulated conditions. This chapter summarizes some of aspects of the test methodology included in ARP5485, and some aspects which are not included in ARP5485. The chapter includes sections for test sites, equipment, procedures, precipitation rates and ambient temperatures used in Type IV endurance time testing, and freezing precipitation droplet sizes. The final subsection describes the analysis methodology used to evaluate Type IV endurance time data.

2.1 Test Sites

The test sites used to conduct natural snow and freezing precipitation tests are described in Subsections 2.1.1 and 2.1.2, respectively.

2.1.1 Natural Snow and Natural Frost

Natural snow and natural frost testing is typically 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. Photos 2.1 and 2.2 show the test site as seen from the test pads and main trailer, respectively.

2.1.2 Freezing Precipitation

Tests under conditions of freezing fog, rain on cold-soaked surface, freezing drizzle, and light freezing rain were conducted indoors at the 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.

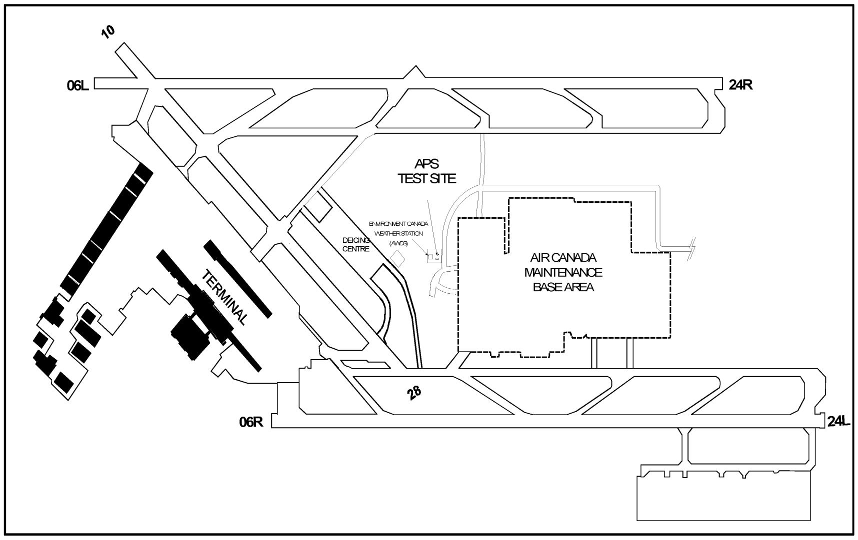


Figure 2.1: APS Test Site at Montréal-Pierre-Elliott-Trudeau International Airport

2.2 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.

2.2.1 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.

2.2.2 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.

2.2.3 Test Surface Structures

The majority of endurance time testing is carried out on standard flat plates. A schematic of a standard flat plate is provided in Figure 2.2. 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 2.3.4) are achieved. Photo 2.5, taken outdoors at the APS test site, shows six test plates mounted on a test stand.

Figure 2.3 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. A box shaped reservoir is welded to the bottom of the plate. Photo 2.6 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.

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 2.7 shows a white-painted aluminum frosticator plate.

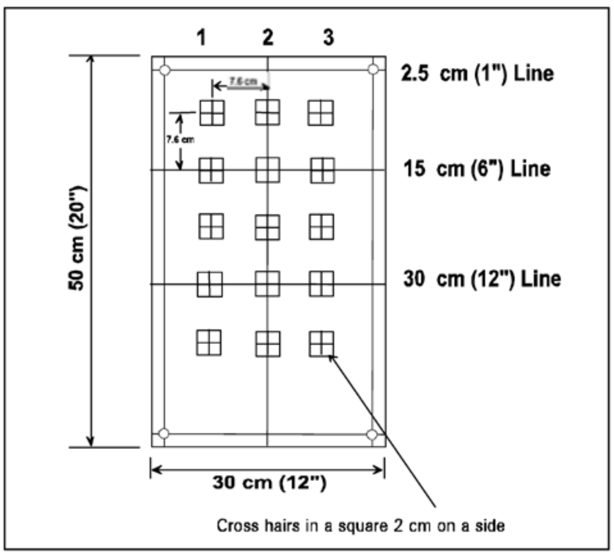


Figure 2.2: Standard Test Plate Schematic

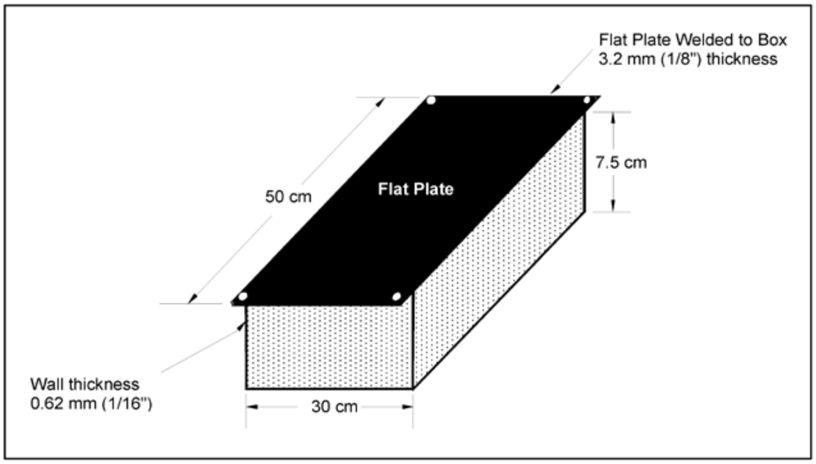


Figure 2.3: Cold Soak Box Schematic

2.2.4 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.

2.2.5 Test Stands

Figure 2.4 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. Photos 2.4 and 2.5 show the test stands set up for indoor and outdoor testing, respectively.

2.2.6 Collection Pans

Figure 2.5 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 2.8 shows the collection pans used for measuring precipitation rates indoors at the NRC.

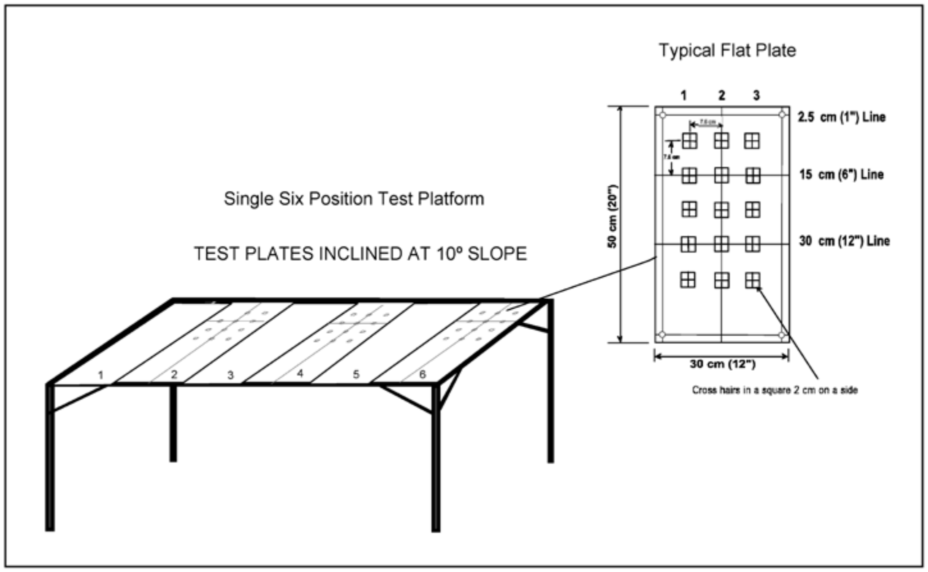


Figure 2.4: Test Stand Setup Schematic

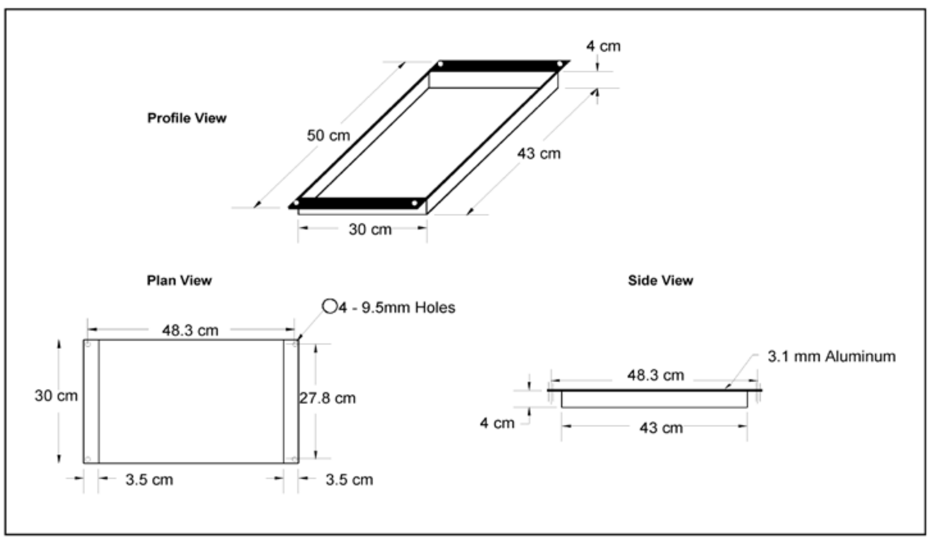


Figure 2.5: Schematic of Outdoor Precipitation Measurement Pan

2.2.7 NRC Sprayer Assembly

NRC developed an improved sprayer assembly, shown in Photos 2.9 and 2.10, 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 2.11.

2.2.8 Fluids

Testing was carried out with Clariant Safewing MP IV LAUNCH PLUS in the standard Type II, III and IV fluid test dilutions: neat, 75/25 and 50/50. The fluid sample was diluted by the manufacturer.

2.3 Test Procedures

ARP5485 provides the 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 2.3.4), when a specified degree of freezing occurs. The following subsections provide summaries of the test procedures followed for natural snow and simulated freezing precipitation testing.

2.3.1 Test Protocol – 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 2.2.3);

- Fluid is applied at ambient temperature; and
- 1 L of fluid is hand-poured on the test surface.

2.3.2 Test Protocol – 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 2.2.3);
- Rain on cold-soak surface tests are conducted on filled cold-soak boxes (see Section 2.2.3);
- Fluid is applied at ambient temperature; and
- 1 L of fluid is hand-poured on the test surface.

2.3.3 Test Protocol – 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 2.2.3);
- Fluid is applied at ambient temperature; and
- 1 L of fluid is hand-poured on the test surface.

2.3.4 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.

2.3.5 Precipitation Rate Measurement Procedures

The procedures for measuring and determining precipitation rates during simulated precipitation and natural precipitation conditions are provided below.

2.3.5.1 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.

2.3.5.2 Natural precipitation conditions

Two rate collection pans per test stand are 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 anti-icing 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 (see Figure 2.4) and are allowed to collect precipitation for 10-minute intervals in normal conditions and 5-minute intervals in periods of high precipitation rates and high winds. 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 has failed.

The rate for any HOT 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 this particular test. To measure and document the rate of frost accretion, two test surfaces were weighed at half hour to one hour intervals depending on the frost accretion intensity.

An example of the rate calculation method for tests in natural snow conditions is displayed in Figure 2.6. Typically, two collections pans are used for each test. The start and end times of the test shown in Figure 2.6 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). 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 2.6, 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.

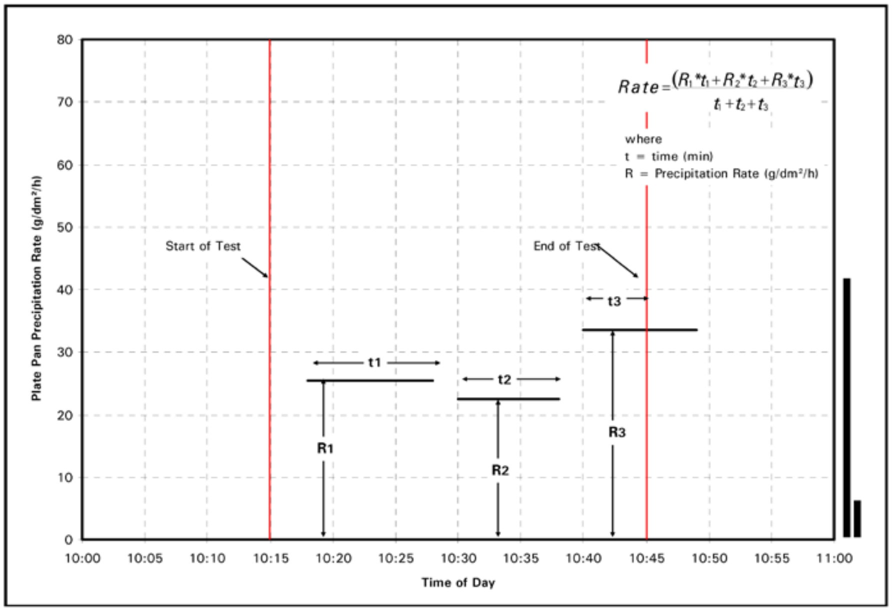


Figure 2.6: Calculation of Outdoor Precipitation Rate

2.4 Precipitation Rate Limits in Type II/IV Endurance Time Testing

Upper and lower precipitation rate limits are an important part of the test methodology for measuring fluid endurance times. Table 2.1 provides the meteorologically accepted definitions of weather phenomenon / precipitation types. It also includes the criteria used to determine precipitation intensity. This table 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/IV endurance time testing are provided in ARP5485 and represented graphically in Figure 2.7. Subsections 2.4.1 to 2.4.5 provide detailed definitions and explanations of the precipitation types and rate boundaries used in Type II/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 2.1.

Table 2.1: 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 visibility at the earth's surface to less than 1 km (5/8 mile).
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 (23°F), the crystals are generally agglomerated into snowflakes.
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 the ground or other exposed objects.
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 mm (0.02 in.) or smaller drops which, in contrast to drizzle, are widely separated.
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)	Precipitation of white and opaque grains of ice. These grains are spherical or sometimes conical; their diameter is about 2-5 mm (0.1-0.2 in.). Grains are brittle, easily crushed; they bounce and break on hard ground.
SNOW GRAINS (SG)	Precipitation of very small white and opaque grains of ice. These grains are fairly flat or elongated; their diameter is less than 1 mm (0.04 in.). When the grains hit hard ground, they do not bounce or shatter.
HAIL (GR)	Precipitation of small balls or pieces of ice with a diameter ranging from 5 to > 50 mm (0.2 to 2.0 in.) falling either separately or agglomerated.
ICE PELLETS (PE) Note: Includes Sleet and Small Hail	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.) or less. The pellets of ice usually bounce when hitting hard ground.

Intensity Criteria**

	Snow(SN),Pellets(GS),Grains(SG),Frz Drizzle(FZDZ)		Ice Pellets (PE)
Estimated Intensity	Horizontal Visibility (statute mile)	Liquid Equivalent Snow (S) Intensity***	Definition and Horizontal Visibility
Light (-)	If visibility is: ≥ 5/8 mi (≥ 1.0 km)	Trace to 0.05 in/hr (≤ 1.0 mm or 10.0 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 or 25.0 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 shown that visibility and precipitation intensity are not always directly correlated.

	Drizzle Intensity (FZDZ)
Light(-)	Trace to 0.01 in/hr (0.254 mm 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 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 exposed surface up to a condition where individual drops are easily seen.
Moderate	Measured Intensity	0.11 in to 0.30 in/hr (7.6 mm 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 pavement and other hard surfaces.
Heavy (+)	Measured Intensity	More than 0.30 in/hr (7.6 mm 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 spray to height of several inches is observed over hard surfaces.

* 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 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 June 17, 1997 (Updated for METAR codes)

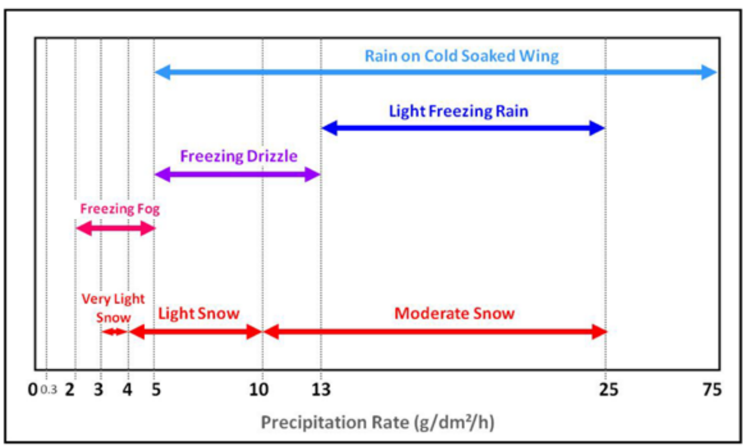


Figure 2.7: Precipitation Rate Limits Used in Endurance Time Testing

2.4.1 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.

2.4.2 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.

2.4.3 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.

2.4.4 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 $g/dm^2/h$).

2.4.5 Snow

The precipitation rate limits used to determine holdover times for Type II/IV fluids in snow are 3, 4, 10 and 25 $g/dm^2/h$. These rate limits encompass very light, light and moderate snow.

2.5 Ambient Temperatures in Type II/IV Endurance Time Testing

The Type II/IV holdover time tables provide holdover times for three temperature ranges:

- -3°C and above;
- Below -3 to -10°C (freezing drizzle, light freezing rain, cold soak wing) or Below -3 to -14°C (freezing fog, snow); and
- Below -14°C to LOUT

In natural snow testing, endurance time testing is carried out under a range of temperatures. In simulated freezing precipitation testing, endurance time testing is typically conducted at the lower limit of each temperature band.

- Freezing Fog: -3°C, -10°C and -25°C
- Freezing Drizzle: -3°C and -10°C
- Light Freezing Rain: -3°C and -10°C
- Rain on Cold Soaked Surface: +1°C

2.6 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 $g/dm^2/h$

The theoretical MVDs for rain at various rates of precipitation were determined based on this equation. These values are listed in Table 2.2 beside the experimental MVDs for each precipitation condition.

Table 2.2: Theoretical and Experimental MVDs

Precipitation Condition	Experimental MVD (mm)	Theoretical MVD (mm)
Moderate Rain (High rate: 75 $g/dm^2/h$)	1.4	1.6
Light Rain (Low rate: 13 $g/dm^2/h$)	1.0	< 1.1
Light Rain (High rate: 25 $g/dm^2/h$)	1.0	1.2
Drizzle (Low rate: 5 $g/dm^2/h$)	0.25	< 0.5
Drizzle (High rate: 13 $g/dm^2/h$)	0.35	< 0.5
Fog		< 0.1

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 P.E.T. 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
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

2.7 Summary of Freezing Precipitation Test Conditions

The precipitation types/rates, ambient temperatures and droplet sizes for freezing precipitation testing with Type II/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 2.3.

Table 2.3: Summary of Freezing Precipitation Test Conditions (Type II/IV Fluids)

Precipitation Type	Ambient Temperature	Precipitation Rate (Droplet Size)
Freezing Fog	-3°C	2 g/dm²/h (30 µm)
		5 g/dm²/h (30 µm)
	-10°C	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)

2.8 Analysis Methodology

A multi-variable regression procedure is used to derive fluid-specific holdover times for Type II/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 2.4. 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.

2.8.1 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 2.4).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 2.8.3.

2.8.2 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:

- $t = 10^I R^a (2-T)^b$, 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 2.8.3.

2.8.3 Natural Frost Tests

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 data under all temperatures encompassed by the frost HOT table.

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 current 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.

2.8.4 Rounding and Capping Protocols

Regression-generated holdover times are subject to rounding and capping protocols. For Type II/IV fluids they are as follows:

- Rounding Protocol: 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. In cases where the regression-generated holdover times are below 10 minutes, the numbers are rounded down to the nearest whole minute as a precautionary measure. For example, 9.6 minutes is rounded down to 9 minutes.

- Capping Protocol: 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 Transport Canada and 3 hours by FAA.

2.8.5 Example

Sample plots of **Log t** versus **Log R** are shown in Figure 2.8. 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 2.9. 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.

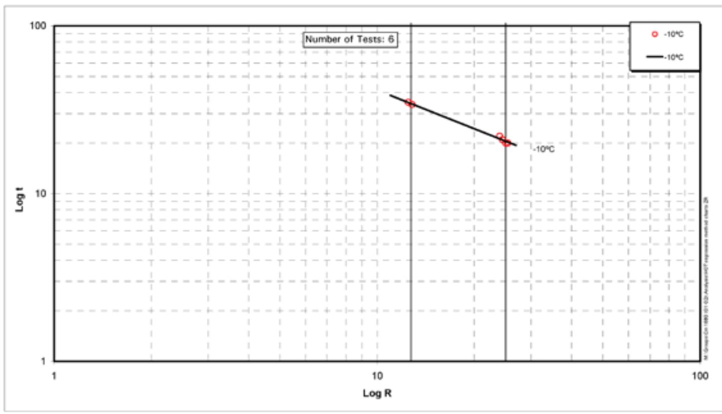


Figure 2.8: Regression Method on Log-Log Chart – Type IV Neat, Freezing Rain

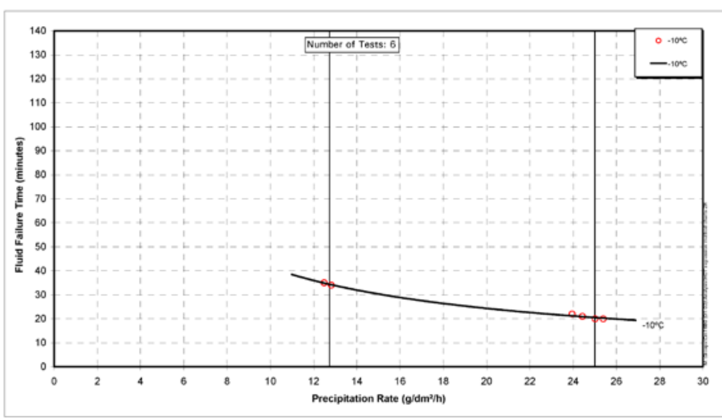


Figure 2.9: Regression Method on Standard Chart – Type IV Neat, Freezing Rain

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

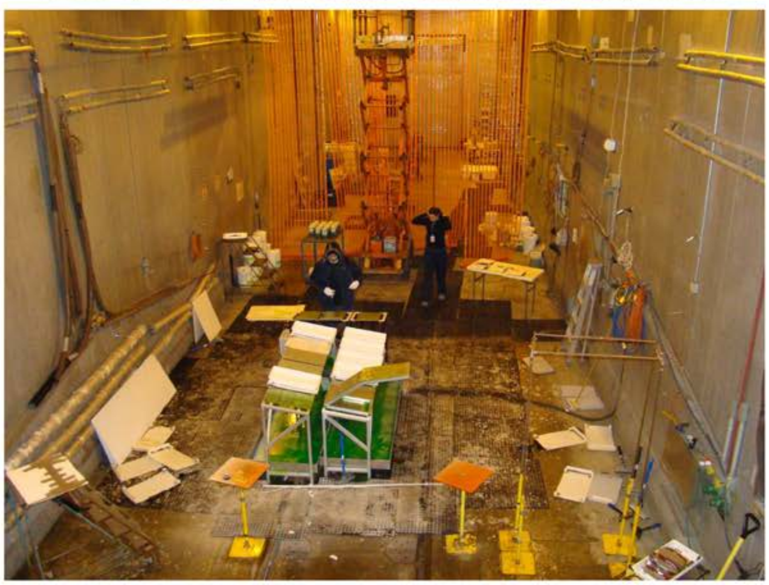


Photo 2.5: Test Plates Mounted on Stand

Photo 2.6: Cold-Soak / Leading Edge Thermal Equivalent Box

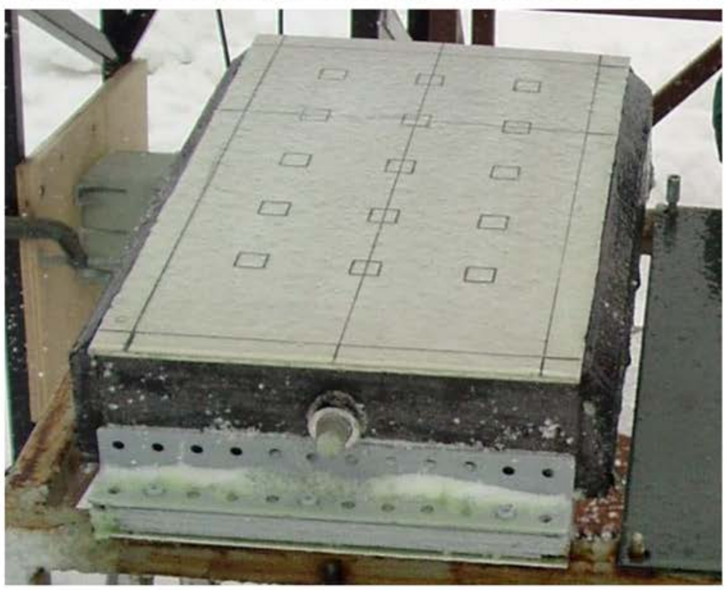


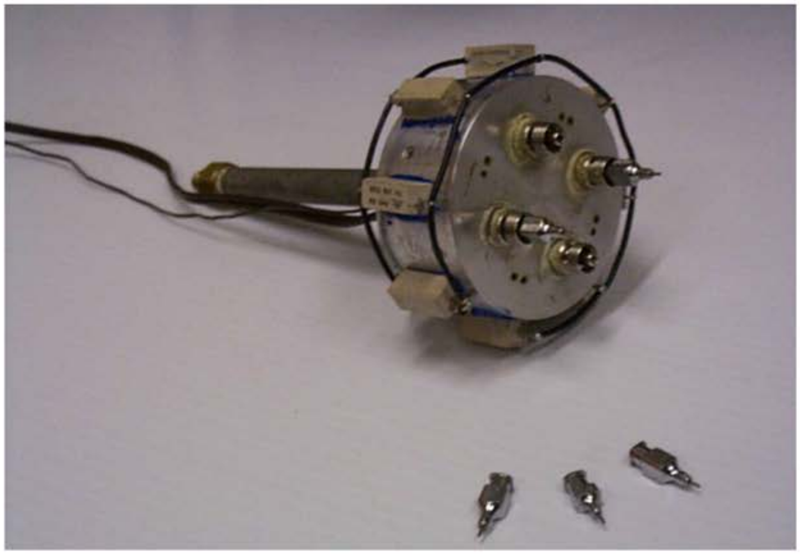
Photo 2.7: Frost Plate with Insulated Backing

Photo 2.8: Collection Pans Used Indoors at the NRC

Photo 2.9: Sprayer Assembly

Photo 2.10: Sprayer Assembly in Use

Photo 2.11: Sprayer Nozzle



3. DESCRIPTION OF DATA

This section provides a summary of the number of tests conducted in natural snow, light freezing rain, freezing drizzle, freezing fog and rain on cold soaked wing. Breakdowns are provided for the number of tests performed by fluid type and temperature.

Logs of the tests conducted are provided at the end of this section as follows: Table 3.1 (snow), Table 3.2 (freezing precipitation), and Table 3.3 (frost). The logs provide details of each test conducted.

3.1 Freezing Fog Tests

Tests were conducted in freezing fog conditions at the NRC CEF. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

	-3°C	**-14°C**	**-25°C**
Neat	4	6	4
75/25	4	4	0
50/50	4	0	0

3.2 Freezing Drizzle and Light Freezing Rain Tests

Tests were conducted in freezing drizzle and light freezing rain conditions at the NRC CEF. The breakdown of tests conducted is summarized below by precipitation type, fluid dilution and temperature.

	Freezing Drizzle		**Light Freezing Rain**	
	-3°C	-10°C	-3°C	-10°C
Neat	4	4	4	4
75/25	4	4	4	4
50/50	4	0	4	0

3.3 Rain on Cold-Soaked Surface Tests

Tests were conducted in rain on cold-soaked surface conditions at the NRC CEF with Neat and 75/25 diluted fluids. The breakdown of tests conducted is summarized below by fluid dilution and temperature.

	+1°C
Neat	4
75/25	4
50/50	0

3.4 Natural Snow Tests

Tests were conducted in natural snow conditions at the APS test site and at several mobile test sites (see Subsection 2.2.1). The breakdown of tests conducted is summarized below by fluid dilution and temperature.

