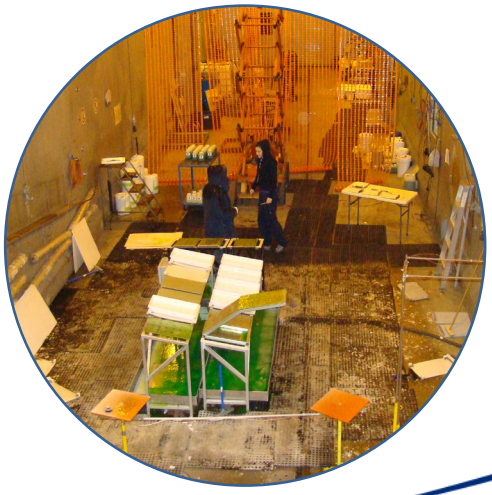
TP 15203E

Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2011-12 Winter







Prepared for

Transportation Development Centre

In cooperation with

Civil Aviation
Transport Canada

and

The Federal Aviation Administration
William J. Hughes Technical Center

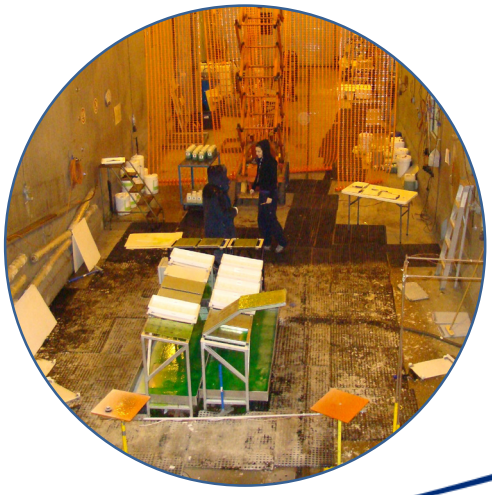
Prepared by

APS Aviation Inc.

October 2012
Final Version 1.0

TP 15203E

Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2011-12 Winter







by

Stephanie Bendickson

October 2012
Final Version 1.0

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.

DOCUMENT ORIGIN AND APPROVAL RECORD

Prepared by:



Oct. 9, 2019

Stephanie Bendickson, B.Comm. Date
Project Analyst

Reviewed by:



Oct. 11, 2019

John D'Avirro, Eng., PBDM Date
Director, Aviation Services

Approved by: **

John Detombe Date
Chief Engineer
ADGA Group Consultant Inc.

Un sommaire français se trouve avant la table des matières.

This report was first provided to Transport Canada as Final Draft 1.0 in October 2012.
It has been published as Final Version 1.0 in October 2019.

***Final Draft 1.0 of this report was signed and provided to Transport Canada in October 2012. A Transport Canada technical and editorial review was subsequently completed and the report was finalized in October 2019; John Detombe was not available to participate in the final review or to sign the current version of the report.*

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 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 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 evaluate the use of sensors in determining active frost conditions;
- To continue research for development of ice detection capabilities for pre-deicing, engine deicing and departing aircraft at the runway threshold;
- To update the regression coefficient report with the newly-qualified de/anti-icing fluids; and
- To evaluate if Type II/IV holdover times can be developed for light and very light snow categories.

The research activities of the program conducted on behalf of Transport Canada during the winter of 2011-12 are documented in six reports. The titles of the reports are as follows:

- TP 15198E Regression Coefficients and Equations Used to Develop the Winter 2012-13 Aircraft Ground Deicing Holdover Time Tables;
- TP 15199E Research to Assess the Need for Remote On-Ground Ice Detection Systems (ROGIDS) at End-of-Runway;
- TP 15200E Cold Climate Technologies – Investigation of Sensor Technologies as an Alternative Means of Detecting Aircraft Icing (Year 1 of 3);
- TP 15201E Winter Weather Impact on Holdover Time Table Format (1995-2012);
- TP 15202E Aircraft Ground Icing General Research Activities During the 2011-12 Winter; and
- TP 15203E Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2011-12 Winter.

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

- *Evaluation of Endurance Times on Extended Flaps and Slats;*
- *Further Development of Ice Pellet Allowance Times: Characterization and Calibration of Wind Tunnel for Examining Anti-Icing Fluid Flow-Off Characteristics; and*
- *Investigation of Ice Phobic Technologies to Reduce Aircraft Icing in Northern and Cold Climates.*

This report, TP 15203E has the following objective:

- To develop holdover time data for all newly qualified 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 primarily 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: Steven Baker, Stephanie Bendickson, Jeffrey Bourgerois, John D'Avirro, Jesse Dybka, Daniel Fata, Benjamin Guthrie, Dany Posteraro, Marco Ruggi, James Smyth, 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 a location for outdoor testing, and the fluid manufacturers for providing support and funding.

Transport Canada / Transports Canada

PUBLICATION DATA FORM

1. Transport Canada Publication No.	2. Project No.	3. Recipient's Catalogue No.
TP 15203E	B14W	

4. Title and Subtitle	5. Publication Date
Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2011-12 Winter	October 2012
	6. Performing Organization Document No.: CM2265.001
7. Author(s): Stephanie Bendickson	8. Transport Canada File No.: 2450-BP-14
9. Performing Organization Name and Address: APS Aviation Inc., 6700 Côte-de-Liesse Rd., Suite 105, Montreal, Quebec, H4T 2B5	10. PWGSC File No.: TOR-4-37170
	11. PWGSC or Transport Canada Contract No.: T8156-140243/001/TOR
12. Sponsoring Agency Name and Address: Transportation Development Centre, Transport Canada, 330 Sparks St., 26th Floor, Ottawa, Ontario, K1A 0N5	13. Type of Publication and Period Covered: Final
	14. Project Officer: Antoine Lacroix for Yvan Chabot

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 2011-12 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 516 tests were conducted with five fluids.

Changes to the holdover time guidelines for the winter of 2012-13 include:

- Fluid-specific holdover time tables were added for two new Type II fluids, Clariant Safewing MP II Flight Plus and LNT P250;
- Two obsolete Type II fluids (Clariant Safewing MP II 2025 ECO and Octagon E Max II) were removed from the guidelines. This did not impact the generic Type II holdover times;
- Two obsolete Type IV fluids (Clariant Safewing MP IV 2001 and Dow Chemical UCAR ADF/AAF ULTRA+) were removed from the guidelines. This resulted in twelve increases to the generic Type IV holdover times;
- The lowest temperature band in the Type I portion of the active frost table was changed from "below -21 to -25°C" to "below -21 to LOUT;"
- Clarification was added to the ice pellets operational guidelines to identify additional precipitation conditions where outside air temperature must not decrease, to indicate that the table applies only to Type IV neat fluids, and to identify the different glycol based fluids;
- Text was added to the fluid application procedure tables to indicate that the time available between the first and second steps of a two-step application procedure may be greater or less than three minutes; and
- Text was added to the Type I fluid application procedure table to clarify that the minimum fluid application quantities and temperature apply to all conditions including active frost.

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 2012-13 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
Anti-icing, deicing, deicing fluid, holdover times, precipitation, endurance times, Type I, Type II, Type III, Type IV, aircraft, ground, test, winter	Limited number of copies available from the Transportation Development Centre

19. Security Classification (of this publication)	20. Security Classification (of this page)	21. Declassification (date)	22. No. of Pages	23. Price
Unclassified	Unclassified	—	xviii, 80 apps	—

CDT/TDC 79-005
Rev. 96

Canada

Transports Canada Transport Canada

FORMULE DE DONNÉES POUR PUBLICATION

1. N° de la publication de Transports Canada	2. N° de l'étude	3. N° de catalogue du destinataire
TP 15203E	B14W	

4. Titre et sous-titre	5. Date de la publication
Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2011-12 Winter	Octobre 2012
	6. N° de document de l'organisme exécutant CM2265.001

7. Auteur(s)	8. N° de dossier - Transports Canada
Stephanie Bendickson	2450-BP-14

9. Nom et adresse de l'organisme exécutant	10. N° de dossier - TPSGC
APS Aviation Inc. 6700, Chemin de la Côte-de-Liesse, Bureau 105 Montréal (Québec) H4T 2B5	TOR-4-37170
	11. N° de contrat - TPSGC ou Transports Canada T8156-140243/001/TOR

12. Nom et adresse de l'organisme parrain	13. Genre de publication et période visée
Centre de développement des transports Transports Canada 330, rue Sparks, 26ième étage Ottawa (Ontario) K1A 0N5	Final
	14. Agent de projet Antoine Lacroix pour Yvan Chabot

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 2011-2012 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 516 essais ont été menés, avec cinq liquides.

Parmi les changements apportés aux lignes directrices relatives aux durées d'efficacité pour l'hiver 2012-2013, on note ce qui suit.

- Des tableaux des durées d'efficacité spécifiques à deux nouveaux liquides de type II, soit Clariant Safewing MP II Flight Plus et LNT P250, ont été ajoutés.
- Deux liquides de type II périmés (Clariant Safewing MP II 2025 ECO et Octagon E Max II) ont été retirés des lignes directrices. Ces retraits n'ont pas eu d'incidence sur les durées d'efficacité génériques des liquides de type II.
- Deux liquides de type IV périmés (Clariant Safewing MP IV 2001 et Dow Chemical UCAR ADF/AAF ULTRA+) ont été retirés des lignes directrices. Le retrait de ces liquides a entraîné l'augmentation, dans douze cas, des durées d'efficacité génériques des liquides de type IV.
- La plus basse plage de température de la portion sur les liquides de type I du tableau sur le givre actif est passée de « au-dessous de -21 à -25 °C » à « au-dessous de -21 °C à LOUT ».
- Une précision a été ajoutée aux lignes directrices opérationnelles sur les granules de glace pour définir les conditions de précipitations supplémentaires dans lesquelles la température ambiante extérieure ne doit pas diminuer, indiquer que le tableau s'applique uniquement aux liquides de type IV purs et identifier les divers liquides à base de glycol.
- Le contenu des tableaux des procédures d'application des liquides a été étoffé afin de préciser que l'intervalle de temps disponible entre la première et la deuxième étape d'une procédure d'application en deux étapes peut être supérieur ou inférieur à trois minutes.
- Le contenu du tableau des procédures d'application des liquides de type I a été étoffé afin de préciser que les valeurs minimales relatives à la quantité de liquide appliqué et à la température s'appliquent dans toutes les conditions, y compris en cas de givre actif.

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 2012-2013, 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	18. Diffusion
Antigivrage, dégivrage, liquide de dégivrage, durées d'efficacité, précipitation, temps d'endurance, type I, type II, type III, type IV, aéronef, sol, essai, hiver	Le Centre de développement des transports dispose d'un nombre limité d'exemplaires

19. Classification de sécurité (de cette publication)	20. Classification de sécurité (de cette page)	21. Déclassification (date)	22. Nombre de pages	23. Prix
Non classifiée	Non classifiée	—	xviii, 80 ann.	—

CDT/TDC 79-005
Rev. 96

Canada

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 all changes made to the HOT guidelines for the winter of 2012-13.

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 HOT 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 2011-12 test season, data was collected during natural snow events at the APS test site at Montreal-Trudeau Airport in Montreal and at several mobile test locations in Quebec and New Brunswick. Data was also collected 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 516 tests in the winter of 2011-12. The results of testing were incorporated into the winter 2012-13 HOT guidelines.

Changes to the HOT Guidelines

The changes below were made to the HOT guidelines for winter 2012-13.

1. Fluid-specific HOT guidelines were added for two new Type II fluids, Clariant Safewing MP II Flight Plus and LNT P250. The addition of these tables did not affect the Type II generic holdover times.
2. Two obsolete Type II fluids, Clariant Safewing MP II 2025 ECO and Octagon E Max II, were removed from the guidelines as per the protocol for removing obsolete data. The removal of these fluids did not impact the generic holdover times.
3. Two obsolete Type IV fluids, Clariant Safewing MP IV 2001 and Dow Chemical UCAR ADF/AAF ULTRA+, were removed from the guidelines as per the protocol for removing obsolete data. The removal of these fluids resulted in twelve increases to the generic Type IV fluid holdover times.
4. The lowest temperature band in the Type I portion of the active frost table was changed from "below -21 to -25°C" to "below -21 to LOUT" to clarify that the Type I active frost holdover times can be used at temperatures below -25°C as long as the fluid Lower Operational Use Temperature (LOUT) is respected.
5. Due to the acquisition of Octagon Process by Clariant GmbH, fluids previously listed under the Octagon brand name were changed and are now listed under the Clariant brand name.
6. Clarification was added to the ice pellets operational guidelines to identify additional precipitation conditions where outside air temperature must not decrease, to indicate that the table applies only to Type IV neat fluids, and to identify the different glycol based fluids.
7. Text was added to the fluid application procedure tables to indicate that the time available between the first and second steps of a two-step application procedure may be greater or less than three minutes.
8. Text was added to the Type I fluid application procedure table to clarify that the minimum fluid application quantities and temperature apply to all conditions including active frost.

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 2012-13 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 2012-2013.

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 2011-2012 concernaient des tests sous neige naturelle menés à l'installation d'essai d'APS, à l'aéroport Montréal-Trudeau, à Montréal, ainsi que sur plusieurs sites d'essai mobiles situés ailleurs au Québec et au Nouveau-Brunswick. Les données ont également été collectées 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 2011-2012, un total de 516 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 2012-2013.

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 2012-2013.

1. Des lignes directrices relatives aux durées d'efficacité spécifiques à deux nouveaux liquides de type II, soit Clariant Safewing MP II Flight Plus et LNT P250, ont été ajoutées. L'ajout de ces tableaux n'a eu aucune incidence sur les durées d'efficacité génériques des liquides de type II.
2. Deux liquides de type II périmés, soit Clariant Safewing MP II 2025 ECO et Octagon E Max II, ont été retirés des lignes directrices, conformément au protocole régissant le retrait des données obsolètes. Le retrait de ces liquides n'a eu aucune incidence sur les durées d'efficacité génériques.
3. Deux liquides de type IV périmés, soit Clariant Safewing MP IV 2001 et Dow Chemical UCAR ADF/AAF ULTRA+, ont été retirés des lignes directrices, conformément au protocole régissant le retrait des données obsolètes. Le retrait de ces liquides a entraîné l'augmentation, dans douze cas, des durées d'efficacité génériques des liquides de type IV.
4. La plus basse plage de température de la portion sur les liquides de type I du tableau sur le givre actif est passée de « au-dessous de -21 à -25 °C » à « au-dessous de -21 °C à LOUT », afin de préciser que les durées d'efficacité des liquides de type I dans des conditions de givre actif peuvent être utilisées à des températures inférieures à -25 °C, pourvu que les températures minimales d'utilisation opérationnelle (LOUT) des liquides soient respectées.
5. En raison de l'acquisition du fabricant de liquides Octagon Process par la société Clariant GmbH, les liquides précédemment classés sous la marque Octagon le sont désormais sous la marque Clariant.
6. Une précision a été ajoutée aux lignes directrices opérationnelles sur les granules de glace pour définir les conditions de précipitations supplémentaires dans lesquelles la température ambiante extérieure ne doit pas diminuer, indiquer que le tableau s'applique uniquement aux liquides de type IV purs et identifier les divers liquides à base de glycol.

7. Le contenu des tableaux des procédures d'application des liquides a été étoffé afin de préciser que l'intervalle de temps disponible entre la première et la deuxième étape d'une procédure d'application en deux étapes peut être supérieur ou inférieur à trois minutes.
8. Le contenu du tableau des procédures d'application des liquides de type I a été étoffé afin de préciser que les valeurs minimales relatives à la quantité de liquide appliqué et à la température s'appliquent dans toutes les conditions, y compris en cas de givre actif.

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 2012-2013, 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.

This page intentionally left blank.

CONTENTS

Page

1. INTRODUCTION 1

1.1 Background 1
1.2 Objectives 1
1.3 Content of this Report 5
1.4 Report Format 5
1.5 Publication of HOT Guidelines 6
1.5.1 Transport Canada 6
1.5.2 FAA 6

2. TESTING IN 2011-12 7

2.1 Procedures 7
2.2 Test Sites 8
2.3 Fluids Tested 8
2.4 Description of Tests 11
2.5 Reporting 11
2.6 Light Snow and Very Light Snow Holdover Times for Type II and Type IV Fluids 11
2.7 Type III Composite Research 12
2.8 Analysis of Visibility vs. Snowfall Intensity Data 12

3. CHANGES TO THE TYPE I HOT GUIDELINES 13

3.1 New Fluids/Data 13
3.1.1 Hokkaido Fever Snow AG 13
3.1.2 Octagon EcoFlo 2 13
3.2 Changes to HOT Guidelines Format 14
3.3 Type I Generic Holdover Time Values 14

4. CHANGES TO THE TYPE II HOT GUIDELINES 15

4.1 New Fluids/Data 15
4.2 Removed Fluids/Data 15
4.3 Changes to HOT Guidelines Format 15
4.4 Type II Generic Holdover Time Values 16
4.4.1 Use of Generic Holdover Times in Very Cold Snow 16
4.4.2 Impact of New and Removed Fluids/Data 16
4.4.3 Fluids Responsible for Type II Generic Holdover Time Values 17
4.4.4 Evolution of Type II Generic Holdover Time Values 18

5. CHANGES TO THE TYPE III HOT GUIDELINES 43

5.1 New Fluids/Data 43
5.2 Changes to HOT Guidelines Format 43
5.3 Type III Generic Holdover Time Values 43
5.4 Future Changes to the Type III HOT Guidelines 43
5.5 Supplemental Research – Endurance Times of Type III Fluids on Composite Surfaces 44

6. CHANGES TO THE TYPE IV HOT GUIDELINES 45

6.1 New Fluids/Data 45
6.2 Removed Fluids/Data 45
6.3 Changes to HOT Guidelines Format 45
6.4 Type IV Generic Holdover Time Values 45
6.4.1 Use of Generic Holdover Times in Very Cold Snow 45
6.4.2 Impact of New and Removed Fluids/Data 46
6.4.3 Fluids Responsible for the Type IV Generic Holdover Time Values 46

6.4.4 Evolution of Type IV Generic Holdover Time Values 48
7. CONCLUSIONS 73
7.1 Type I Fluids 73
7.2 Type II Fluids 73
7.3 Type III Fluids 73
7.4 Type IV Fluids 73
7.5 Other HOT Guidelines Changes 74
7.5.1 Frost Table 74
7.5.2 Ice Pellet Allowance Time Guidance 74
7.5.3 Fluid Application Procedure Tables 74
7.5.4 Visibility vs. Snowfall Intensity Table (FAA only) 74
7.5.5 LOUT Table 75
7.5.6 Optimization of HOT Guidelines for Tablet Computers (Transport Canada only) 75
7.5.7 Octagon Branded Fluids 75
8. RECOMMENDATIONS 77
REFERENCES 79

LIST OF APPENDICES

A Transportation Development Centre Work Statement Excerpt – Aircraft & Anti-Icing Fluid Winter Testing 2011-12

B Procedures for Holdover Time Testing

C Fluid Manufacturer Report: Hokkaido Fever Snow AG (Type I)

D Fluid Manufacturer Report: Octagon EcoFlo 2 (Type I)

E Fluid Manufacturer Report: Clariant Safewing MP II Flight Plus (Type II)

F Fluid Manufacturer Report: LNT P250 (Type II)

G Transport Canada and Federal Aviation Administration 2012-13 Holdover Time Guidelines

LIST OF TABLES

Page

Table 1.1: Summary of APS Holdover Time Testing Activities 2
Table 2.1: Fluid Receipt Data (Commercialized Fluids) 9
Table 2.2: Fluid Brix and Viscosity (Commercialized Fluids) 10
Table 2.3: Fluid Freeze Point, LOUT and WSET (Commercialized Fluids) 10
Table 2.4: Summary of Tests Conducted 11
Table 4.1: Fluids Responsible for Type II Generic Holdover Time Values 17
Table 4.2: Type II Neat Fluid, Snow, -3ºC and Above 19
Table 4.3: Type II 75/25 Fluid, Snow, -3ºC and Above 20
Table 4.4: Type II 50/50 Fluid, Snow, -3ºC and Above 21
Table 4.5: Type II Neat Fluid, Snow, Below -3ºC to -14ºC 22
Table 4.6: Type II 75/25 Fluid, Snow, Below -3ºC to -14ºC 23
Table 4.7: Type II Neat Fluid, Snow, Below -14ºC to -25ºC 24
Table 4.8: Type II Neat Fluid, Freezing Drizzle, -3ºC and Above 25
Table 4.9: Type II 75/25 Fluid, Freezing Drizzle, -3ºC and Above 26
Table 4.10: Type II 50/50 Fluid, Freezing Drizzle, -3ºC and Above 27
Table 4.11: Type II Neat Fluid, Freezing Drizzle, Below -3ºC to -10ºC 28
Table 4.12: Type II 75/25 Fluid, Freezing Drizzle, Below -3ºC to -10ºC 29
Table 4.13: Type II Neat Fluid, Light Freezing Rain, -3ºC and Above 30
Table 4.14: Type II 75/25 Fluid, Light Freezing Rain, -3ºC and Above 31
Table 4.15: Type II 50/50 Fluid, Light Freezing Rain, -3ºC and Above 32
Table 4.16: Type II Neat Fluid, Light Freezing Rain, Below -3ºC to -10ºC 33
Table 4.17: Type II 75/25 Fluid, Light Freezing Rain, Below -3ºC to -10ºC 34
Table 4.18: Type II Neat Fluid, Freezing Fog, -3ºC and Above 35
Table 4.19: Type II 75/25 Fluid, Freezing Fog, -3ºC and Above 36
Table 4.20: Type II 50/50 Fluid, Freezing Fog, -3ºC and Above 37
Table 4.21: Type II Neat Fluid, Freezing Fog, Below -3ºC to -14ºC 38
Table 4.22: Type II 75/25 Fluid, Freezing Fog, Below -3ºC to -14ºC 39
Table 4.23: Type II Neat Fluid, Freezing Fog, Below -14ºC to -25ºC 40
Table 4.24: Type II Neat Fluid, Rain on Cold-Soaked Wing, Above 0ºC 41
Table 4.25: Type II 75/25 Fluid, Rain on Cold-Soaked Wing, Above 0ºC 42
Table 6.1: Fluids Responsible for the Type IV Generic Holdover Time Values 47
Table 6.2: Type IV Neat Fluid, Snow, -3ºC and Above 49
Table 6.3: Type IV 75/25 Fluid, Snow, -3ºC and Above 50
Table 6.4: Type IV 50/50 Fluid, Snow, -3ºC and Above 51
Table 6.5: Type IV Neat Fluid, Snow, Below -3ºC to -14ºC 52
Table 6.6: Type IV 75/25 Fluid, Snow, Below -3ºC to -14ºC 53
Table 6.7: Type IV Neat Fluid, Snow, Below -14ºC to -25ºC 54
Table 6.8: Type IV Neat Fluid, Freezing Drizzle, -3ºC and Above 55
Table 6.9: Type IV 75/25 Fluid, Freezing Drizzle, -3ºC and Above 56
Table 6.10: Type IV 50/50 Fluid, Freezing Drizzle, -3ºC and Above 57
Table 6.11: Type IV Neat Fluid, Freezing Drizzle, Below -3ºC to -10ºC 58
Table 6.12: Type IV 75/25 Fluid, Freezing Drizzle, Below -3ºC to -10ºC 59
Table 6.13: Type IV Neat Fluid, Light Freezing Rain, -3ºC and Above 60
Table 6.14: Type IV 75/25 Fluid, Light Freezing Rain, -3ºC and Above 61
Table 6.15: Type IV 50/50 Fluid, Light Freezing Rain, -3ºC and Above 62
Table 6.16: Type IV Neat Fluid, Light Freezing Rain, Below -3ºC to -10ºC 63
Table 6.17: Type IV 75/25 Fluid, Light Freezing Rain, Below -3ºC to -10ºC 64
Table 6.18: Type IV Neat Fluid, Freezing Fog, -3ºC and Above 65
Table 6.19: Type IV 75/25 Fluid, Freezing Fog, -3ºC and Above 66
Table 6.20: Type IV 50/50 Fluid, Freezing Fog, -3ºC and Above 67

Table 6.21: Type IV Neat Fluid, Freezing Fog, Below -3ºC to -14ºC..... 68
Table 6.22: Type IV 75/25 Fluid, Freezing Fog, Below -3ºC to -14ºC..... 69
Table 6.23: Type IV Neat Fluid, Freezing Fog, Below -14ºC to -25ºC..... 70
Table 6.24: Type IV Neat Fluid, Rain on a Cold-Soaked Wing, Above 0ºC 71
Table 6.25: Type IV 75/25 Fluid, Rain on a Cold-Soaked Wing, Above 0ºC 72

LIST OF FIGURES

Page

Figure 2.1: Natural Snow Test Site Locations..... 8
Figure 5.1: Type III Composite vs. Aluminum Comparative Test Results..... 44

GLOSSARY

AMS	Aerospace Material Specification
APS	APS Aviation Inc.
ARP	Aerospace Recommended Practice
CEF	Climatic Engineering Facility
FAA	Federal Aviation Administration
HOT	Holdover Time
LOUT	Lower Operational Use Temperature
MSC	Meteorological Service of Canada
NRC	National Research Council Canada
SAE	SAE International
TDC	Transportation Development Centre
WSET	Water Spray Endurance Test

This page intentionally left blank.

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 potential solutions 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 2011-12 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 2012-13.

The detailed objectives of the 2011-12 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)

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. Key changes are listed below.

- Removal of the detailed methodology section. For this information the reader is directed to the 2002-03 report on holdover time testing, Transport Canada report, TP 14144E, *Aircraft Ground De/Anti-Icing Fluid Holdover Time Development Program for the 2002-03 Winter* (1). Any changes from the 2002-03 methodology are addressed in the current report.

- Removal of individual fluid data. This information is included in the individual fluid reports provided to the fluid manufacturers. Reports for any fluids that are qualified or expected to be qualified are included as appendices to the HOT report.

- Removal of the fluid thickness section. This information is included in the individual fluid reports provided to the fluid manufacturers.

In the winter of 2009-10, a decision was made that this report would include detailed test information only for fluids that are expected to be qualified and commercialized.

The 2011-12 report is presented as described above.

1.4 Report Format

The subsequent sections of this report contain the following:

a) Section 2 summarizes 2011-12 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 presents conclusions derived from the test program; and

g) Section 8 lists recommendations for future testing.

1.5 Publication of HOT Guidelines

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

For a thorough understanding of the subject matter, the Transport Canada HOT guidelines should 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 should be used in conjunction with N 8900.196, *Revised FAA-Approved Deicing Program Updates, Winter 2012-2013* (3), which provides additional guidance and reference material. N 8900.196 (3) is available on the FAA website.

2. TESTING IN 2011-12

2.1 Procedures

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

Because this report serves as the publishing vehicle for the APS endurance time test program, all of the 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 2011-12 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; and
4. Overall Program of Tests at NRC, March 2012.

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 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 at the APS test site at the Pierre Elliott Trudeau Airport in Montreal and at several mobile test sites in Quebec (Rimouski, St-Jovite, Gaspésie National Park) and New Brunswick (Edmundston). Mobile testing was required due to a lack of suitable weather conditions in Montreal following the late submission of several fluids. The natural snow test sites are mapped in Figure 2.1.

Artificial snow testing was required in the winter of 2011-12 (see Section 4.1). It was conducted at the APS test site at the Montreal airport.

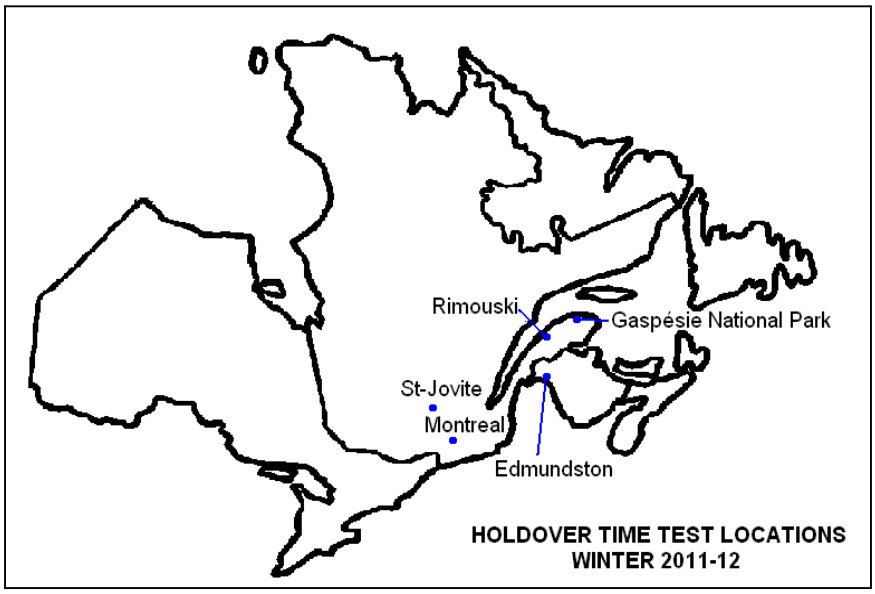


Figure 2.1: Natural Snow Test Site Locations

2.3 Fluids Tested

Five fluids were submitted for endurance time testing in the winter of 2011-12. As per the protocol 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 five fluids submitted for testing in 2011-12 are listed below.

- Hokkaido Fever Snow AG: This Type I non-glycol fluid underwent a complete set of testing and is expected to be commercialized in the winter of 2012-13. The results of testing with this fluid are provided in Appendix C.
- Octagon EcoFlo 2: Testing was conducted with this Type I non-glycol fluid in natural snow in the winter of 2011-12. Simulated precipitation and artificial snow testing was completed in July 2011 and therefore was not required. The results of testing with this fluid are provided in Appendix D.
- Clariant Safewing MP II Flight Plus: This Type II fluid underwent a complete set of testing and is expected to be commercialized in the winter of 2012-13. The results of testing with this fluid are provided in Appendix E.
- LNT P250: This Type II fluid underwent a complete set of testing and is expected to be commercialized in the winter of 2012-13. The results of testing with this fluid are provided in Appendix F.
- Type III Fluid: A Type III fluid was submitted for testing using the heated application test protocol. A complete set of tests was completed. Due to issues with the fluid sample, the test results will not be incorporated into the HOT guidelines and therefore will not be provided in this report.

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

Table 2.1: Fluid Receipt Data (Commercialized Fluids)

Fluid Manufacturer	Fluid Name	Fluid Type	Fluid Formulation	Date Received	Dilution(s) Received	Batch #
Clariant	Safewing MP II Flight Plus	II	Propylene Glycol	1-Mar-12	100%, 75%, 50%	TV 513
LNT	P250	II	Propylene Glycol	20-Mar-12	100%, 75%, 50%	53563-40
Hokkaido	Fever Snow AG	I	Non-Glycol	18-Nov-11	Ready to Use	11-11-11
Octagon*	EcoFlo 2	I	Non-Glycol	12-Jul-11	Concentrate	52620-76

* Fluid was submitted by Battelle but commercialized under the Octagon brand name. Manufacturer of this fluid is referred to as Octagon throughout this report.

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)
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]
LNT P250	100%	36.25°	4,500 [2]	5,050 [2]	4,500 [2]	5,050 [2]
	75%	28.5°	4,800 [2]	4,650 [2]	4,800 [2]	4,650 [2]
	50%	19.0°	3,400 [2]	2,350 [2]	3,400 [2]	2,350 [2]
Hokkaido Fever Snow AG	Ready to Use	>50°	n/a	n/a	n/a	n/a
Octagon EcoFlo 2	Conc.	>50°	n/a	n/a	n/a	n/a

[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

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

Fluid	Fluid Dilution	WSET (AMIL)	Freeze Point (Stated)	LOUT (Stated)
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
LNT P250	100%	83 mins	Not provided	Not provided
	75%	n/a	Not provided	Not provided
	50%	n/a	Not provided	Not provided
Hokkaido Fever Snow AG	Ready to Use	6.7 mins (as is)	-33°C	-21.5°C [1] -23.0°C [2]
Octagon EcoFlo 2	Conc.	4.9 mins (50/50)	-	-29°C [3]

[1] Low speed ramp (as supplied)
[2] High speed ramp (as supplied)
[3] High speed ramp (65/35 dilution), low speed ramp not conducted

2.4 Description of Tests

In total, 516 endurance time tests were conducted during the winter of 2011-12. 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	191
Artificial Snow	8
Freezing Fog	109
Freezing Drizzle	93
Light Freezing Rain	82
Rain on Cold-Soaked Surface	33
Total	**516**

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 the protocol described in Subsection 1.3, copies of the reports for fluids which were expected to be qualified/commercialized have been included as appendices to this report. The relevant reports can be found in Appendices C, D, E and F.

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

Further analysis was completed in the winter of 2011-12 in support of the development of light and very light snow holdover times for Type II and Type IV fluids. This work is documented in the Transport Canada report, TP 15202E, *Aircraft Ground Icing General Research Activities During the 2011-12 Winter* (6). It is expected that light and very light snow holdover times for select fluids will be added to the winter 2013-14 HOT guidelines.

2.7 Type III Composite Research

Several tests were conducted in the winter of 2011-12 to investigate the impact of composite surfaces on the endurance times of Type III fluids applied heated. These tests are described in Subsection 5.5.

2.8 Analysis of Visibility vs. Snowfall Intensity Data

APS provided further analysis of the relationship between visibility and snowfall intensity to the FAA in the summer of 2012. This work is documented in TP 15202E (6).

3. CHANGES TO THE TYPE I HOT GUIDELINES

Changes made to the Type I HOT guidelines for the winter of 2012-13 are documented in this chapter. The Transport Canada and FAA 2012-13 Type I HOT guidelines are included in Appendix G.

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 the endurance times of Type I deicing fluids formulated with propylene glycol, ethylene glycol or diethylene glycol be measured. However, they do require that the endurance times 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 are similar to the performance of the Type I fluids used to generate the currently accepted values in the Type I HOT table.

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

One new Type I fluid was submitted for endurance time testing in 2011-12 and one existing fluid underwent additional testing.

3.1.1 Hokkaido Fever Snow AG

Hokkaido Fever Snow AG, a non-glycol based fluid, was submitted for endurance time testing in 2011-12. The detailed test results are included in the test report included as Appendix C.

The test results show Hokkaido Fever Snow AG performs similarly to Type I fluids tested in past years and therefore can be used with the generic Type I HOT guidelines.

3.1.2 Octagon EcoFlo 2

Octagon EcoFlo 2, a non-glycol based fluid, was submitted for endurance time testing in July 2011. It underwent testing in simulated precipitation and in artificial snow. The purpose of testing in the winter of 2011-12 was to conduct tests in natural

snow to verify the artificial snow results. The detailed test results are included in the test report included as Appendix D.

The natural snow tests confirmed the artificial snow results and verified that Octagon EcoFlo 2 can be used with the generic Type I HOT guidelines.

3.2 Changes to HOT Guidelines Format

Due to the acquisition of Octagon Process by Clariant GmbH, fluids previously listed under the Octagon brand name and are now listed under the Clariant brand name. The following Type I fluids were impacted by this change:

- EcoFlo Concentrate;
- EcoFlo 2 Concentrate;
- Octaflo EF Concentrate;
- Octaflo EF-80; and
- Octaflo EG Concentrate.

3.3 Type I Generic Holdover Time Values

No changes were made to the Type I generic holdover times for the winter of 2012-13.

4. CHANGES TO THE TYPE II HOT GUIDELINES

Changes made to the Type II HOT guidelines for the winter of 2012-13 are documented in this chapter. The Transport Canada and FAA 2012-13 Type II HOT guidelines are included in Appendix G.

4.1 New Fluids/Data

Two new Type II fluids were added to the HOT guidelines for the winter of 2012-13: Clariant Safewing MP II Flight Plus and LNT P250. Both fluids are new Type II fluids that underwent endurance time testing in the winter of 2011-12.

Due to the submission of both fluids late in the test season and unfavourable natural snow test conditions thereafter, it was not possible to collect natural snow data at cold temperatures. Supplemental testing was therefore conducted with an artificial snowmaker. The data enabled the fluids to be given generic holdover times in the below -3 to -14°C snow cells. Additional data will be collected in natural snow in the winter of 2012-13 and the fluid-specific holdover times will be modified accordingly for the winter of 2013-14.

The detailed endurance time test results for the two new Type II fluids are given in the test reports provided to the fluid manufacturers. Copies of these reports are included in Appendix E (Flight Plus) and Appendix F (P250). The addition of these fluids did not impact the generic Type II holdover times.

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). As per the protocol, Clariant Safewing MP II 2025 ECO and Octagon E Max II were removed from the Type II guidelines for the winter of 2012-13. The removal of these fluids did not impact the generic Type II holdover times.

4.3 Changes to HOT Guidelines Format

No changes were made to the format of the Type II HOT guidelines for the winter of 2012-13.

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.

4.4.2 Impact of New and Removed Fluids/Data

Neither the addition of the two new Type II fluids nor the removal of the two obsolete Type II fluids impacted 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.

Table 4.1: Fluids Responsible for Type II 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	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)**	Grandfather **(B)**			

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

M:\Groups\PM2265.001\Reports\HOT\Working Documents\Fluids Responsible for Generic Table Values At: Type II

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 through a series of tables presented 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 2012-13 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+);
- Kilfrost ABC-2000 (K2000);
- Kilfrost ABC-K Plus (ABC-K+);
- LNT P250 (L-P250); and
- Newave Aerochemical FCY-2 (N-FCY-2).

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 +	L-P250
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										
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	0:50-1:10
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	0:50-1:10

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 +	L-P250
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										
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	0:30-0:50
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	0:30-0:50

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 +	L-P250
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										
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	0:10-0:15
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	0:10-0:15

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 +	L-P250
1998-99 HOT Table Values	0:150:40									
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						0:150:30				
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										
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	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	0:15-0:30

Table 4.6: Type II 75/25 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 +	L-P250
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						~~0:10-0:20~~				
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										
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	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	0:10-0:20

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 +	L-P250
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		0:20-0:35								
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					0:35-0:55					
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						0:10-0:25				
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							0:05-0:15			
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								0:15-0:30		
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*	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 +	L-P250
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										
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	1:20-1:40
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	1:20-1:40

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 +	L-P250
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										
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	0:35-1:05
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	0:35-1:05

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 +	L-P250
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										
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	0:15-0:25
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	0:15-0:25

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 +	L-P250
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										
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	0:30-1:40
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	0:30-1:40

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 +	L-P250
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										
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	0:25-1:15
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	0:25-1:15

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 +	L-P250
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										
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	0:40-1:05
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	0:40-1:05

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+	L-P250
1998-99 HOT Table Values	~~0:10~~0:25									
1998-99 ETTest Results										
1999-00 HOT Table Values	0:10-0:25									
1999-00 ET Test Results		0:15~~0:25~~								
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						0:15~~0:25~~				
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										
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	0:20-0:35
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	0:20-0:35

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+	L-P250
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										
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	0:07-0:15
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	0:07-0:15

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 +	L-P250
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										
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	1:00-1:25
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	1:00-1:25

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 +	L-P250
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										
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	0:35-0:50
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	0:35-0:50

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 +	L-P250
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										
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	1:45-3:00
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	1:45-3:00

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 +	L-P250
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										
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	1:00-1:45
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	1:00-1:45

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+	L-P250
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										
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	0:25-0:40
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	0:25-0:40

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 +	L-P250
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										
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	0:45-2:35
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	0:45-2:35

* 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 +	L-P250
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										
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	0:25-1:20
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	0:25-1:20

* 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 -14°C to -25°C

	GENERIC	C-1951	A-E26	K2000	C-Flight	N-FCY-2	ABC-K +	AS CII	C-Flight +	L-P250
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						0:250:35				
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										
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	0:20-0:45
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	0:20-0:45

* 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 0ºC

	GENERIC	C-1951	A-E26	K2000	C-Flight	N-FCY-2	ABC-K +	AS CII	C-Flight +	L-P250
1998-99 HOT Table Values	0:10-0:40									
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										
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	0:20-1:30
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	0:20-1:30

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 +	L-P250
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										
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	0:10-1:15
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	0:10-1:15

5. CHANGES TO THE TYPE III HOT GUIDELINES

Changes made to the Type III HOT guidelines for the winter of 2012-13 are documented in this chapter. The Transport Canada and FAA 2012-13 generic Type III HOT guidelines are included in Appendix G.

5.1 New Fluids/Data

No new Type III fluids were tested during the winter of 2011-12. No additional holdover time data was collected with Type III fluids that will be incorporated into the guidelines.

5.2 Changes to HOT Guidelines Format

No changes were made to the format of the Type III HOT guidelines for the winter of 2011-12.

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 that endurance times of Type III fluids differ depending on the temperature of the fluid at the time of application. 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 applied at ambient temperature, applied 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.

It is expected that fluid-specific and application temperature-specific tables will be published in the winter of 2013-14. Consideration will need to be given as to how to grandfather the current Type III fluid into the new Type III table format.

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 show endurance times are longer on composite surfaces than on aluminum surfaces in some cases. As these results are counterintuitive, further testing in more conditions is recommended. Brix and temperature profile measurements should be taken for some of these tests.

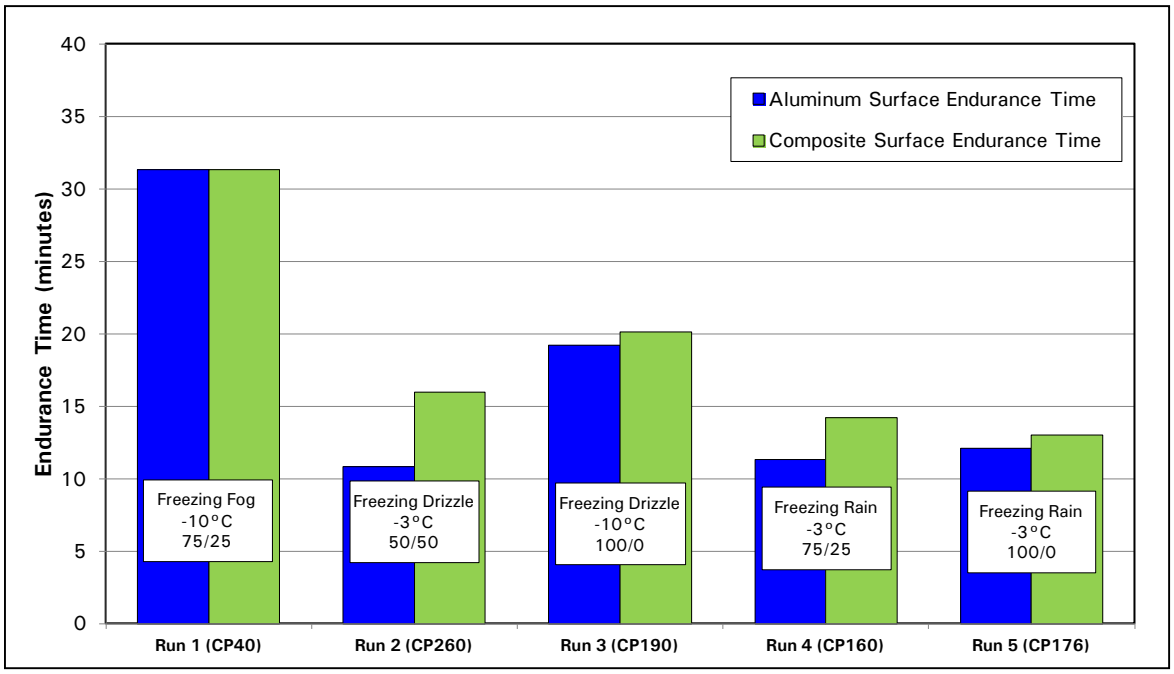


Figure 5.1: Type III Composite vs. Aluminum Comparative Test Results

6. CHANGES TO THE TYPE IV HOT GUIDELINES

Changes made to the Type IV HOT guidelines for the winter of 2012-13 are documented in this chapter. The Transport Canada and FAA 2012-13 Type IV HOT guidelines are included in Appendix G.

6.1 New Fluids/Data

No new Type II fluids were tested in the winter of 2011-12 and/or added to the HOT guidelines for 2012-13.

6.2 Removed Fluids/Data

The protocol for removing obsolete holdover time data is given in ARP5718 (7). As per the protocol, Clariant Safewing MP IV 2001 and Dow Chemical UCAR ADF/AAF ULTRA+ were removed from the Type IV guidelines for the winter of 2012-13. The removal of these two fluids resulted in twelve increases to the generic Type IV fluid holdover times.

6.3 Changes to HOT Guidelines Format

Due to the acquisition of Octagon Process by Clariant GmbH, fluids previously listed under the Octagon brand name are now listed under the Clariant brand name. One Type IV fluid, Max-Flight 04, was impacted by this change.

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 list.

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.

6.4.2 Impact of New and Removed Fluids/Data

The removal of Clariant Safewing MP IV 2001 resulted in six increases to the Type IV generic holdover times: five 5 minute increases and one 25-minute increase. The removal of Dow Chemical UCAR ADF/AAF ULTRA+ resulted in six different increases to the Type IV generic holdover times: four 5 minute increases, one 10-minute increase, and one 15-minute increase.

6.4.3 Fluids Responsible for the Type IV Generic Holdover Time Values

The fluids responsible for the values in the 2012-13 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	K-ABC-4S **(L)** D-EG106 **(U)** L-AS **(U)**	A/D-480 **(B)** D-EG106 **(B)**	A/D-480 **(B)**	A/D-480 **(B)**	A/D-49 **(L)** K-ABC-S **(U)**
		75/25	K-ABC-4S **(L)** K-ABC-S **(U)**	K-ABC-S **(B)** K-ABC-4S **(B)** A/D-480 **(L)**	K-ABC-4S **(B)**	K-ABC-4S **(B)**	L-AS **(L)** CR-PGA **(L)** K-ABC-S **(U)**
		50/50	K-ABC-S **(B)** K-ABC-4S **(B)**	K-ABC-S **(B)** K-ABC-4S **(B)** CR-PG **(U)**	K-ABC-4S **(B)** K-ABC-S **(U)**	K-ABC-4S **(B)** K-ABC-S **(U)**	
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-EG106 **(L)**	K-ABC-S **(B)**	K-ABC-S **(L)** A/D-49 **(U)**	
		75/25	A/D-480 **(B)** K-ABC-S **(L)**	CR-PG **(B)** A/D-480 **(L)**	A/D-49 **(L)** O-Max04 **(U)**	K-ABC-S **(L)** K-ABC-S+ **(U)** A/D-49 **(U)**	
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0	A/D-480 **(B)** K-ABC-S **(U)** A/D-49 **(U)** CR-PG **(U)**	Historic Generic **(B)**			

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

M:\Groups\PM2265.001\Reports\HOT\Working Documents\Fluids Responsible for Generic Table Values At: Type IV

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 2012-13 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-480);
- ABAX Ecowing AD-49 / Dow UCAR FlightGuard AD-49 (A-49);
- Clariant Max-Flight 04 (C-Max 04);
- Clariant Safewing MP IV Launch (C-Launch);
- Cryotech Polar Guard (CR-PG);
- Cryotech Polar Guard Advance (CR-PGA);
- Dow UCAR Endurance EG106 (D-E106);
- Kilfrost ABC-S (K-ABC-S);
- Kilfrost ABC-S PLUS (K-ABCS+);
- Kilfrost ABC-4^{sustain} (K-ABC4S); and
- Lyondell ARCTIC Shield® (L-AS).