	≥ -3°C	-3 to -14°C	<-14°C
Neat	12	7	0
75/25	12	7	0
50/50	12	0	0

3.5 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.

	≥-1°C	<-1 to -3°C	<-3 to -10°C	<-10°C
Neat	1	1	3	0
75/25	1	2	3	0
50/50	1	1	0	0

3.6 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.

The film thickness profiles are displayed in Figure 3.1. The final fluid thicknesses are displayed in Figure 3.2.

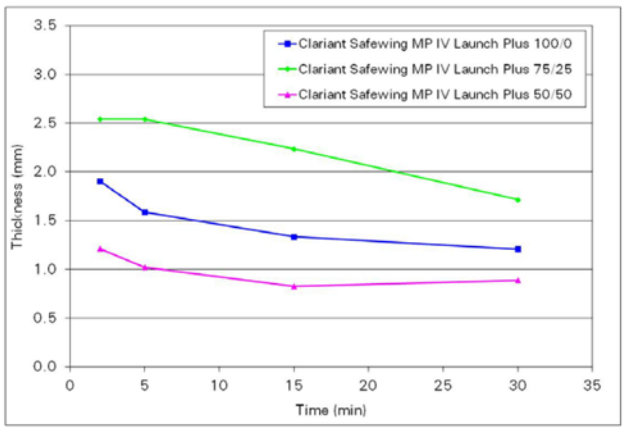


Figure 3.1: Fluid Thickness Profiles of Clariant Safewing MP IV LAUNCH PLUS

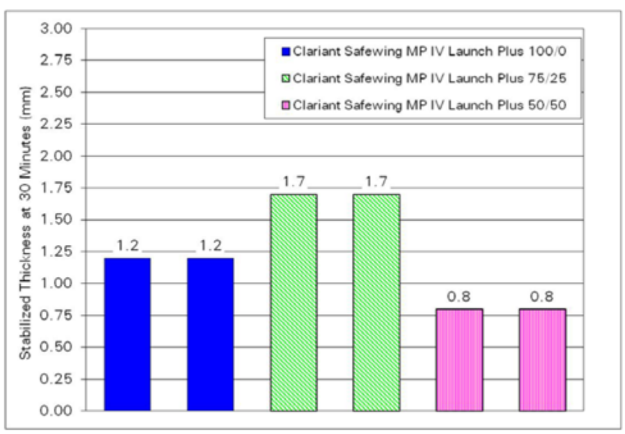


Figure 3.2: Final Fluid Thickness of Clariant Safewing MP IV LAUNCH PLUS

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)
84	15-Feb-13	Natural	MP IV Launch Plus	50%	-0.8	3.4	135.6
88	15-Feb-13	Natural	MP IV Launch Plus	100%	-0.6	6.3	221.8
102	15-Feb-13	Natural	MP IV Launch Plus	50%	-0.6	9.9	49.8
109	19-Feb-13	Natural	MP IV Launch Plus	100%	-2.9	6.2	127.7
110	19-Feb-13	Natural	MP IV Launch Plus	75%	-2.9	6.0	124.6
111	19-Feb-13	Natural	MP IV Launch Plus	50%	-3.3	4.0	82.4
116	19-Feb-13	Natural	MP IV Launch Plus	100%	-3.2	13.5	76.5
118	19-Feb-13	Natural	MP IV Launch Plus	75%	-3.2	19.9	48.0
122	19-Feb-13	Natural	MP IV Launch Plus	100%	-3.8	10.7	103.9
124	19-Feb-13	Natural	MP IV Launch Plus	75%	-3.8	10.5	102.4
128	19-Feb-13	Natural	MP IV Launch Plus	75%	-3.2	16.1	83.2
129	19-Feb-13	Natural	MP IV Launch Plus	100%	-3.2	20.4	37.1
130	19-Feb-13	Natural	MP IV Launch Plus	75%	-3.2	20.7	36.8
132	19-Feb-13	Natural	MP IV Launch Plus	100%	-3.2	20.0	49.6
135	19-Feb-13	Natural	MP IV Launch Plus	50%	-2.3	22.2	21.8
141	19-Feb-13	Natural	MP IV Launch Plus	50%	-1.4	27.2	20.9
154	20-Feb-13	Natural	MP IV Launch Plus	100%	-4.6	5.4	190.3
155	20-Feb-13	Natural	MP IV Launch Plus	75%	-5.1	5.4	202.7
172	20-Feb-13	Natural	MP IV Launch Plus	100%	-10.3	3.0	292.6
173	20-Feb-13	Natural	MP IV Launch Plus	75%	-10.3	3.0	268.2
181	23-Feb-13	Natural	MP IV Launch Plus	50%	0.0	4.6	108.3
182	23-Feb-13	Natural	MP IV Launch Plus	75%	0.1	9.5	167.8
195	23-Feb-13	Natural	MP IV Launch Plus	100%	0.1	10.0	157.2
201	23-Feb-13	Natural	MP IV Launch Plus	100%	0.4	8.8	191.7
204	23-Feb-13	Natural	MP IV Launch Plus	75%	0.4	8.3	182.3
212	27-Feb-13	Natural	MP IV Launch Plus	75%	0.2	37.8	56.2
214	27-Feb-13	Natural	MP IV Launch Plus	50%	0.2	37.3	17.6
236	27-Feb-13	Natural	MP IV Launch Plus	50%	0.2	33.4	23.4
248	02-Mar-13	Natural	MP IV Launch Plus	100%	-4.2	4.3	305.0
249	02-Mar-13	Natural	MP IV Launch Plus	75%	-4.2	4.3	319.0
250	02-Mar-13	Natural	MP IV Launch Plus	50%	-3.5	2.9	131.2
263	02-Mar-13	Natural	MP IV Launch Plus	100%	-4.9	4.7	248.6
264	02-Mar-13	Natural	MP IV Launch Plus	75%	-4.9	4.5	301.4
280	15-Mar-13	Natural	MP IV Launch Plus	50%	-2.9	2.0	169.4

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)
290	19-Mar-13	Natural	MP IV Launch Plus	100%	-4.0	42.7	36.0
291	19-Mar-13	Natural	MP IV Launch Plus	75%	-4.0	42.9	29.1
296	19-Mar-13	Natural	MP IV Launch Plus	100%	-3.6	10.2	185.1
297	19-Mar-13	Natural	MP IV Launch Plus	75%	-3.8	10.9	88.5
306	19-Mar-13	Natural	MP IV Launch Plus	100%	-2.5	14.1	121.2
307	19-Mar-13	Natural	MP IV Launch Plus	75%	-2.3	13.9	77.8
311	19-Mar-13	Natural	MP IV Launch Plus	50%	-2.3	15.6	28.9
315	19-Mar-13	Natural	MP IV Launch Plus	100%	-3.1	10.9	143.0
319	19-Mar-13	Natural	MP IV Launch Plus	50%	-2.6	13.5	42.9
322	19-Mar-13	Natural	MP IV Launch Plus	75%	-2.8	14.7	68.0
338	12-Apr-13	Natural	MP IV Launch Plus	75%	-0.2	44.0	39.2
345	12-Apr-13	Natural	MP IV Launch Plus	100%	-0.1	23.3	92.8
346	12-Apr-13	Natural	MP IV Launch Plus	75%	-0.1	27.8	67.4
347	12-Apr-13	Natural	MP IV Launch Plus	100%	-0.2	51.5	47.0
348	12-Apr-13	Natural	MP IV Launch Plus	75%	-0.2	52.1	43.2
349	12-Apr-13	Natural	MP IV Launch Plus	100%	-0.2	44.0	43.9

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)
1	04-Apr-13	Freezing Fog	MP IV Launch Plus	100/0	-3.1	1.9	>240
2	04-Apr-13	Freezing Fog	MP IV Launch Plus	100/0	-3.1	2.0	>240
3	04-Apr-13	Freezing Fog	MP IV Launch Plus	75/25	-3.1	2.1	>240
4	04-Apr-13	Freezing Fog	MP IV Launch Plus	75/25	-3.1	2.2	>240
5	04-Apr-13	Freezing Fog	MP IV Launch Plus	50/50	-3.0	1.9	112.3
6	04-Apr-13	Freezing Fog	MP IV Launch Plus	50/50	-3.0	2.1	108.7
13	04-Apr-13	Freezing Fog	MP IV Launch Plus	100/0	-3.1	5.0	239.9
14	04-Apr-13	Freezing Fog	MP IV Launch Plus	100/0	-3.0	5.0	231.4
15	04-Apr-13	Freezing Fog	MP IV Launch Plus	75/25	-3.0	5.0	231.2
16	04-Apr-13	Freezing Fog	MP IV Launch Plus	75/25	-3.1	5.0	239.6
17	04-Apr-13	Freezing Fog	MP IV Launch Plus	50/50	-3.0	4.7	75.0
18	04-Apr-13	Freezing Fog	MP IV Launch Plus	50/50	-3.0	4.6	80.7
33	05-Apr-13	Freezing Fog	MP IV Launch Plus	100/0	-14.1	1.9	140.3
34	05-Apr-13	Freezing Fog	MP IV Launch Plus	100/0	-14.1	1.9	139.5
35	05-Apr-13	Freezing Fog	MP IV Launch Plus	75/25	-14.1	2.1	117.1
36	05-Apr-13	Freezing Fog	MP IV Launch Plus	75/25	-14.1	2.0	116.6
37	05-Apr-13	Freezing Fog	MP IV Launch Plus	100/0	-14.2	4.7	54.5
37R	05-Apr-13	Freezing Fog	MP IV Launch Plus	100	-14.3	4.8	58.6
38	05-Apr-13	Freezing Fog	MP IV Launch Plus	100/0	-14.2	4.6	60.5
38R	05-Apr-13	Freezing Fog	MP IV Launch Plus	100	-14.3	4.8	57.3
39	05-Apr-13	Freezing Fog	MP IV Launch Plus	75/25	-14.3	4.8	44.6
40	05-Apr-13	Freezing Fog	MP IV Launch Plus	75/25	-14.3	4.7	44.2
41	08-Apr-13	Freezing Fog	MP IV Launch Plus	100/0	-25.2	1.9	49.9
42	08-Apr-13	Freezing Fog	MP IV Launch Plus	100/0	-25.2	2.0	49.8
45	08-Apr-13	Freezing Fog	MP IV Launch Plus	100/0	-25.1	4.9	23.0
46	08-Apr-13	Freezing Fog	MP IV Launch Plus	100/0	-25.1	5.0	23.5
49	09-Apr-13	Light Freezing Rain	MP IV Launch Plus	100/0	-3.1	13.5	122.3
50	09-Apr-13	Light Freezing Rain	MP IV Launch Plus	100/0	-3.1	12.7	115.2
51	09-Apr-13	Light Freezing Rain	MP IV Launch Plus	75/25	-3.1	13.1	85.1
52	09-Apr-13	Light Freezing Rain	MP IV Launch Plus	75/25	-3.1	12.8	86.2
53	09-Apr-13	Light Freezing Rain	MP IV Launch Plus	50/50	-2.9	13.2	17.9
54	09-Apr-13	Light Freezing Rain	MP IV Launch Plus	50/50	-2.9	13.3	19.2
61	11-Apr-13	Light Freezing Rain	MP IV Launch Plus	100/0	-3.1	24.6	65.5
62	11-Apr-13	Light Freezing Rain	MP IV Launch Plus	100/0	-3.1	24.8	60.4
63	11-Apr-13	Light Freezing Rain	MP IV Launch Plus	75/25	-3.1	24.6	78.1
64R	11-Apr-13	Light Freezing Rain	MP IV Launch Plus	75/25	-3.1	24.4	84.1
65	11-Apr-13	Light Freezing Rain	MP IV Launch Plus	50/50	-3.0	24.1	13.2
66	11-Apr-13	Light Freezing Rain	MP IV Launch Plus	50/50	-3.0	24.5	14.3

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)
73	09-Apr-13	Light Freezing Rain	MP IV Launch Plus	100/0	-10.2	13.1	38.5
74	09-Apr-13	Light Freezing Rain	MP IV Launch Plus	100/0	-10.2	12.9	38.5
75	09-Apr-13	Light Freezing Rain	MP IV Launch Plus	75/25	-10.2	13.1	31.5
76	09-Apr-13	Light Freezing Rain	MP IV Launch Plus	75/25	-10.2	13.0	31.5
81	08-Apr-13	Light Freezing Rain	MP IV Launch Plus	100/0	-10.0	25.2	26.1
82	08-Apr-13	Light Freezing Rain	MP IV Launch Plus	100/0	-9.9	25.7	26.7
83	08-Apr-13	Light Freezing Rain	MP IV Launch Plus	75/25	-9.9	25.5	21.5
84	08-Apr-13	Light Freezing Rain	MP IV Launch Plus	75/25	-9.9	25.7	21.3
89	10-Apr-13	Freezing Drizzle	MP IV Launch Plus	100/0	-3.3	5.4	>120
90	10-Apr-13	Freezing Drizzle	MP IV Launch Plus	100/0	-3.3	5.2	>120
91	10-Apr-13	Freezing Drizzle	MP IV Launch Plus	75/25	-3.2	4.8	119.4
92	10-Apr-13	Freezing Drizzle	MP IV Launch Plus	75/25	-3.2	4.6	118.9
93	10-Apr-13	Freezing Drizzle	MP IV Launch Plus	50/50	-3.1	5.2	58.0
94	10-Apr-13	Freezing Drizzle	MP IV Launch Plus	50/50	-3.2	5.0	57.4
101	10-Apr-13	Freezing Drizzle	MP IV Launch Plus	100/0	-3.2	13.1	111.2
102	10-Apr-13	Freezing Drizzle	MP IV Launch Plus	100/0	-3.2	13.3	126.6
103	10-Apr-13	Freezing Drizzle	MP IV Launch Plus	75/25	-3.2	13.4	129.6
104	10-Apr-13	Freezing Drizzle	MP IV Launch Plus	75/25	-3.1	13.1	106.2
105	10-Apr-13	Freezing Drizzle	MP IV Launch Plus	50/50	-3.1	13.0	22.0
106	10-Apr-13	Freezing Drizzle	MP IV Launch Plus	50/50	-3.1	13.2	23.0
113	09-Apr-13	Freezing Drizzle	MP IV Launch Plus	100/0	-10.1	5.4	88.6
114	09-Apr-13	Freezing Drizzle	MP IV Launch Plus	100/0	-10.1	5.0	88.6
115	09-Apr-13	Freezing Drizzle	MP IV Launch Plus	75/25	-10.1	5.0	65.7
116	09-Apr-13	Freezing Drizzle	MP IV Launch Plus	75/25	-10.1	4.8	62.4
121	08-Apr-13	Freezing Drizzle	MP IV Launch Plus	100/0	-10.4	13.0	27.1
122	08-Apr-13	Freezing Drizzle	MP IV Launch Plus	100/0	-10.3	12.5	27.5
123	08-Apr-13	Freezing Drizzle	MP IV Launch Plus	75/25	-10.4	13.5	21.6
124	08-Apr-13	Freezing Drizzle	MP IV Launch Plus	75/25	-10.4	13.3	21.1
129	11-Apr-13	Cold Soak Box	MP IV Launch Plus	100/0	0.9	5.1	120.0
130	11-Apr-13	Cold Soak Box	MP IV Launch Plus	100/0	0.9	5.0	115.4
131	11-Apr-13	Cold Soak Box	MP IV Launch Plus	75/25	0.9	5.0	120.0
132	11-Apr-13	Cold Soak Box	MP IV Launch Plus	75/25	1.0	4.9	101.3
137	11-Apr-13	Cold Soak Box	MP IV Launch Plus	100/0	0.9	75.9	19.2
138	11-Apr-13	Cold Soak Box	MP IV Launch Plus	100/0	0.9	76.5	19.6
139	11-Apr-13	Cold Soak Box	MP IV Launch Plus	75/25	0.9	75.3	18.7
140	11-Apr-13	Cold Soak Box	MP IV Launch Plus	75/25	0.9	76.4	19.1

Table 3.3: Summary of Tests Performed (Natural Frost)

Test No.	Date	Precip. Type	Fluid Name	Fluid Dilution	Endurance Time (min.)	Average Rate (g/dm²/h)	Temp (°C)	Wind Speed (km/h)	Average RH (%)	Comments
7	13-Feb-13	Natural Frost	Launch Plus	100%	522.7	0.031	-1.3	4	86	not failed
12	13-Feb-13	Natural Frost	Launch Plus	75%	523.3	0.031	-1.3	4	86	not failed
17	18-Feb-13	Natural Frost	Launch Plus	100%	603.1	0.047	-9.3	6	60	not failed
22	18-Feb-13	Natural Frost	Launch Plus	75%	602.0	0.047	-9.3	6	60	not failed
25	21-Feb-13	Natural Frost	Launch Plus	100%	390.0	0.004	-5.9	9	78	not failed
32	21-Feb-13	Natural Frost	Launch Plus	75%	386.5	0.004	-5.9	9	78	not failed
36	8-Mar-13	Natural Frost	Launch Plus	75%	625.1	0.146	-3.5	4	79	not failed
44	8-Mar-13	Natural Frost	Launch Plus	50%	227.1	0.143	-3.2	5	78	failed
45	8-Mar-13	Natural Frost	Launch Plus	100%	642.9	0.146	-3.5	4	79	not failed
58	9-Mar-13	Natural Frost	Launch Plus	75%	365.4	0.051	-1.3	4	84	not failed
60	9-Mar-13	Natural Frost	Launch Plus	100%	500.0	0.051	-0.4	4	72	not failed
69	9-Mar-13	Natural Frost	Launch Plus	50%	363.2	0.051	-0.3	4	72	not failed
70	9-Mar-13	Natural Frost	Launch Plus	75%	360.6	0.051	-0.4	4	72	not failed

4. RESULTS AND DISCUSSION

The methods used to evaluate the test data were reviewed in Subsection 2.8. The holdover times and data used to generate holdover times for Clariant Safewing MP IV LAUNCH PLUS are presented in this section.

4.1 Data – Natural Snow and Freezing Precipitation

Figures 4.1 to 4.14 present the data collected in natural snow, 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.

Table 4.1 illustrates the outputs from the multi-variable regression analyses performed on the natural snow, freezing fog, freezing drizzle, freezing rain and cold soak data. These outputs were used to derive fluid-specific holdover times for all cells in the fluid-specific HOT table, with the exception of the values in the “Below -3 to -14°C” and “Below -14°C to LOUT” snow cells.

4.2 Data – Natural Frost

The natural frost data was presented in Table 3.3. All completed (“failed”) tests surpassed the generic holdover times, as did most of the tests that were not completed (due to active frost ending before fluid failure could occur). Observations from the remaining tests indicated the generic frost holdover times would have been achieved had the tests been completed. Thus the data indicates the generic frost holdover times have been substantiated for Clariant Safewing MP IV LAUNCH PLUS.

4.3 Holdover Time Table

Fluid-specific HOT tables for Clariant Safewing MP IV LAUNCH PLUS are shown in Table 4.2 (Transport Canada format) and Table 4.3 (FAA format) at the end of this section. Most of the values in the table were derived from standard regression analysis of the endurance time data collected; exceptions are described below in Subsections 4.2.1, 4.2.2 and 4.2.3.

As Clariant intends to commercialize this fluid, it is expected this table will be published in the 2013-14 FAA and TC HOT guidelines. Commercialization of this fluid will not affect the generic Type IV holdover times.

4.3.1 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 snow data at temperatures below -14°C. As a result of this testing, the existing propylene Type IV and Type IV fluids were given generic values in the "Below -14 to LOUT" snow cell. It was also decided that all new Type II and Type IV fluids would be given the generic values. Accordingly, Clariant Safewing MP IV LAUNCH PLUS has been given generic values in the "Below -14°C to LOUT" snow cell.

4.3.2 Holdover Times in Frost

In May 2009, a decision was made by TC and the FAA 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 fluid-specific HOT table for Clariant Safewing MP IV LAUNCH PLUS.

4.3.3 Fluid Viscosity

The viscosities of the fluid samples used in this testing were measured using both the AIR 9968 method and the manufacturer's designated method. The APS measured viscosities appear at the beginning of this document and will also be published in the HOT Guidelines 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.

4.4 Discussion

Clariant has indicated it will commercialize Safewing MP IV LAUNCH PLUS; therefore, it is expected the HOT table created for this fluid, as well as the LOWV and LOUT information, will be published in the 2012-13 FAA and TC HOT guidelines.