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

	GENERIC	K-ABC-S	A-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A-49	K-ABC4S	CR-PG	CR-PGA
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				1:25-2:00								
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		1:15-2:00	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	1:00-1:45		
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	1:00-1:45		
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	1:00-1:45	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	1:00-1:45	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	1:00-1:45	0:50-1:30	1:20-1:50

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

	GENERIC	K-ABC-S	A-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A-49	K-ABC4S	CR-PG	CR-PGA
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	~~0:30~~0:55		
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	0:30-0:55		
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	0:30-0:55	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	0:30-0:55	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	0:30-0:55	0:35-1:10	0:45-1:20

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

	GENERIC	K-ABC-S	A-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A-49	K-ABC4S	CR-PG	CR-PGA
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	~~0:07~~-~~0:15~~		
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	0:05-0:15		
2009-10 ET Test Results											0:10~~0:15~~	
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	0:05-0:15	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	0:07-0:15	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	0:07-0:15	0:10-0:15	0:15-0:35

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

	GENERIC	K-ABC-S	A-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A-49	K-ABC4S	CR-PG	CR-PGA
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	1:00-1:45		
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	1:00-1:45		
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	1:00-1:45	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	1:00-1:45	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	1:00-1:45	0:30-0:55	0:55-1:15

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

	GENERIC	K-ABC-S	A-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A-49	K-ABC4S	CR-PG	CR-PGA
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	0:30-0:55		
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	0:30-0:55		
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	0:30-0:55	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	0:30-0:55	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	0:30-0:55	0:20-0:40	0:35-1:00

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

	GENERIC	K-ABC-S	A-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A-49	K-ABC4S	CR-PG	CR-PGA
1996-97 Test Results and Table Values used in 97-98	~~0:15~~0:30	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~~	0:25-0:55	~~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	0:40-1:10				
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									1:10-1:50	1:00-1:45		
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*	0:15-0:30*		
2009-10 ET Test Results											0:25-0:40	
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*	0:15-0:30*	
2010-11 ET Test Results												0:45-1:05
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*	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*	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-ABC-S	A-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A-49	K-ABC4S	CR-PG	CR-PGA
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	1:35-2:00		
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	1:35-2:00		
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	1:35-2:00	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	1:35-2:00	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	1:35-2:00	1:15-2:00	1:35-2:00

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

	GENERIC	K-ABC-S	A-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A-49	K-ABC4S	CR-PG	CR-PGA
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	~~0:40~~-1:05		
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	0:40-1:05		
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	0:40-1:05	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	0:40-1:05	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	0:40-1:05	1:05-1:25	1:40-2:00

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

	GENERIC	K-ABC-S	A-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A-49	K-ABC4S	CR-PG	CR-PGA
1996-97 Test Results and Table Values used in 97-98	0:10-0:20	0:15~~0:25~~										
1997-98 ET Test Results		0:15~~0:20~~	~~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		0:15~~0:20~~										
1999-00 HOT Table Values	0:10-0:20	0:15-0:20	0:15-0:35									
1999-00 ET Test Results			0:15-0:25									
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							0:15-0:40	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									0:15-0:30	~~0:10~~0:20		
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	0:10-0:20		
2009-10 ET Test Results											0:15-0:25	
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	0:10-0:20	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	0:10-0:20	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	0:10-0:20	0:15-0:25	0:20-0:45

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

	GENERIC	K-ABC-S	A-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A-49	K-ABC4S	CR-PG	CR-PGA
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	0:35-1:50		
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	0:35-1:50		
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	0:35-1:50	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	0:35-1:50	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	0:35-1:50	0:25-1:10	0:35-1:35

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

	GENERIC	K-ABC-S	A-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A-49	K-ABC4S	CR-PG	CR-PGA
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	0:25-1:20		
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	0:25-1:20		
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	0:25-1:20	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	0:25-1:20	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	0:25-1:20	0:25-1:05	0:25-1:05

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

	GENERIC	K-ABC-S	A-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A-49	K-ABC4S	CR-PG	CR-PGA
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	1:05-1:30		
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	1:05-1:30		
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	1:05-1:30	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	1:05-1:30	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	1:05-1:30	0:50-1:15	1:15-1:30

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

	GENERIC	K-ABC-S	A-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A-49	K-ABC4S	CR-PG	CR-PGA
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~~	1:05-1:25		
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	1:05-1:25		
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	1:05-1:25	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	1:05-1:25	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	1:05-1:25	0:15-0:35	0:35-0:45

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

	GENERIC	K-ABC-S	A-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A-49	K-ABC4S	CR-PG	CR-PGA
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							0:15~~0:25~~	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									0:15~~0:25~~	0:15-0:40		
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	0:15-0:40		
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	0:15-0:40	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	0:15-0:40	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	0:15-0:40	0:20-0:30	0:35-0:45

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

	GENERIC	K-ABC-S	A-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A-49	K-ABC4S	CR-PG	CR-PGA
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~~	1:05-1:25		
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	1:05-1:25		
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	1:05-1:25	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	1:05-1:25	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	1:05-1:25	0:15-0:35	0:35-0:45

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

	GENERIC	K-ABC-S	A-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A-49	K-ABC4S	CR-PG	CR-PGA
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							0:15~~0:25~~	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									0:15~~0:25~~	0:15-0:40		
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	0:15-0:40		
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	0:15-0:40	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	0:15-0:40	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	0:15-0:40	0:20-0:30	0:35-0:45

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

	GENERIC	K-ABC-S	A-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A-49	K-ABC4S	CR-PG	CR-PGA
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	~~1:45~~3:55		
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	1:45-3:55		
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	1:45-3:55	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	1:45-3:55	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	1:45-3:55	2:15-3:30	2:50-4:00

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

	GENERIC	K-ABC-S	A-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A-49	K-ABC4S	CR-PG	CR-PGA
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		1:05~~1:45~~										
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	~~1:00~~1:50		
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	1:00-1:50		
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	1:00-1:50	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	1:00-1:50	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	1:00-1:50	1:40-2:40	2:30-4:00

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

	GENERIC	K-ABC-S	A-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A-49	K-ABC4S	CR-PG	CR-PGA
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	~~0:20-0:35~~		
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	0:20-0:35		
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	0:20-0:35	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	0:20-0:35	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	0:20-0:35	0:25-0:40	0:50-1:25

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

	GENERIC	K-ABC-S	A-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A-49	K-ABC4S	CR-PG	CR-PGA
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	0:55-2:55		
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	0:55-2:55		
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	0:55-2:55	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	0:55-2:55	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	0:55-2:55	0:45-1:45	0:55-2:30

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

	GENERIC	K-ABC-S	A-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A-49	K-ABC4S	CR-PG	CR-PGA
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	0:35-2:10		
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	0:35-2:10		
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	0:35-2:10	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	0:35-2:10	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	0:35-2:10	0:35-1:30	0:40-1:30

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

	GENERIC	K-ABC-S	A-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A-49	K-ABC4S	CR-PG	CR-PGA
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~~	0:40-1:00		
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	0:40-1:00		
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	0:40-1:00	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	0:40-1:00	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	0:40-1:00	0:20-0:40	0:25-0:50

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

	GENERIC	K-ABC-S	A-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A-49	K-ABC4S	CR-PG	CR-PGA
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	0:20-2:00		
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	0:20-2:00		
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	0:20-2:00	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	0:20-2:00	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	0:20-2:00	0:15-1:25	0:15-2:00

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

	GENERIC	K-ABC-S	A-480	C-Max 04	C-Launch	D-E106	K-ABCS+	L-AS	A-49	K-ABC4S	CR-PG	CR-PGA
1996-97 Test Results and Table Values used in 97-98	~~0:05-0:35~~											
1997-98 ET Test Results		0:10~~0:50~~										
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	0:10-1:20		
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	0:10-1:20		
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	0:10-1:20	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	0:10-1:20	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	0:10-1:20	0:10-1:15	0:09-1:40

7. CONCLUSIONS

Endurance time testing was carried out with five de/anti-icing fluids in the winter of 2011-12. 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.

7.1 Type I Fluids

No changes were made to the Type I fluid HOT guidelines for the winter of 2012-13.

7.2 Type II Fluids

Several changes were made to the Type II fluid HOT guidelines for the winter of 2012-13:

1. Fluid-specific HOT tables were added for two new Type II fluids, Clariant Safewing MP II Flight Plus and LNT P250; and
2. Two obsolete Type II fluids, Clariant Safewing MP II 2025 ECO and Octagon E Max II, were removed from the guidelines as per the protocol for removing obsolete data.

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

7.3 Type III Fluids

No changes were made to the Type III fluid HOT guideline values for the winter of 2012-13.

7.4 Type IV Fluids

Two obsolete Type IV fluids, Clariant Safewing MP IV 2001 and Dow Chemical UCAR ADF/AAF ULTRA+, were removed from the Type IV fluid HOT guidelines for the winter of 2012-13 as per the protocol for removing obsolete data. The removal of these fluids resulted in twelve increases to the generic Type IV fluid holdover times.

7.5 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 2012-13.

7.5.1 Frost Table

The lowest temperature band in the Type I portion of the active frost table was changed from "below -21 to -25°C" to "below -21 to LOUT" to clarify that the Type I active frost holdover times can be used at temperatures below -25°C as long as the fluid LOUT is respected.

7.5.2 Ice Pellet Allowance Time Guidance

Several changes were made to the ice pellet allowance time guidance material.

1. The ice pellets operational guidance was modified to identify additional precipitation conditions where outside air temperature must not decrease.
2. Clarification notes were added to the allowance time table title to indicate the table applies only to Type IV neat fluids and to identify the different glycol based fluids.

No changes were made to the ice pellet allowance time values.

7.5.3 Fluid Application Procedure Tables

Several changes were made to the wording in the fluid application procedure tables to improve clarity.

1. Type I and Type II/III/IV Tables: Text was added to indicate that the time available between the first and second steps of a two-step application procedure may be greater or less than three minutes.
2. Type I Table: Text was added to clarify that the minimum fluid application quantities and temperature apply to all conditions including active frost.

7.5.4 Visibility vs. Snowfall Intensity Table (FAA only)

The FAA visibility vs. snowfall intensity table was modified as follows:

1. The snow intensity in the cell for night, temperature ≤-1°C, and visibility ¾ mile was changed to moderate;
2. The snow intensity in the cell for night, temperature >-1°C, and visibility 1 mile was changed to moderate;
3. New columns were added for 1¼ and 1¾ mile visibilities; and
4. Metric (metre) visibility measurements were added.

No changes were made to the Transport Canada visibility table.

7.5.5 LOUT Table

The lowest operational use temperatures table was updated with new information provided by the fluid manufacturers.

7.5.6 Optimization of HOT Guidelines for Tablet Computers (Transport Canada only)

The Transport Canada HOT guidelines publication was indexed and optimized for better viewing using tablet computers.

7.5.7 Octagon Branded Fluids

Due to the acquisition of Octagon Process by Clariant GmbH, fluids previously listed under the Octagon brand name were changed and are now listed under the Clariant brand name.

This page intentionally left blank.

8. 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 2012-13 and that further research be conducted to evaluate endurance times of Type III fluids applied heated to composite surfaces.

This page intentionally left blank.

REFERENCES

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

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

3. Federal Aviation Administration N 8900.196, *Revised FAA-Approved Deicing Program Updates, Winter 2012-2013*, August 2012.

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

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

6. Bendickson, S., D'Avirro, J., Gravito, P., Ruggi, M., Youssef, D, Zoitakis, V., *Aircraft Ground Icing General Research Activities During the 2011-12 Winter,* APS Aviation Inc., Transportation Development Centre, Montreal, March 2013, TP 15202E, XX (to be published).

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

8. Bendickson, S., Dawson, P., Pineau, M., Zoitakis, V., *Aircraft Ground Icing General Research Activities During the 2008-09 Winter*, APS Aviation Inc., Transportation Development Centre, Montreal, December 2009, TP 14936E, XX (to be published).

This page intentionally left blank.

APPENDIX A

TRANSPORTATION DEVELOPMENT CENTRE
WORK STATEMENT EXCERPT –
AIRCRAFT & ANTI-ICING FLUID
WINTER TESTING 2011-12

TRANSPORTATION DEVELOPMENT CENTRE
WORK STATEMENT EXCERPT –
AIRCRAFT & ANTI-ICING FLUID
WINTER TESTING 2011-12

7. DETAILED STATEMENT OF PREPARATORY WORK

(Contract T-8200-088510/001/MTB)

7.4 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 at the P.E.T. test site (under a wide range of temperature, precipitation rate, precipitation type, and wind conditions);

7.8 Infrastructure for FAA/TC HOT Guideline Development

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 2011-12;

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

c) Evaluate current methods for measuring snowfall intensity; and

d) Develop improved, more efficient methods to measure snowfall intensity, if appropriate.

3. INFRASTRUCTURE COSTS, FACILITY RENTALS, AND EXTERNAL SERVICES

(Contract T8125-110167/001/TOR)

3.25 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 as Section 2.4 of this document and will be funded by the fluid manufacturers.

Preparation and Setup for Natural Snow Testing at Trudeau International Airport
Preparation and Setup for Simulated Precipitation Testing at NRC

a) Prepare a test plan to coordinate all simulated precipitation required by the winter 2011-12 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 HOT's;

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, March 2012

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

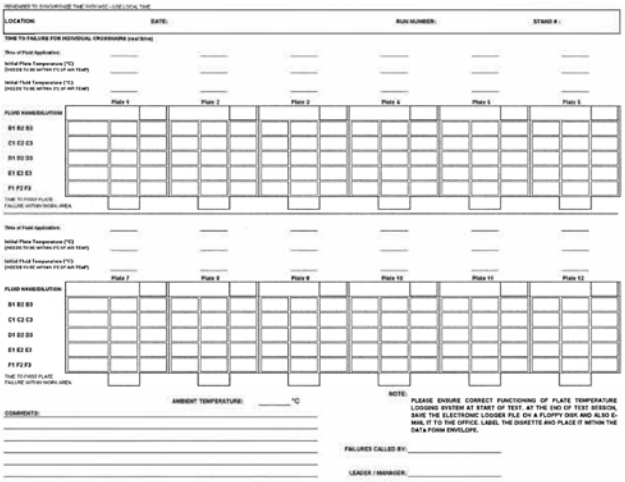


Table 2.2: Meteorological and Precipitation Rate Data Form

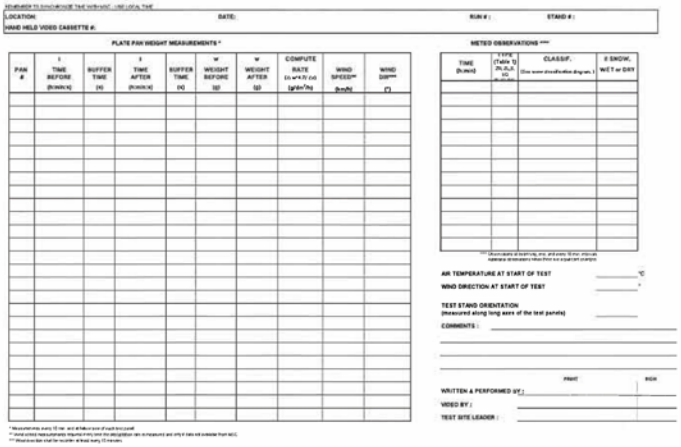


Table 2.3: General Form for Each Testing Session – Natural Snow

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.

This page intentionally left blank.

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 60°C, 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		Fluid Conc.	Fluid Type
		AMOUNT (L)	TEMP (°C)		
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.

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

1	2	3	4	5
Rate Pan	ColdSoak BOX	ColdSoak BOX	ColdSoak BOX	ColdSoak BOX

OTHER COMMENTS (Fluid Batch, etc):

FAILURES CALLED BY : PRINT SIGN

*TIME (After Fluid Application) TO FAILURE FOR INDIVIDUAL CROSSHAIRS (hr:min)

Time of Fluid Application: _____ hr:min:ss _____ hr:min:ss _____ hr:min:ss

	BOX ____			BOX ____			BOX ____		
FLUID NAME									
B1 B2 B3									
C1 C2 C3									
D1 D2 D3									
F1 F2 F3									
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA									
CALCULATED FAILURE TIME (MINUTES)									
BRIX / FLUID TEMPERATURE AT START	/			/			/		

Time of Fluid Application: _____ hr:min:ss _____ hr:min:ss _____ hr:min:ss

	BOX ____			BOX ____			BOX ____		
FLUID NAME									
B1 B2 B3									
C1 C2 C3									
D1 D2 D3									
E1 E2 E3									
F1 F2 F3									
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA									
CALCULATED FAILURE TIME (MINUTES)									
BRIX / FLUID TEMPERATURE AT START	/			/			/		

Cm1747\Procedures\Type I protocol\Type I ETV\Attachment I

M:\Groups\PM2103.001 (TC-Deicing 07-08)\Procedures\Type I Fluids (Nat. Snow)\Version 1.0.doc
Version 1.0,December 07

Page 6 of 8

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 ETA ttachment 2

COMMENTS : _____

PRINT — SIGN

WRITTEN & PERFORMED BY : _____ _____

PHOTO BY : _____ _____

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



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/dm²/h;
   Droplet median volume diameter: 250 μm;
   Air temperature: +1°C.

4. Moderate Rain on Cold-Soaked Surface:
   Precipitation rate: 75 g/dm²/h;
   Droplet median volume diameter: 1 400 μm;
   Air temperature: +1°C.

5. Freezing Fog:
   Precipitation rate: 2 and 5 g/dm²/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;

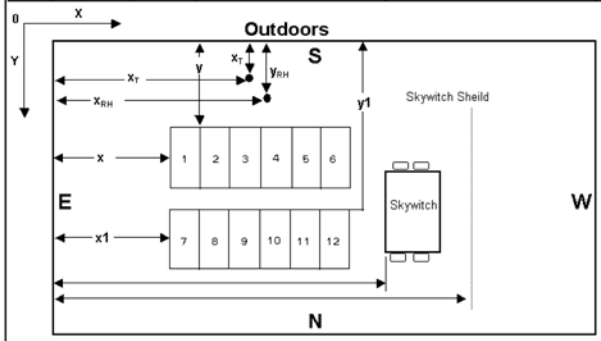
Figure 2.7: Rate Management Form at NRC, and;

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

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

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**

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

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)

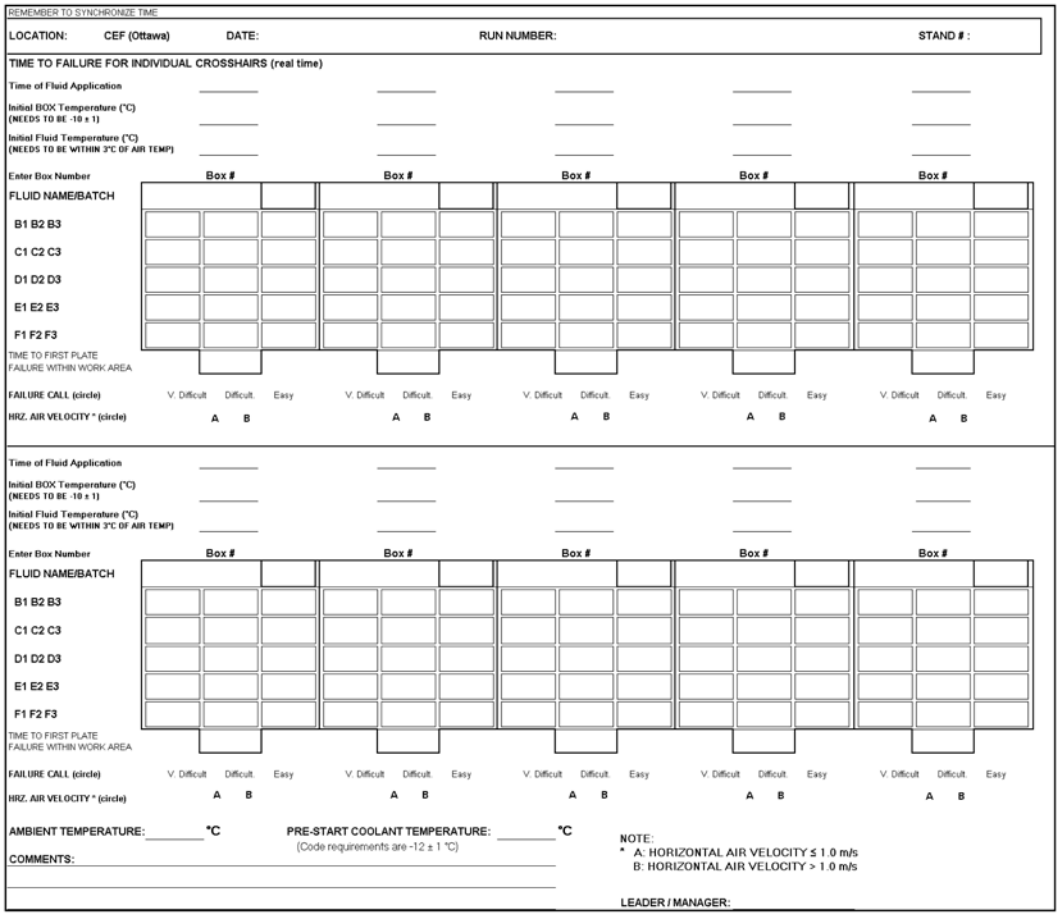
Plate Temperature (°C):
(to be recorded by APS at the end of the each condition, saved on floppy disks and included in the envelope along with the forms)
The plate temperature data is saved to the following files (provide filename and extension):

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

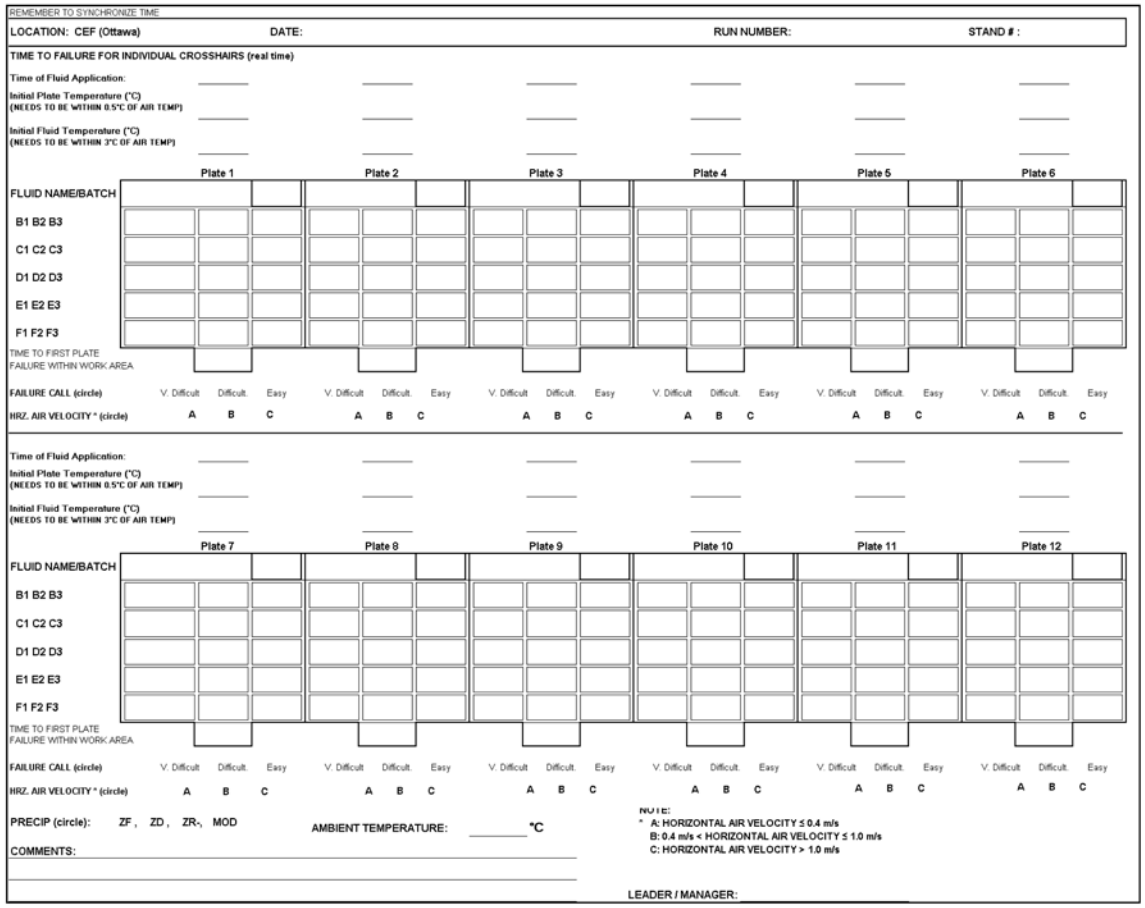
PRE-START COOLANT TEMPERATURE: _____ °C
(Code requirements are -12 ± 1 °C)

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

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 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 1	2	3	4	5	6	MT'S on 1	2	3	4	5	6	Last Date
ZR 3 L	**2x20**	**1 GPM**	**60**	**12.5**	**78**	**2**	**75**	**full**	**low**	**full**	**high**		**y**	**y**					**y**	**y**	**y**				**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 1	2	3	4	5	6	MT'S on 1	2	3	4	5	6	Date

COMPUTER TECHNICIAN: _____ LEADER: _____

Figure 2.6: Chamber Setting for Each Condition at NRC

RATE MANAGEMENT FORM AT NRC

CONDITION: _____

DATE: _____ WEIGH SCALE TECHNICIAN: _____

PAN #	TIME OUT	1st or 2nd Rate	TIME*	Chamber Temperature	STDEV

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** ___/___/_____

This page intentionally left blank.

OVERALL PROGRAM OF TESTS AT NRC, MARCH 2012

CM2265.001 (11-12)

OVERALL PROGRAM OF TESTS AT NRC, MARCH 2012

Winter 2011-12

Prepared for

Transportation Development Centre
Transport Canada

Prepared by: Stephanie Bendickson

Reviewed by: John D'Avirro

APS Aviation Inc.

March 20, 2012
Final Version 1.0

OVERALL PROGRAM OF TESTS AT NRC, MARCH 2012

Winter 2011-12

1. INTRODUCTION

This document was prepared to bring together several projects that require testing at the National Research Council Climactic Engineering Facility (NRC) in Ottawa. Tests will be carried out from March 21-28, 2012.

The primary objective of the test session is to measure the endurance times of new de/anti-icing fluids. Testing for several other related research projects will be scheduled around the endurance time tests as time and space permit. This document provides the schedule, personnel, fluid, and equipment requirements for each of the projects involved.

A tentative test schedule is included in Figure 1.

2. PROJECTS, PROCEDURES AND OBJECTIVES

The projects that will be carried out at the March 2012 NRC test session are listed in this section. Each project has been given a shortened name (shown in brackets following full title) which will be used in subsequent sections of this document.

The test procedures for several projects are provided in separate detailed documents. These documents are referenced in the appropriate subsection and listed in Section 9.

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 stands that will be used for each project are noted below.

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 I, Type II, Type III and Type IV tests, as described below.

Type I Tests: 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 tables, including aluminum and composite surfaces. This fluid is ready-to-use and therefore will not be diluted. It should be noted that Type I fluids are not tested in freezing rain at -3°C because the latent heat of freezing in calm test conditions produces artificially long endurance times. The fluid will be tested under fluid code "F1".

Type II Tests: A new Type II fluid will be tested over the entire range of freezing precipitation conditions encompassed by the Type II HOT tables. The fluid will be tested under fluid code "C2".

Type III Tests: Tests will be conducted with a commercial Type III fluid 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. The fluid will be tested under fluid code "C3".

Type III Supplemental Tests: Several sets of supplemental Type III endurance times will be conducted with the Type III fluid coded "C3":

- Composite Surface Tests: Limited tests (5) 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 (10) will be conducted with fluid applied at ambient temperature to compare endurance times of the 2012 fluid sample to those obtained with the original endurance time testing sample (tested in 2004).

Type IV Tests: A new Type IV fluid will be tested over the entire range of freezing precipitation conditions encompassed by the Type IV HOT tables. The fluid will be tested under fluid code "T4".

The procedure for conducting endurance time tests is given in the document *Test Requirements for Simulated Freezing Precipitation Flat Plate Testing* (1). The test stands should be situated in the cold chamber as per the measurements provided in Figure 2. The 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 all new de/anti-icing fluids (listed in Subsection 2.1) 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. It should be noted that Type I/III tests will be conducted with fluid at 20°C and Type II/IV tests will be conducted with fluid at ambient temperature (-3°C).

The test plan for Fluid Thickness tests is given in Table 2. The tests will be conducted at the small end of the chamber outside of the spray area.

2.3 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 must return to de/anti-ice again. The objective of this project is to evaluate the appropriateness of this guidance by evaluating the condition of a test plate five minutes after fluid failure is called.

This project will be carried out by conducting additional observations on a selection of the new fluid endurance time tests (see Section 2.1), including Type I, II, III and IV tests. No separate tests are scheduled for this project and it has no formal procedure. However, the following points are of importance:

- The comments column in the New Fluid ETs test plan (Table 1) indicates which tests require additional observations for this project.
- 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 test data form).
- Testing will be conducted in the following conditions:
    - Freezing Rain, -3°C, 13 and 25 g/dm^2/h;
    - Freezing Rain, -6°C, 13 and 25 g/dm^2/h;
    - Freezing Rain, -10°C, 25 g/dm^2/h;
    - Freezing Drizzle, -3°C, 5 g/dm^2/h; and
    - Freezing Fog, -3°C, 2 g/dm^2/h.

As tests are being conducted as part of the New Fluid ETs project, no additional test plan is required for this project.

2.4 Effect of Ice Phobic Products on Fluid Holdover Times (Ice Phobic)

This project has four objectives as described below.

1. New Product Testing: Investigate new ice phobic products NUSIL 11 (R-3975 with R-1182) and AAC2 (optional). Investigation of the new ice phobic products will include three types of testing:
    - Endurance time testing: comparative testing with Type I and II fluids in a subset of holdover time conditions (inline with previous test plans);
    - Fluid thickness/wetting tests; and
    - Ice adherence/accumulation tests.

2. Type I Fluid Failure on Ice Phobic Surface: Investigate previous concerns regarding Type I fluid not wetting ice phobic surfaces but ice not forming due to contact angle. Will include comparative Type I tests in freezing drizzle and light freezing rain.

3. Drainage Characteristics in Quiet Areas: Investigate potential application of ice phobic products in quiet areas.
    - Quiet areas to be simulated using aluminum containers (cube type cups) with a drain hole drilled into the bottom
    - Containers will be coated and un-coated and will be filled with Type I, II or III fluid and left to drip out
    - Containers will be weighed dry, and at several time intervals during drainage, i.e. 10-min, 30-min, 60-min, etc.
    - Coated performance will be compared to un-coated
    - Tests will be conducted outside spray area

4. Overnight Ice: Investigate potential benefits of having ice phobic products prevent ice formation on critical surfaces.
    - Parts of HOT test stand which are notorious for accreting large amounts of ice (while only being exposed to minimal amounts of fluid) will be treated with ice phobic products
    - Coated surface accretion will be compared to non-coated accretion
    - Surfaces will be examined at the end of each test day, or once significant ice has formed and needs to be removed for holdover time testing purposes
    - These tests will be done inside the spray area, but do not require plate positions

The test plans for Ice Phobic tests are given in Table 3 (new product endurance time tests and Type I fluid failure tests), Table 4 (new product thickness tests), Table 5 (new product adherence tests) and Table 6 (drainage tests). There is no test plan required for the overnight ice tests.

The endurance time and adherence tests will be conducted on the main and/or side stand. The thickness and drainage tests will be conducted at the small end of the chamber outside of the spray area.

2.5 Endurance Times on Deployed Flaps (Deployed Flaps)

The objective of this project is to evaluate the endurance time performance of anti-icing fluids on wing surfaces with deployed flaps. Previous testing has been conducted with both nested and non-nested flat plate testing. More recently, full scale testing to correlate simulated plates with actual wing failure has identified non-nested flaps to have reduced holdover times. Limited testing with Type I and Type III fluids is being carried out at this test session to supplement previously collected indoor data.

The procedure for the conduct of these tests is provided in the document *Evaluation of Endurance Times on Deployed Flaps* (3). 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). 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 7. The tests will be conducted on the main and/or side stand.

2.6 Evaluation of Windshield Washer Fluids Used for Frost De/Anti-Icing (Windshield Washer Fluids)

Because frost often has the appearance of being a minor contamination, it does not offer the same obvious signal of danger as other types of contamination. However, the irregular and rough accretion patterns of frost can result in a significant loss of lift on critical aircraft surfaces. The current frost holdover times have been evaluated and substantiated for use during natural active frost conditions, but it is not known if these holdover times can be applied to

commercial windshield washer fluids. Transport Canada has indicated that General Aviation users apply these products to remove frost before flight in active frost.

The objective of this project is to approximate how much protection these fluids provide and if additional guidance is necessary for their use for this purpose. Preliminary tests have been completed in the NRC PIWT and at the APS test site in Montreal. The project authority suggested "piggy-backing" additional tests onto the March 2012 NRC test session.

Freezing fog conditions will be used to simulate frost at the NRC because frost is not easily generated in the NRC cold chamber. Tests will be conducted in three climatic conditions: freezing fog at a rate of 2 g/dm^2/h at ambient temperatures of -3, -14 and -25°C. The tests may be conducted at 5 g/dm^2/h if scheduling issues arise.

Each climatic condition will include 3 sets of tests:

- Set 1 [in spray zone]: HOT test of clean plate.
- Set 2 [in spray zone]: HOT test of iced plate (do not scrape ZF)
- Set 3 [outside spray zone]: Deicing only of iced plate (do not scrape ZF). Will measure refreezing if applicable.

Each test set will consist of 3 test plates:

- Plate 1: Baseline Type I 10° Buffer
- Plate 2: WWF 1 Green
- Plate 3: WWF 2 Yellow

Tests will be carried out using standard endurance time test protocols, including 1 litre of test fluid applied at 20°C.

The test plan for Windshield Washer Fluid tests is given in Table 8. The non-spray tests will be conducted at the small end of the chamber outside of the spray area. The spray tests will be conducted on the main stand.

3. PERSONNEL REQUIREMENTS/RESPONSIBILITIES

The personnel responsibilities are listed below.

1. New Fluid ETs:
    - 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 Tests (run in conjunction with New Fluid ET tests):
    - Manager: JD (records failure 5 minutes after test)
    - Assistant: VZ (tracks timing, records measurements)
    - Rates Team: SB, YOW1
4. Ice Phobic:
    - Manager: MR (runs tests, takes measurements)
    - Assistant: YOW2 (records measurements, assists as needed)
    - Rates Team: SB, YOW1
5. Deployed Flaps:
    - Manager: MR (runs tests, takes measurements)
    - Assistant: YOW2 (records measurements)
    - Rates Team: SB, YOW1
6. Windshield Washer:
    - 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: VZ, YOW2

In addition, personnel will be designated responsible for:

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

4. FLUIDS

The required fluids and fluid quantities are shown in Table 9. Type I fluids will be diluted prior to testing using the dilution tables provided in Table 10.

5. EQUIPMENT

Table 11 provides a list of the 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. 5 Minute Rule:
   - No data forms required; observations recorded on New Fluid ET endurance time data forms.
4. Ice Phobic:
   - Ice Phobic End Condition Data Form (Figure 6)
   - Ice Phobic Thickness Data Form (Figure 7)
   - Overnight Ice Stand Inspection Data Form (Figure 8)
   - Ice Phobic Drainage Data Form (Figure 9)
5. Deployed Flaps:
   - Freezing Precipitation Endurance Time Data Form (Figure 3)
6. Windshield Wiper Fluids:
   - Freezing Precipitation Endurance Time Data Form (Figure 3)

7. PRE–TEST SET–UP ACTIVITIES

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

1. Mark plates and boxes. (MR).
2. Check rate pans: check quantity, check for holes, and check all pans are properly labelled (PG).
3. Ensure plates and boxes are equipped with operational and verified thermistors (MR).
4. Determine number of loggers required (loggers on stands already) (MR).
5. Prepare PC for logging plate temperatures (MR).
6. Ensure fluids are prepared in advance according to Table 9 (MR/JD).
7. Prepare labels for pour containers (SB).
8. Clean and label 1 litre pour containers (MR/JD).
9. Check laptops (2) work for rate station (MR).
10. Rent cube van (VZ)
11. Book hotel (VZ)
12. Update and print chamber settings file – time permitting (DY)
13. Print data forms and procedures (SB/PG)
14. Print chamber condition sheets (SB/PG)

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

1. Blue towels
2. White gloves
3. Scrapers x5
4. Rubber squeegees x10

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. Test Requirements For Simulated Freezing Precipitation Flat Plate Testing, Version 1.0, January 15, 2004.
2. Experimental Program to Establish Film Thickness Profiles for De-Icing and Anti-Icing Fluids on Flat Plates, Version 1.0, April 3, 2002.
3. Evaluation of Endurance Times on Deployed Flaps, Final Version 1.0, January 25, 2012.

OVERALL PROGRAM OF TESTS AT NRC, MARCH 2012

FIGURE 1: TEST SCHEDULE

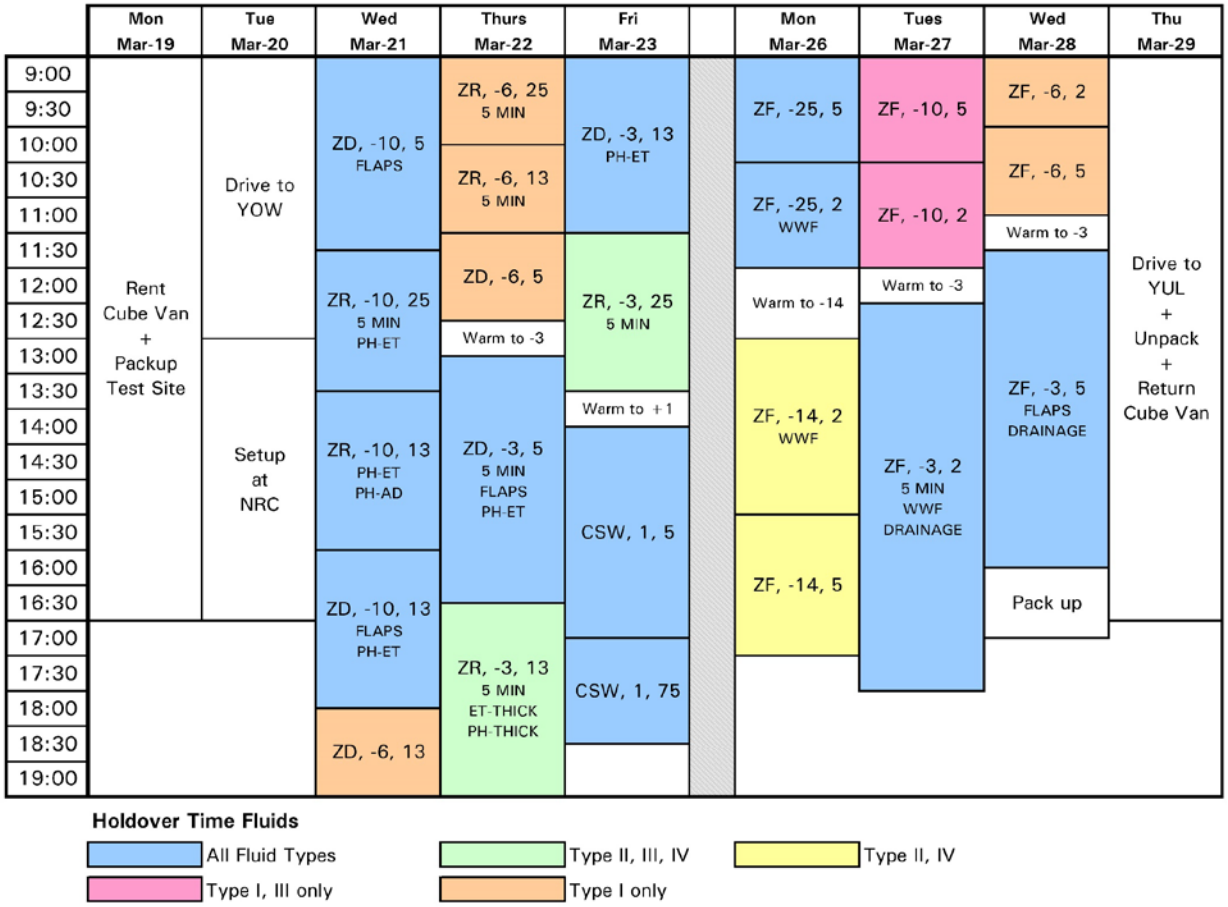
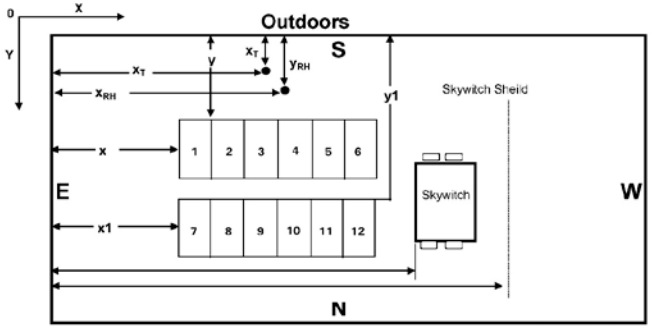


FIGURE 2: TEST STAND LOCATION MEASUREMENTS

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).

TABLE 1: ENDURANCE TIME TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid Code	Fluid Dilution (%)	Test Surface	Comments
1	Freezing Fog	-25	2	C2	100	Al. Plate	
2	Freezing Fog	-25	2	C2	100	Al. Plate	
3	Freezing Fog	-25	2	T4	100	Al. Plate	
4	Freezing Fog	-25	2	T4	100	Al. Plate	
5	Freezing Fog	-25	2	C3	100	Al. Plate	
6	Freezing Fog	-25	2	C3	100	Al. Plate	
7	Freezing Fog	-25	2	F1	Conc.	Al. Plate	
8	Freezing Fog	-25	2	F1	Conc.	Al. Plate	
9	Freezing Fog	-25	2	F1	Conc.	Comp. Plate	
10	Freezing Fog	-25	2	F1	Conc.	Comp. Plate	
11	Freezing Fog	-25	5	C2	100	Al. Plate	
12	Freezing Fog	-25	5	C2	100	Al. Plate	
13	Freezing Fog	-25	5	T4	100	Al. Plate	
14	Freezing Fog	-25	5	T4	100	Al. Plate	
15	Freezing Fog	-25	5	C3	100	Al. Plate	
16	Freezing Fog	-25	5	C3	100	Al. Plate	
17	Freezing Fog	-25	5	F1	Conc.	Al. Plate	
18	Freezing Fog	-25	5	F1	Conc.	Al. Plate	
19	Freezing Fog	-25	5	F1	Conc.	Comp. Plate	
20	Freezing Fog	-25	5	F1	Conc.	Comp. Plate	
21	Freezing Fog	-14	2	C2	100	Al. Plate	
22	Freezing Fog	-14	2	C2	100	Al. Plate	
23	Freezing Fog	-14	2	T4	100	Al. Plate	
24	Freezing Fog	-14	2	T4	100	Al. Plate	
25	Freezing Fog	-14	2	C2	75	Al. Plate	
26	Freezing Fog	-14	2	C2	75	Al. Plate	
27	Freezing Fog	-14	2	T4	75	Al. Plate	
28	Freezing Fog	-14	2	T4	75	Al. Plate	
29	Freezing Fog	-14	5	C2	100	Al. Plate	
30	Freezing Fog	-14	5	C2	100	Al. Plate	
31	Freezing Fog	-14	5	T4	100	Al. Plate	
32	Freezing Fog	-14	5	T4	100	Al. Plate	
33	Freezing Fog	-14	5	C2	75	Al. Plate	
34	Freezing Fog	-14	5	C2	75	Al. Plate	
35	Freezing Fog	-14	5	T4	75	Al. Plate	
36	Freezing Fog	-14	5	T4	75	Al. Plate	
37	Freezing Fog	-10	2	C3	100	Al. Plate	
38	Freezing Fog	-10	2	C3	100	Al. Plate	
39	Freezing Fog	-10	2	C3	75	Al. Plate	
40	Freezing Fog	-10	2	C3	75	Al. Plate	
CD40	Freezing Fog	-10	2	C3	75	Al. Plate	Fluid @ OAT
CP40	Freezing Fog	-10	2	C3	75	Comp. Plate	
41	Freezing Fog	-10	2	F1	Conc.	Al. Plate	
42	Freezing Fog	-10	2	F1	Conc.	Al. Plate	
43	Freezing Fog	-10	2	F1	Conc.	Comp. Plate	
44	Freezing Fog	-10	2	F1	Conc.	Comp. Plate	
45	Freezing Fog	-10	5	C3	100	Al. Plate	
46	Freezing Fog	-10	5	C3	100	Al. Plate	

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

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid Code	Fluid Dilution (%)	Test Surface	Comments
47	Freezing Fog	-10	5	C3	75	Al. Plate	
48	Freezing Fog	-10	5	C3	75	Al. Plate	
49	Freezing Fog	-10	5	F1	Conc.	Al. Plate	
50	Freezing Fog	-10	5	F1	Conc.	Al. Plate	
51	Freezing Fog	-10	5	F1	Conc.	Comp. Plate	
52	Freezing Fog	-10	5	F1	Conc.	Comp. Plate	
53	Freezing Fog	-6	2	F1	Conc.	Al. Plate	
54	Freezing Fog	-6	2	F1	Conc.	Al. Plate	
55	Freezing Fog	-6	2	F1	Conc.	Comp. Plate	
56	Freezing Fog	-6	2	F1	Conc.	Comp. Plate	
57	Freezing Fog	-6	5	F1	Conc.	Al. Plate	
58	Freezing Fog	-6	5	F1	Conc.	Al. Plate	
59	Freezing Fog	-6	5	F1	Conc.	Comp. Plate	
60	Freezing Fog	-6	5	F1	Conc.	Comp. Plate	
61	Freezing Fog	-3	2	C2	100	Al. Plate	5 min failure
62	Freezing Fog	-3	2	C2	100	Al. Plate	
63	Freezing Fog	-3	2	T4	100	Al. Plate	5 min failure
64	Freezing Fog	-3	2	T4	100	Al. Plate	
65	Freezing Fog	-3	2	C2	75	Al. Plate	5 min failure
66	Freezing Fog	-3	2	C2	75	Al. Plate	
67	Freezing Fog	-3	2	T4	75	Al. Plate	5 min failure
68	Freezing Fog	-3	2	T4	75	Al. Plate	
69	Freezing Fog	-3	2	C2	50	Al. Plate	5 min failure
70	Freezing Fog	-3	2	C2	50	Al. Plate	
71	Freezing Fog	-3	2	T4	50	Al. Plate	5 min failure
72	Freezing Fog	-3	2	T4	50	Al. Plate	
73	Freezing Fog	-3	2	C3	100	Al. Plate	5 min failure
74	Freezing Fog	-3	2	C3	100	Al. Plate	
75	Freezing Fog	-3	2	C3	75	Al. Plate	5 min failure
76	Freezing Fog	-3	2	C3	75	Al. Plate	
77	Freezing Fog	-3	2	C3	50	Al. Plate	5 min failure
78	Freezing Fog	-3	2	C3	50	Al. Plate	
79	Freezing Fog	-3	2	F1	Conc.	Al. Plate	5 min failure
80	Freezing Fog	-3	2	F1	Conc.	Al. Plate	
81	Freezing Fog	-3	2	F1	Conc.	Comp. Plate	5 min failure
82	Freezing Fog	-3	2	F1	Conc.	Comp. Plate	
83	Freezing Fog	-3	5	C2	100	Al. Plate	
84	Freezing Fog	-3	5	C2	100	Al. Plate	
85	Freezing Fog	-3	5	T4	100	Al. Plate	
86	Freezing Fog	-3	5	T4	100	Al. Plate	
87	Freezing Fog	-3	5	C2	75	Al. Plate	
88	Freezing Fog	-3	5	C2	75	Al. Plate	
89	Freezing Fog	-3	5	T4	75	Al. Plate	
90	Freezing Fog	-3	5	T4	75	Al. Plate	
91	Freezing Fog	-3	5	C2	50	Al. Plate	
92	Freezing Fog	-3	5	C2	50	Al. Plate	
93	Freezing Fog	-3	5	T4	50	Al. Plate	
94	Freezing Fog	-3	5	T4	50	Al. Plate	

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

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid Code	Fluid Dilution (%)	Test Surface	Comments
95	Freezing Fog	-3	5	C3	100	Al. Plate	
96	Freezing Fog	-3	5	C3	100	Al. Plate	
97	Freezing Fog	-3	5	C3	75	Al. Plate	
98	Freezing Fog	-3	5	C3	75	Al. Plate	
99	Freezing Fog	-3	5	C3	50	Al. Plate	
100	Freezing Fog	-3	5	C3	50	Al. Plate	
CD100	Freezing Fog	-3	5	C3	50	Al. Plate	Fluid @ OAT
101	Freezing Fog	-3	5	F1	Conc.	Al. Plate	
102	Freezing Fog	-3	5	F1	Conc.	Al. Plate	
103	Freezing Fog	-3	5	F1	Conc.	Comp. Plate	
104	Freezing Fog	-3	5	F1	Conc.	Comp. Plate	
105	Light Freezing Rain	-10	13	C2	100	Al. Plate	
106	Light Freezing Rain	-10	13	C2	100	Al. Plate	
107	Light Freezing Rain	-10	13	T4	100	Al. Plate	
108	Light Freezing Rain	-10	13	T4	100	Al. Plate	
109	Light Freezing Rain	-10	13	C2	75	Al. Plate	
110	Light Freezing Rain	-10	13	C2	75	Al. Plate	
111	Light Freezing Rain	-10	13	T4	75	Al. Plate	
112	Light Freezing Rain	-10	13	T4	75	Al. Plate	
113	Light Freezing Rain	-10	13	C3	100	Al. Plate	
114	Light Freezing Rain	-10	13	C3	100	Al. Plate	
CD114	Light Freezing Rain	-10	13	C3	100	Al. Plate	Fluid @ OAT
115	Light Freezing Rain	-10	13	C3	75	Al. Plate	
116	Light Freezing Rain	-10	13	C3	75	Al. Plate	
117	Light Freezing Rain	-10	13	F1	Conc.	Al. Plate	
118	Light Freezing Rain	-10	13	F1	Conc.	Al. Plate	
119	Light Freezing Rain	-10	13	F1	Conc.	Comp. Plate	
120	Light Freezing Rain	-10	13	F1	Conc.	Comp. Plate	
121	Light Freezing Rain	-10	25	C2	100	Al. Plate	5 min failure
122	Light Freezing Rain	-10	25	C2	100	Al. Plate	
123	Light Freezing Rain	-10	25	T4	100	Al. Plate	5 min failure
124	Light Freezing Rain	-10	25	T4	100	Al. Plate	
125	Light Freezing Rain	-10	25	C2	75	Al. Plate	5 min failure
126	Light Freezing Rain	-10	25	C2	75	Al. Plate	
127	Light Freezing Rain	-10	25	T4	75	Al. Plate	5 min failure
128	Light Freezing Rain	-10	25	T4	75	Al. Plate	
129	Light Freezing Rain	-10	25	C3	100	Al. Plate	5 min failure
130	Light Freezing Rain	-10	25	C3	100	Al. Plate	
131	Light Freezing Rain	-10	25	C3	75	Al. Plate	5 min failure
132	Light Freezing Rain	-10	25	C3	75	Al. Plate	
CD132	Light Freezing Rain	-10	25	C3	75	Al. Plate	Fluid @ OAT
133	Light Freezing Rain	-10	25	F1	Conc.	Al. Plate	5 min failure
134	Light Freezing Rain	-10	25	F1	Conc.	Al. Plate	
135	Light Freezing Rain	-10	25	F1	Conc.	Comp. Plate	5 min failure
136	Light Freezing Rain	-10	25	F1	Conc.	Comp. Plate	
137	Light Freezing Rain	-6	13	F1	Conc.	Al. Plate	5 min failure
138	Light Freezing Rain	-6	13	F1	Conc.	Al. Plate	
139	Light Freezing Rain	-6	13	F1	Conc.	Comp. Plate	5 min failure