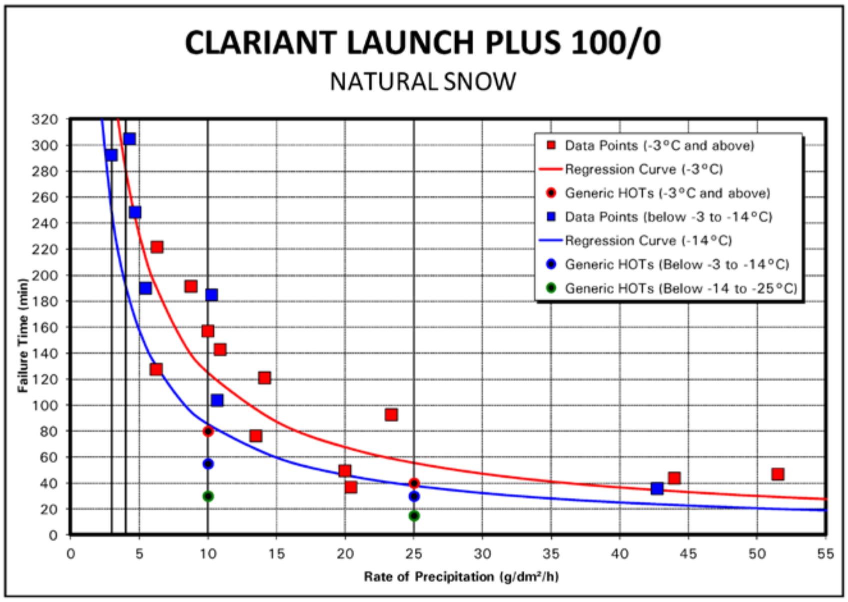


Figure 4.1: Type IV Neat – Natural Snow

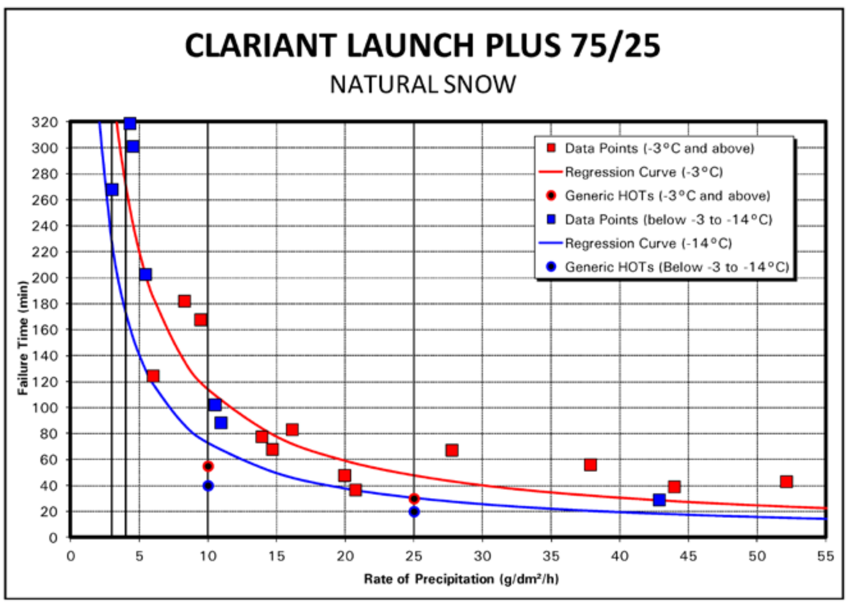


Figure 4.2: Type IV 75/25 – Natural Snow

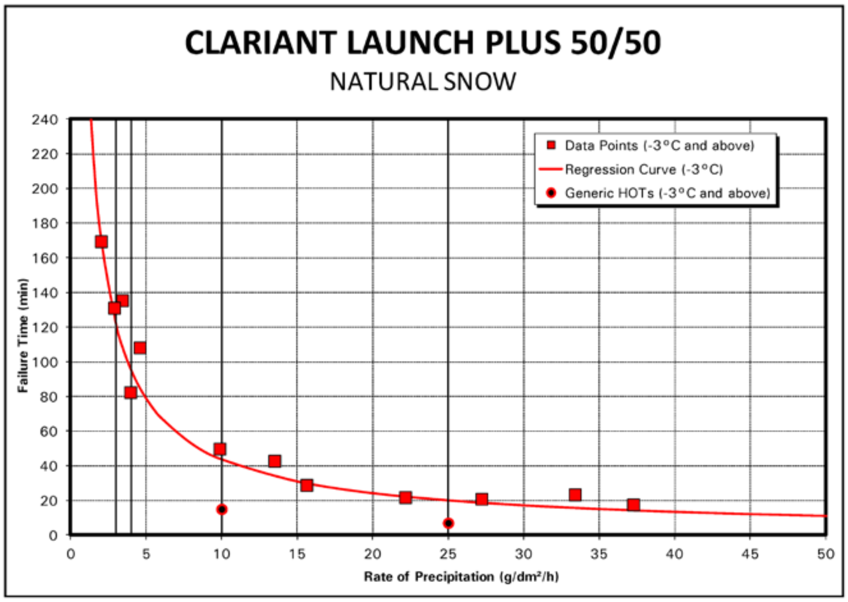


Figure 4.3: Type IV 50/50 – Natural Snow

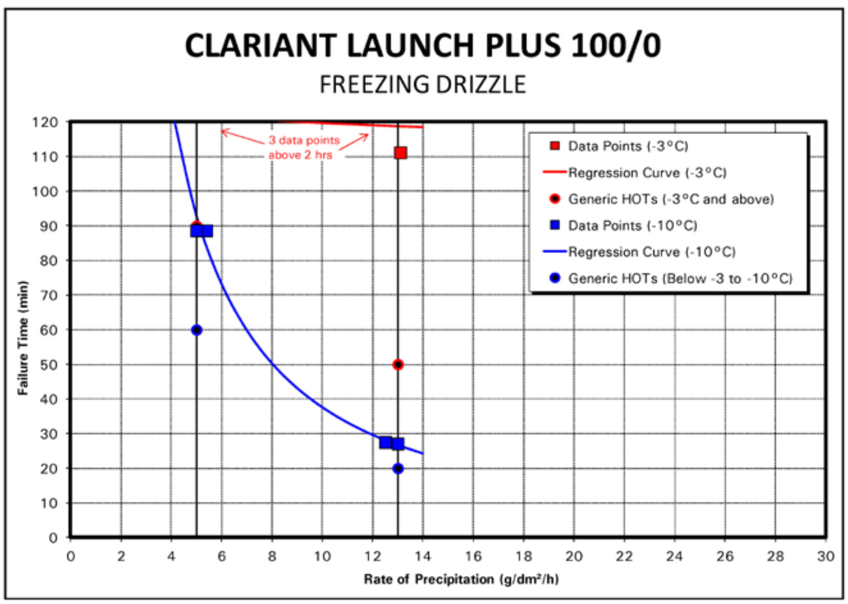


Figure 4.4: Type IV Neat – Freezing Drizzle

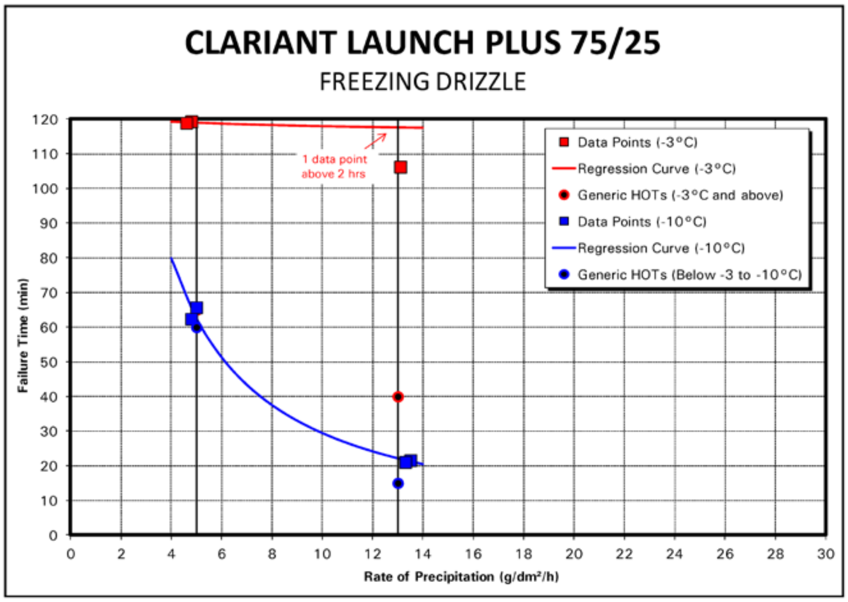


Figure 4.5: Type IV 75/25 – Freezing Drizzle

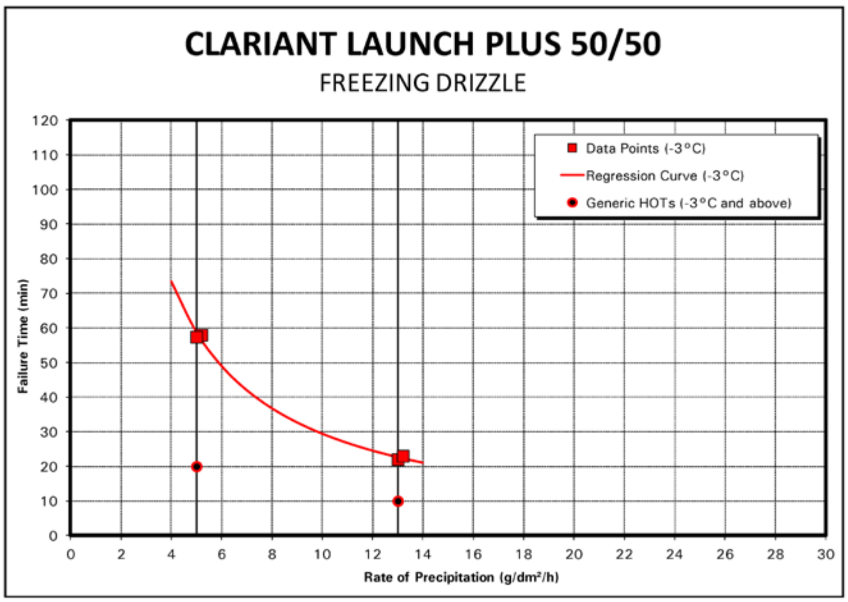


Figure 4.6: Type IV 50/50 – Freezing Drizzle

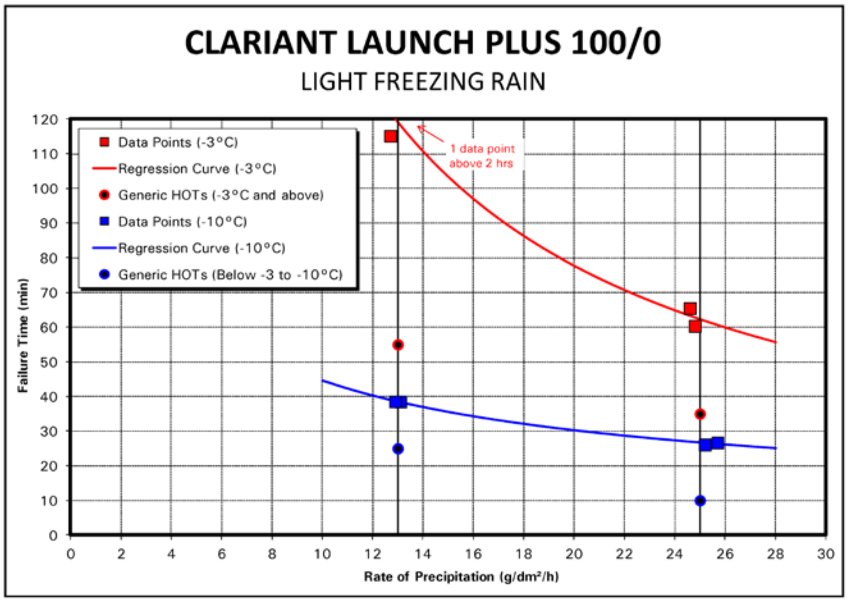


Figure 4.7: Type IV Neat – Light Freezing Rain

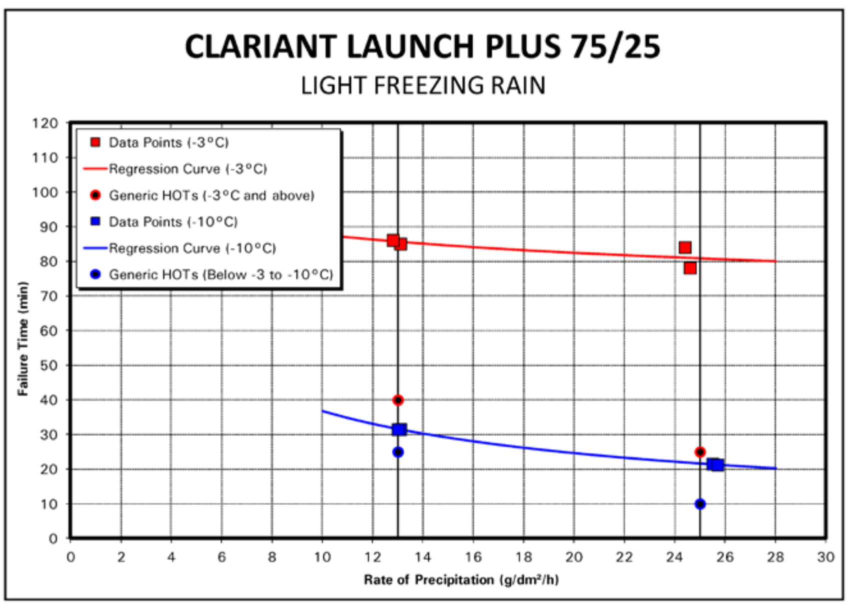


Figure 4.8: Type IV 75/25 – Light Freezing Rain

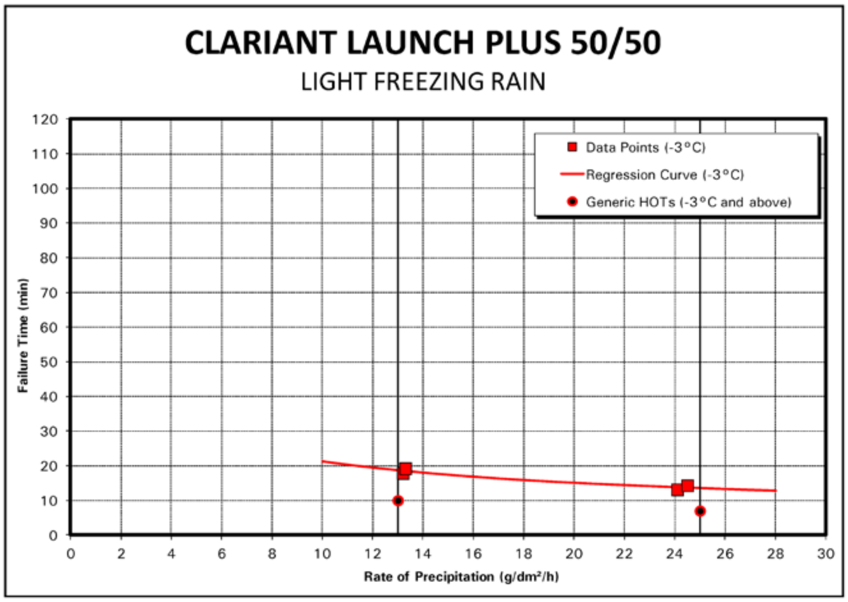


Figure 4.9: Type IV 50/50 – Light Freezing Rain

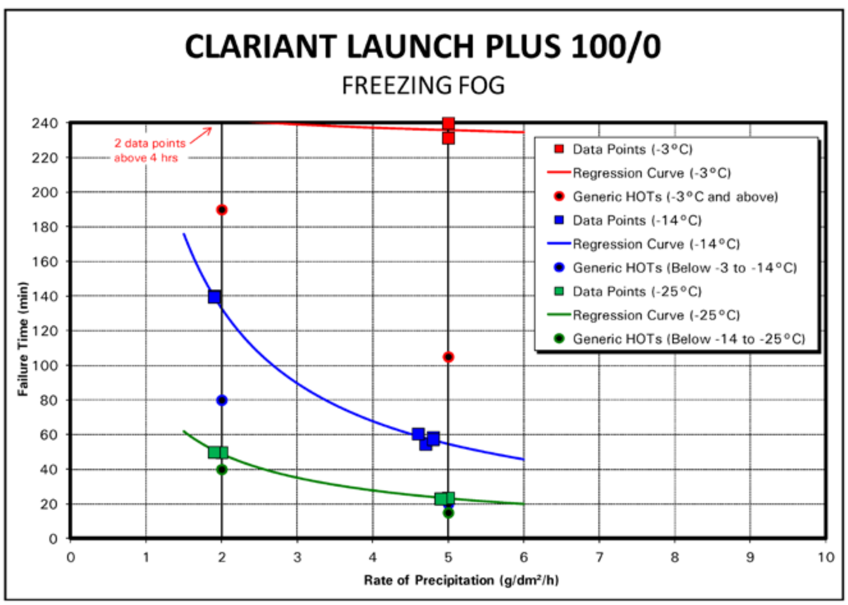


Figure 4.10: Type IV Neat – Freezing Fog

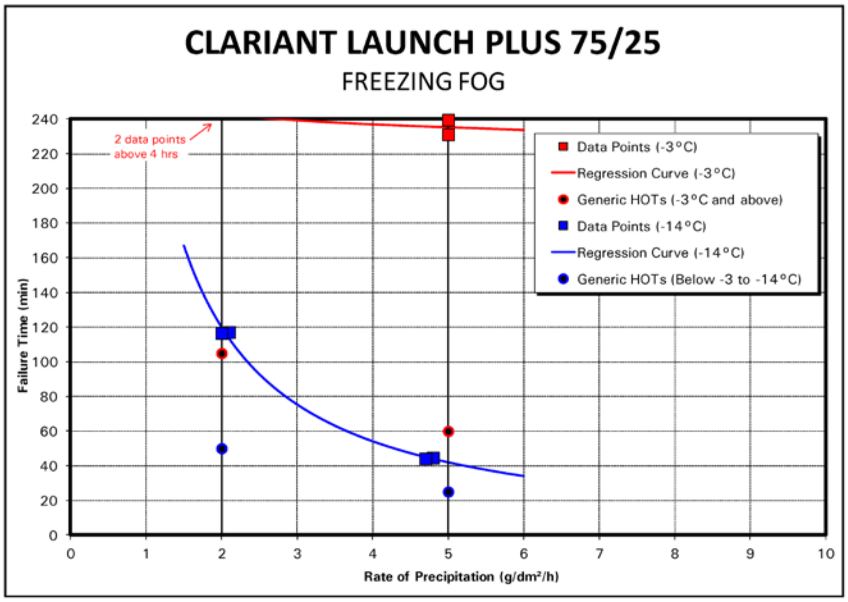


Figure 4.11: Type IV 75/25 – Freezing Fog

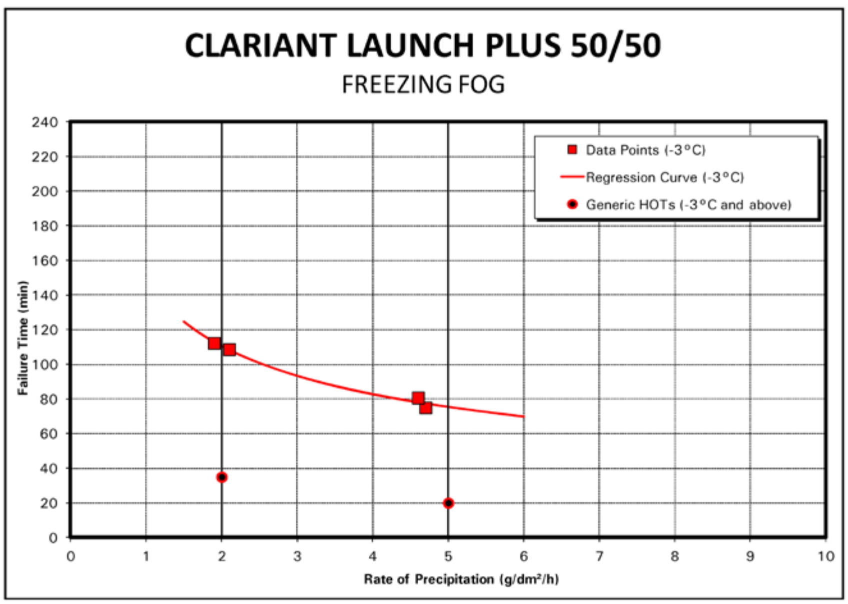


Figure 4.12: Type IV 50/50 – Freezing Fog

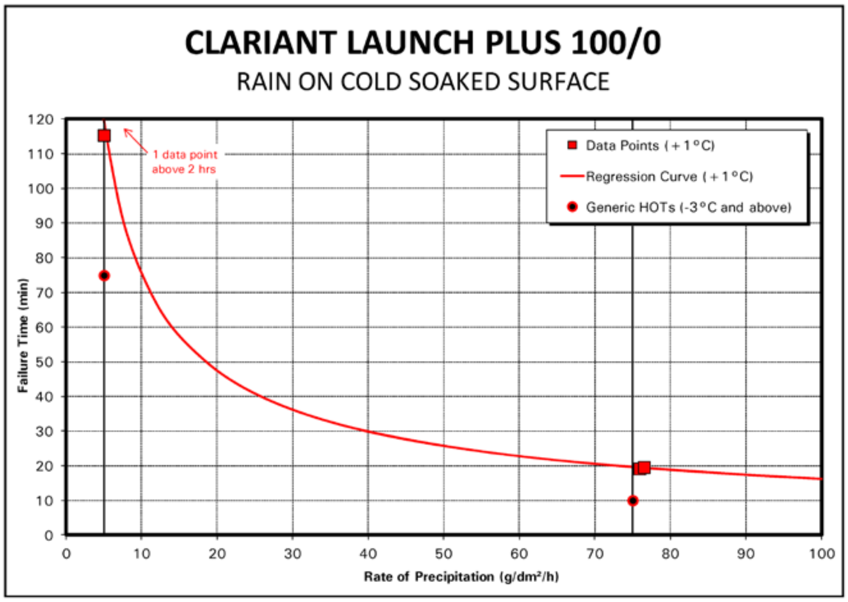


Figure 4.13: Type IV Neat – Rain on Cold-Soaked Surface

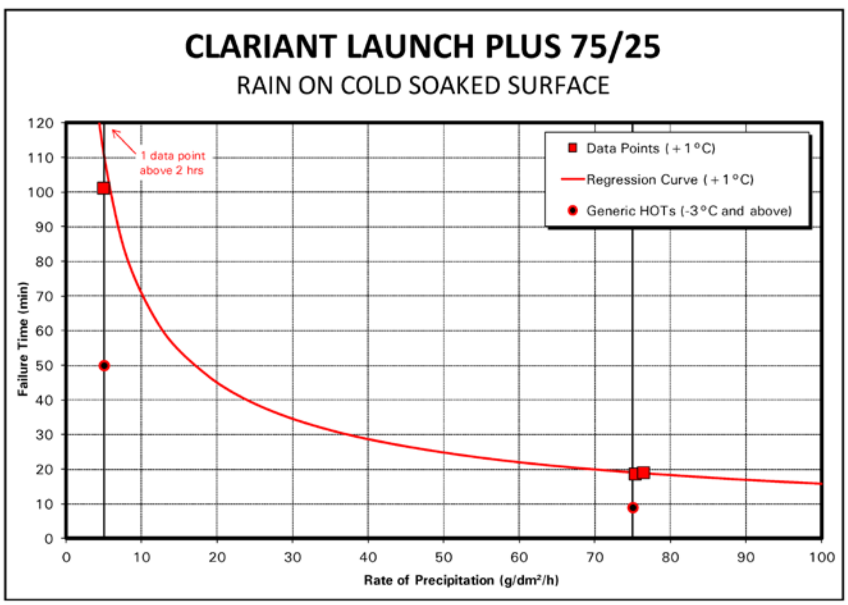


Figure 4.14: Type IV 75/25 – Rain on Cold-Soaked Surface

Table 4.1: Regression Equation Coefficients for Clariant Safewing MP IV LAUNCH PLUS

Natural Snow Conditions

Fluid	Dil	R^2	Intercept (I)	Coeff. Rate (A)	Coeff. Tem (B)	Total Pts.
Clariant Safewing MP IV Launch Plus	Neat	88%	3.2161	-0.8902	-0.3284	19
Clariant Safewing MP IV Launch Plus	75%	92%	3.2776	-0.9501	-0.3856	19
Clariant Safewing MP IV Launch Plus	50%	99%	2.6868	-0.8488	-0.2819	12

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 MP IV Launch Plus	Neat	-3°C	52%	2.3920	-0.0283	4
Clariant Safewing MP IV Launch Plus	75/25	-3°C	55%	2.3948	-0.0330	4
Clariant Safewing MP IV Launch Plus	50/50	-3°C	98%	2.1682	-0.4153	4
Clariant Safewing MP IV Launch Plus	Neat	-14°C	100%	2.4166	-0.9721	6
Clariant Safewing MP IV Launch Plus	75/25	-14°C	100%	2.4251	-1.1486	4
Clariant Safewing MP IV Launch Plus	Neat	-25°C	100%	1.9339	-0.8158	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 MP IV Launch Plus	Neat	-3°C	8%	2.1074	-0.0294	4
Clariant Safewing MP IV Launch Plus	75/25	-3°C	1%	2.0839	-0.0124	4
Clariant Safewing MP IV Launch Plus	50/50	-3°C	100%	2.4651	-0.9953	4
Clariant Safewing MP IV Launch Plus	Neat	-10°C	100%	2.8810	-1.3058	4
Clariant Safewing MP IV Launch Plus	75/25	-10°C	100%	2.5583	-1.0902	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 MP IV Launch Plus	Neat	-3°C	98%	3.1822	-0.9927	4
Clariant Safewing MP IV Launch Plus	75/25	-3°C	26%	2.0297	-0.0872	5
Clariant Safewing MP IV Launch Plus	50/50	-3°C	93%	1.8233	-0.4948	4
Clariant Safewing MP IV Launch Plus	Neat	-10°C	100%	2.2126	-0.5630	4
Clariant Safewing MP IV Launch Plus	75/25	-10°C	100%	2.1385	-0.5738	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 MP IV Launch Plus	Neat	+1°C	100%	2.5435	-0.6674	4
Clariant Safewing MP IV Launch Plus	75/25	+1°C	99%	2.4962	-0.6485	4

General Equation $t = 10^{I} R^{A}$

Table 4.2: Fluid Specific Holdover Time Guidelines – Clariant Safewing MP IV LAUNCH PLUS (Transport Canada Format)

TABLE 4-C-LAUNCH+

CLARIANT TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2013-2014[1]

SAFEWING MP IV LAUNCH PLUS

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		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: Very Light[3]	Light[3]	Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[6]	Other[5]
-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	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

1. These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
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 guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7. These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

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.**
- **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 MP IV LAUNCH PLUS (FAA Format)

TABLE 4E. FAA GUIDELINES FOR HOLDOVER TIMES CLARIANT SAFEWING MP IV LAUNCH PLUS TYPE IV FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Manufacturer Specific 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			Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing[3]	Other[4]
				Very Light[1]	Light[1]	Moderate				
-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[5]	0:25-0:40[5]		
		75/25	0:40-2:00	2:55-3:00	1:15-2:55	0:30-1:15	0:20-1:05[5]	0:20-0:30[5]		
below -14 to -29	below 7 to -20.2	100/0	0:25-0:50	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 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
3 This column is for use at temperatures above 0 °C (32 °F) only.
4 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
5 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 OAT.
- CLARIANT SAFEWING MP IV LAUNCH PLUS TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

APPENDIX F

TRANSPORT CANADA AND FEDERAL AVIATION ADMINISTRATION 2013-14 HOLDOVER TIME GUIDELINES

TRANSPORT CANADA
HOLDOVER TIME (HOT) GUIDELINES
WINTER 2013-2014

Transport Canada
Holdover Time (HOT) Guidelines
Winter 2013-2014

Original Issue, August 2013

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 613-949-4204 TTY (613) 990-4500 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

- The active frost holdover time (HOT) guidelines are unchanged.

Type I Fluid

- The Type I HOT guidelines are unchanged.

Type II Fluid

- Changes have been made to the Clariant Safewing MP II FLIGHT PLUS 100/0 and 75/25 snow holdover times as the result of supplemental testing carried out in the winter of 2012-2013.
- A fluid-specific HOT guideline has been created for the new Type II fluid Cryotech Polar Guard II.
- LNT Solutions P250 has been removed from the guidelines at the request of the manufacturer. This fluid was never commercialized.
- Some Type II fluid-specific HOT tables have been upgraded to include three columns of snow holdover times. The three columns provide holdover times for three snowfall intensities: very light, light and moderate. Snowfall intensity must be determined using Table 8 “Visibility In Snow vs. Snowfall Intensity”. The affected Type II HOT tables are: ABAX Ecowing 26, Clariant Safewing MP II FLIGHT and Cryotech Polar Guard II.
- The Type II generic HOT guidelines are unchanged. No changes have been made to the table values or table format; the table retains a single column for snow.

Type III Fluid

- The Type III HOT guidelines are unchanged.

Type IV Fluid

- Clariant Max Flight 04 75/25 and 50/50 dilutions have been removed from the guidelines at the request of the manufacturer. As of the publication of this document, no holdover times exist for dilutions of this fluid.
- A fluid-specific HOT guideline has been created for the new Type IV fluid Clariant Safewing MP IV LAUNCH PLUS.
- Kilfrost ABC-4^{sustain} has been removed from the guidelines at the request of the manufacturer. This fluid was never commercialized.
- Some Type IV fluid-specific HOT tables have been upgraded to include three columns of snow holdover times. The three columns provide holdover times for three snowfall intensities: very light, light and moderate. Snowfall intensity must be determined using Table 8 “Visibility In Snow vs. Snowfall Intensity”. The affected Type IV HOT tables are: ABAX Ecowing AD-49, Kilfrost ABC-S Plus, Clariant Max Flight 04, Clariant Safewing MP IV LAUNCH, Clariant Safewing MP IV LAUNCH PLUS, Cryotech Polar Guard Advance, Dow UCAR™ Endurance EG106 and Dow UCAR™ FlightGuard AD-49.
- Nine increases have been made to the Type IV generic HOT guidelines as a result of the removal of Kilfrost ABC-4^{sustain} and Clariant Max Flight 04 dilutions. No changes have been made to the table format; the table retains a single column for snow.

Ice Crystals

- Recent testing has shown that freezing fog holdover times can be used in ice crystal conditions. As a result, the freezing fog columns in all Type I, Type II, Type III and Type IV fluid HOT tables have been modified to include ice crystals. Furthermore, TP 14052 has been modified to include guidance for operating without fluids in certain ice crystal conditions (cold temperatures when it can be determined the ice crystals are not adhering to the wing).

Guidance on Use of Visibility Table and Determination of Snowfall Intensity

- New guidance has been added to the visibility table and TP 14052 to clarify proper use of the visibility table, including: operational examples with METARs, improper use of RVR to determine visibility, and obscuration of visibility by freezing fog.

Ice Pellet Allowance Times

- The ice pellet allowance times are unchanged.

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.

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.

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 6 and 7 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:

http://www.tc.gc.ca/media/documents/ca-opssvs/602-001.pdf

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) List of Fluids Tested for Anti-Icing Performance and Aerodynamic Acceptance;
g) SAE Type I De/Anti-Icing Fluid Application Procedures;
h) SAE Types II, Type III and Type IV De/Anti-Icing Fluid Application Procedures;
i) Visibility in Snow vs. Snowfall Intensity Chart;
j) Lowest On-Wing Viscosity Values for De/Anti-Icing Fluids;
k) Lowest Operational Use Temperatures of De/Anti-Icing Fluids; and
l) Ice Pellet Allowance Times.

Replace Sub-Paragraph 11.1.4.1 a) "Estimating the Precipitation Rate" with the following: ***(modified 2013-14)***

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 "visibility in snow vs. snowfall intensity chart" contained in the holdover time guidelines.

The METAR/SPECI reported visibility or flight crew observed visibility will be used with the "visibility in snow vs. snowfall intensity chart" to establish snowfall intensity for Type I, II, III and IV holdover time guidelines, during snow, snow grain, or snow pellet precipitation conditions.

The "visibility in snow vs. snowfall intensity chart", 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 "visibility in snow vs. snowfall intensity chart", 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 "visibility in snow vs. snowfall intensity chart", 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 "visibility in snow vs. snowfall intensity chart", 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 "visibility in snow vs. snowfall intensity chart", 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 'visibility in snow vs. snowfall intensity' chart can be found along with the current HOT Guidelines through the Transport Canada website: www.tc.gc.ca.

Use of Runway Visual Range (RVR) with the TC "Visibility in Snow vs Snowfall Intensity" Chart

There has been some confusion regarding the values indicated below the visibility (in parentheses) on the Snowfall Intensity Chart. 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:

- RVR transmissometers were never intended to measure visibility with respect to snowfall intensity for use with holdover time guidelines.
- 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.
- 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 Chart (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 Chart 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, 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 yet been identified for ice pellet conditions. Instead, an allowance time based upon research has been developed for operations during ice pellet 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 AMS 1424 or SAE AMS 1428 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 AMS 1424 or SAE AMS 1428) and aerodynamic acceptance (SAE AMS 1424 or SAE AMS 1428) only.

Therefore, the end user is cautioned that they must confirm that other SAE AMS 1424 or SAE AMS 1428 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 AMS 1424 or AMS 1428. 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: ***(added 2013-14)***

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: ***(added 2013-14)***

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.

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: ***(modified 2013-14)***

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) are 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 take-off. It cannot be assumed that snow (or ice crystals) on a wing will "blow off" during the take-off. 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 0ºC; at a dew point of -40ºC, the frost point is 3.2ºC warmer (-36.8ºC). 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 (i.e. SKC, high FEW or high SCT), low wind (i.e. less than 10 knots), and low light (i.e. 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.

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 take-off in an aircraft that has frost adhering to the underside of its wings that is caused by cold-soaked fuel, if the take-off is conducted in accordance with the aircraft manufacturer's instructions for take-off 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.