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

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid Code	Fluid Dilution (%)	Test Surface	Comments
140	Light Freezing Rain	-6	13	F1	Conc.	Comp. Plate	
141	Light Freezing Rain	-6	25	F1	Conc.	Al. Plate	5 min failure
142	Light Freezing Rain	-6	25	F1	Conc.	Al. Plate	
143	Light Freezing Rain	-6	25	F1	Conc.	Comp. Plate	5 min failure
144	Light Freezing Rain	-6	25	F1	Conc.	Comp. Plate	
145	Light Freezing Rain	-3	13	C2	100	Al. Plate	5 min failure
146	Light Freezing Rain	-3	13	C2	100	Al. Plate	
147	Light Freezing Rain	-3	13	T4	100	Al. Plate	5 min failure
148	Light Freezing Rain	-3	13	T4	100	Al. Plate	
149	Light Freezing Rain	-3	13	C2	75	Al. Plate	5 min failure
150	Light Freezing Rain	-3	13	C2	75	Al. Plate	
151	Light Freezing Rain	-3	13	T4	75	Al. Plate	5 min failure
152	Light Freezing Rain	-3	13	T4	75	Al. Plate	
153	Light Freezing Rain	-3	13	C2	50	Al. Plate	5 min failure
154	Light Freezing Rain	-3	13	C2	50	Al. Plate	
155	Light Freezing Rain	-3	13	T4	50	Al. Plate	5 min failure
156	Light Freezing Rain	-3	13	T4	50	Al. Plate	
157	Light Freezing Rain	-3	13	C3	100	Al. Plate	5 min failure
158	Light Freezing Rain	-3	13	C3	100	Al. Plate	
159	Light Freezing Rain	-3	13	C3	75	Al. Plate	5 min failure
160	Light Freezing Rain	-3	13	C3	75	Al. Plate	
CD160	Light Freezing Rain	-3	13	C3	75	Al. Plate	Fluid @ OAT
CP160	Light Freezing Rain	-3	13	C3	75	Comp. Plate	
161	Light Freezing Rain	-3	13	C3	50	Al. Plate	5 min failure
162	Light Freezing Rain	-3	13	C3	50	Al. Plate	
163	Light Freezing Rain	-3	25	C2	100	Al. Plate	5 min failure
164	Light Freezing Rain	-3	25	C2	100	Al. Plate	
165	Light Freezing Rain	-3	25	T4	100	Al. Plate	5 min failure
166	Light Freezing Rain	-3	25	T4	100	Al. Plate	
167	Light Freezing Rain	-3	25	C2	75	Al. Plate	5 min failure
168	Light Freezing Rain	-3	25	C2	75	Al. Plate	
169	Light Freezing Rain	-3	25	T4	75	Al. Plate	5 min failure
170	Light Freezing Rain	-3	25	T4	75	Al. Plate	
171	Light Freezing Rain	-3	25	C2	50	Al. Plate	5 min failure
172	Light Freezing Rain	-3	25	C2	50	Al. Plate	
173	Light Freezing Rain	-3	25	T4	50	Al. Plate	5 min failure
174	Light Freezing Rain	-3	25	T4	50	Al. Plate	
175	Light Freezing Rain	-3	25	C3	100	Al. Plate	5 min failure
176	Light Freezing Rain	-3	25	C3	100	Al. Plate	
CD176	Light Freezing Rain	-3	25	C3	100	Al. Plate	Fluid @ OAT
CP176	Light Freezing Rain	-3	25	C3	100	Comp. Plate	
177	Light Freezing Rain	-3	25	C3	75	Al. Plate	5 min failure
178	Light Freezing Rain	-3	25	C3	75	Al. Plate	
179	Light Freezing Rain	-3	25	C3	50	Al. Plate	5 min failure
180	Light Freezing Rain	-3	25	C3	50	Al. Plate	
181	Freezing Drizzle	-10	5	C2	100	Al. Plate	
182	Freezing Drizzle	-10	5	C2	100	Al. Plate	
183	Freezing Drizzle	-10	5	T4	100	Al. Plate	

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

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid Code	Fluid Dilution (%)	Test Surface	Comments
184	Freezing Drizzle	-10	5	T4	100	Al. Plate	
185	Freezing Drizzle	-10	5	C2	75	Al. Plate	
186	Freezing Drizzle	-10	5	C2	75	Al. Plate	
187	Freezing Drizzle	-10	5	T4	75	Al. Plate	
188	Freezing Drizzle	-10	5	T4	75	Al. Plate	
189	Freezing Drizzle	-10	5	C3	100	Al. Plate	
190	Freezing Drizzle	-10	5	C3	100	Al. Plate	
CD190	Freezing Drizzle	-10	5	C3	100	Al. Plate	Fluid @ OAT
CP190	Freezing Drizzle	-10	5	C3	100	Comp. Plate	
191	Freezing Drizzle	-10	5	C3	75	Al. Plate	
192	Freezing Drizzle	-10	5	C3	75	Al. Plate	
193	Freezing Drizzle	-10	5	F1	Conc.	Al. Plate	
194	Freezing Drizzle	-10	5	F1	Conc.	Al. Plate	
195	Freezing Drizzle	-10	5	F1	Conc.	Comp. Plate	
196	Freezing Drizzle	-10	5	F1	Conc.	Comp. Plate	
197	Freezing Drizzle	-10	13	C2	100	Al. Plate	
198	Freezing Drizzle	-10	13	C2	100	Al. Plate	
199	Freezing Drizzle	-10	13	T4	100	Al. Plate	
200	Freezing Drizzle	-10	13	T4	100	Al. Plate	
201	Freezing Drizzle	-10	13	C2	75	Al. Plate	
202	Freezing Drizzle	-10	13	C2	75	Al. Plate	
203	Freezing Drizzle	-10	13	T4	75	Al. Plate	
204	Freezing Drizzle	-10	13	T4	75	Al. Plate	
205	Freezing Drizzle	-10	13	C3	100	Al. Plate	
206	Freezing Drizzle	-10	13	C3	100	Al. Plate	
CD206	Freezing Drizzle	-10	13	C3	100	Al. Plate	Fluid @ OAT
207	Freezing Drizzle	-10	13	C3	75	Al. Plate	
208	Freezing Drizzle	-10	13	C3	75	Al. Plate	
209	Freezing Drizzle	-10	13	F1	Conc.	Al. Plate	
210	Freezing Drizzle	-10	13	F1	Conc.	Al. Plate	
211	Freezing Drizzle	-10	13	F1	Conc.	Comp. Plate	
212	Freezing Drizzle	-10	13	F1	Conc.	Comp. Plate	
213	Freezing Drizzle	-6	5	F1	Conc.	Al. Plate	
214	Freezing Drizzle	-6	5	F1	Conc.	Al. Plate	
215	Freezing Drizzle	-6	5	F1	Conc.	Comp. Plate	
216	Freezing Drizzle	-6	5	F1	Conc.	Comp. Plate	
217	Freezing Drizzle	-6	13	F1	Conc.	Al. Plate	
218	Freezing Drizzle	-6	13	F1	Conc.	Al. Plate	
219	Freezing Drizzle	-6	13	F1	Conc.	Comp. Plate	
220	Freezing Drizzle	-6	13	F1	Conc.	Comp. Plate	
221	Freezing Drizzle	-3	5	C2	100	Al. Plate	5 min failure
222	Freezing Drizzle	-3	5	C2	100	Al. Plate	
223	Freezing Drizzle	-3	5	T4	100	Al. Plate	5 min failure
224	Freezing Drizzle	-3	5	T4	100	Al. Plate	
225	Freezing Drizzle	-3	5	C2	75	Al. Plate	5 min failure
226	Freezing Drizzle	-3	5	C2	75	Al. Plate	
227	Freezing Drizzle	-3	5	T4	75	Al. Plate	5 min failure
228	Freezing Drizzle	-3	5	T4	75	Al. Plate	

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

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid Code	Fluid Dilution (%)	Test Surface	Comments
229	Freezing Drizzle	-3	5	C2	50	Al. Plate	5 min failure
230	Freezing Drizzle	-3	5	C2	50	Al. Plate	
231	Freezing Drizzle	-3	5	T4	50	Al. Plate	5 min failure
232	Freezing Drizzle	-3	5	T4	50	Al. Plate	
233	Freezing Drizzle	-3	5	C3	100	Al. Plate	5 min failure
234	Freezing Drizzle	-3	5	C3	100	Al. Plate	
235	Freezing Drizzle	-3	5	C3	75	Al. Plate	5 min failure
236	Freezing Drizzle	-3	5	C3	75	Al. Plate	
CD236	Freezing Drizzle	-3	5	C3	75	Al. Plate	Fluid @ OAT
237	Freezing Drizzle	-3	5	C3	50	Al. Plate	5 min failure
238	Freezing Drizzle	-3	5	C3	50	Al. Plate	
239	Freezing Drizzle	-3	5	F1	Conc.	Al. Plate	5 min failure
240	Freezing Drizzle	-3	5	F1	Conc.	Al. Plate	
241	Freezing Drizzle	-3	5	F1	Conc.	Comp. Plate	5 min failure
242	Freezing Drizzle	-3	5	F1	Conc.	Comp. Plate	
243	Freezing Drizzle	-3	13	C2	100	Al. Plate	
244	Freezing Drizzle	-3	13	C2	100	Al. Plate	
245	Freezing Drizzle	-3	13	T4	100	Al. Plate	
246	Freezing Drizzle	-3	13	T4	100	Al. Plate	
247	Freezing Drizzle	-3	13	C2	75	Al. Plate	
248	Freezing Drizzle	-3	13	C2	75	Al. Plate	
249	Freezing Drizzle	-3	13	T4	75	Al. Plate	
250	Freezing Drizzle	-3	13	T4	75	Al. Plate	
251	Freezing Drizzle	-3	13	C2	50	Al. Plate	
252	Freezing Drizzle	-3	13	C2	50	Al. Plate	
253	Freezing Drizzle	-3	13	T4	50	Al. Plate	
254	Freezing Drizzle	-3	13	T4	50	Al. Plate	
255	Freezing Drizzle	-3	13	C3	100	Al. Plate	
256	Freezing Drizzle	-3	13	C3	100	Al. Plate	
257	Freezing Drizzle	-3	13	C3	75	Al. Plate	
258	Freezing Drizzle	-3	13	C3	75	Al. Plate	
259	Freezing Drizzle	-3	13	C3	50	Al. Plate	
260	Freezing Drizzle	-3	13	C3	50	Al. Plate	
CD260	Freezing Drizzle	-3	13	C3	50	Al. Plate	Fluid @ OAT
CP260	Freezing Drizzle	-3	13	C3	50	Comp. Plate	
261	Freezing Drizzle	-3	13	F1	Conc.	Al. Plate	
262	Freezing Drizzle	-3	13	F1	Conc.	Al. Plate	
263	Freezing Drizzle	-3	13	F1	Conc.	Comp. Plate	
264	Freezing Drizzle	-3	13	F1	Conc.	Comp. Plate	
265	Cold Soak Box	1	5	C2	100	Al. Box	
266	Cold Soak Box	1	5	C2	100	Al. Box	
267	Cold Soak Box	1	5	T4	100	Al. Box	
268	Cold Soak Box	1	5	T4	100	Al. Box	
269	Cold Soak Box	1	5	C2	75	Al. Box	
270	Cold Soak Box	1	5	C2	75	Al. Box	
271	Cold Soak Box	1	5	T4	75	Al. Box	
272	Cold Soak Box	1	5	T4	75	Al. Box	
273	Cold Soak Box	1	5	C3	100	Al. Box	

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

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid Code	Fluid Dilution (%)	Test Surface	Comments
274	Cold Soak Box	1	5	C3	100	Al. Box	
275	Cold Soak Box	1	5	C3	75	Al. Box	
276	Cold Soak Box	1	5	C3	75	Al. Box	
277	Cold Soak Box	1	5	F1	Conc.	Al. Box	
278	Cold Soak Box	1	5	F1	Conc.	Al. Box	
279	Cold Soak Box	1	5	F1	Conc.	Comp. Box	
280	Cold Soak Box	1	5	F1	Conc.	Comp. Box	
281	Cold Soak Box	1	75	C2	100	Al. Box	
282	Cold Soak Box	1	75	C2	100	Al. Box	
283	Cold Soak Box	1	75	T4	100	Al. Box	
284	Cold Soak Box	1	75	T4	100	Al. Box	
285	Cold Soak Box	1	75	C2	75	Al. Box	
286	Cold Soak Box	1	75	C2	75	Al. Box	
287	Cold Soak Box	1	75	T4	75	Al. Box	
288	Cold Soak Box	1	75	T4	75	Al. Box	
289	Cold Soak Box	1	75	C3	100	Al. Box	
290	Cold Soak Box	1	75	C3	100	Al. Box	
291	Cold Soak Box	1	75	C3	75	Al. Box	
292	Cold Soak Box	1	75	C3	75	Al. Box	
293	Cold Soak Box	1	75	F1	Conc.	Al. Box	
294	Cold Soak Box	1	75	F1	Conc.	Al. Box	
295	Cold Soak Box	1	75	F1	Conc.	Comp. Box	
296	Cold Soak Box	1	75	F1	Conc.	Comp. Box	

TABLE 2: FLUID THICKNESS TEST PLAN

Test #	Fluid Code	Fluid Dilution	Fluid Temp	Test Surface	Ambient Air Temp
TH1	F1	concentrate	20°C	Al. Plate	-3°C
TH2	F1	concentrate	20°C	Al. Plate	-3°C
TH3	C2	100/0	-3°C	Al. Plate	-3°C
TH4	C2	100/0	-3°C	Al. Plate	-3°C
TH5	C2	75/25	-3°C	Al. Plate	-3°C
TH6	C2	75/25	-3°C	Al. Plate	-3°C
TH7	C2	50/50	-3°C	Al. Plate	-3°C
TH8	C2	50/50	-3°C	Al. Plate	-3°C
TH9	C3 WARM	100/0	20°C	Al. Plate	-3°C
TH10	C3 WARM	100/0	20°C	Al. Plate	-3°C
TH11	C3 WARM	75/25	20°C	Al. Plate	-3°C
TH12	C3 WARM	75/25	20°C	Al. Plate	-3°C
TH13	C3 WARM	50/50	20°C	Al. Plate	-3°C
TH14	C3 WARM	50/50	20°C	Al. Plate	-3°C
TH15	T4	100/0	-3°C	Al. Plate	-3°C
TH16	T4	100/0	-3°C	Al. Plate	-3°C
TH17	T4	75/25	-3°C	Al. Plate	-3°C
TH18	T4	75/25	-3°C	Al. Plate	-3°C
TH19	T4	50/50	-3°C	Al. Plate	-3°C
TH20	T4	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 3: ICE PHOBIC ENDURANCE TIME TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid Code	Fluid Dilution	Test Surface	Comments
PH1	Light Freezing Rain	-10	13 (25)	Octagon Octaflo EF	10°B (B=27.0)	Baseline	1 L at 20°C, Brix/thick t=5 min + fail, temp profile
PH2	Light Freezing Rain	-10	13 (25)	Octagon Octaflo EF	10°B (B=27.0)	NUSIL 11	1 L at 20°C, Brix/thick t=5 min + fail, temp profile
PH3	Light Freezing Rain	-10	13 (25)	Octagon Octaflo EF	10°B (B=27.0)	AA C2 (Optional)	1 L at 20°C, Brix/thick t=5 min + fail, temp profile
PH4	Light Freezing Rain	-10	13 (25)	C2	75/25	Baseline	Brix/thick t=5 min and failure
PH5	Light Freezing Rain	-10	13 (25)	C2	75/25	NUSIL 11	Brix/thick t=5 min and failure
PH6	Freezing Drizzle	-10	13 (5)	C2	100/0	Baseline	Brix/thick t=5 min and failure
PH7	Freezing Drizzle	-10	13 (5)	C2	100/0	NUSIL 11	Brix/thick t=5 min and failure
PH8	Light Freezing Rain	-10	25 (13)	Dow UCAR EG106	100/0	Baseline	Brix/thick t=5 min and failure
PH9	Light Freezing Rain	-10	25 (13)	Dow UCAR EG106	100/0	NUSIL 11	Brix/thick t=5 min and failure
PH10	Freezing Drizzle	-3	5 (13)	Dow UCAR ADF (EG)	10°B (B=17.6)	Baseline	1 L at 20°C, Brix/thick t=5 min + fail, temp profile
PH11	Freezing Drizzle	-3	5 (13)	Dow UCAR ADF (EG)	10°B (B=17.6)	NUSIL 11	2 L at 20°C, Brix/thick t=5 min + fail, temp profile
PH12	Freezing Drizzle	-3	5 (13)	Dow UCAR ADF (EG)	10°B (B=17.6)	AA C2 (Optional)	3 L at 20°C, Brix/thick t=5 min + fail, temp profile
PH13	Freezing Drizzle	-3	5 (13)	Octagon Octaflo EF	10°B (B=21.25)	Baseline	4 L at 20°C, Brix/thick t=5 min + fail, temp profile
PH14	Freezing Drizzle	-3	5 (13)	Octagon Octaflo EF	10°B (B=21.25)	NUSIL 11	5 L at 20°C, Brix/thick t=5 min + fail, temp profile
PH15	Freezing Drizzle	-3	5 (13)	Octagon Octaflo EF	10°B (B=21.25)	AA C2 (Optional)	6 L at 20°C, Brix/thick t=5 min + fail, temp profile
PH16	Freezing Drizzle	-3	13 (5)	C2	50/50	Baseline	Brix/thick t=5 min and failure
PH17	Freezing Drizzle	-3	13 (5)	C2	50/50	NUSIL 11	Brix/thick t=5 min and failure
PH18	Freezing Drizzle	-3	13 (5)	Dow UCAR ADF (EG)	10°B (B=17.6)	Baseline	7 L at 20°C, Brix/thick t=5 min + fail, temp profile
PH19	Freezing Drizzle	-3	13 (5)	Dow UCAR ADF (EG)	10°B (B=17.6)	NUSIL 11	8 L at 20°C, Brix/thick t=5 min + fail, temp profile
PH20	Freezing Drizzle	-3	13 (5)	Dow UCAR ADF (EG)	10°B (B=17.6)	AA C2 (Optional)	9 L at 20°C, Brix/thick t=5 min + fail, temp profile

Note: NUSIL 11 = R-3975 with R-1182

TABLE 4: ICE PHOBIC THICKNESS TEST PLAN

Test #	Fluid Name/Code	Fluid Type	Fluid Dilution	Fluid Temp	Test Surface*	Ambient Air Temp
PH-TH1	Dow UCAR ADF (EG)	Type I EG	10°B (B=17.6)	+20°C	Baseline	-3°C
PH-TH2	Dow UCAR ADF (EG)	Type I EG	10°B (B=17.6)	+20°C	NUSIL 11	-3°C
PH-TH3	Dow UCAR ADF (EG)	Type I EG	FFP=-35°C (B=30.5)	+20°C	Baseline	-3°C
PH-TH4	Dow UCAR ADF (EG)	Type I EG	FFP=-35°C (B=30.5)	+20°C	NUSIL 11	-3°C
PH-TH5	C2	Type II PG	100/0	-3°C	Baseline	-3°C
PH-TH6	C2	Type II PG	100/0	-3°C	NUSIL 11	-3°C

* Baseline = Standard aluminum test plate; NuSil = NuSil Ice Phobic treated test plate

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

TABLE 5: ICE PHOBIC ADHERENCE TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate ($g/dm^2/h$)	Fluid Code	Fluid Dilution	Test Surface	Comments
PH-AD1	Light Freezing Rain	-10	13	No fluid	n/a	Standard Plate	Measure adherence
PH-AD2	Light Freezing Rain	-10	13	No fluid	n/a	NUSIL 11	Measure adherence

TABLE 6: ICE PHOBIC DRAINAGE TEST PLAN

Test #	Fluid Name	Fluid Type	Fluid Dilution	DRAIN HOLE TYPE	Test Surface Treatment*	Ambient Air Temp
PH-D1	Dow UCAR ADF (EG)	Type I EG	10°B (B = 17.6)	CIRCULAR	Baseline	-3°C
PH-D2	Dow UCAR ADF (EG)	Type I EG	10°B (B = 17.6)	CIRCULAR	NUSIL 2 (R-1082)	-3°C
PH-D3	Dow UCAR ADF (EG)	Type I EG	10°B (B = 17.6)	CIRCULAR	NUSIL 4 (R-3975)	-3°C
PH-D4	Dow UCAR ADF (EG)	Type I EG	10°B (B = 17.6)	CIRCULAR	Powernano	-3°C
PH-D5	Dow UCAR ADF (EG)	Type I EG	FFP = -35°C (B = 30.5)	CIRCULAR	Baseline	-3°C
PH-D6	Dow UCAR ADF (EG)	Type I EG	FFP = -35°C (B = 30.5)	CIRCULAR	NUSIL 2 (R-1082)	-3°C
PH-D7	Dow UCAR ADF (EG)	Type I EG	FFP = -35°C (B = 30.5)	CIRCULAR	NUSIL 4 (R-3975)	-3°C
PH-D8	Dow UCAR ADF (EG)	Type I EG	FFP = -35°C (B = 30.5)	CIRCULAR	Powernano	-3°C
PH-D9	C3 WARM	TYPE III PG	100/0	CIRCULAR	Baseline	-3°C
PH-D10	C3 WARM	TYPE III PG	100/0	CIRCULAR	NUSIL 2 (R-1082)	-3°C
PH-D11	C3 WARM	TYPE III PG	100/0	CIRCULAR	NUSIL 4 (R-3975)	-3°C
PH-D12	C3 WARM	TYPE III PG	100/0	CIRCULAR	Powernano	-3°C
PH-D13	C2	Type II PG	100/0	CIRCULAR	Baseline	-3°C
PH-D14	C2	Type II PG	100/0	CIRCULAR	NUSIL 2 (R-1082)	-3°C
PH-D15	C2	Type II PG	100/0	CIRCULAR	NUSIL 4 (R-3975)	-3°C
PH-D16	C2	Type II PG	100/0	CIRCULAR	Powernano	-3°C
PH-D17	Dow UCAR ADF (EG)	Type I EG	10°B (B = 17.6)	OVAL	Baseline	-3°C
PH-D18	Dow UCAR ADF (EG)	Type I EG	10°B (B = 17.6)	OVAL	NUSIL 2 (R-1082)	-3°C
PH-D19	Dow UCAR ADF (EG)	Type I EG	10°B (B = 17.6)	OVAL	NUSIL 4 (R-3975)	-3°C
PH-D20	Dow UCAR ADF (EG)	Type I EG	10°B (B = 17.6)	OVAL	Powernano	-3°C
PH-D21	Dow UCAR ADF (EG)	Type I EG	FFP = -35°C (B = 30.5)	OVAL	Baseline	-3°C
PH-D22	Dow UCAR ADF (EG)	Type I EG	FFP = -35°C (B = 30.5)	OVAL	NUSIL 2 (R-1082)	-3°C
PH-D23	Dow UCAR ADF (EG)	Type I EG	FFP = -35°C (B = 30.5)	OVAL	NUSIL 4 (R-3975)	-3°C
PH-D24	Dow UCAR ADF (EG)	Type I EG	FFP = -35°C (B = 30.5)	OVAL	Powernano	-3°C
PH-D25	C3 WARM	TYPE III PG	100/0	OVAL	Baseline	-3°C
PH-D26	C3 WARM	TYPE III PG	100/0	OVAL	NUSIL 2 (R-1082)	-3°C
PH-D27	C3 WARM	TYPE III PG	100/0	OVAL	NUSIL 4 (R-3975)	-3°C
PH-D28	C3 WARM	TYPE III PG	100/0	OVAL	Powernano	-3°C
PH-D29	C2	Type II PG	100/0	OVAL	Baseline	-3°C
PH-D30	C2	Type II PG	100/0	OVAL	NUSIL 2 (R-1082)	-3°C
PH-D31	C2	Type II PG	100/0	OVAL	NUSIL 4 (R-3975)	-3°C
PH-D32	C2	Type II PG	100/0	OVAL	Powernano	-3°C
PH-D33	Dow UCAR ADF (EG)	Type I EG	10°B (B = 17.6)	NARROW SLIT	Baseline	-3°C
PH-D34	Dow UCAR ADF (EG)	Type I EG	10°B (B = 17.6)	NARROW SLIT	NUSIL 2 (R-1082)	-3°C
PH-D35	Dow UCAR ADF (EG)	Type I EG	10°B (B = 17.6)	NARROW SLIT	NUSIL 4 (R-3975)	-3°C
PH-D36	Dow UCAR ADF (EG)	Type I EG	10°B (B = 17.6)	NARROW SLIT	Powernano	-3°C
PH-D37	Dow UCAR ADF (EG)	Type I EG	FFP = -35°C (B = 30.5)	NARROW SLIT	Baseline	-3°C
PH-D38	Dow UCAR ADF (EG)	Type I EG	FFP = -35°C (B = 30.5)	NARROW SLIT	NUSIL 2 (R-1082)	-3°C
PH-D39	Dow UCAR ADF (EG)	Type I EG	FFP = -35°C (B = 30.5)	NARROW SLIT	NUSIL 4 (R-3975)	-3°C
PH-D40	Dow UCAR ADF (EG)	Type I EG	FFP = -35°C (B = 30.5)	NARROW SLIT	Powernano	-3°C
PH-D41	C3 WARM	TYPE III PG	100/0	NARROW SLIT	Baseline	-3°C
PH-D42	C3 WARM	TYPE III PG	100/0	NARROW SLIT	NUSIL 2 (R-1082)	-3°C
PH-D43	C3 WARM	TYPE III PG	100/0	NARROW SLIT	NUSIL 4 (R-3975)	-3°C
PH-D44	C3 WARM	TYPE III PG	100/0	NARROW SLIT	Powernano	-3°C
PH-D45	C2	Type II PG	100/0	NARROW SLIT	Baseline	-3°C
PH-D46	C2	Type II PG	100/0	NARROW SLIT	NUSIL 2 (R-1082)	-3°C
PH-D47	C2	Type II PG	100/0	NARROW SLIT	NUSIL 4 (R-3975)	-3°C
PH-D48	C2	Type II PG	100/0	NARROW SLIT	Powernano	-3°C

Procedure: Measure weight at 15, 30, 45, 60, 90, 120 minutes etc. after pouring

TABLE 7: DEPLOYED FLAPS TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid Code	Fluid Dilution (%)	Test Surface	Comments
DF1	Freezing Drizzle	-3	5	C3 WARM	100/0	Plate (10°)	Thickness at 5 mins, Brix at failure
DF2	Freezing Drizzle	-3	5	C3 WARM	100/0	Plate (20°)	Thickness at 5 mins, Brix at failure
DF3	Freezing Drizzle	-3	5	C3 WARM	100/0	Plate (35°)	Thickness at 5 mins, Brix at failure
DF4	Freezing Drizzle	-10	5	C3 WARM	75/25	Plate (10°)	Brix/thickness every 15 mins
DF5	Freezing Drizzle	-10	5	C3 WARM	75/25	Plate (20°)	Brix/thickness every 15 mins
DF6	Freezing Drizzle	-10	5	C3 WARM	75/25	Plate (35°)	Brix/thickness every 15 mins
DF7	Freezing Drizzle	-10	13	F1	Concentrate	Plate (10°)	Thickness at 5 mins, Brix at failure
DF8	Freezing Drizzle	-10	13	F1	Concentrate	Plate (20°)	Thickness at 5 mins, Brix at failure
DF9	Freezing Drizzle	-10	13	F1	Concentrate	Plate (35°)	Thickness at 5 mins, Brix at failure
DF10	Freezing Fog	-3	5	C3 WARM	50/50	Plate (10°)	Thickness at 5 mins, Brix at failure
DF11	Freezing Fog	-3	5	C3 WARM	50/50	Plate (20°)	Thickness at 5 mins, Brix at failure
DF12	Freezing Fog	-3	5	C3 WARM	50/50	Plate (35°)	Thickness at 5 mins, Brix at failure