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 take-off; 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 "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 the following definitions to Section 18 "Glossary": ***(added 2013-14)***

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 2013-2014

Table 0	Active Frost Holdover Guidelines
Table 1-A	SAE Type I Fluid Holdover Guidelines on Aluminum Wing Surfaces
Table 1-C	SAE Type I Fluid Holdover Guidelines on Composite Wing Surfaces
Table 2-Generic	SAE Type II Fluid Holdover Guidelines
Table 2-A-E26	ABAX Type II Fluid Holdover Guidelines Ecowing 26
Table 2-AS-Cleanwing II	Aviation Shaanxi Hi-Tech Type II Fluid Holdover Guidelines Cleanwing II
Table 2-C-FLIGHT	Clariant Type II Fluid Holdover Guidelines Safewing MP II FLIGHT
Table 2-C-FLIGHT+	Clariant Type II Fluid Holdover Guidelines Safewing MP II FLIGHT PLUS
Table 2-CR-PG-II	Cryotech Type II Fluid Holdover Guidelines Polar Guard II
Table 2-K-ABC-2000	Kilfrost Type II Fluid Holdover Guidelines ABC-2000
Table 2-K-ABC-K+	Kilfrost Type II Fluid Holdover Guidelines ABC-K Plus
Table 2-N-FCY-2	Newave Aerochemical Type II Fluid Holdover Guidelines FCY-2
Table 3	SAE Type III Fluid Holdover Guidelines
Table 4-Generic	SAE Type IV Fluid Holdover Guidelines
Table 4-A-AD-480	ABAX Type IV Fluid Holdover Guidelines AD-480
Table 4-A-Ecowing AD-49	ABAX Type IV Fluid Holdover Guidelines Ecowing AD-49
Table 4-C-MF-04	Clariant Type IV Fluid Holdover Guidelines Max Flight 04 *(formerly Octagon Max Flight 04)*
Table 4-C-LAUNCH	Clariant Type IV Fluid Holdover Guidelines Safewing MP IV LAUNCH
Table 4-C-LAUNCH+	Clariant Type IV Fluid Holdover Guidelines Safewing MP IV LAUNCH PLUS
Table 4-CR-PG	Cryotech Type IV Fluid Holdover Guidelines Polar Guard
Table 4-CR-PG-A	Cryotech Type IV Fluid Holdover Guidelines Polar Guard Advance
Table 4-D-E106	Dow Chemical Type IV Fluid Holdover Guidelines UCAR™ Endurance EG106
Table 4-D-AD-480	Dow Chemical Type IV Fluid Holdover Guidelines UCAR™ FlightGuard AD-480
Table 4-D-AD-49	Dow Chemical Type IV Fluid Holdover Guidelines UCAR™ FlightGuard AD-49
Table 4-K-ABC-S	Kilfrost Type IV Fluid Holdover Guidelines ABC-S
Table 4-K-ABC-S+	Kilfrost Type IV Fluid Holdover Guidelines ABC-S Plus
Table 4-L-ARCTIC Shield	Lyondell Type IV Fluid Holdover Guidelines ARCTIC Shield™
Table 5	List of Fluids Tested for Anti-Icing Performance and Aerodynamic Acceptance
Table 6	SAE Type I De/Anti-icing Fluid Application Procedures
Table 7	SAE Type II, Type III and Type IV De/Anti-Icing Fluid Application Procedures
Table 8	Visibility in Snow vs. Snowfall Intensity Chart
Table 9	Lowest On-Wing Viscosity Values for De/Anti-Icing Fluids
Table 10	Lowest Operational Use Temperatures of De/Anti-Icing Fluids
Table 11	Ice Pellet Allowance Times

Transport Canada Holdover Time Guidelines — Winter 2013-2014

TABLE 0

ACTIVE FROST HOLDOVER GUIDELINES FOR WINTER 2013-2014

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature Degrees Celsius	Outside Air Temperature Degrees Fahrenheit	Approximate Holdover Times (hours:minutes) Active Frost Type I[1,2]
-1 and above	30 and above	0:45 (0:35)[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 Degrees Celsius	Outside Air Temperature Degrees Fahrenheit	Concentration Neat Fluid/Water (Volume %/ Volume %)	Approximate Holdover Times (hours:minutes) Active Frost Type II[2,3]	Type III[2,3]	Type IV[2,3]
-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

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 (see Table 10).
3 These fluids may not be used below -25°C (-13°F) in active frost conditions.
4 Value in parentheses is for composite surfaces.

CAUTIONS

- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

Transport Canada Holdover Time Guidelines — Winter 2013-2014

TABLE 1-A

SAE TYPE I FLUID HOLDOVER GUIDELINES ON ALUMINUM WING SURFACES FOR WINTER 2013-2014[1]

This table applies 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: Very Light[3]	Snow, Snow Grains or Snow Pellets: Light[3]	Snow, Snow Grains or Snow Pellets: Moderate	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	CAUTION: No holdover time guidelines exist
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	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 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, 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.**
- **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 2013-2014

TABLE 1-C

SAE TYPE I FLUID HOLDOVER GUIDELINES ON COMPOSITE WING SURFACES FOR WINTER 2013-2014[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			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	9 – 16	12	6 – 12	3 – 6	8 – 13	4 – 6	1 – 5	CAUTION: No holdover time guidelines exist
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 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, 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.**
- **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 2013-2014

TABLE 2-Generic

SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2013-2014[1]

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		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[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 – 0:55	0:15 – 0:30	0:08 – 0:40	CAUTION: No holdover time guidelines exist
		75/25	0:25 – 1:00	0:15 – 0:30	0:20 – 0:45	0:10 – 0:25	0:05 – 0:25	
		50/50	0:15 – 0:30	0:05 – 0:15	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	0:10 – 0:20	0:15 – 0:30[7]	0:08 – 0:15[7]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15 – 0:35	0:15 – 0:30				

NOTES

1 Based on the lowest holdover times of the fluids listed in Table 5-2 and Table 5-4.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
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 guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

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.**
- **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 2013-2014

TABLE 2-A-E26

ABAX TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2013-2014[1]
ECOWING 26

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		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: Very Light[3]	Snow, Snow Grains or Snow Pellets: Light[3]	Snow, Snow Grains or Snow Pellets: 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	CAUTION: No holdover time guidelines exist
		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		
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	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
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 guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

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.**
- **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-AS-CLEANWING II

AVIATION SHAANXI HI-TECH TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2013-2014[1]
CLEANWING II

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		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[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	0:15 – 0:30				

NOTES
1. These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
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 guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7. These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

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.**
- **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 2013-2014

TABLE 2-C-FLIGHT

CLARIANT TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2013-2014[1]
SAFEWING MP II FLIGHT

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		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: Very Light[3]	Snow, Snow Grains or Snow Pellets: Light[3]	Snow, Snow Grains or Snow Pellets: 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		
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]	CAUTION: No holdover time guidelines exist	
		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	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

1. These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
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 guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7. These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

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.**
- **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-C-FLIGHT+

CLARIANT TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2013-2014[1]
SAFEWING MP II FLIGHT PLUS

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		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[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 LOUT	below 7 to LOUT	100/0	0:20 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
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 guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

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.**
- **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 2013-2014

TABLE 2-CR-PG-II

CRYOTECH TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2013-2014[1]
POLAR GUARD II

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		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: Very Light[3]	Snow, Snow Grains or Snow Pellets: Light[3]	Snow, Snow Grains or Snow Pellets: 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	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

1. These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
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 guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7. These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

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.**
- **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 2013-2014

TABLE 2-K-ABC-2000

KILFROST TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2013-2014[1]
ABC-2000

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		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[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	1:30 – 3:05	0:30 – 1:00	0:55 – 1:35	0:40 – 0:50	0:15 – 1:10	CAUTION: No holdover time guidelines exist
		75/25	1:40 – 3:30	0:30 – 1:05	0:45 – 1:15	0:40 – 0:50	0:15 – 1:40	
		50/50	1:00 – 2:10	0:15 – 0:30	0:15 – 0:25	0:08 – 0:15		
below -3 to -14	below 27 to 7	100/0	0:35 – 1:25	0:25 – 0:45	0:25 – 0:50[7]	0:10 – 0:30[7]		
		75/25	0:35 – 1:15	0:25 – 0:50	0:25 – 0:55[7]	0:15 – 0:30[7]		
below -14 to -27.5	below 7 to -17.5	100/0	0:20 – 0:45	0:15 – 0:30				

NOTES

1. These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
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 guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7. These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

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.**
- **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 2013-2014

TABLE 2-K-ABC-K+

KILFROST TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2013-2014[1]
ABC-K PLUS

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		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[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	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
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 guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

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.**
- **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 2013-2014

TABLE 2-N-FCY-2

NEWAVE AEROCHEMICAL TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2013-2014[1]

FCY-2

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		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[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	CAUTION: No holdover time guidelines exist
		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]		
		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	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type II fluid cannot be used.
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 guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

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.**
- **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 2013-2014

TABLE 3

SAE TYPE III FLUID HOLDOVER GUIDELINES FOR WINTER 2013-2014

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[1]		Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (minutes)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets: Very Light[2]	Snow, Snow Grains or Snow Pellets: Light[2]	Snow, Snow Grains or Snow Pellets: Moderate	Freezing Drizzle[3]	Light Freezing Rain	Rain on Cold Soaked Wing[4]	Other[5]
-3 and above	27 and above	100/0	20 – 40	35	20 – 35	10 – 20	10 – 20	8 – 10	6 – 20	
		75/25	15 – 30	25	15 – 25	8 – 15	8 – 15	6 – 10	2 – 10	
		50/50	10 – 20	15	8 – 15	4 – 8	5 – 9	4 – 6	CAUTION: No holdover time guidelines exist	
below -3 to -10	below 27 to 14	100/0	20 – 40	30	15 – 30	9 – 15	10 – 20	8 – 10		
		75/25	15 – 30[6]	25[6]	10 – 25[6]	7 – 10[6]	9 – 12[6]	6 – 9[6]		
below -10	below 14	100/0	20 – 40	30	15 – 30	8 – 15				

NOTES

1. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type III fluid cannot be used.
2. Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
3. Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
4. No holdover guidelines exist for this condition for 0°C (32°F) and below.
5. Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
6. For aircraft with a take-off profile conforming to the low speed aerodynamic test criterion (refer to Section 8.1.6.1 f) of TP 14052E), these holdover times only apply to outside air temperatures from below -3°C to -9°C (below 27°F to 15.8°F). If uncertain whether the aircraft performance conforms to this criterion, consult the aircraft manufacturer.

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.**
- **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 2013-2014

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2013-2014[1]

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		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[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	1:55 – 3:10	0:40 – 1:20	0:50 – 1:30	0:35 – 0:55	0:10 – 1:15	
		75/25	1:05 – 1:45	0:30 – 0:55	0:45 – 1:10	0:30 – 0:45	0:09 – 0:50	
		50/50	0:20 – 0:35	0:07 – 0:15	0:15 – 0:20	0:08 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:30 – 0:55	0:20 – 1:00[7]	0:10 – 0:25[7]		
		75/25	0:25 – 0:50[8]	0:20 – 0:40[8]	0:15 – 1:05[7,8]	0:10 – 0:25[7,8]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	0:15 – 0:40[9]	0:15 – 0:30[9]				

NOTES

1. Based on the lowest holdover times of the fluids listed in Table 5-4.
2. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
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 guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7. These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
8. For Lyondell Arctic Shield, the temperature is limited to -9.5°C (14.9°F); and for Cryotech Polar Guard, the temperature is limited to -5.5°C (22.1°F). If the fluid is unknown, these holdover times only apply down to -5.5°C (22.1°F).
9. For Lyondell Arctic Shield, the temperature is limited to -24.5°C (-12.1°F), and for Cryotech Polar Guard, the temperature is limited to -23.5°C (-10.3°F). If the fluid is unknown, these holdover times only apply down to -23.5°C (-10.3°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.**
- **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-A-AD-480

ABAX TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2013-2014[1]
AD-480

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		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[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	2:00 – 3:30	0:40 – 1:20	0:50 – 1:30	0:35 – 0:55	0:15 – 1:35	
		75/25	1:30 – 2:45	0:30 – 1:05	0:50 – 1:15	0:30 – 0:45	0:10 – 1:15	
		50/50	0:30 – 0:45	0:09 – 0:20	0:15 – 0:25	0:09 – 0:15	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:30 – 0:55	0:25 – 1:20[7]	0:15 – 0:30[7]		
		75/25	0:25 – 0:50	0:20 – 0:45	0:25 – 1:05[7]	0:15 – 0:30[7]		
below -14 to -26	below 7 to -14.8	100/0	0:15 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
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 guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

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.**
- **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-A-Ecowing AD-49

ABAX TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2013-2014[1]

ECOWING AD-49

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		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			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	3:20 – 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	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
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 guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

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.**
- **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-MF-04

CLARIANT TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2013-2014[1]
MAX FLIGHT 04 *(formerly Octagon Max Flight 04)*

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		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: 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								
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]	CAUTION: No holdover time guidelines exist	
		75/25								
below -14 to -26.5	below 7 to -15.7	100/0	0:20 – 0:45	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
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 guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

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.**
- **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-LAUNCH

CLARIANT TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2013-2014[1]
SAFEWING MP IV LAUNCH

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		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: Very Light[3]	Snow, Snow Grains or Snow Pellets: Light[3]	Snow, Snow Grains or Snow Pellets: 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	2:00	1:45 – 2:00	1:05 – 1:45	1:30 – 2:00	1:00 – 1:40	0:15 – 1:40	CAUTION: No holdover time guidelines exist
		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		
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	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES
1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
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 guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

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.**
- **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 2013-2014

TABLE 4-C-LAUNCH+

CLARIANT TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2013-2014[1]
SAFEWING MP IV LAUNCH PLUS

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		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: 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	
		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	CAUTION: No holdover time guidelines exist	
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	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
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 guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

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.**
- **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-PG

CRYOTECH TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2013-2014[1]
POLAR GUARD

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		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[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 – 3:30	0:50 – 1:30	1:15 – 2:00	0:50 – 1:15	0:15 – 1:25	CAUTION: No holdover time guidelines exist
		75/25	1:40 – 2:40	0:35 – 1:10	1:05 – 1:25	0:35 – 1:00	0:10 – 1:15	
		50/50	0:25 – 0:40	0:10 – 0:15	0:15 – 0:25	0:10 – 0:15		
below -3 to -14	below 27 to 7	100/0	0:45 – 1:45	0:30 – 0:55	0:25 – 1:10[7]	0:15 – 0:35[7]		
		75/25	0:35 – 1:30[8]	0:20 – 0:40[8]	0:25 – 1:05[8]	0:20 – 0:30[8]		
below -14 to -23.5	below 7 to -10.3	100/0	0:20 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
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 guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
8 These holdover times only apply to outside air temperatures to -5.5°C (22.1°F) and above.

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.**
- **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-PG-A

CRYOTECH TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2013-2014[1]
POLAR GUARD ADVANCE

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		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: 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	
		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]	CAUTION: No holdover time guidelines exist	
		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	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
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 guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

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.**
- **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

DOW CHEMICAL TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2013-2014[1]
UCAR™ ENDURANCE EG106

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		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: Very Light[3]	Snow, Snow Grains or Snow Pellets: Light[3]	Snow, Snow Grains or Snow Pellets: 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							CAUTION: No holdover time guidelines exist	
		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]		
		75/25								
below -14 to -27	below 7 to -16.6	100/0	0:30 – 1:05	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
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 guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

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.**
- **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 2013-2014

TABLE 4-D-AD-480

DOW CHEMICAL TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2013-2014[1]
UCAR™ FLIGHTGUARD AD-480

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		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[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	2:00 – 3:30	0:40 – 1:20	0:50 – 1:30	0:35 – 0:55	0:15 – 1:35	CAUTION: No holdover time guidelines exist
		75/25	1:30 – 2:45	0:30 – 1:05	0:50 – 1:15	0:30 – 0:45	0:10 – 1:15	
		50/50	0:30 – 0:45	0:09 – 0:20	0:15 – 0:25	0:09 – 0:15		
below -3 to -14	below 27 to 7	100/0	0:20 – 1:20	0:30 – 0:55	0:25 – 1:20[7]	0:15 – 0:30[7]		
		75/25	0:25 – 0:50	0:20 – 0:45	0:25 – 1:05[7]	0:15 – 0:30[7]		
below -14 to -26	below 7 to -14.8	100/0	0:15 – 0:40	0:15 – 0:30				

NOTES

1. These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
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 guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7. These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

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.**
- **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-AD-49

DOW CHEMICAL TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2013-2014[1]
UCAR™ FLIGHTGUARD AD-49

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		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: Very Light[3]	Snow, Snow Grains or Snow Pellets: Light[3]	Snow, Snow Grains or Snow Pellets: 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	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

1. These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
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 guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7. These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

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.**
- **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 2013-2014

TABLE 4-K-ABC-S

KILFROST TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2013-2014[1]
ABC-S

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		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[3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:35 – 4:00	1:00 – 1:40	1:20 – 1:50	1:00 – 1:25	0:20 – 1:15	CAUTION: No holdover time guidelines exist
		75/25	1:05 – 1:45	0:30 – 0:55	0:45 – 1:10	0:35 – 0:50	0:10 – 0:50	
		50/50	0:20 – 0:35	0:07 – 0:15	0:15 – 0:20	0:08 – 0:10		
below -3 to -14	below 27 to 7	100/0	0:45 – 2:05	0:45 – 1:20	0:20 – 1:00[7]	0:10 – 0:30[7]		
		75/25	0:25 – 1:00	0:25 – 0:50	0:20 – 1:10[7]	0:10 – 0:35[7]		
below -14 to -28	below 7 to -18.4	100/0	0:20 – 0:40	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
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 guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

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.**
- **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 2013-2014

TABLE 4-K-ABC-S+

KILFROST TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2013-2014[1]
ABC-S PLUS

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		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: Very Light[3]	Snow, Snow Grains or Snow Pellets: Light[3]	Snow, Snow Grains or Snow Pellets: 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	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	0:40	0:30 – 0:40	0:15 – 0:30				

NOTES

1. These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2. Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
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 guidelines exist for this condition for 0°C (32°F) and below.
6. Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7. These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.

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.**
- **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 2013-2014

TABLE 4-L-ARCTIC Shield

LYONDELL TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2013-2014[1]
ARCTIC SHIELD™

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

Outside Air Temperature[2]		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[3]**	**Freezing Drizzle[4]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[5]**	**Other[6]**
-3 and above	27 and above	100/0	1:55 – 3:10	0:50 – 1:25	0:55 – 1:40	0:45 – 1:05	0:15 – 1:25	
		75/25	1:20 – 2:15	0:40 – 1:05	0:55 – 1:25	0:30 – 0:45	0:09 – 1:20	
		50/50	0:35 – 0:45	0:20 – 0:35	0:20 – 0:30	0:10 – 0:15	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	1:00 – 2:25	0:45 – 1:15	0:25 – 1:30[7]	0:25 – 0:30[7]		
		75/25	0:50 – 1:45[8]	0:35 – 0:55[8]	0:30 – 1:15[8]	0:25 – 0:30[8]		
below -14 to -24.5	below 7 to -12.1	100/0	0:25 – 0:45	0:15 – 0:30				

NOTES

1 These holdover times are derived from tests of this fluid having a viscosity as listed in Table 9.
2 Ensure that the lowest operational use temperature (LOUT) is respected. Consider use of Type I when Type IV fluid cannot be used.
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 guidelines exist for this condition for 0°C (32°F) and below.
6 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
7 These holdover times only apply to outside air temperatures to -10°C (14°F) under freezing drizzle and light freezing rain.
8 These holdover times only apply to outside air temperatures to -9.5°C (14.9°F) and above.

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.**
- **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 5

LIST OF FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE (2013-2014)

Table 5-1: Tested Type I De/Anti-icing Fluids(1)			
#	**COMPANY NAME**	**FLUID NAME**	**EXPIRY (2) (Y-M-D)**
1-1	ABAX Industries	DE-950	14-05-15
1-2	*ABAX Industries*	*DE-950 Colorless*	*12-06-26* (3)
1-3	AllClear Systems	Lift-Off P-88	14-06-22
1-4	AllClear Systems	Lift-Off E-188	14-06-22
1-5	Arcton Ltd.	Arctica DG ready-to-use	17-07-15
1-6	Arcton Ltd.	Arctica DG 91 Concentrate	17-07-16
1-7	Aviation Shaanxi High-Tech Physical Co. Ltd.	Cleanwing I	15-12-19
1-8	Aviation Xi'an High-Tech Physical Co. Ltd.	KHF-1	15-08-16
1-9	*Beijing Phoenix Air Traffic Product Development and Trading Co.*	*CBSX-1*	*12-04-21* (3)
1-10	Beijing Wangye Aviation Chemical Product Co Ltd.	KLA-1	15-08-25
1-11	Beijing Yadilite Aviation Chemical Product Co. Ltd	YD-101 Type I	17-05-27
1-12	*Clariant Produkte (Deutschland) GmbH*	*EcoFlo Concentrate (formerly Octagon EcoFlo Concentate)*	*13-07-06* (3)
1-13	*Clariant Produkte (Deutschland) GmbH*	*EcoFlo 2 Concentrate (formerly Octagon EcoFlo 2 Concentrate)*	*13-07-25* (3)
1-14	Clariant Produkte (Deutschland) GmbH	Octaflo EF Concentrate *(formerly Octagon Octaflo EF Concentrate)*	14-03-25
1-15	Clariant Produkte (Deutschland) GmbH	Octaflo EF-80 *(formerly Octagon Octaflo EF-80)*	13-12-21
1-16	*Clariant Produkte (Deutschland) GmbH*	*Octaflo EG Concentrate (formerly Octagon Octaflo EG Concentrate)*	*13-06-10* (4)
1-17	*Clariant Produkte (Deutschland) GmbH*	*Safewing EG I 1996*	*12-06-10* (3)
1-18	Clariant Produkte (Deutschland) GmbH	Safewing EG I 1996 (88)	15-10-19
1-19	Clariant Produkte (Deutschland) GmbH	Safewing MP I 1938 ECO	16-06-26
1-20	Clariant Produkte (Deutschland) GmbH	Safewing MP I 1938 ECO (80)	16-07-09
1-21	Clariant Produkte (Deutschland) GmbH	Safewing MP I 1938 ECO (80) PreMix 55% i.g. ready-to-use	15-07-15

See next page for additional Type I fluids

(1) Concentrate fluids have also been tested at 50/50 (glycol/water) dilution.

(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) Fluids listed in italics have expired and will be removed from this listing four years after expiry.

(4) Currently in the test/re-retest process.

CAUTION: This table lists fluids that have been tested with respect to anti-icing performance and aerodynamic acceptance (SAE AMS1424 §3.5.2 and AMS1424 §3.5.3) only. These tests were conducted by Anti-icing Materials International Laboratory: www.uqac.ca/amil/index.htm. The end user is responsible for contacting the fluid manufacturer to confirm all other SAE AMS1424 technical requirement tests, such as fluid stability, toxicity, materials compatibility, etc. have been conducted.

Transport Canada Holdover Time Guidelines — Winter 2013-2014

TABLE 5 (cont.)

LIST OF FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE (2013-2014)

Table 5-1: Tested Type I De/Anti-icing Fluids (cont.) [(1)]

#	COMPANY NAME	FLUID NAME	EXPIRY [(2)] (Y-M-D)
1-22	Clariant Produkte (Deutschland) GmbH	Safewing MP I ECO PLUS (80)	15-03-15
1-23	Clariant Produkte (Deutschland) GmbH	Safewing MP I SKY (80)	14-07-03
1-24	Cryotech Deicing Technology	Polar Plus	16-01-16
1-25	Cryotech Deicing Technology	Polar Plus (80)	13-09-28
1-26	Deicing Solutions LLC	Safetemp ES Plus	16-08-07
1-27	Dow Chemical Company	UCAR™ Aircraft Deicing Fluid Concentrate	15-09-09
1-28	Dow Chemical Company	UCAR™ ADF XL54	17-01-18
1-29	Dow Chemical Company	UCAR™ PG Aircraft Deicing Fluid Concentrate	15-12-08
1-30	*Dow Chemical Company*	*UCAR™ PG ADF Dilute 55/45*	*12-02-05* [(3)]
1-31	Harbin Aeroclean Aviation Tech Co. Ltd.	HJF-1	13-10-05
1-32	HOC Industries	SafeTemp ES Plus	16-08-07
1-33	Hokkaido NOF Corporation	Fever Snow AG	17-07-15
1-34	Inland Technologies CANADA Inc.	Duragly-E Concentrate	15-02-04
1-35	Inland Technologies CANADA Inc.	Duragly-P Concentrate	15-02-04
1-36	Kilfrost Limited	DF Plus	14-07-30
1-37	Kilfrost Limited	DF Plus (80)	14-07-30
1-38	Kilfrost Limited	DF Plus (88)	14-07-30
1-39	Kilfrost Limited	DFsustain™	17-02-22
1-40	LNT Solutions	E188	13-09-21
1-41	LNT Solutions	P180	13-09-19
1-42	LNT Solutions	P188	13-09-21
1-43	Newave Aerochemical Co. Ltd.	FCY-1A	15-05-16
1-44	Shaanxi Cleanway Aviation Chemical Co., Ltd	Cleansurface I	13-08-02[(4)]
1-45	Shaanxi Cleanway Aviation Chemical Co., Ltd	Cleansurface I-BIO	14-11-27

(1) Concentrate fluids have also been tested at 50/50 (glycol/water) dilution.

(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) Fluids listed in italics have expired and will be removed from this listing four years after expiry.

(4) Currently in the test/re-retest process.

CAUTION: This table lists fluids that have been tested with respect to anti-icing performance and aerodynamic acceptance (SAE AMS1424 §3.5.2 and AMS1424 §3.5.3) only. These tests were conducted by Anti-icing Materials International Laboratory: www.uqac.ca/amil/index.htm. The end user is responsible for contacting the fluid manufacturer to confirm all other SAE AMS1424 technical requirement tests, such as fluid stability, toxicity, materials compatibility, etc. have been conducted.

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TABLE 5 (cont.)

LIST OF FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE (2013-2014)

Table 5-2: Tested Type II De/Anti-icing Fluids

#	Company Name	Fluid Name	Expiry (1) (Y-M-D)
2-1	ABAX Industries	Ecowing 26	15-05-15
2-2	*Aviation Shaanxi Hi-Tech Physical Chemical Co. Ltd.*	*Cleanwing II*	*13-07-26* (3)
2-3	*Clariant Produkte (Deutschland) GmbH*	*Safewing MP II 1951*	*11-05-20* (2)
2-4	Clariant Produkte (Deutschland) GmbH	Safewing MP II FLIGHT	14-07-17
2-5	Clariant Produkte (Deutschland) GmbH	Safewing MP II FLIGHT PLUS	Y-M-D (3)
2-6	Cryotech Deicing Technology	Polar Guard II	15-07-15
2-7	Kilfrost Limited	ABC-3	14-09-27
2-8	*Kilfrost Limited*	*ABC-2000*	*10-07-21* (2)
2-9	Kilfrost Limited	ABC-K Plus	14-11-15
2-10	Newave Aerochemical Co. Ltd.	FCY-2	15-06-26

Table 5-3: Tested Type III De/Anti-icing Fluids

#	Company Name	Fluid Name	Expiry (1) (Y-M-D)
3-1	Clariant Produkte (Deutschland) GmbH	Safewing MP III 2031 ECO	13-08-31

Table 5-4: Tested Type IV De/Anti-icing Fluids

#	Company Name	Fluid Name	Expiry (1) (Y-M-D)
4-1	*ABAX Industries*	*AD-480*	*11-07-17* (2)
4-2	ABAX Industries	Ecowing AD-49	14-05-22
4-3	Clariant Produkte (Deutschland) GmbH	Max Flight 04 *(formerly Octagon Max Flight 04)*	14-06-26
4-4	Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH	14-07-18
4-5	Clariant Produkte (Deutschland) GmbH	Safewing MP IV LAUNCH PLUS	15-07-19
4-6	*Cryotech Deicing Technology*	*Polar Guard*	*12-08-30* (2)
4-7	Cryotech Deicing Technology	Polar Guard Advance	15-07-15
4-8	Dow Chemical Company	UCAR™ Endurance EG106 De/Anti-Icing Fluid	15-07-25
4-9	*Dow Chemical Company*	*UCAR™ FlightGuard AD-480*	*12-06-15* (2)
4-10	Dow Chemical Company	UCAR™ FlightGuard AD-49	15-05-15
4-11	*Kilfrost Limited*	*ABC-S*	*11-07-06* (2)
4-12	Kilfrost Limited	ABC-S Plus	15-06-27
4-13	*Lyondell Chemical Company*	*ARCTIC Shield™*	*10-05-21* (2)

(1) 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.
(2) Fluids listed in italics have expired and will be removed from this listing four years after expiry.
(3) Currently in the test/re-test process.

CAUTION: This table lists fluids that have been tested with respect to anti-icing performance and aerodynamic acceptance (SAE AMS1428 §3.2.5 and AMS1428 §3.2.4) only. These tests were conducted by Anti-icing Materials International Laboratory: www.uqac.ca/amil/index.htm. The end user is responsible for contacting the fluid manufacturer to confirm all other SAE AMS1428 technical requirement tests, such as fluid stability, toxicity, materials compatibility, etc. have been conducted.