TABLE 8: WINDSHIELD WASHER FLUIDS TEST PLAN

Test #	Precipitation Type	Temp (°C)	Precip. Rate (g/dm²/h)	Fluid Name/Code	Fluid Dilution (%)	Test Surface	Comments
WW1	Freezing Fog	-3	2	Octagon Octaflo EF	10° Buf	Clean Plate	Apply 1 L @ 20°C
WW2	Freezing Fog	-3	2	WWF 1 Green	n/a	Clean Plate	Apply 1 L @ 20°C
WW3	Freezing Fog	-3	2	WWF 2 Yellow	n/a	Clean Plate	Apply 1 L @ 20°C
WW4	Freezing Fog	-3	2	Octagon Octaflo EF	10° Buf	Iced Plate Under Spray	Apply 1 L @ 20°C
WW5	Freezing Fog	-3	2	WWF 1 Green	n/a	Iced Plate Under Spray	Apply 1 L @ 20°C
WW6	Freezing Fog	-3	2	WWF 2 Yellow	n/a	Iced Plate Under Spray	Apply 1 L @ 20°C
WW7	Freezing Fog	-3	2	Octagon Octaflo EF	10° Buf	Iced Plate Outside Spray	Apply 1 L @ 20°C
WW8	Freezing Fog	-3	2	WWF 1 Green	n/a	Iced Plate Outside Spray	Apply 1 L @ 20°C
WW9	Freezing Fog	-3	2	WWF 2 Yellow	n/a	Iced Plate Outside Spray	Apply 1 L @ 20°C
WW10	Freezing Fog	-14	2	Octagon Octaflo EF	10° Buf	Clean Plate	Apply 1 L @ 20°C
WW11	Freezing Fog	-14	2	WWF 1 Green	n/a	Clean Plate	Apply 1 L @ 20°C
WW12	Freezing Fog	-14	2	WWF 2 Yellow	n/a	Clean Plate	Apply 1 L @ 20°C
WW13	Freezing Fog	-14	2	Octagon Octaflo EF	10° Buf	Iced Plate Under Spray	Apply 1 L @ 20°C
WW14	Freezing Fog	-14	2	WWF 1 Green	n/a	Iced Plate Under Spray	Apply 1 L @ 20°C
WW15	Freezing Fog	-14	2	WWF 2 Yellow	n/a	Iced Plate Under Spray	Apply 1 L @ 20°C
WW16	Freezing Fog	-14	2	Octagon Octaflo EF	10° Buf	Iced Plate Outside Spray	Apply 1 L @ 20°C
WW17	Freezing Fog	-14	2	WWF 1 Green	n/a	Iced Plate Outside Spray	Apply 1 L @ 20°C
WW18	Freezing Fog	-14	2	WWF 2 Yellow	n/a	Iced Plate Outside Spray	Apply 1 L @ 20°C
WW19	Freezing Fog	-25	2	Octagon Octaflo EF	10° Buf	Clean Plate	Apply 1 L @ 20°C
WW20	Freezing Fog	-25	2	WWF 1 Green	n/a	Clean Plate	Apply 1 L @ 20°C
WW21	Freezing Fog	-25	2	WWF 2 Yellow	n/a	Clean Plate	Apply 1 L @ 20°C
WW22	Freezing Fog	-25	2	Octagon Octaflo EF	10° Buf	Iced Plate Under Spray	Apply 1 L @ 20°C
WW23	Freezing Fog	-25	2	WWF 1 Green	n/a	Iced Plate Under Spray	Apply 1 L @ 20°C
WW24	Freezing Fog	-25	2	WWF 2 Yellow	n/a	Iced Plate Under Spray	Apply 1 L @ 20°C
WW25	Freezing Fog	-25	2	Octagon Octaflo EF	10° Buf	Iced Plate Outside Spray	Apply 1 L @ 20°C
WW26	Freezing Fog	-25	2	WWF 1 Green	n/a	Iced Plate Outside Spray	Apply 1 L @ 20°C
WW27	Freezing Fog	-25	2	WWF 2 Yellow	n/a	Iced Plate Outside Spray	Apply 1 L @ 20°C

Notes:

- Consider doing duplicate runs with backpack sprayer in 1 or 2 of the 9 sets
- If necessary, tests can be run at a rate of 5 g/dm²/h

TABLE 9: LIST OF FLUIDS

Fluid	Fluid Code	Batch #	Fluid Temp	Fluid Dil or Brix (FFP)	Litres Required per Project							Total Litres	Pour Bottles	Notes
					ET	TH	IP-ET	IP-TH	IP-D	DF	WW			
Clariant Safewing 2031	C3 WARM	TV512	20°C	100	34	2	-	-	5	3	-	44	8	
Clariant Safewing 2031	C3 WARM	TV512	20°C	75	30	2	-	-	-	3	-	35	8	
Clariant Safewing 2031	C3 WARM	TV512	20°C	50	13	2	-	-	-	3	-	18	8	
Clariant Safewing 2031	C3 COLD	TV512	OAT	100	4	-	-	-	-	-	-	4	4	*
Clariant Safewing 2031	C3 COLD	TV512	OAT	75	4	-	-	-	-	-	-	4	4	*
Clariant Safewing 2031	C3 COLD	TV512	OAT	50	2	-	-	-	-	-	-	2	2	*
Clariant Flight Plus	C2	TV513	OAT	100	32	2	2	2	5	-	-	43	8	
Clariant Flight Plus	C2	TV513	OAT	75	28	2	2	-	-	-	-	32	8	
Clariant Flight Plus	C2	TV513	OAT	50	12	2	2	-	-	-	-	16	8	
TBD	T4	TBD	OAT	100	32	2	-	-	-	-	-	34	8	
TBD	T4	TBD	OAT	75	28	2	-	-	-	-	-	30	8	
TBD	T4	TBD	OAT	50	12	2	-	-	-	-	-	14	8	
Dow EG106	n/a	WT.11.12.EG106	OAT	100	-	-	2	-	-	-	-	2	2	*
Hokkaido Fever Snow	F1	11/11/2011	20°C	Concentrate	80	2	-	2	-	3	-	87	8	
Octagon Octaflo EF	n/a	WL102009	20°C	21.25 (-13°C)	-	-	15	-	-	-	3	18	3	
Octagon Octaflo EF	n/a	WL102009	20°C	27.0 (-20°C)	-	-	3	-	-	-	-	3	3	**
Octagon Octaflo EF	n/a	WL102009	20°C	29.5 (-24°C)	-	-	-	-	-	-	3	3	3	**
Octagon Octaflo EF	n/a	WL102009	20°C	34.5 (-35°C)	-	-	-	-	-	-	3	3	3	**
Dow UCAR EG	n/a	Aeromag 2009 or 2011	20°C	17.6 (-13°C)	-	-	30	2	5	-	-	37	4	
Dow UCAR EG	n/a		20°C	30.5 (-35°C)	-	-		-	5	-	-	5	0	***
All Fluids					311	20	56	6	20	12	9	434	108	

Warm Storage Fluid

Cold Storage Fluid

Notes:

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

**Fluid requirements met by fluid brought in pour containers, consider bringing 5L concentrate in large container for spare (label made)

***Pack 5 L in one jug, no pour containers needed as all fluid for drainage project

Attention: WARM and COLD labels should go on ALL pour and large C3 containers

TABLE 10: 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
-35	-25	50.3	30.5	2.0	2.0

TABLE 11: EQUIPMENT LIST

HOT, 5 MIN, PH-ET,THICKNESS AND PH-TH PROJECTS	
EQUIPMENT	**LOCATION**
1L Pour containers (see separate list)	Site
20L/gas jug for PH-ET tests	Site
Barrel Opener	Site
Boards for cold-soak test x13	Site
Brixometer x 3	Site
Close circuit TV camera for rates	Site
Cold-soak boxes (all in good condition)	Site
Collection pans for stands (one per stand)	Site
Composite Boxes x2	Site
Composite Plates x2	Site
Electrical Extension Cords x2	Site
Empty 20 L cont. for -30C CSW fluid	Site
Fluids (see Table 7)	Site
Funnels x 4	Site
Gloves - yellow	Site
Hard Water (1x18L)	Site
Hard water chemicals	Site
Ice Phobic Plates x2 (AA, Nusil)	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 (various sizes)	Site
Memory Card Reader	Site
Mixing buckets for Type I fluids	Site
Nuts to separate plates x 100	Site
Plate covers x 16	Site
Plates: 12 w/logging +15 w/o logging	Site
Printer & Ink Cartridge	Site
Protective clothing x 4	Site
Scrapers x 10 (Buy 5)	Buy/Site
Shelving unit x 1	Site
Shop Vac + Sump Pump + Tubing	Site
Speed tape	Site
Tape measure (yellow + small)	Site
Temperature probes: immersion x 2	Site
Temperature probes: surface x 2	Site
Test Stand Shims (poker chips)	Site
Test Stands: 2 x 6-position (main stand)	Site
Test Stands: 3 position (side stand)	Site
Test Stands: 6 position (for small end)	Site
Thermistor Kit/blue USB/black RS232/box	Site
Thickness Gauges x 4 (both types)	Site
Vise grip (large) for containers	Site
Walkie Talkies x 4	Site
Weigh Scale x 2 (sartorius) + wiring	Site
White boards for water run-off	Site
Yellow Carrying Cases x2	Site
Yellow Ice Pic	Site
Scrapers x 10 (Buy 5)	Buy/Site

Gloves - cotton	Buy
Paper Towels (lots)	Buy
Rubber squeegees x 10	Buy

Cold-soak box filling stand	NRC
Cold-soak fluid pump	NRC
Fluid for cold-soak boxes (barrel)	NRC
Rubber Mats	NRC
Tote for Waste Fluid	NRC

Accordian Folder	Office
Camera Suitcase Pack	Office
Chamber Settings	Office
Clipboards x 10	Office
Data Forms (on water phobic paper)	Office
Envelopes (9x12) x box	Office
Hard Drive with Current Project folder	Office
Mouse for Rate Station	Office
MR camera x 1 (has video capability)	Office
One Temp Logger Laptop (MR)	Office
Paper for printer (1 pack)	Office
Pencils (sharpened) + pens + markers	Office
Precipitation Rate Pans x 100	Office
Rate computer x2	Office
Test Procedures x 2 (1 sided)	Office
Waterproof paper (100 sheets)	Office

WWF PROJECT	
EQUIPMENT	**LOCATION**
WWF 1 Green x 9 L	Site
WWF 2 Yellow x 9 L	Site

DEPLOYED FLAPS PROJECT	
EQUIPMENT	**LOCATION**
20° Stand x1	Site
35° Stand x1	Site

PH-ADHERENCE PROJECT	
EQUIPMENT	**LOCATION**
Adhesion probe	Site

PH-DRAINAGE PROJECT	
EQUIPMENT	**LOCATION**
Drainage containers - uncoated	Buy (MR)
Drainage containers - coated	Buy (MR)
Measuring cups/containers	Buy (MR)

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)

Time of Fluid Application:

Initial Plate Temperature (°C)
(NEEDS TO BE WITHIN 0.5°C OF AIR TEMP)

Initial Fluid Temperature (°C)
(NEEDS TO BE WITHIN 3°C OF AIR TEMP)

	Plate 1			Plate 2			Plate 3			Plate 4			Plate 5			Plate 6		
FLUID NAME/BATCH																		
B1 B2 B3																		
C1 C2 C3																		
D1 D2 D3																		
E1 E2 E3																		
F1 F2 F3																		
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA																		
FAILURE CALL (circle)	V. Difficult	Difficult	Easy	V. Difficult	Difficult	Easy	V. Difficult	Difficult	Easy	V. Difficult	Difficult	Easy	V. Difficult	Difficult	Easy	V. Difficult	Difficult	Easy
HRZ. AIR VELOCITY * (circle)	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C

Time of Fluid Application:

Initial Plate Temperature (°C)
(NEEDS TO BE WITHIN 0.5°C OF AIR TEMP)

Initial Fluid Temperature (°C)
(NEEDS TO BE WITHIN 3°C OF AIR TEMP)

	Plate 7			Plate 8			Plate 9			Plate 10			Plate 11			Plate 12		
FLUID NAME/BATCH																		
B1 B2 B3																		
C1 C2 C3																		
D1 D2 D3																		
E1 E2 E3																		
F1 F2 F3																		
TIME TO FIRST PLATE FAILURE WITHIN WORK AREA																		
FAILURE CALL (circle)	V. Difficult	Difficult	Easy	V. Difficult	Difficult	Easy	V. Difficult	Difficult	Easy	V. Difficult	Difficult	Easy	V. Difficult	Difficult	Easy	V. Difficult	Difficult	Easy
HRZ. AIR VELOCITY * (circle)	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C

PRECIP (circle): ZF , ZD , ZR-, MOD AMBIENT TEMPERATURE: _____ °C

COMMENTS: _____

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

LEADER / MANAGER: _____

FIGURE 4: NRC RATE MANAGEMENT FORM

DATE: _____

CONDITION: _____ TECHNICIAN: _____

PAN #	TAB	TIME OUT	1st or 2nd Rate

FIGURE 5: FLUID THICKNESS DATA FORM

DATE: _____ TEMPERATURE °C (beg.): _____ PERFORMED BY: _____

TEST #: _____to_____ WIND SPEED, kph (beg.): _____ WRITTEN BY: _____

STAND: _____ LOCATION: CEF (NRC)

THICKNESS (mil)											
Plate: U Run #: Fluid: Application Time:		Plate: V Run #: Fluid: Application Time:		Plate: W Run #: Fluid: Application Time:		Plate: X Run #: Fluid: Application Time:		Plate: Y Run #: Fluid: Application Time:		Plate: Z Run #: Fluid: Application Time:	
TIME	6" LINE	TIME	6" LINE	TIME	6" LINE	TIME	6" LINE	TIME	6" LINE	TIME	6" LINE

I:\Groups\Cm1680 (01-02)\Procedures\Thickness\Thickness Form

Notes:

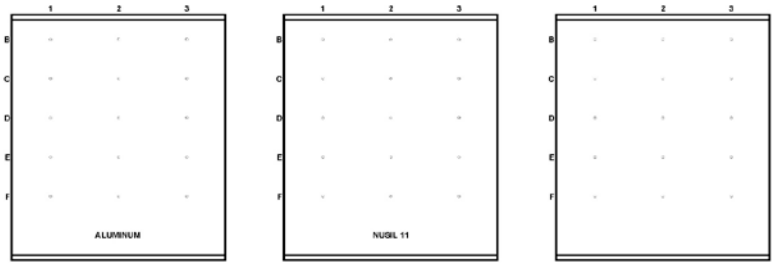
- The quantity of fluid that will be poured for each test is 1.0 L
- Measurements should be made at the 15-cm line at the time of fluid application, and after 2, 5, 15 and 30 minutes
- If the results for one fluid vary by more than 10% repeat the two tests and disregard the highest and lowest values

FIGURE 6: ICE PHOBIC END CONDITION DATA FORM

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

PLATE #			
SURFACE	Aluminum	NUSIL 11	
FLUID NAME			
TIME OF FLUID APPLICATION			
TIME OF FLUID FAILURE			

DESCRIDE ADHESION AND DRAW FAILURE AT TIME OF PLATE 1 FAILURE



BRIX MEASUREMENTS (TIME / BRIX)

5 MIN	/	5 MIN	/	5 MIN	/
END	/	END	/	END	/
AT P1 FAIL	/	AT P1 FAIL	/	AT P1 FAIL	/

THICKNESS MEASUREMENTS (TIME / THICKNESS)

5 MIN	/	5 MIN	/	5 MIN	/
END	/	END	/	END	/
AT P1 FAIL	/	AT P1 FAIL	/	AT P1 FAIL	/

ADDITIONAL COMMENTS

ALUMINUM	NUSIL 11	

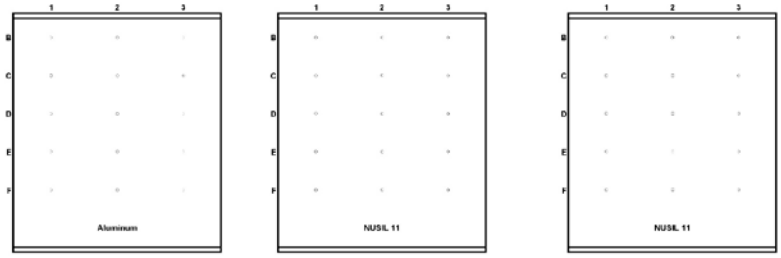
check if there are more notes on the other side ☐

PERFORMED BY: _____ WRITTEN BY: _____

FIGURE 7: ICE PHOBIC THICKNESS DATA FORM

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

PLATE #			
SURFACE	Aluminum	NUSIL 11	
FLUID NAME			
TIME OF FLUID APPLICATION			



THICKNESS MEASUREMENTS (mil)

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

PERFORMED BY: _____ WRITTEN BY: _____

M:\Projects\PM2265.001 (TC Deicing 2011-2012)\Procedures\NRC March 2012\Final Version 1.0
Final Version 1.0, March 12

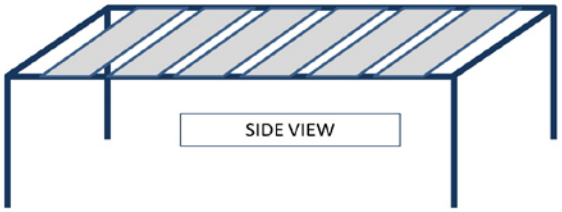
35 of 38

FIGURE 8: OVERNIGHT ICE STAND INSPECTION DATA FORM

FORM FOR OVERNIGHT ICE (STAND INSPECTION)

LOCATION: NRC	CONDITION:	DATE:	TIME:	STAND#:

DESCRIBE ADHESION AND DRAW ICE ON DIAGRAMS



SIDE VIEW



TOP VIEW



ZOOM VIEW

ADDITIONAL COMMENTS _____

check if there are more notes on the other side ☐

PERFORMED BY: _____ WRITTEN BY: _____

FIGURE 9: ICE PHOBIC DRAINAGE DATA FORM

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

PAN #			
DRAIN HOLE TYPE			
FLUID NAME			
FLUID QUANTITY			
TIME OF FLUID APPLICATION			

TOP VIEW OF PAN

DRAW DRAIN HOLE AND DESCRIBE GEL FORMATIONS

THICKNESS MEASUREMENTS (mil)

Time	WEIGHT	Time	WEIGHT	Time	WEIGHT

ADDITIONAL COMMENTS

PERFORMED BY: WRITTEN BY:

FIGURE 10: FLUID BRIX / THICKNESS DATA FORM

FLUID BRIX/THICKNESS DATA FORM

DATE: _____ PERFORMED BY: _____

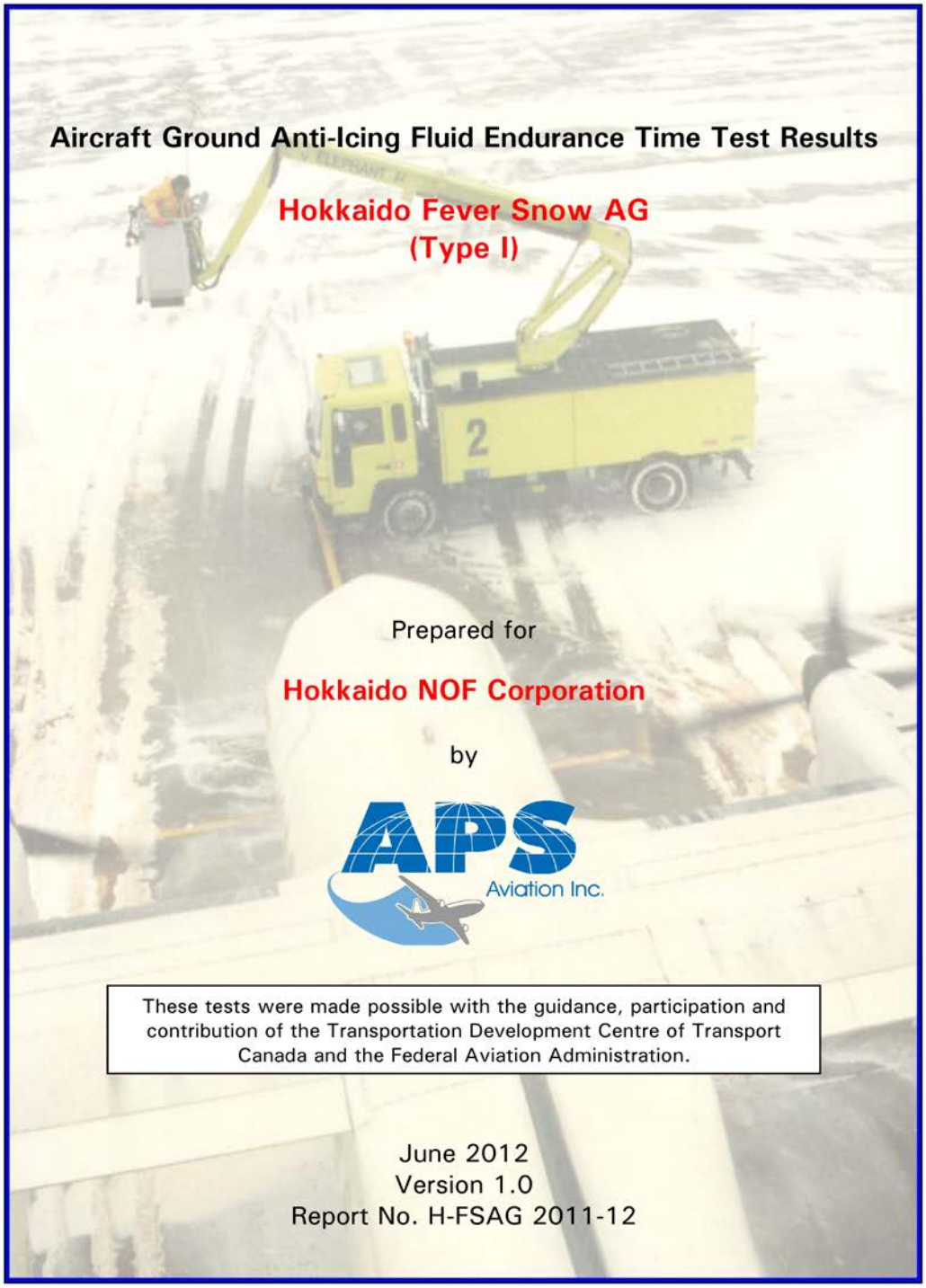
RUN #: _____ WRITTEN BY: _____

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

APPENDIX C

FLUID MANUFACTURER REPORT:
HOKKAIDO FEVER SNOW AG (TYPE I)


Aircraft Ground Anti-Icing Fluid Endurance Time Test Results
Hokkaido Fever Snow AG
(Type I)
Prepared for
Hokkaido NOF Corporation
by
APS
Aviation Inc.
These tests were made possible with the guidance, participation and contribution of the Transportation Development Centre of Transport Canada and the Federal Aviation Administration.
June 2012
Version 1.0
Report No. H-FSAG 2011-12

Aircraft Ground Anti-Icing Fluid Endurance Time Test Results

Hokkaido Fever Snow AG
(Type I)

Prepared for

Hokkaido NOF Corporation

Prepared by: Stephanie Bendickson, Project Analyst — June 13, 2012 (Date)

Reviewed by: John D'Avirro, Program Manager, Eng. — June 13, 2012 (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.

June 2012
Version 1.0
Report No. H-FSAG 2011-12

FLUID IDENTIFICATION AND CHARACTERISTICS

Manufacturer:	Hokkaido NOF Corporation
Fluid Test Name:	Fever Snow AG
Fluid Commercial Name:	Fever Snow AG
Fluid Type / Colour:	Type I / Clear
Fluid Formulation:	Non-glycol
Fluid Dilution Tested:	Ready-to-Use
Batch #:	11-11-11
Date of Receipt:	November 18, 2011
Brix (Measured):	Concentrate: > 50°
WSET (from AMIL):	6.7 minutes

This page intentionally left blank.

SUMMARY

The primary objective of this project was to measure the endurance time performance of Hokkaido Fever Snow AG 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).

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 natural snow and in simulated freezing fog, freezing drizzle, light freezing rain, and rain on cold soaked wing. 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 were similar or superior to those of Type I fluids tested in past years. As a result, it was concluded that Hokkaido Fever Snow AG can be used with the Type I generic HOT guidelines.

This page intentionally left blank.