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TABLE 6

SAE TYPE I DE/ANTI-ICING FLUID APPLICATION PROCEDURES

Guidelines for the application of SAE Type I fluid mixtures at minimum concentrations for the prevailing outside air temperature (OAT)

Outside Air Temperature (OAT)[1]	One-Step Procedure De/Anti-icing	Two-Step Procedure	
		First Step: Deicing	**Second Step: Anti-icing[2]**
-3°C (27°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 mix of fluid and water	Heated mix of fluid and water with a freezing point of at least 10°C (18°F) below OAT
Below -3°C (27°F)		Freezing point of heated fluid mixture shall not be more than 3°C (5°F) above OAT	

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
- 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 time guidelines in all conditions including active frost, at least 1 litre/m² (~ 2 gal./100 sq. ft.) must be applied to the deiced surfaces.
- 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.
- The lowest operational use temperature (LOUT) for a given fluid is the higher 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 7

SAE TYPE II, TYPE III and TYPE IV DE/ANTI-ICING FLUID APPLICATION PROCEDURES

Guidelines for the application of SAE Type II, III and IV fluid mixtures
(minimum concentrations in % by volume) as a function of outside air temperature (OAT)

Outside Air Temperature (OAT)[1]	One-Step Procedure De/Anti-icing	Two-Step Procedure	
		First Step: Deicing	Second Step: Anti-icing[2]
-3°C (27°F) and above	50/50 Heated[3] Type II/III/IV	Heated water or a heated mix of Type I, II, III or IV with water	50/50 Type II/III/IV
-14°C (7°F) and above	75/25 Heated[3] Type II/III/IV	Heated suitable mix of Type I, Type II/III/IV and water with FP not more than 3°C (5°F) above actual OAT	75/25 Type II/III/IV
-25°C (-13°F) and above	100/0 Heated[3] Type II/III/IV	Heated suitable mix of Type I, Type II/III/IV and water with FP not more than 3°C (5°F) above actual OAT	100/0 Type II/III/IV
Below -25°C (-13°F)	Type II/III/IV fluid may be used below -25°C (-13°F) provided that the OAT is at or above the LOUT. Consider the use of Type I when Type II/III/IV fluid cannot be used (see Table 6).		

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.)
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. When the first step is performed using a fluid/water mix with a freezing point above OAT, the temperature at the nozzle shall be at least 60°C and at least 1 litre/m^2 (2 gal./100 sq. ft.) shall be applied to the surfaces to be de-iced.
- Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendations.
- The lowest operational use temperature (LOUT) for a given fluid is the higher 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 7°C (13°F).

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, III 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.**

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TABLE 8

VISIBILITY IN SNOW VS. SNOWFALL INTENSITY CHART[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)
	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)
	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 chart.

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 "visibility in snow vs. snowfall intensity chart", 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.

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TABLE 9

LOWEST ON-WING VISCOSITY VALUES FOR DE/ANTI-ICING FLUIDS
(See Table 9 endnotes)

Table 9-1: Type II De/Anti-Icing Fluids

FLUID NAME	FLUID DILUTION	LOWEST ON-WING VISCOSITY [1] (mPa.s)	
		MANUFACTURER METHOD	AIR 9968 REVISION A METHOD
ABAX Ecowing 26	100/0	4 900 [h]	4 600 [a]
	75/25	2 200 [a]	2 200 [a]
	50/50	50 [a]	50 [a]
Aviation Shaanxi Hi-Tech Cleanwing II	100/0	4 650 [e]	4 500 [a]
	75/25	9 450 [e]	10 000 [a]
	50/50	10 150 [e]	10 200 [a]
Clariant Safewing MP II FLIGHT	100/0	3 340 [a]	3 340 [a]
	75/25	12 900 [c]	12 900 [c]
	50/50	11 500 [a]	11 500 [a]
Clariant Safewing MP II FLIGHT PLUS	100/0	3,650 [n]	3 100 [a]
	75/25	12,400 [n]	10 450 [a]
	50/50	7,800 [n]	7 050 [a]
Clariant Safewing MP II 1951	100/0	2 500 [g]	2 750 [a]
	75/25	2 900 [g]	3 000 [a]
	50/50	50 [g]	50 [a]
Cryotech Polar Guard II	100/0	4 400 [f]	4 050 [a]
	75/25	11 600 [f]	9 750 [a]
	50/50	80 [a]	80 [a]
Kilfrost ABC-3	100/0	2 500 [e]	2 500 [a]
	75/25	2 000 [e]	2 000 [a]
	50/50	400 [e]	400 [a]
Kilfrost ABC-2000	100/0	2 350 [e]	2 350 [a]
	75/25	3 000 [e]	3 000 [a]
	50/50	1 000 [e]	1 000 [a]
Kilfrost ABC-K Plus	100/0	2 850 [e]	2 640 [a]
	75/25	12 650 [e]	12 650 [c]
	50/50	4 200 [e]	5 260 [a]
Newave Aerochemical FCY-2	100/0	7 000 [e]	8 920 [a]
	75/25	18 550 [e]	18 550 [e]
	50/50	6 750 [e]	7 030 [a]

Table 9-2: Type III De/Anti-Icing Fluids

FLUID NAME	FLUID DILUTION	LOWEST ON-WING VISCOSITY [1] (mPa.s)	
		MANUFACTURER METHOD	AIR 9968 REVISION A METHOD
Clariant Safewing MP III 2031 ECO	100/0	30 [m]	Not Applicable
	75/25	55 [m]	Not Applicable
	50/50	10 [m]	Not Applicable

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TABLE 9 (cont.)

LOWEST ON-WING VISCOSITY VALUES FOR DE/ANTI-ICING FLUIDS
(See Table 9 endnotes)

Table 9-3: Type IV De/Anti-Icing Fluids

FLUID NAME	FLUID DILUTION	LOWEST ON-WING VISCOSITY [1] (mPa.s)	
		MANUFACTURER METHOD	AIR 9968 REVISION A METHOD
ABAX AD-480	100/0	15 200 [h]	12 800 [d]
	75/25	16 000 [h]	12 400 [d]
	50/50	4 000 [h]	3 800 [a]
ABAX Ecowing AD-49	100/0	12 150 [i]	11 000 [a]
	75/25	30 700 [i]	32 350 [c]
	50/50	19 450 [i]	21 150 [c]
Clariant Max Flight 04 *(formerly Octagon Max Flight 04)*	100/0	5 540 [b]	5 540 [a]
	75/25	Dilution Not Applicable	Dilution Not Applicable
	50/50	Dilution Not Applicable	Dilution Not Applicable
Clariant Safewing MP IV LAUNCH	100/0	7 550 [a]	7 550 [a]
	75/25	18 000 [a]	18 000 [a]
	50/50	17 800 [a]	17 800 [a]
Clariant Safewing MP IV LAUNCH PLUS	100/0	8,700 [o]	8,450 [a]
	75/25	18,800 [p]	17,200 [c]
	50/50	9,700 [o]	12,150 [a]
Cryotech Polar Guard	100/0	32 100 [k]	36 300 [c]
	75/25	24 200 [k]	27 800 [c]
	50/50	6 200 [k]	7 500 [a]
Cryotech Polar Guard Advance	100/0	4 400 [f]	4 050 [a]
	75/25	11 600 [f]	9 750 [a]
	50/50	80 [a]	80 [a]
Dow UCAR™ Endurance EG106	100/0	24 850 [j]	2 230 [a]
	75/25	Dilution Not Applicable	Dilution Not Applicable
	50/50	Dilution Not Applicable	Dilution Not Applicable
Dow UCAR™ FlightGuard AD-480	100/0	15 200 [h]	12 800 [d]
	75/25	16 000 [h]	12 400 [d]
	50/50	4 000 [h]	3 800 [a]
Dow UCAR™ FlightGuard AD-49	100/0	12 150 [i]	11 000 [a]
	75/25	30 700 [i]	32 350 [c]
	50/50	19 450 [i]	21 150 [c]
Kilfrost ABC-S	100/0	17 000 [e]	17 000 [c]
	75/25	12 000 [e]	12 000 [c]
	50/50	2 000 [e]	2 000 [a]
Kilfrost ABC-S Plus	100/0	17 900 [e]	17 900 [c]
	75/25	18 300 [e]	18 300 [c]
	50/50	7 500 [e]	7 500 [a]
Lyondell ARCTIC Shield™	100/0	23 150 [l]	28 000 [e]
	75/25	21 700 [l]	22 100 [e]
	50/50	6 400 [l]	7 640 [a]

TABLE 9 (cont.)

LOWEST ON-WING VISCOSITY VALUES FOR DE/ANTI-ICING FLUIDS
(Table 9 endnotes)

NOTES

[1] The Aerospace Information Report (AIR) 9968 Revision A (December 2004) 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 beside each viscosity value. Details of each measurement method are shown in the table below.

Method	Brookfield Spindle	Container	Fluid Volume	Temp.	Speed	Duration
a	LV1 (with guard leg)	600 mL low form (Griffin) beaker	500 mL*	20°C	0.3 rpm	10 minutes 0 seconds
b	LV1 (with guard leg)	600 mL low form (Griffin) beaker	500 mL*	20°C	0.3 rpm	33 minutes 20 seconds
c	LV2-disc (with guard leg)	600 mL low form (Griffin) beaker	500 mL*	20°C	0.3 rpm	10 minutes 0 seconds
d	LV2-disc (with guard leg)	250 mL tall form (Berzelius) beaker	150 mL*	20°C	0.3 rpm	10 minutes 0 seconds
e	LV2-disc (with guard leg)	150 mL tall form (Berzelius) beaker	150 mL*	20°C	0.3 rpm	10 minutes 0 seconds
f	SC4-34/13R	small sample adapter	10 mL	20°C	0.3 rpm	10 minutes 0 seconds
g	SC4-34/13R	small sample adapter	10 mL	20°C	0.3 rpm	15 minutes 0 seconds
h	SC4-34/13R	small sample adapter	10 mL	20°C	0.3 rpm	30 minutes 0 seconds
i	SC4-31/13R	small sample adapter	10 mL	20°C	0.3 rpm	10 minutes 0 seconds
j	SC4-31/13R	small sample adapter	10 mL	0°C	0.3 rpm	10 minutes 0 seconds
k	SC4-31/13R	small sample adapter	9 mL	20°C	0.3 rpm	10 minutes 0 seconds
l	SC4-31/13R	small sample adapter	9 mL	20°C	0.3 rpm	33 minutes 0 seconds
m	LV0	UL adapter	16 mL	20°C	0.3 rpm	10 minutes 0 seconds
n	LV1	big sample adapter	50 mL	20°C	0.3 rpm	10 minutes 0 seconds
o	LV1	big sample adapter	55 mL	20°C	0.3 rpm	10 minutes 0 seconds
p	LV2-disc	big sample adapter	60 mL	20°C	0.3 rpm	10 minutes 0 seconds

*If necessary, adjust fluid volume to ensure fluid is level with notch on the spindle shaft

SIGNIFICANCE OF THIS TABLE

The viscosity values of the fluids in this table are those of the fluids provided by the manufacturers for holdover time testing. For the holdover time guidelines to be valid, the viscosity of the fluid on the wing shall not be lower than that listed in this table. The user should periodically ensure that the viscosity value of a fluid sample taken from the wing surface is not lower than that listed.

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TABLE 10
LOWEST OPERATIONAL USE TEMPERATURES[1] OF DE/ANTI-ICING FLUIDS (2013-2014)

Table 10-1: Type I De/Anti-Icing Fluids		
FLUID NAME	LOWEST OPERATIONAL USE TEMPERATURES[1] (°C) WITH CORRESPONDING FLUID DILUTION, NEAT FLUID/WATER (VOLUME %/VOLUME %)	
	LOW SPEED AERODYNAMIC TEST[2]	HIGH SPEED AERODYNAMIC TEST[2]
ABAX DE-950	**-26** for 71/29 dilution	**-31** for 71/29 dilution
ABAX DE-950 Colorless	Not tested[4]	**-24** for 60/40 dilution
AllClear Systems Lift-Off P-88	**-24.5** for 70/30 dilution	**-29.5** for 70/30 dilution
AllClear Systems Lift-Off E-188	**-40** for 70/30 dilution	**-41.5** for 70/30 dilution
Arcton Arctica DG ready-to-use	**-26** as supplied	**-26** as supplied
Arcton Arctica DG 91 Concentrate	**-25** for 75/25 dilution	**-25** for 75/25 dilution
Aviation Shaanxi Hi-Tech Cleanwing I	Not tested[4]	**-39** for 75/25 dilution
Aviation Xi'an Hi-Tech KHF-1	Not available[3]	**-38** for 75/25 dilution
Beijing Phoenix Air Traffic CBSX-1	Not available[3]	Not available[3]
Beijing Wangye Aviation Chemical KLA-1	Not available[3]	**-30.5** for 60/40 dilution
Beijing Yadilite Aviation Chemical Product Co. Ltd YD-101 Type I	Not tested[4]	**-30** for 60/40 dilution
Clariant EcoFlo Concentrate *(formerly Octagon EcoFlo Concentrate)*	Not tested[4]	**-30.5** for 65/35 dilution
Clariant EcoFlo 2 Concentrate *(formerly Octagon EcoFlo 2 Concentrate)*	Not tested[4]	**-29** for 65/35 dilution
Clariant Octaflo EF Concentrate *(formerly Octagon Octaflo EF Concentrate)*	**-25** for 65/35 dilution	**-33** for 65/35 dilution
See next page for additional Type I fluids		

NOTES

1 The lowest operational use temperature (LOUT) for a given fluid is the higher 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).
The values in this table were determined using 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.

2 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 AS 5900 (latest version).

3 Manufacturer has not provided LOUT information at the time of this publication. Contact the fluid manufacturer or use another fluid.

4 Manufacturer has indicated fluid was not tested. Consult with the fluid manufacturer and/or airframe manufacturer for further guidance.

CAUTION

- LOUT data provided in this table is based strictly on the manufacturer's data, the end user is responsible for verifying the validity of this data. In case of discrepancies between the values in this table and the fluid manufacturer's data, use the manufacturer's data.
- Fluids supplied in concentrated form must not be used in that form and must be diluted.
- For the fluids in the table that are intended to be diluted, the LOUT is derived from a dilution that provides the lowest possible operational use temperature. For other 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.

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TABLE 10 (cont.)

LOWEST OPERATIONAL USE TEMPERATURES[1] OF DE/ANTI-ICING FLUIDS (2013-2014)

Table 10-1: Type I De/Anti-Icing Fluids (cont.)		
FLUID NAME	LOWEST OPERATIONAL USE TEMPERATURES[1] (°C) WITH CORRESPONDING FLUID DILUTION, NEAT FLUID/WATER (VOLUME %/VOLUME %)	
	LOW SPEED AERODYNAMIC TEST[2]	HIGH SPEED AERODYNAMIC TEST[2]
Clariant Octaflo EF-80 *(formerly Octagon Octaflo EF-80)*	**-25** for 70/30 dilution	**-33** for 70/30 dilution
Clariant Octaflo EG Concentrate *(formerly Octagon Octaflo EG Concentrate)*	**-40.5** for 70/30 dilution	**-44** for 70/30 dilution
Clariant Safewing EG I 1996	**-35.5** for 75/25 dilution	**-43** for 75/25 dilution
Clariant Safewing EG I 1996 (88)	**-39.5** for 70/30 dilution	**-41.5** for 70/30 dilution
Clariant Safewing MP I 1938 ECO	**-25.5** for 65/35 dilution	**-32** for 65/35 dilution
Clariant Safewing MP I 1938 ECO (80)	**-25** for 71/29 dilution	**-32.5** for 71/29 dilution
Clariant Safewing MP I 1938 ECO (80) PreMix 55 i.e. ready-to-use	Not tested[4]	**-19** as supplied
Clariant Safewing MP I ECO PLUS (80)	**-25** for 71/29 dilution	**-33** for 71/29 dilution
Clariant MP I SKY (80)	**-26** for 71/29 dilution	**-31.5** for 71/29 dilution
Cryotech Polar Plus	**-27** for 63/37 dilution	**-32** for 63/37 dilution
Cryotech Polar Plus (80)	**-27.5** for 70/30 dilution	**-32.5** for 70/30 dilution
Deicing Solutions LLC Safetemp ES Plus	**-25.5** for 65/35 dilution	**-29** for 65/35 dilution
Dow UCAR™ Aircraft Deicing Fluid Concentrate	**-36.5** for 75/25 dilution	**-45** for 75/25 dilution
See next page for additional Type I fluids		

NOTES

1 The lowest operational use temperature (LOUT) for a given fluid is the higher 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).
  The values in this table were determined using 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.

2 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 AS 5900 (latest version).

3 Manufacturer has not provided LOUT information at the time of this publication. Contact the fluid manufacturer or use another fluid.

4 Manufacturer has indicated fluid was not tested. Consult with the fluid manufacturer and/or airframe manufacturer for further guidance.

CAUTION

- LOUT data provided in this table is based strictly on the manufacturer's data, the end user is responsible for verifying the validity of this data. In case of discrepancies between the values in this table and the fluid manufacturer's data, use the manufacturer's data.
- Fluids supplied in concentrated form must not be used in that form and must be diluted.
- For the fluids in the table that are intended to be diluted, the LOUT is derived from a dilution that provides the lowest possible operational use temperature. For other 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.

TABLE 10 (cont.)

LOWEST OPERATIONAL USE TEMPERATURES[1] OF DE/ANTI-ICING FLUIDS (2013-2014)

Table 10-1: Type I De/Anti-Icing Fluids (cont.)		
FLUID NAME	**LOWEST OPERATIONAL USE TEMPERATURES[1] (°C)** WITH CORRESPONDING FLUID DILUTION, NEAT FLUID/WATER (VOLUME %/VOLUME %)	
	LOW SPEED AERODYNAMIC TEST[2]	HIGH SPEED AERODYNAMIC TEST[2]
Dow UCAR™ ADF XL54	**-33** as supplied	**-33** as supplied
Dow UCAR™ PG Aircraft Deicing Fluid Concentrate	**-25** for 65/35 dilution	**-32** for 65/35 dilution
Dow UCAR™ PG ADF Dilute 55/45	**-24** as supplied	**-25** as supplied
Harbin Aeroclean Aviation HJF-1	Not tested[4]	**-32** for 60/40 dilution
HOC SafeTemp ES Plus	**-25.5** for 65/35 dilution	**-29** for 65/35 dilution
Hokkaido Fever Snow AG	**-21.5** as supplied	**-23** as supplied
Inland Technologies Duragly-E Concentrate	**-26** for 60/40 dilution	**-26** for 60/40 dilution
Inland Technologies Duragly-P Concentrate	**-25** for 60/40 dilution	**-25** for 60/40 dilution
Kilfrost DF Plus	**-25.5** for 69/31 dilution	**-32** for 69/31 dilution
Kilfrost DF Plus (80)	**-26** for 69/31 dilution	**-31.5** for 69/31 dilution
Kilfrost DF Plus (88)	**-26.5** for 63/37 dilution	**-32** for 63/37 dilution
Kilfrost DF^{sustain}™	Not tested[4]	**-41.5** for 68/32 dilution
See next page for additional Type I fluids		

NOTES

1 The lowest operational use temperature (LOUT) for a given fluid is the higher 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).
   The values in this table were determined using 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.

2 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 AS 5900 (latest version).

3 Manufacturer has not provided LOUT information at the time of this publication. Contact the fluid manufacturer or use another fluid.

4 Manufacturer has indicated fluid was not tested. Consult with the fluid manufacturer and/or airframe manufacturer for further guidance.

CAUTION

- LOUT data provided in this table is based strictly on the manufacturer's data, the end user is responsible for verifying the validity of this data. In case of discrepancies between the values in this table and the fluid manufacturer's data, use the manufacturer's data.
- Fluids supplied in concentrated form must not be used in that form and must be diluted.
- For the fluids in the table that are intended to be diluted, the LOUT is derived from a dilution that provides the lowest possible operational use temperature. For other 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.

TABLE 10 (cont.)

LOWEST OPERATIONAL USE TEMPERATURES[1] OF DE/ANTI-ICING FLUIDS (2013-2014)

Table 10-1: Type I De/Anti-Icing Fluids (cont.)		
FLUID NAME	LOWEST OPERATIONAL USE TEMPERATURES[1] (°C) WITH CORRESPONDING FLUID DILUTION, NEAT FLUID/WATER (VOLUME %/VOLUME %)	
	LOW SPEED AERODYNAMIC TEST[2]	HIGH SPEED AERODYNAMIC TEST[2]
LNT Solutions E188	**-36** for 70/30 dilution	**-41** for 70/30 dilution
LNT Solutions P180	**-29** for 69/31 dilution	**-32** for 69/31 dilution
LNT Solutions P188	**-24.5** for 70/30 dilution	**-31.5** for 70/30 dilution
Newave FCY-1A	**-40** for 75/25 dilution	**-40** for 75/25 dilution
Shaanxi Cleanway Cleansurface I	**-32.5** for 75/25 dilution	**-34.5** for 75/25 dilution
Shaanxi Cleanway Cleansurface I-BIO	Not tested[4]	**-37** for 75/25 dilution

NOTES

1 The lowest operational use temperature (LOUT) for a given fluid is the higher 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).
The values in this table were determined using 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.

2 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 AS 5900 (latest version).

3 Manufacturer has not provided LOUT information at the time of this publication. Contact the fluid manufacturer or use another fluid.

4 Manufacturer has indicated fluid was not tested. Consult with the fluid manufacturer and/or airframe manufacturer for further guidance.

CAUTION

- LOUT data provided in this table is based strictly on the manufacturer's data, the end user is responsible for verifying the validity of this data. In case of discrepancies between the values in this table and the fluid manufacturer's data, use the manufacturer's data.
- Fluids supplied in concentrated form must not be used in that form and must be diluted.
- For the fluids in the table that are intended to be diluted, the LOUT is derived from a dilution that provides the lowest possible operational use temperature. For other 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.

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TABLE 10 (cont.)

LOWEST OPERATIONAL USE TEMPERATURES[1] OF DE/ANTI-ICING FLUIDS (2013-2014)

Table 10-2: Type II De/Anti-Icing Fluids		
FLUID NAME	DILUTION, NEAT FLUID/WATER (VOLUME %/VOLUME %)	LOWEST OPERATIONAL USE TEMPERATURES[1] (°C)
		HIGH SPEED AERODYNAMIC TEST[2]
ABAX Ecowing 26	100/0	-25
	75/25	-14
	50/50	-3
Aviation Shaanxi Hi-Tech Cleanwing II	100/0	-29
	75/25	-14
	50/50	-3
Clariant Safewing MP II 1951	100/0	-28
	75/25	-14
	50/50	-3
Clariant Safewing MP II FLIGHT	100/0	-29
	75/25	-14
	50/50	-3
Clariant Safewing MP II FLIGHT PLUS	100/0	Not available, contact fluid manufacturer
	75/25	Not available, contact fluid manufacturer
	50/50	Not available, contact fluid manufacturer
Cryotech Polar Guard II	100/0	-30.5
	75/25	-14
	50/50	-3
See next page for additional Type II fluids		

NOTES

1 The lowest operational use temperature (LOUT) for a given fluid is the higher 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 7°C (13°F).
For the 75/25 and 50/50 dilutions, the holdover time table temperature band limits are posted in the cases where the manufacturer's LOUT is lower than those limits.
The values in this table were determined using 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.

2 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 AS 5900 (latest version).

CAUTION

- LOUT data provided in this table is based strictly on the manufacturer's data, the end user is responsible for verifying the validity of this data. In case of discrepancies between the values in this table and the fluid manufacturer's data, use the manufacturer's data.

TABLE 10 (cont.)

LOWEST OPERATIONAL USE TEMPERATURES[1] OF DE/ANTI-ICING FLUIDS (2013-2014)

Table 10-2: Type II De/Anti-Icing Fluids (cont.)		
FLUID NAME	DILUTION, NEAT FLUID/WATER (VOLUME %/VOLUME %)	LOWEST OPERATIONAL USE TEMPERATURES[1] (°C)
		HIGH SPEED AERODYNAMIC TEST[2]
Kilfrost ABC-3	100/0	-27
	75/25	-14
	50/50	-3
Kilfrost ABC-2000	100/0	-27.5
	75/25	-14
	50/50	-3
Kilfrost ABC-K Plus	100/0	-29
	75/25	-14
	50/50	-3
Newave Aerochemical FCY-2	100/0	-28
	75/25	-14
	50/50	-3

Table 10-3: Type III De/Anti-Icing Fluids			
FLUID NAME	DILUTION, NEAT FLUID/WATER (VOLUME %/VOLUME %)	LOWEST OPERATIONAL USE TEMPERATURES[1] (°C)	
		LOW SPEED AERODYNAMIC TEST[2]	HIGH SPEED AERODYNAMIC TEST[2]
Clariant Safewing MP III 2031 ECO	100/0	-16.5	-29
	75/25	-9	-10
	50/50	-3	-3

NOTES

1 The lowest operational use temperature (LOUT) for a given fluid is the higher 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 7°C (13°F).
   For the 75/25 and 50/50 dilutions, the holdover time table temperature band limits are posted in the cases where the manufacturer's LOUT is lower than those limits.
   The values in this table were determined using 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.

2 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 AS 5900 (latest version).

3 Manufacturer has not provided LOUT information at the time of this publication. Contact the fluid manufacturer or use another fluid.

CAUTION

- LOUT data provided in this table is based strictly on the manufacturer's data, the end user is responsible for verifying the validity of this data. In case of discrepancies between the values in this table and the fluid manufacturer's data, use the manufacturer's data.

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TABLE 10 (cont.)

LOWEST OPERATIONAL USE TEMPERATURES[1] OF DE/ANTI-ICING FLUIDS (2013-2014)

Table 10-4: Type IV De/Anti-Icing Fluids

FLUID NAME	DILUTION, NEAT FLUID/WATER (VOLUME %/VOLUME %)	LOWEST OPERATIONAL USE TEMPERATURES[1] (°C) HIGH SPEED AERODYNAMIC TEST[2]
ABAX AD-480	100/0	-26
	75/25	-14
	50/50	-3
ABAX Ecowing AD-49	100/0	-26
	75/25	-14
	50/50	-3
Clariant Max Flight 04 *(formerly Octagon Max Flight 04)*	100/0	-26.5
	75/25	Dilution Not Applicable
	50/50	Dilution Not Applicable
Clariant Safewing MP IV LAUNCH	100/0	-28.5
	75/25	-14
	50/50	-3
Clariant Safewing MP IV LAUNCH PLUS	100/0	-29
	75/25	-14
	50/50	-3
Cryotech Polar Guard	100/0	-23.5
	75/25	-5.5
	50/50	-3
Cryotech Polar Guard Advance	100/0	-30.5
	75/25	-14
	50/50	-3

See next page for additional Type IV fluids

NOTES

1 The lowest operational use temperature (LOUT) for a given fluid is the higher 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 7°C (13°F).
For the 75/25 and 50/50 dilutions, the holdover time table temperature band limits are posted in the cases where the manufacturer's LOUT is lower than those limits.
The values in this table were determined using 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.

2 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 AS 5900 (latest version).

CAUTION

- LOUT data provided in this table is based strictly on the manufacturer's data, the end user is responsible for verifying the validity of this data. In case of discrepancies between the values in this table and the fluid manufacturer's data, use the manufacturer's data.

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TABLE 10 (cont.)

LOWEST OPERATIONAL USE TEMPERATURES[1] OF DE/ANTI-ICING FLUIDS (2013-2014)

Table 10-4: Type IV De/Anti-Icing Fluids (cont.)

FLUID NAME	DILUTION, NEAT FLUID/WATER (VOLUME %/VOLUME %)	LOWEST OPERATIONAL USE TEMPERATURES[1] (°C)
		HIGH SPEED AERODYNAMIC TEST[2]
Dow UCAR™ Endurance EG106 De/Anti-Icing Fluid	100/0	-27
	75/25	Dilution Not Applicable
	50/50	Dilution Not Applicable
Dow UCAR™ FlightGuard AD-480	100/0	-26
	75/25	-14
	50/50	-3
Dow UCAR™ FlightGuard AD-49	100/0	-26
	75/25	-14
	50/50	-3
Kilfrost ABC-S	100/0	-28
	75/25	-14
	50/50	-3
Kilfrost ABC-S Plus	100/0	-28
	75/25	-14
	50/50	-3
Lyondell ARCTIC Shield™	100/0	-24.5
	75/25	-9.5
	50/50	-3

NOTES

1 The lowest operational use temperature (LOUT) for a given fluid is the higher 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 7°C (13°F).
   For the 75/25 and 50/50 dilutions, the holdover time table temperature band limits are posted in the cases where the manufacturer's LOUT is lower than those limits.
   The values in this table were determined using 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.

2 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 AS 5900 (latest version).

CAUTION

- LOUT data provided in this table is based strictly on the manufacturer's data, the end user is responsible for verifying the validity of this data. In case of discrepancies between the values in this table and the fluid manufacturer's data, use the manufacturer's data.