TABLE OF CONTENTS

Page

1. INTRODUCTION 1

2. METHODOLOGY 3

2.1 Test Sites 3
2.2 Test Equipment 4
2.2.1 Calibration 4
2.2.2 Environmental Chamber Equipment 4
2.2.3 Test Surface Structures 4
2.2.4 Test Surface Materials 6
2.2.5 Test Stands 6
2.2.6 Collection Pans 7
2.2.7 NRC Sprayer Assembly 7
2.2.8 Refractometer 8
2.2.9 12-Hole Spreader 8
2.2.10 Fluids 8
2.3 Test Procedures 8
2.3.1 Test Protocol – Natural Snow Tests 8
2.3.2 Test Protocol – Simulated Precipitation Tests 9
2.3.3 End Condition Definitions 9
2.3.4 Precipitation Rate Measurement Procedures 9
2.4 Precipitation Rate Limits in Type I Endurance Time Testing 12
2.4.1 Freezing Fog 13
2.4.2 Freezing Drizzle 13
2.4.3 Light Freezing Rain 14
2.4.4 Rain on a Cold-Soaked Surface 14
2.4.5 Snow 14
2.5 Ambient Temperatures in Type I Endurance Time Testing 14
2.6 Freezing Precipitation Droplet Sizes 15
2.7 Summary of Freezing Precipitation Test Conditions 16
2.8 Analysis Methodology 17

3. DESCRIPTION OF DATA 25

3.1 Natural Snow Tests 25
3.2 Freezing Fog Tests 25
3.3 Freezing Drizzle Tests 25
3.4 Light Freezing Rain Tests 26
3.5 Rain on Cold-Soaked Surface Tests 26
3.6 Fluid Thickness Tests 26
3.7 Summary of Tests Performed 27

4. RESULTS AND DISCUSSION 31

4.1 Data 31
4.2 Discussion 31

This page intentionally left blank.

LIST OF FIGURES

Page

Figure 2.1: APS Test Site at Montréal-Pierre-Elliott-Trudeau International Airport 3
Figure 2.2: Standard Test Plate Schematic 5
Figure 2.3: Cold Soak Box Schematic 5
Figure 2.4: Test Stand Setup Schematic 6
Figure 2.5: Schematic of Outdoor Precipitation Measurement Pan 7
Figure 2.6: Calculation of Outdoor Precipitation Rate 11
Figure 2.7: Precipitation Rate Limits Used in Endurance Time Testing 13
Figure 4.1: Freezing Fog, -3°C and Above, Aluminum Surface 32
Figure 4.2: Freezing Fog, -3°C and Above, Composite Surface 32
Figure 4.3: Freezing Fog, Below -3 to -6°C, Aluminum Surface 33
Figure 4.4: Freezing Fog, Below -3 to -6°C, Composite Surface 33
Figure 4.5: Freezing Fog, Below -6 to -10°C, Aluminum Surface 34
Figure 4.6: Freezing Fog, Below -6 to -10°C, Composite Surface 34
Figure 4.7: Freezing Fog, Below -10°C, Aluminum Surface 35
Figure 4.8: Freezing Fog, Below -10°C, Composite Surface 35
Figure 4.9: Freezing Drizzle, -3°C and Above, Aluminum Surface 36
Figure 4.10: Freezing Drizzle, -3°C and Above, Composite Surface 36
Figure 4.11: Freezing Drizzle, Below -3 to -6°C, Aluminum Surface 37
Figure 4.12: Freezing Drizzle, Below -3 to -6°C, Composite Surface 37
Figure 4.13: Freezing Drizzle, Below -6 to -10°C, Aluminum Surface 38
Figure 4.14: Freezing Drizzle, Below -6 to -10°C, Composite Surface 38
Figure 4.15: Light Freezing Rain, Below -3 to -6°C, Aluminum Surface 39
Figure 4.16: Light Freezing Rain, Below -3 to -6°C, Composite Surface 39
Figure 4.17: Light Freezing Rain, Below -6 to -10°C, Aluminum Surface 40
Figure 4.18: Light Freezing Rain, Below -6 to -10°C, Composite Surface 40
Figure 4.19: Rain on Cold-Soaked Surface, -3°C and Above, Aluminum Surface 41
Figure 4.20: Rain on Cold-Soaked Surface, -3°C and Above, Composite Surface 41
Figure 4.21: Natural Snow, -3°C and Above, Aluminum Surface 42
Figure 4.22: Natural Snow, -3°C and Above, Composite Surface 42
Figure 4.23: Natural Snow, Below -3 to -6°C, Aluminum Surface 43
Figure 4.24: Natural Snow, Below -3 to -6°C, Composite Surface 43

LIST OF TABLES

Page

Table 2.1: Definition of Weather Phenomenon 12
Table 2.2: Theoretical and Experimental MVDs 15
Table 2.3: Summary of Freezing Precipitation Test Conditions (Type I Fluids) 17
Table 3.1: Fluid Thickness Measurements 26
Table 3.2: Summary of Tests Performed 28

LIST OF PHOTOS

Page

Photo 2.1: APS Test Site - View from Test Pad 19
Photo 2.2: APS Test Site - View from Trailer 19
Photo 2.3: Outdoor View of NRC Climatic Engineering Facility 20
Photo 2.4: Inside View of NRC Climatic Engineering Facility 20
Photo 2.5: Test Plates Mounted on Stand 21
Photo 2.6: Cold-Soak / Leading Edge Thermal Equivalent Box 21
Photo 2.7: Collection Pans Used Indoors at the NRC 22

Photo 2.8: Sprayer Assembly 22
Photo 2.9: Sprayer Assembly in Use 23
Photo 2.10: Sprayer Nozzle 23
Photo 2.11: Hand Held Brixometer 24
Photo 2.12: Twelve Hole Spreader Used for Fluid Application 24

×

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
SAE	Society of Automotive Engineers, Inc.
TDC	Transportation Development Centre

This page intentionally left blank.

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 that Type I fluids formulated with glycol perform in a similar manner from an endurance time perspective. 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 **Hokkaido Fever Snow AG**, a new non-glycol based Type I fluid. 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).

This page intentionally left blank.

2

2. METHODOLOGY

Society of Automotive Engineers (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 snow testing was performed at the APS test site located at the Montréal-Pierre-Elliott-Trudeau International Airport. The location of the test site is shown on the plan view of the airport shown in Figure 2.1. Photos 2.1 and 2.2 show the test site; the site consists of two trailers and three test stand platforms. The APS test site is located near the Meteorological Services of Canada (a division of Environment Canada) automated weather observation station.

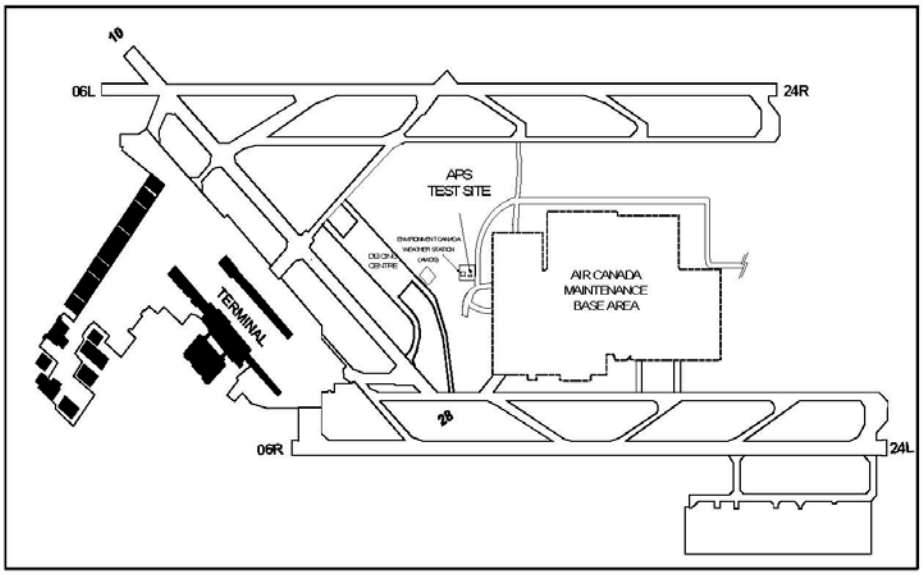


Figure 2.1: APS Test Site at Montréal-Pierre-Elliott-Trudeau International Airport

Tests under conditions of simulated freezing fog, freezing drizzle, light freezing rain and rain on cold soaked wing were 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 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.

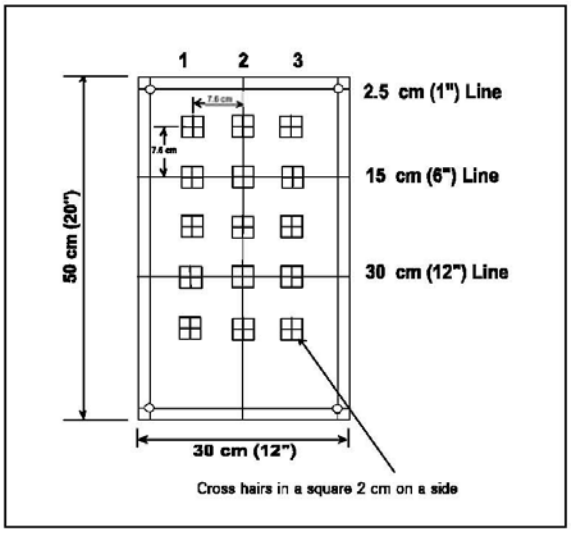


Figure 2.2: Standard Test Plate Schematic

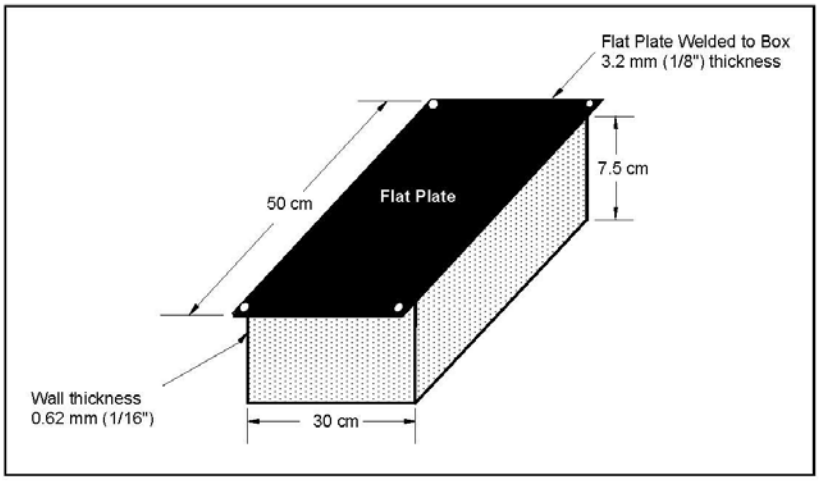


Figure 2.3: Cold Soak Box Schematic

2.2.4 Test Surface Materials

Extensive research has shown holdover 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 new 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.

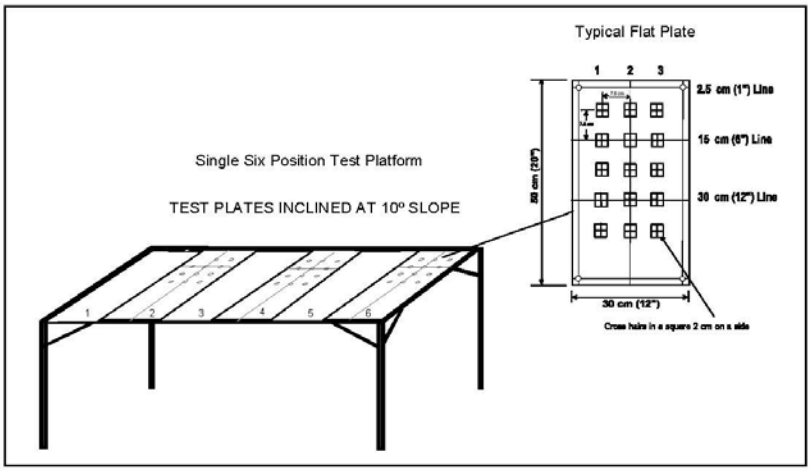


Figure 2.4: Test Stand Setup Schematic

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.

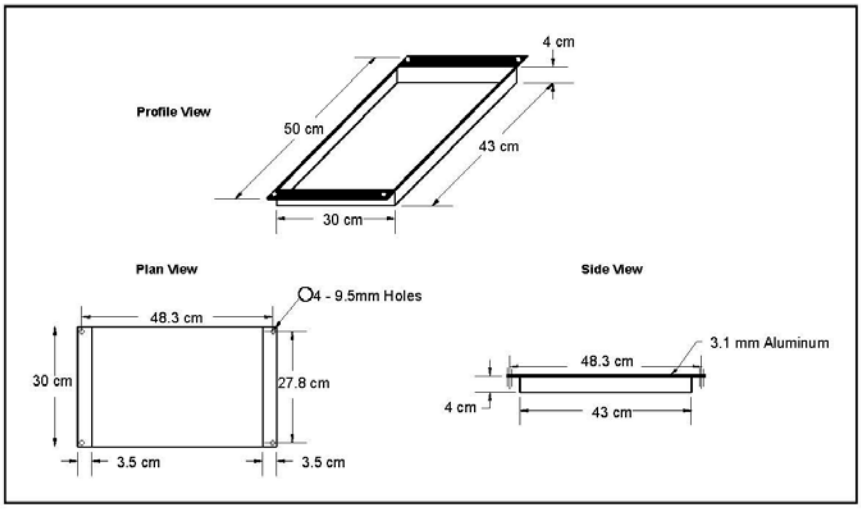


Figure 2.5: Schematic of Outdoor Precipitation Measurement Pan

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 was used to apply fluids during natural snow tests (see Photo 2.12).

2.2.10 Fluids

Hokkaido Fever Snow AG was submitted for testing as a ready-to-use fluid. Therefore all testing was carried out with the fluid in concentrate form; the fluid was not diluted for any tests.

2.3 Test Procedures

ARP5945 provides the procedure for endurance time testing of Type I fluids under natural precipitation conditions and simulated freezing 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 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 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 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);
- Cold-soak surface tests are conducted on filled cold-soak boxes (see Section 2.2.3);
- Fluid is applied at a temperature of 20°C; and
- 1 L of fluid is hand-poured on the test surface.

2.3.3 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.

2.3.4 Precipitation Rate Measurement Procedures

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

2.3.4.1 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.

2.3.4.2 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 2.4) 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. 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).

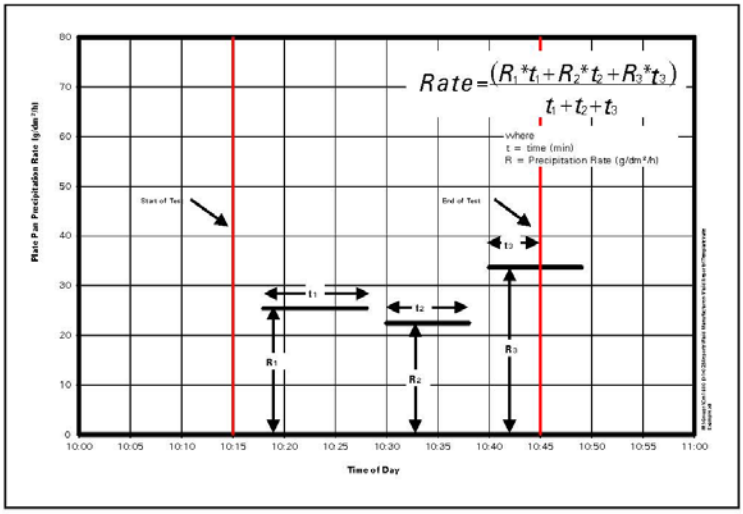


Figure 2.6: Calculation of Outdoor Precipitation Rate

In order to calculate the average rate for this pan, the following formula is then used:

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

In the example shown in Figure 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.

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 2.1 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 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 2.1.

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)
Measured Intensity Light (-)	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.
Measured Intensity Moderate	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.
Measured Intensity Heavy (+)	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)

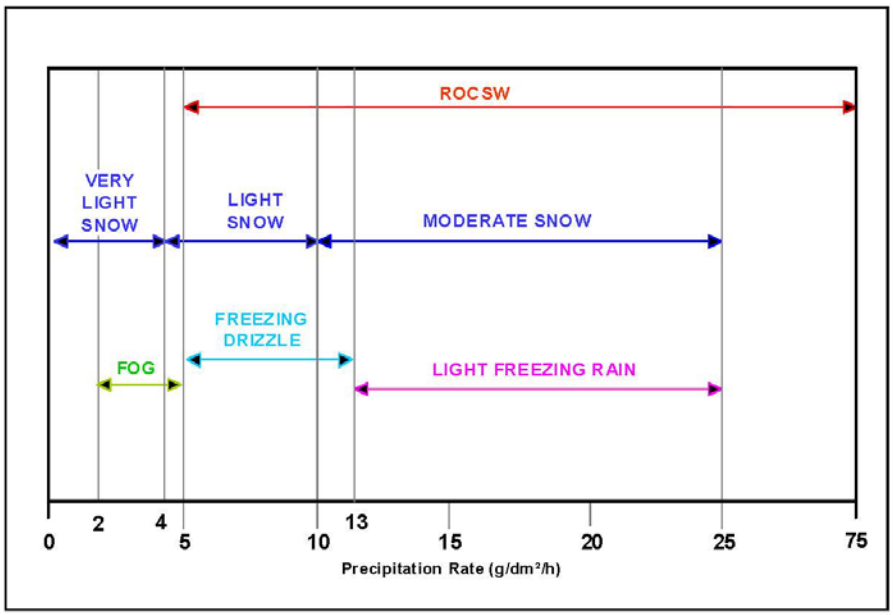


Figure 2.7: Precipitation Rate Limits Used in Endurance Time Testing

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/dm²/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/dm²/h. This range encompasses drizzle (5 to 13 g/dm²/h), light rain (13 to 25 g/dm²/h), and moderate rain (25 to 75 g/dm²/h).

2.4.5 Snow

The precipitation rate limits used to determine holdover times for Type I fluids in snow are as follows:

a) Very light snow: 4 g/dm²/h;

b) Light snow: 4 and 10 g/dm²/h; and

c) Moderate snow: 10 and 25 g/dm²/h.

Notably, Type II and Type IV holdover times are determined using the precipitation rate limits for moderate snow: 10 and 25 g/dm²/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 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 2.2: 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 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 2.3.

Table 2.3: Summary of Freezing Precipitation Test Conditions (Type I Fluids)

Precipitation Type	Ambient Temperature	Precipitation Rate (Droplet Size)
Freezing Fog	-3°C	2 g/dm^2/h (30 μm)
		5 g/dm^2/h (30 μm)
	-6°C	2 g/dm^2/h (30 μm)
		5 g/dm^2/h (30 μm)
	-10°C	2 g/dm^2/h (30 μm)
		5 g/dm^2/h (30 μm)
	-25°C	2 g/dm^2/h (30 μm)
		5 g/dm^2/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)

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.

This page intentionally left blank.

18

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

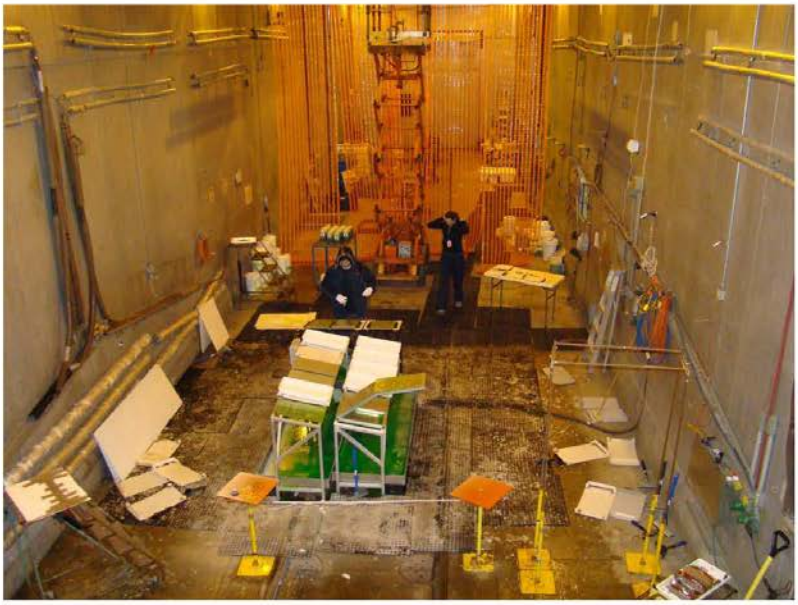


Photo 2.5: Test Plates Mounted on Stand



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

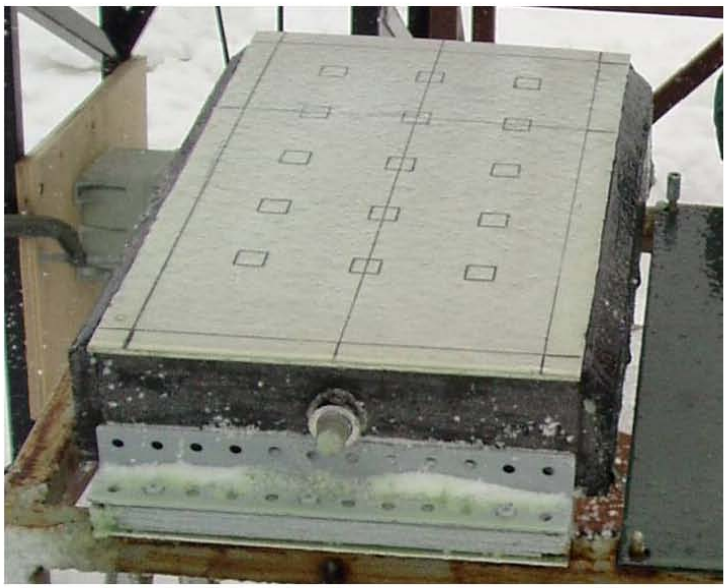


Photo 2.7: Collection Pans Used Indoors at the NRC



Photo 2.8: Sprayer Assembly



Photo 2.9: Sprayer Assembly in Use



Photo 2.10: Sprayer Nozzle

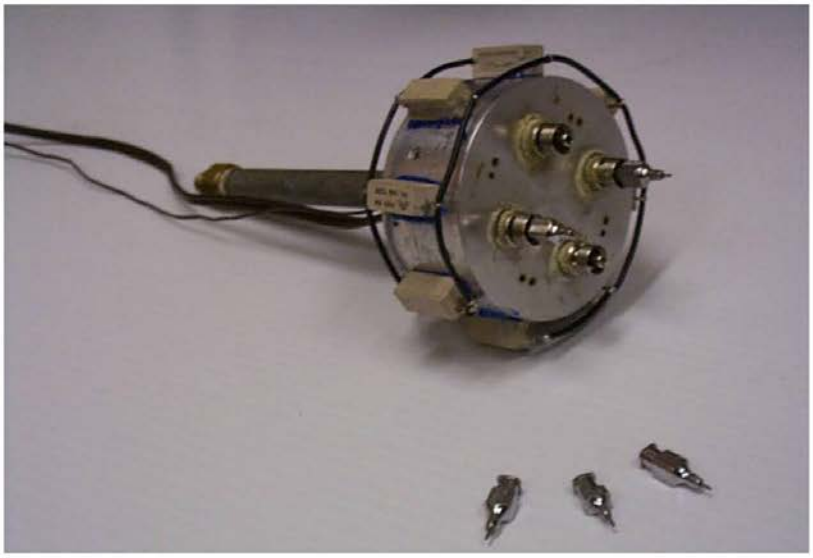


Photo 2.11: Hand Held Brixometer



Photo 2.12: Twelve Hole Spreader Used for Fluid Application



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

Sixteen tests were conducted in natural snow at the APS test site. The number of tests conducted is shown below by fluid dilution, test surface and temperature. For comparison, simultaneous tests were conducted with a baseline Type I fluid.

Fluid Dilution	Test Surface	≥ -3°C	-3 to -6°C	-6 to -10°C	< -10°C
Concentrate	Aluminum	1	7	0	0
Concentrate	Composite	1	7	0	0

3.2 Freezing Fog Tests

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

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

3.3 Freezing Drizzle Tests

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

Fluid Dilution	Test Surface	-3°C	-6°C	-10°C
Concentrate	Aluminum	4	4	4
Concentrate	Composite	4	4	4

3.4 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 fluid dilution, test surface and temperature.

Fluid Dilution	Test Surface	-3°C	-6°C	-10°C
Concentrate	Aluminum	0*	4	4
Concentrate	Composite	0*	4	4

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

3.5 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 fluid dilution, test surface and temperature.

Fluid Dilution	Test Surface	+ 1°C
Concentrate	Aluminum	4
Concentrate	Composite	4

3.6 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 Hokkaido Fever Snow AG under dry conditions. Two tests were performed at an ambient temperature of -3°C. The measurements are displayed in Table 3.1.

Table 3.1: Fluid Thickness Measurements

Measurement	Time After Application (mins)	Thickness (mm)	
		Run 1	Run 2
1	2	0.2	0.2
2	5	0.1	0.1
3	15	0.1	0.1
4	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.

3.7 Summary of Tests Performed

A summary of the details of each test performed is provided in Table 3.2. The table includes the test number, date the test was conducted, fluid name and dilution, the precipitation type, the test surface, the air temperature, the measured precipitation rate and the measured endurance time.