ICE PELLET ALLOWANCE TIMES FOR WINTER 2013-2014

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 or moderate) and light ice pellets mixed with other forms of precipitation.

Results of this research provide the basis for allowance times for operations in ice pellets (light or moderate) and operations in light ice pellets mixed with other forms of precipitation.

Additionally, Type IV anti-icing fluid with ice pellets embedded was evaluated for its aging qualities over periods of time beyond the allowance times, when the active precipitation time was limited to the allowance times.

Operational Guidelines

1) Tests have shown that ice pellets generally remain in a frozen state embedded in Type IV anti-icing fluid and are not 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 dissolved by the fluid (remaining embedded) is an indication that the fluid has failed. These embedded ice pellets are generally not readily detectable by the human eye during pre-takeoff contamination inspection procedures.

2) The research data have also shown that after proper deicing and anti-icing, the accumulation of light ice pellets, moderate ice pellets, and light ice pellets mixed with other forms of precipitation in Type IV fluid will not prevent the fluid from flowing off of the aerodynamic surfaces during takeoff.

3) The allowance times were developed based on this aerodynamic testing and are contained in Table 11.

4) Research has also shown that propylene glycol (PG) and ethylene glycol (EG) fluids behave differently under certain temperature and ice pellet precipitation conditions. Currently all Type IV fluids are PG based with the exception of Dow Chemical EG106 which is EG based. Higher aircraft rotation speeds are required to effectively remove 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 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.

5) Furthermore, recent research with newer generation type airfoils has shown that the allowance times are shorter when using PG fluids under certain conditions. Since it is challenging to determine exactly which aircraft may be affected, the allowance time when using PG fluids at temperatures of -5°C and above is limited to 15 minutes in moderate ice pellets.

6) The ice pellet allowances are contingent on the operator's approved ground icing program being updated to incorporate the ice pellet information contained herein, including the following conditions and restrictions that must be satisfied:

   a) The aircraft critical surfaces must be properly deiced before the application of Type IV anti-icing fluid;

   b) The allowance time is valid only if the aircraft is anti-iced with undiluted Type IV fluid;

   c) These allowance times are applicable from the start of the Type IV anti-icing fluid application;

d) The allowance time is limited to aircraft with a rotation speed of 100 knots or greater (subject to 4) above);

e) If the takeoff is not accomplished within the applicable allowance time in Table 11, the aircraft must be completely deiced, and if precipitation is still present, anti-iced again prior to a subsequent takeoff;

f) The allowance time cannot be extended by an inspection of the aircraft critical surfaces from either inside or outside the aircraft;

g) If the temperature decreases below the temperature on which the allowance time was based, where 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;

h) 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;

i) If the precipitation condition stops at, or before, the time limit of the applicable allowance time in Table 11 and does not restart, the aircraft may take off up to 90 minutes after the start of the application of the Type IV anti-icing fluid. However, the OAT must remain constant or increase during the 90-minute period under the following conditions:

- 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.

7) Examples:

a) 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 take off without any further action until 11:30.

b) 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, 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 no precipitation restarts after the end of the allowance time at 10:25, the aircraft may take off without any further action until 11:30.

c) 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 light freezing rain falls until 10:10, 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 no precipitation restarts after the end of the allowance time at 10:25, the aircraft may take off without any further action until 11:30.

d) 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, stops and restarts at 10:30, with the allowance time stopping at 10:25, the aircraft may not take off, no matter how short the time or type of precipitation after 10:25, without being deiced and anti-iced if precipitation is present.

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TABLE 11

ICE PELLET ALLOWANCE TIMES FOR WINTER 2013-2014

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 Dow Chemical EG106 which is ethylene glycol based.

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

	OAT -5°C and above	**OAT less than -5°C to -10°C**	**OAT less than -10°C[1]**
Light Ice Pellets	50 minutes	30 minutes	30 minutes[2]
Moderate Ice Pellets	25 minutes[3]	10 minutes	10 minutes[2]
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	
Light Ice Pellets Mixed with Light Rain	25 minutes[4]		**Caution: No allowance times currently exist**
Light Ice Pellets Mixed with Moderate Rain	25 minutes[5]		
Light Ice Pellets Mixed with Light Snow	25 minutes	15 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes		

NOTES

1. Ensure that the lowest operational use temperature (LOUT) is respected.
2. 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).
3. Allowance time is 15 minutes for propylene glycol (PG) fluids or when the fluid type is unknown.
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.

CAUTIONS

- **Fluids used during ground de/anti-icing do not provide in-flight icing protection.**

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FAA
HOLDOVER TIME GUIDELINES
WINTER 2013-2014

OFFICIAL FAA HOLDOVER TIME TABLES

WINTER 2013-2014

The information contained in this document is the FAA official guidance, Holdover Tables, and Allowance Times for use the Winter 2013-2014. The content of this document is included by reference in the FAA Winter 2013-2014 Notice (N) 8900.238 that is published in FSIMS. The content of this document in conjunction with N 8900. 238 should be used as the official winter 2013-2014 HOT/Allowance Times and associated guidance.

Questions concerning FAA aircraft ground de/anti-icing requirements or Flight Standards policies should be addressed to charles.j.enders@faa.gov or 202-493-1422.

Questions on the technical content of the holdover time tables should be addressed to warren.underwood@faa.gov or 404-305-7163.

Questions regarding editorial content or web access issues should be addressed to sung.shin@faa.gov or 202-267-8086.

2013-2014 Holdover Times Tables 10/22/13

SUMMARY OF CHANGES FROM 2013-2014

TYPE I FLUIDS. The Type I holdover time tables are unchanged. Previously, they were divided into two tables, Table 1 for aircraft with critical surfaces constructed predominantly of aluminum, and Table 1A for aircraft with critical surfaces constructed predominantly of composites. Table 0 also includes aluminum and composite values for Type I fluid HOTs in active frost conditions. The aluminum values also apply to other metals used in aircraft construction such as titanium. I

The Type I fluid holdover times for composite surfaces, Table 1A, and applicable sections of Table 0, must be applied to aircraft with all critical surfaces that are predominantly or entirely constructed of composite materials. However, the Type I fluid holdover times for composite surfaces do not need to be applied to aircraft that are currently in service, have a demonstrated safe operating history using Type I fluid aluminum structure holdover times, and have critical surfaces only partially constructed of composite material. If there is any doubt, consult with the aircraft manufacturer to determine whether aluminum or composite holdover times are appropriate for the specific aircraft.

TYPE II FLUIDS. A fluid-specific HOT table has been created for the new Type II fluid, Cryotech Polar Guard II. The addition of this fluid did not impact the generic holdover times.

Changes have been made to the Clariant Safewing MP II FLIGHT PLUS 100/0 and 75/25 snow holdover times as the result of supplemental testing conducted during the winter of 2012-2013.

LNT Solutions P250 has been removed from the guidelines at the request of the manufacturer as it was never commercialized.

Some Type II fluid-specific HOT tables have been upgraded to include three columns of snow holdover times. The three columns provide holdover times for three snow intensities; very light, light and moderate. The affected tables are: ABAX Ecowing 26, Clariant Safewing MP II FLIGHT and Cryotech Polar Guard II.

The Type II generic HOT guidelines are unchanged. No changes have been made to the table values or table format; the table retains a single column for snow.

TYPE III FLUIDS. The Type III fluid HOT guidelines are unchanged.

TYPE IV FLUIDS. A fluid-specific HOT table has been created for the new Type IV fluid Clariant Safewing MP IV LAUNCH PLUS.

Kilfrost ABC-4^{SUSTAIN} has been removed from the guidelines at the request of the manufacturer as it was never commercialized.

Clariant Max Flight 04 75/25 and 50/50 dilutions have been removed from the guidelines at the request of the manufacturer, therefore, holdover times no longer exist for these dilutions.

Some Type IV fluid-specific HOT tables have been upgraded to include three columns of snow holdover times. The three columns provide holdover times for three snowfall intensities: very light, light and moderate. The affected Type IV HOT tables are: ABAX Ecowing AD-49, Kilfrost ABC-S Plus, Clariant Max Flight 04, Clariant Safewing MP IV LAUNCH, Clariant Safewing MP IV LAUNCH

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PLUS, Cryotech Polar Guard Advance, Dow UCAR™ Endurance EG106, and Dow UCAR™ FlightGuard AD-49.

Nine increases have been made to Table 4, the Type IV generic HOT guidelines as a result of the removal of Kilfrost ABC-4^{SUSTAIN} and Clariant Max Flight 04 dilutions. Table 4 does not include values for light and very light snow.

HOLDOVER TIMES 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:

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.

ICE CRYSTALS. Recent testing has shown that the freezing fog holdover times can be used with ice crystal precipitation conditions. As a result, the freezing fog columns in all Type I, Type II, Type III, and Type IV tables have been modified to include ice crystals.

ACTIVE FROST HOLDOVER TIMES. The active frost holdover times, Table 0, are unchanged for 20013-14.

SNOWFALL VISIBILITY TABLE . Table 1C, Snowfall Intensities as a Function of Prevailing Visibility, is unchanged for 2013-14. For simplification purposes, portions of the table may be included in an air carrier's winter operations plan in non-table format. An example would be: "Since very light snow is being added to some of the Type II and Type IV tables, and since the METAR and the associated ATIS do not report very light snow, a METAR reported visibility of 2.5 miles or higher can be used as an indication that the snowfall intensity is very light." An air carrier certainly would also have the option of providing a more detailed description utilizing lower METAR reported visibilities for specific day/night and temperature conditions.

SURFACE VISIBILITY. 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.

USE OF RUNWAY VISUAL RANGE (RVR). The use of RVR is not permitted for determining visibility used with the holdover tables.

USE OF ELECTRONIC HAND HELD DEVICES TO DETERMINE HOLDOVER TIMES (eHOT). Electronic devices to determine HOTs may be used as part of an air operator's Title 14 of the Code of Federal Regulations (14 CFR) part 121, § 121.629 winter operations plan submitted to the FAA for approval. If for any reason the device or application fails or if the user has any concern regarding the accuracy of the data being displayed, printed tables sourced from the FAA HOTS must be used as a fall back information source. Questions regarding the use of these devices should be submitted to charles.j.enders@faa.gov, 202-493-1422, or craig.botko@faa.gov, 202-267-7493.

ICE PELLET ALLOWANCE TIMES. The Ice Pellet Allowance Times (Table 9) values are unchanged for 2013-14.

EARLY FLUID FAILURE ON EXTENDED SLATS AND FLAPS. Additional research was conducted on this subject during the winter of 2012-13, and will resume for 2013-14. Research has determined that fluid degradation may be 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. Further research is anticipated to characterize the extent of the effect on the Holdover Times and Allowance times. The FAA advises all operators to review their policies and procedures in light of this information to assure appropriate consideration.

LOWEST OPERATIONAL USE TEMPERATURE (LOUT) TABLE. Lowest Operational Use Temperature (LOUT) information for Types I, II, III and IV fluids has been updated with revised values for some fluids. Information has also been added for new fluids and deleted for obsolete fluids. This information has been derived by the FAA based on data provided by the fluid manufacturers. The LOUT information can be found in Tables 7-1 for Type I fluids and Tables7-2, 7-3, and 7.4 for Types II, III, and IV fluids respectively Tables 7-2, and 7-4 now include data for dilutions of Type II and Type IV fluids. Contact the fluid manufacturer if further clarification with respect to the information in these tables is required.

The Lowest Operational Use Temperature, or LOUT is the lowest temperature at which a de-/anti-icing fluid will adequately flow off aircraft critical surfaces and maintain the required anti-icing freezing point buffer which is 7 ºC (13 ºF) below outside air temperature (OAT) for SAE Type II, Type III, and Type IV fluids and 10 ºC (18 ºF) below (OAT) for SAE Type I fluids,

For example, if a Type IV fluid has been aerodynamically tested and demonstrated adequate flow-off capability down to -30 ºC (-22 ºF), and the freezing point of this fluid is -35 ºC (-31 ºF), the LOUT would be -28 ºC (-18.4 ºF) to account for the required 7 ºC (13 ºF) freezing point buffer. In this case, the freezing point buffer requirement is the LOUT limiting factor

Similarly if a Type I fluid has been found to adequately flow off down to -29 ºC (-20.2 ºF), and the freezing point is -40 ºC (-40 ºF) , the LOUT would be -29 ºC (-20.2 ºF) to account for the lowest temperature at which the fluid adequately flows off the aircraft. Here, in this example, the fluid aerodynamic flow-off capability limits the LOUT.

There are two aerodynamic fluid flow-off test protocols for fluids; the low speed test is for aircraft with rotation speeds less than 100 knots and the high speed test for aircraft with rotation speeds greater than 100 knots. Type II, and Type IV fluids generally do not pass the low speed test. Therefore in order for these fluids to be used on a low rotation speed aircraft (rotation speed of 100 knots or less), the aircraft manufacturer must conduct testing to determine if these fluids can be safely applied on these aircraft and to identify operational procedures that must be implemented to insure the safe operation when these fluids have been applied.

The LOUTs for Type I fluids provided in Table 7-1 also include the manufacturer specified fluid/water concentration used to establish the LOUT for each fluid. This concentration should not be exceeded.

As previously stated, in the cases of Types II, III, and IV fluids, there can be multiple LOUTs to account for the undiluted fluid (100/0) and the 50/50 and 75/25 dilutions. In addition to being provided in Tables 7-2, 7-3, and 7-4, the LOUTs are also listed in their brand-specific holdover tables, but not Table 0, the frost holdover table. For this table, refer to Tables 7-2, 7-3, or 7-4, or the Type II, III, or IV

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HOTs to determine if the LOUT of the fluid being applied is warmer than -25 ºC (-13 ºF) and restrict use to -25 ºC or the LOUT, whichever is warmer. Type I fluid LOUTs are only found in Table 7-1, and are allowed to be used at temperatures down to their actual LOUT.

FLIGHT CREW AWARENESS OF CONDITIONS AFFECTING THE AIRCRAFT ANTI-ICING TREATMENT FOLLOWING DEICING AND ANTI-ICING OPERATIONS. The operator's deicing plan must provide a process that informs the captain of the time of the deicing/anti-icing treatment and conditions that have affected the aircraft anti-icing treatment since that time. If the flight crew is not present at the time of the deicing/anti-icing application, the crew will review this information before calculating the holdover time.

STANDARDIZED INTERNATIONAL GROUND DEICING PROGRAM (SIGDP). For those air carriers participating in the SIGDP one change was agreed upon after the 2010-2011 winter revisions were made to the SIGDP. This change was included in the 2011-2012 revision. This change addresses a concern that the air carriers have expressed over the completion of the annual audits within the anniversary month. In addition to the scheduling difficulties that this has generated, it has also necessitated that many of the audits be conducted in late summer and early fall prior to the service providers being in a full operational mode. In many cases this has limited the auditor's effectiveness and has not been conducive to the high quality audit that is fundamental to the success of the SIGDP. Therefore it was agreed upon by the member air carriers participating in the SIGDP and the FAA policy office that the grace month concept that is currently applied to the training/qualification annual requirements under the SIGDP will be also applied to the annual audit requirements. This allows a three month period in which the audit can be conducted and credited as though it was conducted in the month it was originally due. For example if the audit in 2009 was completed in September the next audit is due in September 2010. The 2010 audit can be completed in either August, September or October 2010 and credited as completed in its original due month of September 2010. The next audit will be due in September 2011 regardless of which of the three months the audit was completed in 2010. The same grace month rational will apply for the 2011 audit as well. If the recurring audit is not completed in the three month applicable period then the service provider would be considered as a new service provider under the SIGDP and an initial detailed qualification audit would need to be completed prior to any SIGDP participating air carrier utilizing their services under the SIGDP. Policy development is continuing in 2013-14.

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TABLE 0. FAA GUIDELINES FOR HOLDOVER TIMES IN ACTIVE FROST, SAE TYPE I, TYPE II, TYPE III, AND TYPE IV FLUIDS

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Approximate Holdover Times (hours:minutes)
		Active Frost
Degrees Celsius	Degrees Fahrenheit	Type I[1,2]
-1 and Above	30 and above	0:45 (0:35)[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		Concentration Neat Fluid/Water (Volume%/Volume%)	Approximate Holdover Times (hours:minutes)		
			Active Frost		
Degrees Celsius	Degrees Fahrenheit		Type II[3]	Type III[3]	Type IV[3]
-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

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) of the fluid is not exceeded (see Table 7.1).
3 These fluids may not be used below -25°C (-13°F) in active frost conditions For Type II, III, or IV fluids with a LOUT warmer than -25°C (-13°F) undiluted or -3°C (27°F) in the 50/50 dilution, or -14°C (7°F) in the 75/25 dilution, limit usage to the actual LOUT value.
4 Value in parenthesis is for composite aircraft.

CAUTION: Fluids used during ground deicing/anti-icing do not provide in-flight icing protection.

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FAA TYPE I HOLDOVER TIME GUIDELINE

TABLE 1. FAA GUIDELINES FOR HOLDOVER TIMES SAE TYPE I FLUID MIXTURES ON CRITICAL AIRCRAFT SURFACES COMPOSED PREDOMINANTLY OF ALUMINUM AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Wing Surface	Approximate Holdover Times Under Various Weather Conditions (hours: minutes)							
			Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets			Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing[3]	Other[4]
Degrees Celsius	Degrees Fahrenheit			Very Light[1]	Light[1]	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	
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	CAUTION: No holdover time guidelines exist	
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 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
3 This column is for use at temperatures above 0 degrees Celsius (32 degrees Fahrenheit) only.
4 Heavy snow, ice pellets, moderate and heavy freezing rain, hail.

SAE Type I fluid/water mixture must be selected so that the freezing point of the mixture is at least 10 °C (18 °F) below OAT.

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 OAT.
- SAE TYPE I fluid used during ground deicing/anti-icing is not intended for and does not provide protection during flight.

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FAA TYPE I HOLDOVER TIME GUIDELINE

TABLE 1A. FAA GUIDELINES FOR HOLDOVER TIMES SAE TYPE I FLUID MIXTURES ON CRITICAL AIRCRAFT SURFACES COMPOSED PREDOMINANTLY OF COMPOSITES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		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			Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing[3]	Other[4]
				Very Light[1]	Light[1]	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	
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				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
3 This column is for use at temperatures above 0 degrees Celsius (32 degrees Fahrenheit) only.
4 Heavy snow, ice pellets, moderate and heavy freezing rain, hail.

SAE Type I fluid/water mixture must selected so that the freezing point of the mixture is at least 10 °C (18 °F) below OAT.

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 OAT.
- SAE TYPE I fluid used during ground deicing/anti-icing is not intended for and does not provide protection during flight.

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TABLE 1B. FAA GUIDELINES FOR THE APPLICATION OF SAE TYPE I FLUID MIXTURE MINIMUM CONCENTRATIONS AS A FUNCTION OF OUTSIDE AIR TEMPERATURE

Outside Air Temperature (OAT)	One-step Procedure Deicing/Anti-icing[1]	Two-step Procedure	
		First step: Deicing	Second step: Anti-icing[1,2]
-3 °C (27 °F) and above	Mix of fluid and water heated to 60 °C (140 °F) minimum at the nozzle, with a freezing point of at least 10 °C (18 °F) below OAT	Heated water or a mix of fluid and water heated to 60 °C (140 °F) minimum at the nozzle	Mix of fluid and water heated to 60 °C (140 °F) minimum at the nozzle, with a freezing point of at least 10 °C (18 °F) below OAT
Below -3 °C (27 °F)		Freezing point of heated fluid mixture shall not be more than 3 °C (5 °F) above OAT	

1) Fluids must only be used at temperatures above 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:
- Upper temperature limit shall not exceed fluid and aircraft manufacturers' recommendations.
- To use Type I holdover time guidelines in all conditions including active frost, at least 1 liter per square meter (~2 gal. per 100 square feet) fluid must be applied to the deiced surfaces.
- 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.
- The lowest operational use temperature (LOUT) for a given Type 1 fluid is the higher 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.

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TABLE 1C. 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: 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 1C 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 Snow Intensity Table, like the FMH-1 Table, uses visibility to determine snowfall intensities, and if the visibility is being reduced by snow along with other forms of obscuration such as fog, haze, smoke, etc., the FAA Snow Intensity Table does not need to be used to estimate the snow fall intensity for HOT determination. Use of the FAA Snow Intensity Table under these conditions may needlessly overestimate the actual snowfall intensity and therefore the snowfall intensity being reported by the weather observer or automated service observing system (ASOS), from the FMH-1 Table may be used.

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FAA TYPE II HOLDOVER TIME GUIDELINE

TABLE 2. FAA GUIDELINES FOR HOLDOVER TIMES SAE TYPE II FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		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[1]	Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing[3]	Other[4]
-3 and above	27 and above	100/0	0:35-1:30	0:20-0:45	0:30-0:55	0:15-0:30	0:08-0:40	CAUTION: No holdover time guidelines exist
		75/25	0:25-1:00	0:15-0:30	0:20-0:45	0:10-0:25	0:05-0:25	
		50/50	0:15-0:30	0:05-0:15	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[5]	0:10-0:20[5]		
		75/25	0:25-0:50	0:10-0:20	0:15-0:30[5]	0: 08-0: 15[5]		
Below -14 to -25 or LOUT	Below 7 to -13 or LOUT	100/0	0:15-0:35	0:15-0:30				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
3 This column is for use at temperatures above 0 °C (32 °F) only.
4 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
5 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 OAT.
- SAE TYPE II fluid used during ground deicing/anti-icing is not intended for and does not provide protection during flight.

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TABLE 2A. FAA GUIDELINES FOR HOLDOVER TIMES ABAX ECOWING 26 TYPE II FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Manufacturer Specific 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			Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing[3]	Other[4]
				Very Light[1]	Light[1]	Moderate				
-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	
		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	CAUTION: No holdover time guidelines exist	
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[5]	0:15-0:35[5]		
		75/25	0:35-1:15	0:55-1:05	0:40-0:55	0:25-0:40	0:20-0:50[5]	0:15-0:25[5]		
below -14 to -25	below 7 to -13	100/0	0:25-0:45	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 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
3 This column is for use at temperatures above 0 °C (32 °F) only.
4 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
5 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 OAT.
- ABAX ECOWING 26 TYPE II fluid used during ground deicing/anti-icing is not intended for and does not provide protection during flight.

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TABLE 2B. FAA GUIDELINES FOR HOLDOVER TIMES AVIATION SHAANXI HI-TECH CLEANWING II TYPE II FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES

Outside Air Temperature		Manufacturer Specific 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[1]	Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing[3]	Other[4]
-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[5]	0:20-0:25[5]		
		75/25	0:40-1:45	0:25-0:45	0:35-0:40[5]	0:20-0:25[5]		
below -14 to -29	below 7 to -20.2	100/0	0:20-0:50	0:15-0:30				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
3 This column is for use at temperatures above 0 °C (32 °F) only.
4 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
5 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 OAT.
- AVIATION SHANXI HI-TECH TYPE II fluid used during ground deicing/anti-icing is not intended for and does not provide protection during flight.

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TABLE 2C. FAA GUIDELINES FOR HOLDOVER TIMES CLARIANT SAFEWING MP II FLIGHT TYPE II FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Manufacturer Specific 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			Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing[3]	Other[4]
				Very Light[1]	Light[1]	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[5]	0:25-0:45[5]		
		75/25	0:25-1:05	1:20-1:40	0:40-1:20	0:20-0:40	0:25-1:10[5]	0:20-0:35[5]		
Below -14 to -29	Below 7 to -20.2	100/0	0:30-0:50	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 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
3 This column is for use at temperatures above 0 °C (32 °F) only.
4 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
5 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 OAT
- CLARIANT SAFEWING MPII FLIGHT TYPE II fluid used during ground deicing/anti-icing is not intended for and does not provide protection during flight.

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TABLE 2D. FAA GUIDELINES FOR HOLDOVER TIMES CLARIANT SAFEWING MP II FLIGHT PLUS TYPE II FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Manufacturer Specific 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[1]	Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing[3]	Other[4]
-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	CAUTION: No holdover time guidelines exist
		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[5]	0:35-0:55[5]		
		75/25	0;30-1:45	0:55-1:40	0:25-1:10[5]	0:30-0:45[5]		
Below -14 to LOUT	Below 7 to LOUT	100/0	0:20-0:40	0:15-0:30				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
3 This column is for use at temperatures above 0 °C (32 °F) only.
4 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
5 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 OAT
- CLARIANT SAFEWING MPII FLIGHT PLUS TYPE II fluid used during ground deicing/anti-icing is not intended for and does not provide protection during flight.

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TABLE 2E. FAA GUIDELINES FOR HOLDOVER TIMES CRYOTECH POLAR GUARD II TYPE II FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Manufacturer Specific 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: Very Light[1]	Light[1]	Moderate	Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing[3]	Other[4]
-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[5]	0:35-0:45[5]	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[5]	0:35-0:45[5]		
Below -14 to -30.5	Below 7 to -22.9	100/0	0:25-0:50	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 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
3 This column is for use at temperatures above 0 °C (32 °F) only.
4 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
5 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 OAT
- CRYOTECH POLAR GUARD II TYPE II fluid used during ground deicing/anti-icing is not intended for and does not provide protection during flight.

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TABLE 2F. FAA GUIDELINES FOR HOLDOVER TIMES KILFROST ABC-2000 TYPE II FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Manufacturer Specific 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[1]	Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing[3]	Other[4]
-3 and above	27 and above	100/0	1:30-3:05	0:30-1:00	0:55-1:35	0:40-0:50	0:15-1:10	CAUTION: No holdover time guidelines exist
		75/25	1:40-3:30	0:30-1:05	0:45-1:15	0:40-0:50	0:15-1:40	
		50/50	1:00-2:10	0:15-0:30	0:15-0:25	0:08-0:15		
below -3 to -14	below 27 to 7	100/0	0:35-1:25	0:25-0:45	0:25-0:50[5]	0:10-0:30[5]		
		75/25	0:35-1:15	0:25-0:50	0:25-0:55[5]	0:15-0:30[5]		
Below -14 to -27.5	Below 7 to -17.5	100/0	0:20-0:45	0:15-0:30				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
3 This column is for use at temperatures above 0 degrees Celsius (32 degrees Fahrenheit) only.
4 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
5 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 OAT.
- KILFROST ABC-2000 TYPE II fluid used during ground deicing/anti-icing is not intended for and does not provide protection during flight.

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TABLE 2G. FAA GUIDELINES FOR HOLDOVER TIMES KILFROST ABC-K PLUS TYPE II FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Manufacturer Specific 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[1]	Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing[3]	Other[4]
-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	
		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	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:30-1:05	0:50-1:25	0:25-1:00[5]	0:15-0:35[5]		
		75/25	0:25-1:25	0:35-1:05	0:20-0:55[5]	0:09-0:30[5]		
below -14 to -29	below 7 to -20.2	100/0	0:30-0:55	0:15-0:30				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
3 This column is for use at temperatures above 0 degrees Celsius (32 degrees Fahrenheit) only.
4 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
5 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 OAT.
- KILFROST ABC-K PLUS TYPE II fluid used during ground deicing/anti-icing is not intended for and does not provide protection during flight.

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TABLE 2H. FAA GUIDELINES FOR HOLDOVER TIMES NEWAVE AEROCHEMICAL FCY-2 TYPE II FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Manufacturer Specific 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[1]**	**Freezing Drizzle[2]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[3]**	**Other[4]**
-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	CAUTION: No holdover time guidelines exist
		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[5]	0:15-0:20[5]		
		75/25	0:30-1:05	0:10-0:20	0:15-0:30[5]	0:08-0:15[5]		
below -14 to -28	below 7 to -18.4	100/0	0:25-0:35	0:15-0:30				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
3 This column is for use at temperatures above 0 °C (32 °F) only.
4 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
5 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 OAT.
- NEWAVE AEROCHEMICAL FCY-2 TYPE II fluid used during ground deicing/anti-icing is not intended for and does not provide protection during flight.

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FAA TYPE III HOLDOVER TIME GUIDELINE

TABLE 3. FAA GUIDELINES FOR HOLDOVER TIMES SAE TYPE III FLUID MIXTURE AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Approximate Holdover Times Under Various Weather Conditions (hours: minutes)								
Degrees Celsius	Degrees Fahrenheit	Type III Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Freezing Fog or Ice Crystals	Snow, Snow Grains or Snow Pellets			Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing[3]	Other[4]
				Very Light[1]	Light[1]	Moderate				
-3 and above	27 and above	100/0	0:20 - 0:40	0:35 - 0:40	0:20 - 0:35	0:10 - 0:20	0:10 - 0:20	0:08 - 0:10	0:06 - 0:20	CAUTION: No holdover time guidelines exist
		75/25	0:15 - 0:30	0:25 - 0:35	0:15 - 0:25	0:08 - 0:15	0:08 - 0:15	0:06 - 0:10	0:02 - 0:10	
		50/50	0:10 - 0:20	0:15 - 0:20	0:08 - 0:15	0:04 - 0:08	0:05 - 0:09	0:04 - 0:06		
below -3 to -10	below 27 to 14	100/0	0:20 - 0:40	0:30 - 0:35	0:15 - 0:30	0:09 - 0:15	0:10 - 0:20	0:08 - 0:10		
		75/25[5]	0:15 - 0:30	0:25 - 0:30	0:10 - 0:25	0:07 - 0:10	0:09 - 0:12	0:06 - 0:09		
below -10	below 14	100/0	0:20 - 0:40	0:30 - 0:35	0:15 - 0:30	0:08 - 0:15				

SAE Type III fluid may be used below -10 °C (14 °F), provided the freezing point of the fluid is at least 7 °C (13 °F) below OAT and aerodynamic acceptance criteria (LOUT) are met. For the currently available Type III product, the High Speed LOUT is -29 °C (-20.2 °F) and the Low Speed LOUT is -16.5 °C (2.3 °F). Consider the use of **SAE Type I** when **Type III** fluid cannot be used.

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
3 This column is for use at temperatures above 0 °C (32 °F) only
4 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail
5 For aircraft with rotation speeds less than 100 knots, these holdover times only apply to outside air temperatures of -9°C (15.8°F) and above.

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 will reduce holdover time below the lowest time stated in the range. Holdover time may be reduced when aircraft skin temperature is lower than OAT.
- SAE TYPE III fluid used during ground deicing/anti-icing is not intended for and does not provide protection during flight.

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FAA TYPE IV HOLDOVER TIME GUIDELINES

TABLE 4. FAA GUIDELINES FOR HOLDOVER TIMES SAE TYPE IV FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		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[1]**	**Freezing Drizzle[2]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[3]**	**Other[4]**
-3 and above	27 and above	100/0	1:55-3:10	0:40-1:20	0:50-1:30	0:35-0:55	0:10-1:15	CAUTION: No holdover time guidelines exist
		75/25	1:05-1:45	0:30-0:55	0:45-1:10	0:30-0:45	0:09-0:50	
		50/50	0:20-0:35	0:07-0:15	0:15-0:20	0:08-0:10		
below -3 to -14	below 27 to 7	100/0	0:20-1:20	0:30-0:55	0:20-1:00[5]	0:10-0:25[5]		
		75/25[6]	0:25-0:50	0:20-0:40	0:15-1:05[5]	0:10-0:25[5]		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0[7]	0:15-0:40	0:15-0:30				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
3 This column is for use at temperatures above 0 °C (32 °F) only
4 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail
5 No holdover time guidelines exist for this condition below -10 °C (14 °F)
6 For Lyondell Arctic Shield temperature is limited to -9.5 ºC (15 ºF); for Cryotech Polar Guard temperature is limited to -5.5 ºC (22 ºF).
7 For Cryotech Polar Guard, temperature is limited to -23.5 ºC (-10.3 ºF) and for Lyondell Arctic Shield temperature limited to -24.5 ºC (-12.1 ºF). If the fluid-specific brand is unknown, all of the temperature limitations in this and the preceding note apply.

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 OAT.
- SAE TYPE IV fluid used during ground deicing/anti-icing is not intended for and does not provide protection during flight.

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TABLE 4A. FAA GUIDELINES FOR HOLDOVER TIMES ABAX AD-480 TYPE IV FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		**Manufacturer Specific 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[1]**	**Freezing Drizzle[2]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[3]**	**Other[4]**
-3 and above	27 and above	100/0	2:00-3:30	0:40-1:20	0:50-1:30	0:35-0:55	0:15-1:35	CAUTION: No holdover time guidelines exist
		75/25	1:30-2:45	0:30-1:05	0:50-1:15	0:30-0:45	0:10-1:15	
		50/50	0:30-0:45	0:09-0:20	0:15-0:25	0:09-0:15		
below -3 to -14	below 27 to 7	100/0	0:20-1:20	0:30-0:55	0:25-1:20[5]	0:15-0:30[5]		
		75/25	0:25-0:50	0:20-0:45	0:25-1:05[5]	0:15-0:30[5]		
below -14 to -26	below 7 to -14.8	100/0	0:15-0:40	0:15-0:30				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
3 This column is for use at temperatures above 0 degrees Celsius (32 degrees Fahrenheit) only.
4 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
5 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 oat.
- ABAX AD-480 TYPE IV fluid used during ground deicing/anti-icing is not intended for and does not provide protection during flight.

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TABLE 4B. FAA GUIDELINES FOR HOLDOVER TIMES ABAX ECOWING AD-49 TYPE IV FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Manufacturer Specific 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[2]	Light Freezing Rain	Rain on Cold Soaked Wing[3]	Other[4]
Degrees Celsius	Degrees Fahrenheit			Very Light[1]	Light[1]	Moderate				
-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	CAUTION: No holdover time guidelines exist	
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[5]	0:20-0:25[5]		
		75/25	0:30-1:10	2:05-2:15	1:40-2:05	1:20-1:40	0:15-1:05[5]	0:15-0:25[5]		
below -14 to -26	below 7 to -14.8	100/0	0:25-0:40	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 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
3 This column is for use at temperatures above 0 °C (32 °F) only.
4 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
5 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 OAT.
- ABAX ECOWING AD-49 TYPE IV fluid used during ground deicing/anti-icing is not intended for and does not provide protection during flight.

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TABLE 4C. FAA GUIDELINES FOR HOLDOVER TIMES CLARIANT MAX FLIGHT 04 *(FORMERLY OCTAGON MAX FLIGHT 04)*
TYPE IV FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		**Manufacturer Specific 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**			**Freezing Drizzle[2]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[3]**	**Other[4]**
				Very Light[1]	**Light[1]**	**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	
		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	0:50-2:30	2:20-2:50	1:10-2:20	0:35-1:10	0:25-1:30[5]	0:20-0:40[5]		
		75/25	N/A	N/A	N/A	N/A	N/A	N/A		
below -14 to -26.5	below 7 to -15.7	100/0	0:20-0:45	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 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
3 This column is for use at temperatures above 0 °C (32 °F) only.
4 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
5 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 OAT.
- CLARIANT MAX FLIGHT 04 TYPE IV fluid used during ground deicing/anti-icing is not intended for and does not provide protection during flight.

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TABLE 4D. FAA GUIDELINES FOR HOLDOVER TIMES CLARIANT SAFEWING MP IV LAUNCH TYPE IV FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Manufacturer Specific 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: Very Light[1]	Snow, Snow Grains or Snow Pellets: Light[1]	Snow, Snow Grains or Snow Pellets: Moderate	Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing[3]	Other[4]
-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	CAUTION: No holdover time guidelines exist
		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		
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[5]	0:25-0:45[5]		
		75/25	0:40-1:20	2:25-2:55	1:25-2:25	0:45-1:25	0:25-1:10[5]	0:25-0:45[5]		
below -14 to -28.5	below 7 to -19.3	100/0	0:30-0:50	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 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
3 This column is for use at temperatures above 0 °C (32 °F) only.
4 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
5 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 OAT.
- CLARIANT SAFEWING MP IV LAUNCH TYPE IV fluid used during ground deicing/anti-icing is not intended for and does not provide protection during flight.

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TABLE 4E. FAA GUIDELINES FOR HOLDOVER TIMES CLARIANT SAFEWING MP IV LAUNCH PLUS TYPE IV FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Manufacturer Specific 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: Very Light[1]	Light[1]	Moderate	Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing[3]	Other[4]
-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	
		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	CAUTION: No holdover time guidelines exist	
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[5]	0:25-0:40[5]		
		75/25	0:40-2:00	2:55-3:00	1:15-2:55	0:30-1:15	0:20-1:05[5]	0:20-0:30[5]		
below -14 to -29	below 7 to -20.2	100/0	0:25-0:50	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 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
3 This column is for use at temperatures above 0 °C (32 °F) only.
4 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
5 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 OAT.
- CLARIANT SAFEWING MP IV LAUNCH PLUS TYPE IV fluid used during ground deicing/anti-icing is not intended for and does not provide protection during flight.

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TABLE 4F. FAA GUIDELINES FOR HOLDOVER TIMES CRYOTECH POLAR GUARD TYPE IV FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Manufacturer Specific 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[1]	Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing[3]	Other[4]
-3 and above	27 and above	100/0	2:15-3:30	0:50-1:30	1:15-2:00	0:50-1:15	0:15-1:25	CAUTION: No holdover time guidelines exist
		75/25	1:40-2:40	0:35-1:10	1:05-1:25	0:35-1:00	0:10-1:15	
		50/50	0:25-0:40	0:10-0:15	0:15-0:25	0:10-0:15		
below -3 to -14	below 27 to 7	100/0	0:45-1:45	0:30-0:55	0:25-1:10[5]	0:15-0:35[5]		
		75/25[6]	0:35-1:30[6]	0:20-0:40[6]	0:25-1:05[6]	0:20-0:30[6]		
Below -14 to -23.5	Below 7 to -10.3	100/0	0:20-0:40	0:15-0:30				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
3 This column is for use at temperatures above 0 °C (32 °F) only.
4 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
5 No holdover time guidelines exist for this condition below -10 °C (14 °F).
6 Temperature is limited to -5.5 ºC (22 ºF) when using 75/25 dilution of this fluid.

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 OAT.
- CRYOTECH POLAR GUARD TYPE IV fluid used during ground deicing/anti-icing is not intended for and does not provide protection during flight.

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TABLE 4G. FAA GUIDELINES FOR HOLDOVER TIMES CRYOTECH POLAR GUARD ADVANCE TYPE IV FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Manufacturer Specific 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: Very Light[1]	Snow, Snow Grains or Snow Pellets: Light[1]	Snow, Snow Grains or Snow Pellets: Moderate	Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing[3]	Other[4]
-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[5]	0:35-0:45[5]		
		75/25	0:40-1:30	1:45-2:05	1:00-1:45	0:35-1:00	0:25-1:05[5]	0:35-0:45[5]		
Below -14 to -30.5	Below 7 to -22.9	100/0	0:25-0:50	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 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
3 This column is for use at temperatures above 0 °C (32 °F) only.
4 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
5 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 OAT.
- CRYOTECH POLAR GUARD ADVANCE TYPE IV fluid used during ground deicing/anti-icing is not intended for and does not provide protection during flight.

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TABLE 4H. FAA GUIDELINES FOR HOLDOVER TIMES DOW CHEMICAL UCAR™ ENDURANCE EG106 TYPE IV FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Manufacturer Specific 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			Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing[3]	Other[4]
				Very Light[1]	Light[1]	Moderate				
-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	CAUTION: No holdover time guidelines exist	
		50/50	N/A	N/A	N/A	N/A	N/A	N/A		
below -3 to -14	below 27 to 7	100/0	1:50-3:20	2:10-2:45	1:05-2:10	0:30-1:05	0:55-1:50[5]	0:45-1:10[5]		
		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	0:40-0:50	0:30-0:40	0:15-0:30	CAUTION: No holdover time guidelines exist			

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
3 This column is for use at temperatures above 0 degrees Celsius (32 degrees Fahrenheit) only.
4 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
5 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 OAT.
- DOW CHEMICAL UCAR ENDURANCE EG106 TYPE IV fluid used during ground deicing/anti-icing is not intended for and does not provide protection during flight.

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TABLE 4I. FAA GUIDELINES FOR HOLDOVER TIMES DOW CHEMICAL UCAR™ FLIGHTGUARD AD-480 TYPE IV FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Manufacturer Specific 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[1]**	**Freezing Drizzle[2]**	**Light Freezing Rain**	**Rain on Cold Soaked Wing[3]**	**Other[4]**
-3 and above	27 and above	100/0	2:00-3:30	0:40-1:20	0:50-1:30	0:35-0:55	0:15-1:35	CAUTION: No holdover time guidelines exist
		75/25	1:30-2:45	0:30-1:05	0:50-1:15	0:30-0:45	0:10-1:15	
		50/50	0:30-0:45	0:09-0:20	0:15-0:25	0:09-0:15		
below -3 to -14	below 27 to 7	100/0	0:20-1:20	0:30-0:55	0:25-1:20[5]	0:15-0:30[5]		
		75/25	0:25-0:50	0:20-0:45	0:25-1:05[5]	0:15-0:30[5]		
below -14 to -26	below 7 to -14.8	100/0	0:15-0:40	0:15-0:30				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
3 This column is for use at temperatures above 0 degrees Celsius (32 degrees Fahrenheit) only.
4 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
5 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 OAT.
- DOW CHEMICAL UCAR FLIGHTGUARD AD-480 TYPE IV fluid used during ground deicing/anti-icing is not intended for and does not provide protection during flight.

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TABLE 4J. FAA GUIDELINES FOR HOLDOVER TIMES DOW CHEMICAL UCAR™ FLIGHTGUARD AD-49 TYPE IV FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Manufacturer Specific 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: Very Light[1]	Snow, Snow Grains or Snow Pellets: Light[1]	Snow, Snow Grains or Snow Pellets: Moderate	Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing[3]	Other[4]
-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	CAUTION: No holdover time guidelines exist	
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[5]	0:20-0:25[5]		
		75/25	0:30-1:10	2:05-2:15	1:40-2:05	1:20-1:40	0:15-:1:05[5]	0:15-0:25[5]		
below -14 to -26	below 7 to -14.8	100/0	0:25-0:40	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 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
3 This column is for use at temperatures above 0 °C (32 °F) only.
4 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
5 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 OAT.
- DOW CHEMICAL UCAR™ AD-49 TYPE IV fluid used during ground deicing/anti-icing is not intended for and does not provide protection during flight.

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TABLE 4K. FAA GUIDELINES FOR HOLDOVER TIMES KILFROST ABC-S TYPE IV FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Manufacturer Specific 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[1]	Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing[3]	Other[4]
-3 and above	27 and above	100/0	2:35-4:00	1:00-1:40	1:20-1:50	1:00-1:25	0:20-1:15	
		75/25	1:05-1:45	0:30-0:55	0:45-1:10	0:35-0:50	0:10-0:50	
		50/50	0:20-0:35	0:07-0:15	0:15-0:20	0:08-0:10		
below -3 to -14	below 27 to 7	100/0	0:45-2:05	0:45-1:20	0:20-1:00[5]	0:10-0:30[5]	CAUTION: No holdover time guidelines exist	
		75/25	0:25-1:00	0:25-0:50	0:20-1:10[5]	0:10-0:35[5]		
below -14 to -28	below 7 to -18.4	100/0	0:20-0:40	0:15-0:30				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
3 This column is for use at temperatures above 0 degrees Celsius (32 degrees Fahrenheit) only
4 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail
5 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 OAT.
- KILFROST ABC-S TYPE IV fluid used during ground deicing/anti-icing is not intended for and does not provide protection during flight.

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TABLE 4L. FAA GUIDELINES FOR HOLDOVER TIMES KILFROST ABC-S PLUS TYPE IV FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Manufacturer Specific 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: Very Light[1]	Snow, Snow Grains or Snow Pellets: Light[1]	Snow, Snow Grains or Snow Pellets: Moderate	Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing[3]	Other[4]
-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[5]	0:20-0:30[5]		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[5]	0:15-0:25[5]		
below -14 to -28	below 7 to -18.4	100/0	0:40-1:00	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 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
3 This column is for use at temperatures above 0 °C (32 °F) only.
4 Heavy snow, ice pellets, moderate and heavy freezing rain, and hail.
5 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 OAT.
- KILFROST ABC-S PLUS TYPE IV fluid used during ground deicing/anti-icing is not intended for and does not provide protection during flight.

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TABLE 4M. FAA GUIDELINES FOR HOLDOVER TIMES LYONDELL ARCTIC SHIELD™ TYPE IV FLUID MIXTURES AS A FUNCTION OF WEATHER CONDITIONS AND OUTSIDE AIR TEMPERATURE

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

Outside Air Temperature		Manufacturer Specific 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[1]	Freezing Drizzle[2]	Light Freezing Rain	Rain on Cold Soaked Wing[3]	Other[4]
-3 and above	27 and above	100/0	1:55-3:10	0:50-1:25	0:55-1:40	0:45-1:05	0:15-1:25	CAUTION: No holdover time guidelines exist
		75/25	1:20-2:15	0:40-1:05	0:55-1:25	0:30-0:45	0:09-1:20	
		50/50	0:35-0:45	0:20-0:35	0:20-0:30	0:10-0:15		
below -3 to -14	below 27 to 7	100/0	1:00-2:25	0:45-1:15	0:25-1:30[5]	0:25-0:30[5]		
		75/25	0:50-1:45[6]	0:35-0:55[6]	0:30-1:15[6]	0:25-0:30[6]		
Below -14 to -24.5	Below 7 to -12.1	100/0	0:25-0:45	0:15-0:30				

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER.

1 Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.
2 Use light freezing rain holdover times if positive identification of freezing drizzle is not possible.
3 This column is for use at temperatures above 0 °C (32 °F) only.
4 Heavy Snow, ice pellets, moderate and heavy freezing rain, and hail.
5 No holdover time guidelines exist for this condition below -10 °C (14 °F).
6 Temperature is limited to -9.5 ºC (15 ºF) when using 75/25 dilution of this fluid.

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 OAT.
- LYONDELL ARCTIC SHIELD TYPE IV fluid used during ground deicing/anti-icing is not intended for and does not provide protection during flight.

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TABLE 5. FAA GUIDELINES FOR THE APPLICATION OF SAE TYPE II, TYPE III, AND TYPE IV FLUID MIXTURES MINIMUM CONCENTRATIONS AS A FUNCTION OF OUTSIDE AIR TEMPERATURE (CONCENTRATIONS IN % VOLUME)

Outside Air Temperature (OAT)	One-step Procedure Deicing/Anti-icing[1]	Two-step Procedure	
		First step: Deicing	Second step: Anti-icing[1,2]
-3 °C (27 °F) and above	50/50 Heated[3] Types II, III or IV	Heated water or a heated mix of Type I, II, III or IV, and water	50/50 Type II, III, or IV
Below -3 °C (27 °F) to -14 °C (7 °F)	75/25 Heated[3] Types II, III or IV	Heated suitable mix of Type I, II, III or IV, and water with a freezing point not more than 3 °C (5 °F) above actual OAT	75/25 Type II, III, or IV
below -14 °C (7 °F) to -25 °C (-13 °F)	100/0 Heated[3] Types II, III or IV	Heated suitable mix of Type I, II, III or IV, and water with a freezing point not more than 3 °C (5 °F) above actual OAT	100/0 Type II, III, or IV
Below -25 °C (-13 °F)	**SAE Type II/IV** fluid may be used below -25 °C (-13 °F) provided that the OAT is at or above the LOUT. **SAE Type III fluid** may be used below -10°C (14°F) provided that the OAT is at or above the LOUT. Consider the use of **SAE Type I (**Table 1A) when **Type II, III, or IV** fluid cannot be used		

1) Fluids must only be used at temperatures above 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, 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 Type II, III, or IV 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.
- The lowest operational use temperature (LOUT) for a given Type II, III, or IV fluid is the higher 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 7°C (13°F).

CAUTIONS:

- Wing skin temperatures may differ and in some cases may be lower than OAT. A stronger mix (more glycol) can be used under these conditions.
- As fluid freezing may occur, 50/50 Types II, III, or IV fluid shall not be used for the anti-icing step of a cold-soaked wing as indicated by frost or ice on the lower surface of the wing in the area of the fuel tank.
- 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.
- Repeated deicing/anti-icing with heated thickened fluids without the frequent use of Type I fluid/water mixtures for deicing can lead to the buildup of residue which can re-hydrate and freeze on control surfaces, hinges, and associated actuators during flight and restrict movement of these devices, leading to an unsafe condition. If repeated deicing/anti-icing with heated thickened fluids occurs, periodic inspections and removal of residue in accordance with the aircraft manufacturer's instructions and procedures should be followed.

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TABLE 6. LOWEST ON-WING VISCOSITY VALUES FOR ANTI-ICING FLUIDS
(See Page 39 for Table 6 Notes)

Table 6-1: Type II De/Anti-Icing Fluids

FLUID NAME	FLUID DILUTION	LOWEST ON-WING VISCOSITY [1] (mPa.s)	
		MANUFACTURER METHOD	AIR 9968 REVISION A METHOD
ABAX Ecowing 26	100/0	4 900 [h]	4 600 [a]
	75/25	2 200 [a]	2 200 [a]
	50/50	50 [a]	50 [a]
Aviation Shaanxi Hi-Tech Cleanwing II	100/0	4 650 [e]	4 500 [a]
	75/25	9 450 [e]	10 000 [a]
	50/50	10 150 [e]	10 200 [a]
Clariant Safewing MP II FLIGHT	100/0	3 340 [a]	3 340 [a]
	75/25	12 900 [c]	12 900 [c]
	50/50	11 500 [a]	11 500 [a]
Clariant Safewing MP II FLIGHT PLUS	100/0	3,650 [n]	3 100 [a]
	75/25	12,400 [n]	10 450 [a]
	50/50	7,800 [n]	7 050 [a]
Clariant Safewing MP II 1951	100/0	2 500 [g]	2 750 [a]
	75/25	2 900 [g]	3 000 [a]
	50/50	50 [g]	50 [a]
Cryotech Polar Guard II	100/0	4 400 [f]	4 050 [a]
	75/25	11 600 [f]	9 750 [a]
	50/50	80 [a]	80 [a]
Kilfrost ABC-3	100/0	2 500 [e]	2 500 [a]
	75/25	2 000 [e]	2 000 [a]
	50/50	400 [e]	400 [a]
Kilfrost ABC-2000	100/0	2 350 [e]	2 350 [a]
	75/25	3 000 [e]	3 000 [a]
	50/50	1 000 [e]	1 000 [a]
Kilfrost ABC-K Plus	100/0	2 850 [e]	2 640 [a]
	75/25	12 650 [e]	12 650 [c]
	50/50	4 200 [e]	5 260 [a]
Newave Aerochemical FCY-2	100/0	7 000 [e]	8 920 [a]
	75/25	18 550 [e]	18 550 [e]
	50/50	6 750 [e]	7 030 [a]

Table 6-2: Type III De/Anti-Icing Fluids

FLUID NAME	FLUID DILUTION	LOWEST ON-WING VISCOSITY [1] (mPa.s)	
		MANUFACTURER METHOD	AIR 9968 REVISION A METHOD
Clariant Safewing MP III 2031 ECO	100/0	120 [m]	Not Applicable
	75/25	55 [m]	Not Applicable
	50/50	10 [m]	Not Applicable

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Table 6-3: Type IV De/Anti-Icing Fluids			
Fluid Name	**Fluid Dilution**	**Lowest On-Wing Viscosity** [1] **(mPa.s)**	
		Manufacturer Method	**AIR 9968 Revision A method**
ABAX AD-480	100/0	15 200 [h]	12 800 [d]
	75/25	16 000 [h]	12 400 [d]
	50/50	4 000 [h]	3 800 [a]
ABAX Ecowing AD-49	100/0	12 150 [i]	11 000 [a]
	75/25	30 700 [i]	32 350 [c]
	50/50	19 450 [i]	21 150 [c]
Clariant Max Flight 04 *(formerly Octagon Max Flight 04)*	100/0	5 540 [b]	5 540 [a]
	75/25	Dilution Not Applicable	Dilution Not Applicable
	50/50	Dilution Not Applicable	Dilution Not Applicable
Clariant Safewing MP IV LAUNCH	100/0	7 550 [a]	7 550 [a]
	75/25	18 000 [a]	18 000 [a]
	50/50	17 800 [a]	17 800 [a]
Clariant Safewing MP IV LAUNCH PLUS	100/0	8,700 [o]	8,450 [a]
	75/25	18,800 [p]	17,200 [c]
	50/50	9,700 [o]	12,150 [a]
Cryotech Polar Guard	100/0	32 100 [k]	36 300 [c]
	75/25	24 200 [k]	27 800 [c]
	50/50	6 200 [k]	7 500 [a]
Cryotech Polar Guard Advance	100/0	4 400 [f]	4 050 [a]
	75/25	11 600 [f]	9 750 [a]
	50/50	80 [a]	80 [a]
Dow UCAR™ Endurance EG106	100/0	24 850 [j]	2 230 [a]
	75/25	Dilution Not Applicable	Dilution Not Applicable
	50/50	Dilution Not Applicable	Dilution Not Applicable
Dow UCAR™ FlightGuard AD-480	100/0	15 200 [h]	12 800 [d]
	75/25	16 000 [h]	12 400 [d]
	50/50	4 000 [h]	3 800 [a]
Dow UCAR™ FlightGuard AD-49	100/0	12 150 [i]	11 000 [a]
	75/25	30 700 [i]	32 350 [c]
	50/50	19 450 [i]	21 150 [c]
Kilfrost ABC-S	100/0	17 000 [e]	17 000 [c]
	75/25	12 000 [e]	12 000 [c]
	50/50	2 000 [e]	2 000 [a]
Kilfrost ABC-S Plus	100/0	17 900 [e]	17 900 [c]
	75/25	18 300 [e]	18 300 [c]
	50/50	7 500 [e]	7 500 [a]
Lyondell ARCTIC Shield™	100/0	23 150 [l]	28 000 [e]
	75/25	21 700 [l]	22 100 [e]
	50/50	6 400 [l]	7 640 [a]

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NOTES

[1] The Aerospace Information Report (AIR) 9968 Revision A (December 2004) 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 beside each viscosity value. Details of each measurement method are shown in the table below.

Method	Brookfield Spindle	Container	Fluid Volume	Temp.	Speed	Duration
a	LV1 (with guard leg)	600 mL low form (Griffin) beaker	500 mL*	20°C	0.3 rpm	10 minutes 0 seconds
b	LV1 (with guard leg)	600 mL low form (Griffin) beaker	500 mL*	20°C	0.3 rpm	33 minutes 20 seconds
c	LV2-disc (with guard leg)	600 mL low form (Griffin) beaker	500 mL*	20°C	0.3 rpm	10 minutes 0 seconds
d	LV2-disc (with guard leg)	250 mL tall form (Berzelius) beaker	150 mL*	20°C	0.3 rpm	10 minutes 0 seconds
e	LV2-disc (with guard leg)	150 mL tall form (Berzelius) beaker	150 mL*	20°C	0.3 rpm	10 minutes 0 seconds
f	SC4-34/13R	small sample adapter	10 mL	20°C	0.3 rpm	10 minutes 0 seconds
g	SC4-34/13R	small sample adapter	10 mL	20°C	0.3 rpm	15 minutes 0 seconds
h	SC4-34/13R	small sample adapter	10 mL	20°C	0.3 rpm	30 minutes 0 seconds
i	SC4-31/13R	small sample adapter	10 mL	20°C	0.3 rpm	10 minutes 0 seconds
j	SC4-31/13R	small sample adapter	10 mL	0°C	0.3 rpm	10 minutes 0 seconds
k	SC4-31/13R	small sample adapter	9 mL	20°C	0.3 rpm	10 minutes 0 seconds
l	SC4-31/13R	small sample adapter	9 mL	20°C	0.3 rpm	33 minutes 0 seconds
m	LV0	UL adapter	16 mL	20°C	0.3 rpm	10 minutes 0 seconds
n	LV1	big sample adapter	50 mL	20°C	0.3 rpm	10 minutes 0 seconds
o	LV1	big sample adapter	55 mL	20°C	0.3 rpm	10 minutes 0 seconds
p	LV2-disc	big sample adapter	60 mL	20°C	0.3 rpm	10 minutes 0 seconds

*If necessary, adjust fluid volume to ensure fluid is level with notch on the spindle shaft

SIGNIFICANCE OF THIS TABLE

The viscosity values of the fluids in this table are those of the fluids provided by the manufacturers for holdover time testing. For the holdover time guidelines to be valid, the viscosity of the fluid on the wing shall not be lower than that listed in this table. The user should periodically ensure that the viscosity value of a fluid sample taken from the wing surface is not lower than that listed.

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TABLE 7. LOWEST OPERATIONAL USE TEMPERATURES[1] OF ANTI-ICING FLUIDS (2013-2014)

(NOTES 1-4 and cautions are located on pages 41-42)

TABLE 7-1: Type I Anti-Icing Fluids				
FLUID NAME	LOWEST OPERATIONAL USE TEMPERATURES WITH DILUTION PER CENT FLUID/WATER AT LOUT IN PARENTHESIS[1]			
	LOW SPEED AERODYNAMIC TEST[2]		HIGH SPEED AERODYNAMIC TEST[2]	
	DEGREES CELSIUS	DEGREES FAHRENHEIT	DEGREES CELSIUS	DEGREES FAHRENHEIT
ABAX DE-950	-26 (71/29)	-14.8 (71/29)	-31 (71/29)	-23.8(71/29)
ABAX DE-950 Colorless	Not tested[4]	Not tested[4]	-24 (60/40)	-11.2 (60/40)
AllClear Systems Lift-Off P-88	-24.5 (70/30)	-12.1 (70/30)	-29.5 (70/30)	-21.1 for 70/30
AllClear Systems Lift-Off E-188	-40 (70/30)	-40 (70/30)	-41.5 (70/30)	-42.7 (70/30)
Arcton Arctica DG ready-to-use	-26 as supplied	-14.8 as supplied	-26 as supplied	-14.8 as supplied
Arcton Arctica DG 91 Concentrate	-25 (75/25)	-13 (75/25)	-25 (75/25)	-13 (75/25)
Aviation Shaanxi Hi-Tech Cleanwing I	Not tested[4]	Not tested[4]	-39 (75/25)	-38.2 (75/25)
Aviation Xi'an Hi-Tech KHF-1	Not available[3]	Not available[3]	-38 (75/25)	-36.4 (75/25)
Baltic Ground Services Defrosol ADF	-25 (65/35)	-13 (65/35)	-30 65/35	-22 (65/35)
Beijing Phoenix Air Traffic CBSX-1	Not available[3]	Not available[3]	Not available[3]	Not available[3]
Beijing Wangye Aviation Chemical KLA-1	Not available[3]	Not available[3]	-30.5 (60/40)	-22.9 (60/40)
Beijing Yadilite Aviation Chemical Product Co. Ltd YD-101 Type I	Not tested[4]	Not tested[4]	-30 (60/40)	-22 (60/40)
Clariant EcoFlo Concentrate *(formerly Octagon EcoFlo Concentrate)*	Not tested[4]	Not tested[4]	-30.5 (65/35)	-22.9 (65/35)
Clariant EcoFlo 2 Concentrate (formerly Octagon Ecoflo 2 Concentrate)	Not tested[4]	Not tested[4]	-29 (65/35)	-20.2 (65/35)
Clariant Octaflo EF Concentrate (formerly Octagon Octaflo EF Concentrate)	-25 (65/35)	-13 (65/35)	-33 (65/35)	-27.4 (65/35)
Clariant Octaflo EF-80 Concentrate (formerly Octagon Octaflo EF Concentrate)	-25 (70/30)	-13 (70/30)	-33 (70/30)	-27.4 (70/30)
Clariant Octaflo EG Concentrate (formerly Octagon Octaflo EG Concentrate)	-40.5 (70/30)	-40.9 (70/30)	-44 (70/30)	-47.2 (70/30)
Clariant Safewing EG I 1996	-35.5 (75/25)	-31.9 (75/25)	-43 (75/25)	-45.4 (75/25)
Clariant Safewing EG I 1996 (88)	-39.5 (70/30)	-39.1 (70/30)	-41.5 (70/30)	-42.7 (70/30)
Clariant Safewing MP I 1938 ECO	-25.5 (65/35)	-13.9 (65/35)	-32 (65/35)	-25.6 (65/35)
Clariant Safewing MP I 1938 ECO (80)	-25 (71/29)	-13 (71/29)	-32.5 (71/29)	-26.5 (71/29)
Clariant Safewing MP I 1938 ECO (80) PreMix 55 i.e. ready-to-use	Not tested[4]	Not tested[4]	-19 as supplied	-2.2 as supplied
Clariant Safewing MP I ECO PLUS (80)	-25 (71/29)	-13 (71/29)	-33 (71/29)	-27.4 (71/29)
Clariant Safewing MP I SKY (80)	-26 (71/29)	-14.8 (71/29)	-31.5 (71/29)	-24.7 (71/29)
Cryotech Polar Plus	-27 (63/37)	-16.6 (63/37)	-32 (63/37)	-25.6 (63/37)
Cryotech Polar Plus (80)	-27.5 (70/30)	-17.5 (70/30)	-32.5 (70/30)	-26.5 (70/30)

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TABLE 7-1: Type I Anti-Icing Fluids (continued)				
FLUID NAME	LOWEST OPERATIONAL USE TEMPERATURES WITH DILUTION PER CENT FLUID/WATER AT LOUT IN PARENTHESIS[1]			
	LOW SPEED AERODYNAMIC TEST[2]		HIGH SPEED AERODYNAMIC TEST[2]	
	DEGREES CELSIUS	DEGREES FAHRENHEIT	DEGREES CELSIUS	DEGREES FAHRENHEIT
Deicing Solutions LLC Safetemp ES Plus	-25.5 (65/35)	-13.9 (65/35)	-29 (65/35)	-20.2 (65/35)
Dow UCAR™ ADF XL54	-33 as supplied	-27.4 as supplied	-33 as supplied	-27.4 as supplied
Dow UCAR™ Aircraft Deicing Fluid Concentrate	-36.5 (75/25)	-33.7 (75/25)	-45 (75/25)	-49 (75/25)
Dow UCAR™ PG ADF Dilute 55/45	-24 as supplied	-11.2 as supplied	-25 as supplied	-13 as supplied
Dow UCAR™ PG Aircraft Deicing Fluid Concentrate	-25 (65/35)	-13 (65/35)	-32 (65/35)	-25.6 (65/35)
Harbin Aeroclean Aviation HJF-1	Not tested[4]	Not tested[4]	-32 (60/40)	-25.6 (60/40)
HOC SafeTemp ES Plus	-25.5 (65/35)	-13.9 (65/35)	-29 (65/35)	-20.2 (65/35)
Hokkaido Fever Snow AG	-21.5 as supplied	-6.7 as supplied	-23 as supplied	-9.4 as supplied
Inland Technologies Duragly-E Concentrate	-26 (60/40)	-14.8 (60/40)	-26 (60/40)	-14.8 (60/40)
Inland Technologies Duragly-P Concentrate	-25 (60/40)	-13 (60/40)	-25 (60/40)	-13 (60/40)
Kilfrost DF Plus	-25.5 (69/31)	-13.9 (69/31)	-32 (69/31)	-25.6 (69/31)
Kilfrost DF Plus (80)	-26 (69/31)	-14.8 (69/31)	-31.5 (69/31)	-24.7 (69/31)
Kilfrost DF Plus (88)	-26.5 (69/31)	-15.7 (69/31)	-32 (63/37)	-25.6 (63/37)
Kilfrost DF^{sustain}™	Not tested[4]	Not tested[4]	-41.5 (68/32)	-43 (68/32)
LNT Solutions E188	-36 (70/30)	-32.8 (70/30)	-41 (70/30)	-41.8 (70/30)
LNT Solutions P180	-29 (69/31)	-20.2 (69/31)	-32 (69/31)	-25.6 (70/30)
LNT Solutions P188	-24.5 (70/30)	-12.1 (70/30)	-31.5 (70/30)	-24.7 (70/30)
Newave FCY-1A	-40 (75/25)	-40 (75/25)	-40 (75/25)	-40 (75/25)
Shanxi Cleanway Cleansurface I	-32.5 (75/25)	-26.5 (75/25)	-34.5 (75/25)	-30.1 (75/25)
Shanxi Cleanway Cleansurface I-BIO	Not tested[4]	Not tested[4]	-37 (75/25)	-34.6 (75/25)

NOTES

1. The lowest operational use temperature (LOUT) for a given fluid is the warmer of:
   a) The lowest temperature at which the fluid meets the low and/or high speed aerodynamic acceptance test; or
   b) The actual freezing point of the fluid plus its freezing point buffer of 10°C (18°F).
   The values in this table were provided by the fluid manufacturer and were determined using pre-production fluid samples when available.
2. If uncertain whether the aircraft to be treated conforms to the low speed or high speed aerodynamic test, consult the aircraft manufacturer. The aerodynamic test is defined in SAE AS 5900 (latest version).
3. Manufacturer has not provided LOUT information at the time of this publication. Contact the fluid manufacturer or use another fluid.
4. Manufacturer has indicated fluid was not tested. Consult with the fluid manufacturer and/or airframe manufacturer for further guidance.

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CAUTIONS:

- LOUT data provided in this table is based on the manufacturer's data. In case of discrepancies between the values in this table and the fluid manufacturer's data, use the manufacturer's data.
- Fluids supplied in concentrated form must not be used in that form and must be diluted.
- For the fluids in the table that are intended to be diluted, the LOUT is derived from a dilution that provides the lowest possible operational use temperature. For other dilutions, determine the freezing point of the fluid and add a 10ºC (18ºF) freezing point buffer, as this will usually yield a higher (warmer) and more restrictive operational use temperature. Consult the fluid manufacturer or fluid documentation for further clarification and guidance on establishing the appropriate operational use of a diluted fluid.

Table 7-2: Type II Anti-Icing Fluids

Fluid Name	Dilution, Neat Fluid/Water (Volume %/Volume %)	Lowest Operational Use Temperatures[1] High Speed Aerodynamic Test[2]	
		Degrees Celsius	Degrees Fahrenheit
ABAX Ecowing 26	100/0	-25	-13
	75/25	-14	7
	50/50	-3	27
Aviation Shaanxi Hi-Tech Cleanwing II	100/0	-29	-20.2
	75/25	-14	7
	50/50	-3	27
Clariant Safewing MP II 1951	100/0	-28	-18.4
	75/25	-14	7
	50/50	-3	27
Clariant Safewing MP II Flight	100/0	-29	-20.2
	75/25	-14	7
	50/50	-3	27
Clariant Safewing MP II Flight Plus	100/0	Not available, contact fluid manufacturer	
	75/25	Not available, contact fluid manufacturer	
	50/50	Not available, contact fluid manufacturer	
Cryotech Polar Guard II	100/0	-30.5	-22.9
	75/25	-14	7
	50/50	-3	27
Kilfrost ABC-3	100/0	-27	-16.6
	75/25	-14	7
	50/50	-3	27
Kilfrost ABC-2000	100/0	-27.5	-17.5
	75/25	-14	7
	50/50	-3	27

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Table 7-2: Type II Anti-Icing Fluids (continued)			
FLUID NAME	DILUTION, NEAT FLUID/WATER (VOLUME %/VOLUME %)	LOWEST OPERATIONAL USE TEMPERATURES[1]	
		HIGH SPEED AERODYNAMIC TEST[2]	
		DEGREES CELSIUS	DEGREES FAHRENHEIT
Kilfrost ABC-K Plus	100/0	-29	-20.2
	75/25	-14	7
	50/50	-3	27
Newave Aerochemical FCY-2	100/0	-28	-18.4
	75/25	-14	7
	50/50	-3	27

Table 7-3: Type III Anti-Icing Fluids				
FLUID NAME	LOWEST OPERATIONAL USE TEMPERATURES[1]			
	LOW SPEED AERODYNAMIC TEST		HIGH SPEED AERODYNAMIC TEST[2]	
	DEGREES CELSIUS	DEGREES FAHRENHEIT	DEGREES CELSIUS	DEGREES FAHRENHEIT
Clariant Safewing MP III 2031 ECO	-16.5	2.3	-29	-20.2
	-9	15.8	-10	14
	-3	27	-3	27

NOTES

1. The lowest operational use temperature (LOUT) for a given fluid is the warmer of:
   a) The lowest temperature at which the fluid meets the low and/or high speed aerodynamic acceptance test; or
   b) The actual freezing point of the fluid plus its freezing point buffer of 10°C (18°F).
   The values in this table were provided by the fluid manufacturer and were determined using 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.
2. 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 SASE AS 5900 (latest version). Manufacturer has not provided LOUT information at the time of this publication. Contact the fluid manufacturer or use another fluid.

CAUTION: LOUT data provided in this table is based on the manufacturer's data. In case of discrepancies between the values in this table and the fluid manufacturer's data, use the manufacturer's data.

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Table 7-4: Type IV (100/0) Anti-Icing Fluids			
FLUID NAME	DILUTION, NEAT FLUID/WATER (VOLUME %/VOLUME %)	LOWEST OPERATIONAL USE TEMPERATURES[1] HIGH SPEED AERODYNAMIC TEST[2]	
		DEGREES CELSIUS	DEGREES FAHRENHEIT
ABAX AD-480	100/0	-26	-14.8
	75/25	-14	7
	50/50	-3	27
ABAX Ecowing AD-49	100/0	-26	-14.8
	75/25	-14	7
	50/50	-3	27
Clariant Max Flight 04 (formerly Octagon Max Flight 04)	100/0	-26.5	-15.7
	75/25	Dilution not applicable	
	50/50	Dilution not applicable	
Clariant Safewing MP IV LAUNCH	100/0	-28.5	-19.3
	75/25	-14	7
	50/50	-3	27
Clariant Safewing MP IV LAUNCH PLUS	100/0	-29	-20.2
	75/25	-14	7
	50/50	-3	27
Cryotech Polar Guard	100/0	-23.5	-10.3
	75/25	-5.5	22.1
	50/50	-3	27
Cryotech Polar Guard Advance	100/0	-30.5	-22.9
	75/25	-14	7
	50/50	-3	27
Dow UCAR™ Endurance EG106 De/Anti-Icing Fluid	100/0	-27	-16.6
	75/25	Dilution not applicable	
	50/50	Dilution not applicable	
Dow UCAR™ FlightGuard AD-480	100/0	-26	-14.8
	75/25	-14	7
	50/50	-3	27
Dow UCAR™ FlightGuard AD-49	100/0	-26	-14.8
	75/25	-14	7
	50/50	-3	27

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Table 7-4: Type IV (100/0) Anti-Icing Fluids (continued)			
Fluid Name	Dilution, Neat Fluid/Water (Volume %/Volume %)	Lowest Operational Use Temperatures[1] — High Speed Aerodynamic Test[2]	
		Degrees Celsius	Degrees Fahrenheit
Kilfrost ABC-S	100/0	-28	-18.4
	75/25	-14	7
	50/50	-3	27
Kilfrost ABC-S PLUS	100/0	-28	-18.4
	75/25	-14	7
	50/50	-3	27
Lyondell ARCTIC Shield™	100/0	-24.5	-12.1
	75/25	-9.5	14.9
	50/50	-3	27

NOTES

1. The lowest operational use temperature (LOUT) for a given fluid is the warmer of:
   a) The lowest temperature at which the fluid meets the low and/or high speed aerodynamic acceptance test; or
   b) The actual freezing point of the fluid plus its freezing point buffer of 10°C (18°F).
   The values in this table were provided by the fluid manufacturer and were determined using 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.
2. 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 SASE AS 5900 (latest version).

CAUTION: LOUT data provided in this table is based on the manufacturer's data. In case of discrepancies between the values in this table and the fluid manufacturer's data, use the manufacturer's data.

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TABLE 8. LIST OF FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE-WINTER 2013-14 (Notes 1-2 are located on pages 47-48)

Type I Deicing/Anti-Icing Fluids[1]

Company Name	Fluid Name
ABAX Industries	DE-950
ABAX Industries	DE-950 Colorless
AllClear Systems	Lift-Off P-88
AllClear Systems	Lift-Off E-188
Arcton Ltd.	Arctica DG Ready to Use
Arcton Ltd.	Arctica DG 91 Concentrate
Aviation Shaanxi High-Tech Physical Co. Ltd.	Cleanwing I
Aviation Xi'an High-Tech	KHF-1
Baltic Ground Services	Defrosol ADF
Beijing Phoenix Air Traffic Product Development and Trading Co.	CBSX-1
Beijing Wangye Aviation Chem. Prod. Co.	KLA-1
Beijing Yadilite Aviation Chemical Product Co. Ltd	YD-101 Type I
Clariant GmbH	EcoFlo Concentrate *(formerly Octagon EcoFlo)*
Clariant GmbH	EcoFlo 2 Concentrate *(formerly Octagon EcoFlo 2)*
Clariant GmbH	Octaflo EF Concentrate *(formerly Octagon Octaflo EF)*
Clariant GmbH	Octaflo EF 80 *(formerly Octagon Octaflo EF-80)*
Clariant GmbH	Octaflo EG Concentrate *(formerly Octagon Octaflo EG)*
Clariant GmbH	Safewing MP I 1938 ECO (80)
Clariant GmbH	Safewing MP I 1938 ECO (80) Pre-mix 55%
Clariant GmbH	Safewing MP I 1938 ECO
Clariant GmbH	Safewing EG I 1996
Clariant GmbH	Safewing EG I 1996 (88)
Clariant GmbH	Safewing MP I ECO PLUS (80)
Clariant GmbH	Safewing MP I SKY (80)
Cryotech Deicing Technology	Polar Plus
Cryotech Deicing Technology	Polar Plus (80)
Deicing Solutions LLC	Safetemp ES Plus
Dow Chemical Company	UCAR™ ADF Concentrate
Dow Chemical Company	UCAR™ ADF XL-54
Dow Chemical Company	UCAR™ PG ADF Concentrate
Dow Chemical Company	UCAR™ PG ADF Dilute 55/45
Harbin Aeroclean Aviation Tech Co. Ltd.	HJF-1
HOC Industries	SafeTemp ES Plus
Hokkaido NOF Corporation	Fever Snow AG
Inland Technologies	Duragly-E Concentrate
Inland Technologies	Duragly-P Concentrate
Kilfrost	Kilfrost DF PLUS
Kilfrost	Kilfrost DF PLUS (80)
Kilfrost	Kilfrost DF PLUS (88)
Kilfrost	Kilfrost DFsustain ™
LNT Solutions	E188
LNT Solutions	P180
LNT Solutions	P188
Newave Aerochemical Co. , Ltd	FCY-1A
Shanxi Cleanway Aviation Chemical Co. , Ltd.	Cleansurface I
Shanxi Cleanway Aviation Chemical Co. , Ltd.	Cleansurface I-BIO

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TABLE 8. CONTINUED. LIST OF FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE-WINTER 2013-2014

Type II Deicing/Anti-Icing Fluids[2]

Company Name	Fluid Name
ABAX Industries	Ecowing 26
Aviation Shaanxi Hi-Tech Physical Chemical Co., Ltd.	Cleanwing II
Clariant GmbH	Safewing MP II 1951
Clariant GmbH	Safewing MP II Flight
Clariant GmbH	Safewing MP II Flight Plus
Cryotech Deicing Technology	Polar Guard II
Kilfrost	Kilfrost ABC-3
Kilfrost	Kilfrost ABC-2000
Kilfrost	Kilfrost ABC-K PLUS
Newave Aerochemical Co Ltd.	FCY-2

Type III Deicing/Anti-Icing Fluids[2]

Company Name	Fluid Name
Clariant GmbH	Safewing MP III 2031 ECO

Type IV Deicing/Anti-Icing Fluids[2]

Company Name	Fluid Name
ABAX Industries	AD-480
ABAX Industries	Ecowing AD-49
Ckariant GmbH	MaxFlight 04 (formerly Octagon MaxFlight 04)
Clariant GmbH	Safewing MP IV LAUNCH
Clariant GmbH	Safewing MP IV LAUNCH PLUS
Cryotech Deicing Technology	Polar Guard
Cryotech Deicing Technology	Polar Guard Advance
Dow Chemical Company	UCAR™ Endurance EG106
Dow Chemical Company	UCAR™ FlightGuard AD-480
Dow Chemical Company	UCAR™ FlightGuard AD-49
Kilfrost	ABC-S
Kilfrost	ABC-S Plus
Lyondell Chemical Company	Shield™

NOTES

1. This table lists fluids that have been tested with respect to anti-icing performance requirements according to SAE AMS 1424, Paragraph 3.5.2 and aerodynamic performance according to SAE AMS 1424, Paragraph 3.5.3 only by the Anti-Icing Materials International Laboratory at the University of Quebec at Chicoutimi, Canada, web site: http://www.uqac.ca/amil/index.htm. The end user is responsible for confirming that other SAE AMS 1424 technical

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requirement tests, such as materials compatibility, and stability, etc, have been performed by contacting the fluid manufacturer.

2. This table lists Types II, III, or IV fluids that have been tested with respect to anti-icing performance requirements according to SAE AMS 1428, Paragraph 3.2.4 and aerodynamic performance according to SAE AMS 1428, Paragraph 3.2.5 only by the Anti-Icing Materials International Laboratory at the University of Quebec at Chicoutimi, Canada, web site: http://www.uqac.ca/amil/index.htm. The end user is responsible for confirming that other SAE AMS 1428 technical requirement tests, such as materials compatibility, and stability, etc, have been performed by contacting the fluid manufacturer.

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ICE PELLET ALLOWANCE TIMES
2013-2014

1. Background

During the winter of 2006-2007, operations in ice pellets were approved 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 during the 2007-2008 winter season.
This research consisted of extensive climatic chamber and wind tunnel testing with ice pellets (light and moderate) and light ice pellets mixed with other forms of precipitation. Additionally, Type IV anti-icing fluid with ice pellets embedded was evaluated for its aging qualities over periods of time beyond the allowance times, when the active precipitation time was limited to the allowance times. Results of this research provide the basis for extended 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.

During the winter of 2009-2010, wind tunnel research conducted with a newer generation type airfoil showed that Propylene Glycol (PG) and Ethylene Glycol (EG) fluids behave differently under certain temperature and ice pellet conditions. Specifically, higher aircraft rotation speeds are required to effectively remove 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 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 PG fluids under certain conditions for all aircraft regardless of the rotation speed. This research resulted in the allowance time when using PG fluids at temperatures of -5°C and above being limited to 15 minutes in moderate ice pellets. Currently all Type IV fluids are PG based with the exception of Dow EG106 which is EG based.

2. Operations in Light and Moderate Ice Pellets and Light Ice Pellets mixed with other forms of precipitation.

A. Tests have shown that ice pellets generally remain in the frozen state imbedded in Type IV anti-icing fluid, and are not absorbed 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 IV fluid will not prevent the fluid from flowing off the aerodynamic surfaces during takeoff except as noted above. This flow-off due to the shearing forces occurs with rotation speeds consistent with Type IV anti-icing fluid recommended applications, and up to the applicable allowance time listed in Table 9 below. These allowance times are from the start of the Type IV 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 Type IV anti-icing fluid effective without any further action up to 90 minutes after the start of the application time of the Type IV anti-icing fluid, however, the OAT must remain constant or increase during the 90 minute period under the following conditions:

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- 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) 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 light freezing rain falls until 10:10, 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 no precipitation restarts after the end of the allowance time at 10:25, the aircraft may take off without any further action until 11:30.

4) On the other hand, if Type IV anti-icing fluid is applied with a start of application time of 10:00, OAT is 0 ^{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 approved in accordance with Title 14 of the Code of Federal Regulations 14 CFR part 121, § 121.629, will be allowed, in the specified ice pellet conditions and corresponding outside air temperatures (OAT) listed in Table-1, up to the specific allowance time listed in Table-1 after the start of the anti-icing fluid application to commence the takeoff with the following restrictions:

1) The aircraft critical surfaces must be free of contaminants before applying Type IV anti-icing fluid. If not, the aircraft must be properly deiced and checked to be free of contaminants before the application of Type IV anti-icing fluid.

2) The allowance time is valid only if the aircraft is anti-iced with undiluted Type IV fluid.

3) Due to the shearing qualities of Type IV fluids with imbedded ice pellets, this allowance is limited to aircraft with a rotation speed of 100 knots or greater or 115 knots as indicated in the Ice Pellet Allowance Table below.

4) If the takeoff is not accomplished within the applicable allowance time in Table-1, 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 in Table-1 and does not restart, the aircraft may takeoff up to 90 minutes after the start of the application of the Type IV anti-icing fluid, subject to the restrictions in 2. B. on the previous page.

5) 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.

6) 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.

7) 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.

TABLE 9. ICE PELLET ALLOWANCE TIMES 2013-2014

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 Dow EG106 which is ethylene glycol based.

CAUTION: THIS TABLE IS FOR DEPARTURE PLANNING ONLY AND SHOULD BE USED IN CONJUNCTION WITH PRETAKEOFF CHECK PROCEDURES.

	OAT -5°C and above	**OAT less than -5°C to -10°C**	**OAT less than -10°C[1]**
Light Ice Pellets	50 minutes	30 minutes	30 minutes[2]
Moderate Ice Pellets	25 minutes[3]	10 minutes	10 minutes[2]
Light Ice Pellets Mixed with Light or Moderate Freezing Drizzle	25 minutes	10 minutes	**Caution: No allowance times currently exist**
Light Ice Pellets Mixed with Light Freezing Rain	25 minutes	10 minutes	
Light Ice Pellets Mixed with Light Rain	25 minutes[4]		
Light Ice Pellets Mixed with Moderate Rain	25 minutes[5]		
Light Ice Pellets Mixed with Light Snow	25 minutes	15 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes		

THE RESPONSIBILITY FOR THE APPLICATION OF THESE DATA REMAINS WITH THE USER

NOTES

1. Ensure that the lowest operational use temperature (LOUT) is respected.
2. 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).
3. Allowance time is 15 minutes for propylene glycol (PG) fluids, or when the fluid type is unknown.
4. No allowance times exist for 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

CAUTION: Fluids used during ground de/anti-icing do not provide in-flight icing protection.

2013-2014 Holdover Times Tables 10/22/13

Operations in Heavy Snow 2013-2014 (No Change from 2012-2013 Guidance)

1. Tactile and Visual Checks of Aircraft. No holdover times (HOT) exist for heavy snow conditions in the current HOT tables. Review of existing data from past testing has indicated takeoffs may be safely conducted with proper tactile and/or visual checks, as appropriate for the aircraft, and a determination that the fluid has not failed. A tactile and/or visual check in heavy snow conditions must be accomplished in a manner that provides an assessment that can be accurately accomplished. It is imperative that the tactile and/or visual check procedures to determine if the anti-icing fluid has failed in heavy snow conditions be at least as comprehensive as the authorized procedures for the operator's pretakeoff contamination check (when HOTs have been exceeded) for those precipitation conditions for which HOTs exist. Anti-icing fluids dissolve the snow and absorb the resulting moisture into the fluid. When the fluid begins to fail it starts to change in appearance (e.g., less glossy and more opaque) and the snow starts to accumulate on and in the fluid. At this stage, the fluid has failed and takeoff is not authorized. If the operator's procedure to accomplish this check is different from the operator's approved pretakeoff contamination check procedures for other precipitation conditions, this check procedure must be verified and approved by the operator's principal operations inspector (POI).

2. Takeoff in Heavy Snow Conditions. Operators with a deicing program approved in accordance with 14 CFR part 121, § 121.629, will be allowed to takeoff in heavy snow conditions subject to the following restrictions:

1) The aircraft must be anti-iced with undiluted Type IV fluid.

2) The aircraft critical surfaces must be free of contaminants, or the aircraft must be properly deiced before the application of the anti-icing fluid.

3) When appropriate, the operator must accomplish an approved tactile and/or visual check of the aircraft critical surfaces within 5 minutes of takeoff.

4) If this check is accomplished visually from within the aircraft, the view must be such that it is not obscured by de/anti-icing fluid, dirt, or fogging. If the critical surfaces cannot be seen due to snowfall, distance from the viewing position, or inadequate lighting, or for any other reason, the check must be a visual or tactile check conducted from outside the aircraft.

5) If a definitive fluid failure determination cannot be made using the checks prescribed, takeoff is not authorized. The aircraft must be completely deiced, and if precipitation is still present, anti-iced again before a subsequent takeoff.

Note: Current aircraft certification standards only require testing of flight instrument sensing devices and engine anti-icing systems in moderate snow levels. Ground operations in heavy snow conditions may exceed the capabilities or limitations of these system and devices to adequately provide anti-icing.

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