Table 3.2: 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)
7	26-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Alum. Plate	-26.0	2.1	18.8
8	26-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Alum. Plate	-26.0	2.0	17.7
9	26-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Comp. Plate	-26.0	2.1	16.8
10	26-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Comp. Plate	-26.0	2.0	16.8
17	26-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Alum. Plate	-26.0	4.7	9.6
18	26-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Alum. Plate	-26.1	4.7	10.7
19	26-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Comp. Plate	-26.2	4.3	9.4
20	26-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Comp. Plate	-26.5	4.7	9.2
41	27-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Alum. Plate	-10.0	1.6	19.9
42	27-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Alum. Plate	-10.0	1.9	20.1
43	27-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Comp. Plate	-10.2	2.0	18.3
44	27-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Comp. Plate	-10.1	1.8	17.5
49	27-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Alum. Plate	-10.2	5.7	9.9
50	27-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Alum. Plate	-10.2	5.6	9.7
51	27-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Comp. Plate	-10.2	5.5	9.8
52	27-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Comp. Plate	-10.2	5.6	9.7
53	27-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Alum. Plate	-5.9	1.7	21.8
54	27-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Alum. Plate	-5.9	1.8	22.4
55	27-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Comp. Plate	-5.9	1.7	21.6
56	27-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Comp. Plate	-5.9	1.7	23.6
57	28-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Alum. Plate	-5.7	4.7	10.9
58	28-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Alum. Plate	-5.8	4.8	11.8
59	28-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Comp. Plate	-6.1	4.7	13.4
60	28-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Comp. Plate	-6.2	4.6	12.7
79	27-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Alum. Plate	-2.6	1.8	25.9
80	27-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Alum. Plate	-2.4	1.7	31.4
81	27-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Comp. Plate	-2.5	1.8	30.2
82	27-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Comp. Plate	-2.5	1.7	29.6
101	28-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Alum. Plate	-3.0	5.0	15.8
102	28-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Alum. Plate	-2.8	5.2	13.8
103	28-Mar-12	Fever Snow AG	Ready to Use	Freezing Fog	Comp. Plate	-3.0	5.0	16.4
117	21-Mar-12	Fever Snow AG	Ready to Use	Light Freezing Rain	Alum. Plate	-10.3	13.5	7.0
118	21-Mar-12	Fever Snow AG	Ready to Use	Light Freezing Rain	Alum. Plate	-10.3	13.4	7.2
119	21-Mar-12	Fever Snow AG	Ready to Use	Light Freezing Rain	Comp. Plate	-10.4	13.3	7.4
120	21-Mar-12	Fever Snow AG	Ready to Use	Light Freezing Rain	Comp. Plate	-10.4	13.4	7.4
133	21-Mar-12	Fever Snow AG	Ready to Use	Light Freezing Rain	Alum. Plate	-10.4	25.3	5.6
134	21-Mar-12	Fever Snow AG	Ready to Use	Light Freezing Rain	Alum. Plate	-10.4	25.3	5.7
135	21-Mar-12	Fever Snow AG	Ready to Use	Light Freezing Rain	Comp. Plate	-10.5	25.6	5.1
136	21-Mar-12	Fever Snow AG	Ready to Use	Light Freezing Rain	Comp. Plate	-10.5	25.1	5.5
137	22-Mar-12	Fever Snow AG	Ready to Use	Light Freezing Rain	Alum. Plate	-5.7	13.3	9.5
138	22-Mar-12	Fever Snow AG	Ready to Use	Light Freezing Rain	Alum. Plate	-5.7	12.8	9.2
139	22-Mar-12	Fever Snow AG	Ready to Use	Light Freezing Rain	Comp. Plate	-5.8	12.6	8.9

Table 3.2 (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)
140	22-Mar-12	Fever Snow AG	Ready to Use	Light Freezing Rain	Comp. Plate	-5.8	12.8	9.7
141	22-Mar-12	Fever Snow AG	Ready to Use	Light Freezing Rain	Alum. Plate	-5.3	25.2	7.6
142	22-Mar-12	Fever Snow AG	Ready to Use	Light Freezing Rain	Alum. Plate	-5.3	25.1	7.1
143	22-Mar-12	Fever Snow AG	Ready to Use	Light Freezing Rain	Comp. Plate	-5.4	25.0	8.8
144	22-Mar-12	Fever Snow AG	Ready to Use	Light Freezing Rain	Comp. Plate	-5.4	25.2	7.5
193	21-Mar-12	Fever Snow AG	Ready to Use	Freezing Drizzle	Alum. Plate	-10.3	5.5	10.7
194	21-Mar-12	Fever Snow AG	Ready to Use	Freezing Drizzle	Alum. Plate	-10.4	6.0	10.3
195	21-Mar-12	Fever Snow AG	Ready to Use	Freezing Drizzle	Comp. Plate	-10.1	5.5	10.4
196	21-Mar-12	Fever Snow AG	Ready to Use	Freezing Drizzle	Comp. Plate	-10.6	5.6	11.0
209	21-Mar-12	Fever Snow AG	Ready to Use	Freezing Drizzle	Alum. Plate	-10.8	13.7	6.8
210	21-Mar-12	Fever Snow AG	Ready to Use	Freezing Drizzle	Alum. Plate	-10.8	13.7	6.8
211	21-Mar-12	Fever Snow AG	Ready to Use	Freezing Drizzle	Comp. Plate	-10.5	13.7	67.6
212	21-Mar-12	Fever Snow AG	Ready to Use	Freezing Drizzle	Comp. Plate	-10.5	13.7	7.7
213	22-Mar-12	Fever Snow AG	Ready to Use	Freezing Drizzle	Alum. Plate	-5.6	5.4	12.1
214	22-Mar-12	Fever Snow AG	Ready to Use	Freezing Drizzle	Alum. Plate	-5.6	5.2	13.2
215	22-Mar-12	Fever Snow AG	Ready to Use	Freezing Drizzle	Comp. Plate	-5.6	5.1	14.3
216	22-Mar-12	Fever Snow AG	Ready to Use	Freezing Drizzle	Comp. Plate	-5.6	5.0	14.2
217	21-Mar-12	Fever Snow AG	Ready to Use	Freezing Drizzle	Alum. Plate	-6.6	13.5	9.5
218	21-Mar-12	Fever Snow AG	Ready to Use	Freezing Drizzle	Alum. Plate	-6.6	12.7	7.4
219	21-Mar-12	Fever Snow AG	Ready to Use	Freezing Drizzle	Comp. Plate	-6.6	12.8	8.7
220	21-Mar-12	Fever Snow AG	Ready to Use	Freezing Drizzle	Comp. Plate	-6.6	13.5	9.3
239	22-Mar-12	Fever Snow AG	Ready to Use	Freezing Drizzle	Alum. Plate	-2.5	5.6	14.9
240	22-Mar-12	Fever Snow AG	Ready to Use	Freezing Drizzle	Alum. Plate	-2.6	5.6	16.8
241	22-Mar-12	Fever Snow AG	Ready to Use	Freezing Drizzle	Comp. Plate	-2.6	5.6	21.3
242	22-Mar-12	Fever Snow AG	Ready to Use	Freezing Drizzle	Comp. Plate	-2.6	5.6	19.0
261	22-Mar-12	Fever Snow AG	Ready to Use	Freezing Drizzle	Alum. Plate	-2.5	13.7	12.4
262	22-Mar-12	Fever Snow AG	Ready to Use	Freezing Drizzle	Alum. Plate	-2.5	13.9	12.1
263	22-Mar-12	Fever Snow AG	Ready to Use	Freezing Drizzle	Comp. Plate	-2.5	13.9	14.5
264	22-Mar-12	Fever Snow AG	Ready to Use	Freezing Drizzle	Comp. Plate	-2.6	13.7	14.5
277	23-Mar-12	Fever Snow AG	Ready to Use	Cold Soak Box	Alum. Box	1.3	5.1	11.4
278	23-Mar-12	Fever Snow AG	Ready to Use	Cold Soak Box	Alum. Box	0.8	5.3	11.3
279	23-Mar-12	Fever Snow AG	Ready to Use	Cold Soak Box	Comp. Box	1.3	5.5	13.7
280	23-Mar-12	Fever Snow AG	Ready to Use	Cold Soak Box	Comp. Box	1.3	5.1	12.9
293	23-Mar-12	Fever Snow AG	Ready to Use	Cold Soak Box	Alum. Box	0.7	76.3	2.7
294	23-Mar-12	Fever Snow AG	Ready to Use	Cold Soak Box	Alum. Box	0.7	75.9	3.0
295	23-Mar-12	Fever Snow AG	Ready to Use	Cold Soak Box	Comp. Box	0.7	76.3	2.7
296	23-Mar-12	Fever Snow AG	Ready to Use	Cold Soak Box	Comp. Box	0.8	76.3	2.6
8	17-Jan-12	Fever Snow AG	Ready to Use	Natural Snow	Alum. Box	-4.3	11.8	10.1
11	17-Jan-12	Fever Snow AG	Ready to Use	Natural Snow	Comp. Box	-4.3	11.9	7.6
14	17-Jan-12	Fever Snow AG	Ready to Use	Natural Snow	Alum. Box	-3.7	10.5	9.9
17	17-Jan-12	Fever Snow AG	Ready to Use	Natural Snow	Comp. Box	-3.7	10.5	8.6
20	17-Jan-12	Fever Snow AG	Ready to Use	Natural Snow	Alum. Box	-3.6	19.8	7.6

Table 3.2 (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)
23	17-Jan-12	Fever Snow AG	Ready to Use	Natural Snow	Comp. Box	-3.6	20.0	5.2
26	17-Jan-12	Fever Snow AG	Ready to Use	Natural Snow	Alum. Box	-3.5	6.1	14.1
29	17-Jan-12	Fever Snow AG	Ready to Use	Natural Snow	Comp. Box	-3.5	6.0	11.2
32	26-Jan-12	Fever Snow AG	Ready to Use	Natural Snow	Alum. Box	-5.3	7.2	12.7
35	26-Jan-12	Fever Snow AG	Ready to Use	Natural Snow	Comp. Box	-5.3	7.4	9.5
38	26-Jan-12	Fever Snow AG	Ready to Use	Natural Snow	Alum. Box	-5.8	6.6	13.6
41	26-Jan-12	Fever Snow AG	Ready to Use	Natural Snow	Comp. Box	-5.8	6.6	9.5
44	26-Jan-12	Fever Snow AG	Ready to Use	Natural Snow	Alum. Box	-5.7	5.7	14.8
47	26-Jan-12	Fever Snow AG	Ready to Use	Natural Snow	Comp. Box	-5.7	5.7	12.8
124	3-Mar-12	Fever Snow AG	Ready to Use	Natural Snow	Alum. Box	-0.3	22.9	9.3
125	3-Mar-12	Fever Snow AG	Ready to Use	Natural Snow	Comp. Box	-0.3	22.8	5.6

4. RESULTS AND DISCUSSION

The endurance time test results of Hokkaido Fever Snow 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 Data

Figures 4.1 to 4.24 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) and the lower temperature snow cells in which data was not collected. Each chart contains the Hokkaido Fever Snow AG 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).

4.2 Discussion

The data collected shows the endurance times Hokkaido Fever Snow AG 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 or in many cases superior to glycol based Type I fluids from an endurance time perspective and therefore can be used with the generic Type I HOT guidelines. The superior results are likely due to the fluid being tested ready-to-use rather than mixed to a 10°C buffer.

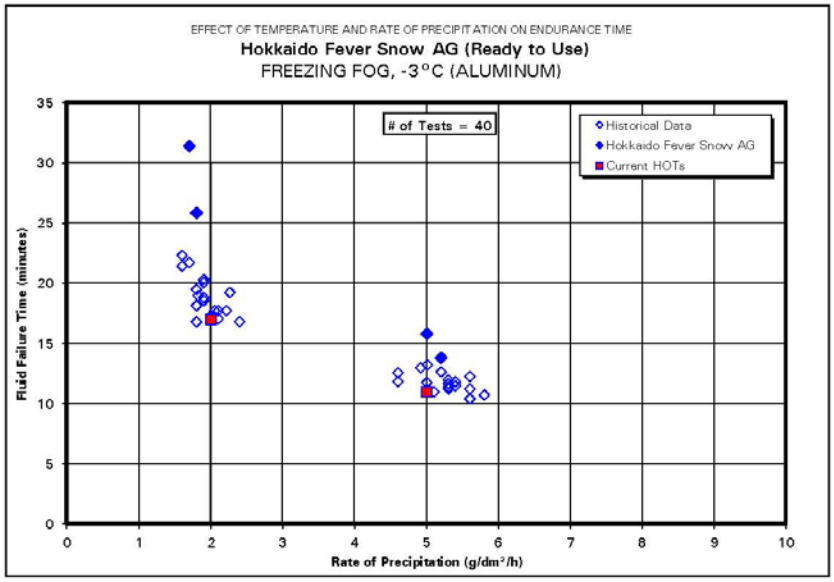


Figure 4.1: Freezing Fog, -3°C and Above, Aluminum Surface

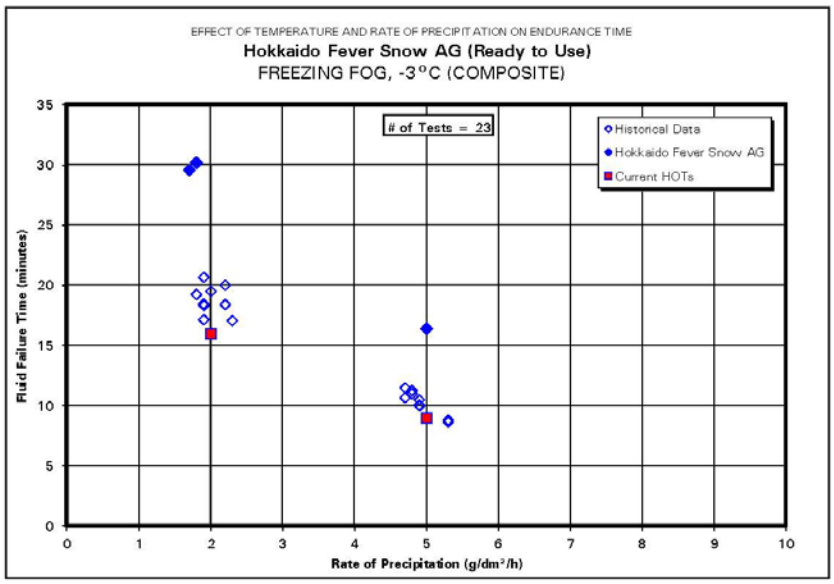


Figure 4.2: Freezing Fog, -3°C and Above, Composite Surface

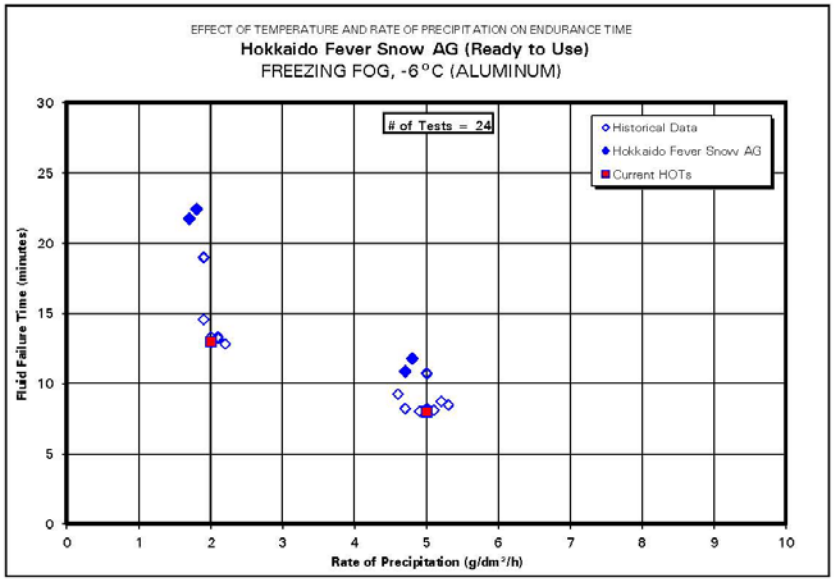


Figure 4.3: Freezing Fog, Below -3 to -6°C, Aluminum Surface

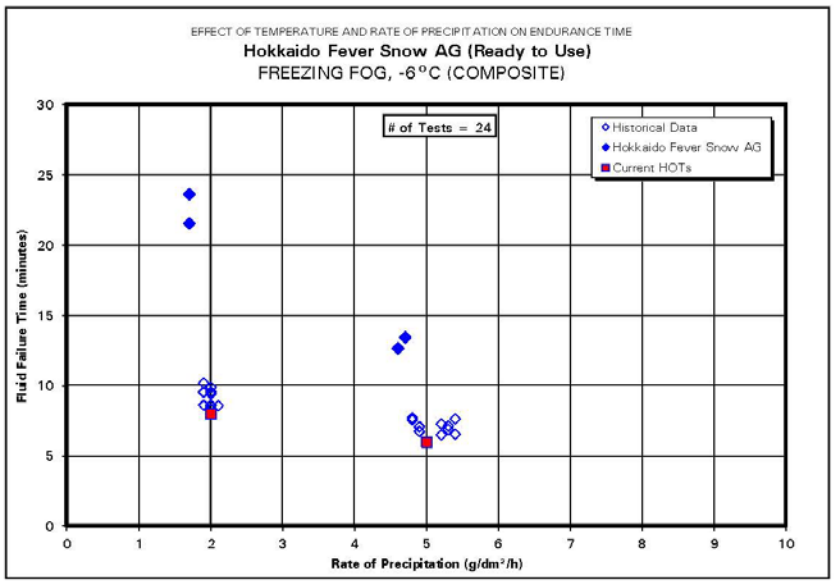


Figure 4.4: Freezing Fog, Below -3 to -6°C, Composite Surface

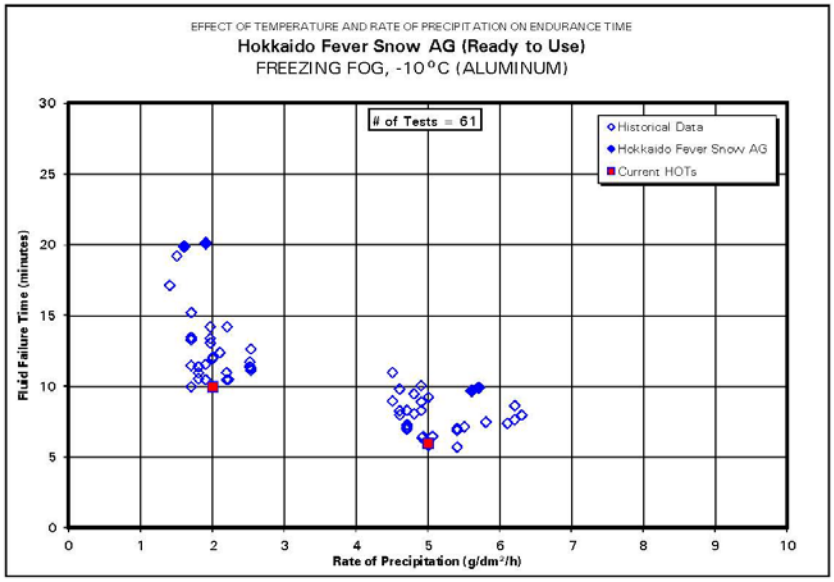


Figure 4.5: Freezing Fog, Below -6 to -10°C, Aluminum Surface

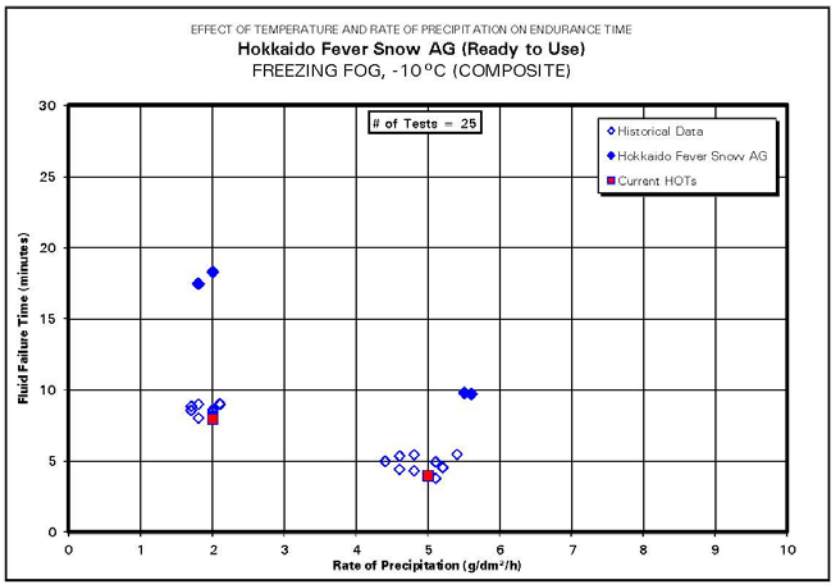


Figure 4.6: Freezing Fog, Below -6 to -10°C, Composite Surface

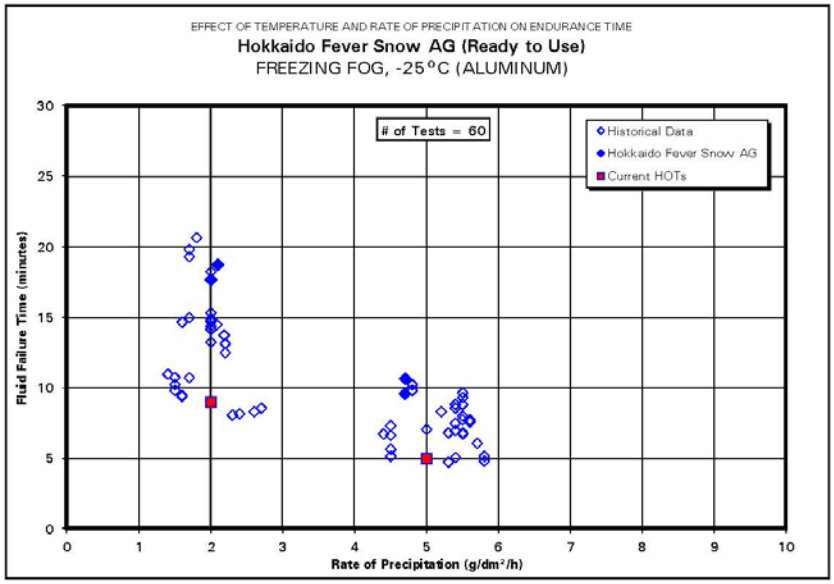


Figure 4.7: Freezing Fog, Below -10°C, Aluminum Surface

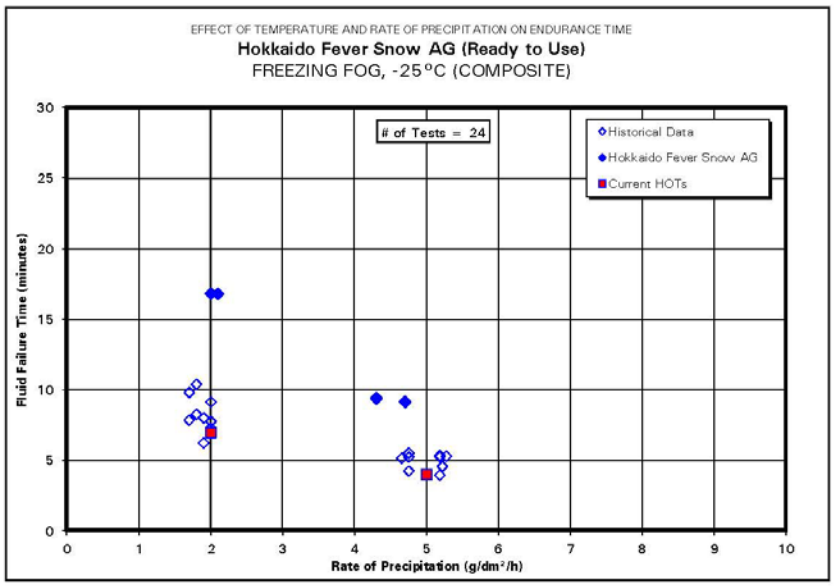


Figure 4.8: Freezing Fog, Below -10°C, Composite Surface

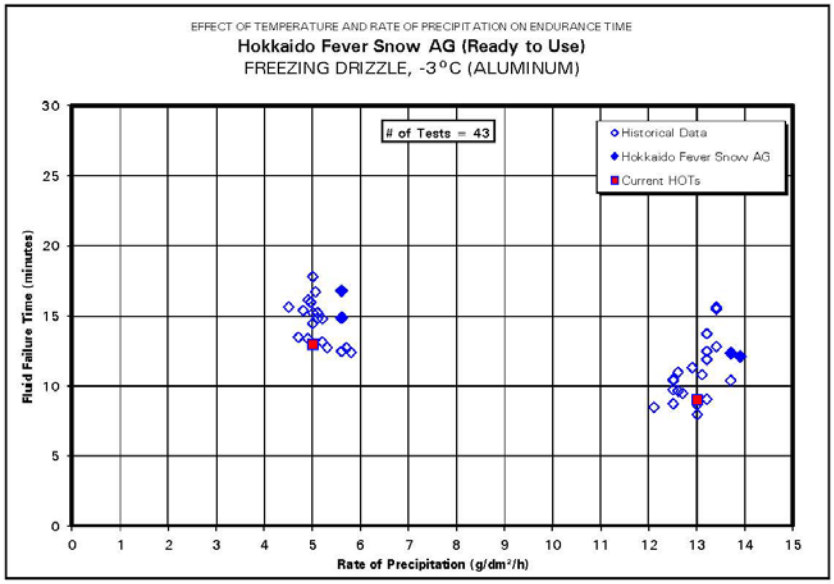


Figure 4.9: Freezing Drizzle, -3°C and Above, Aluminum Surface

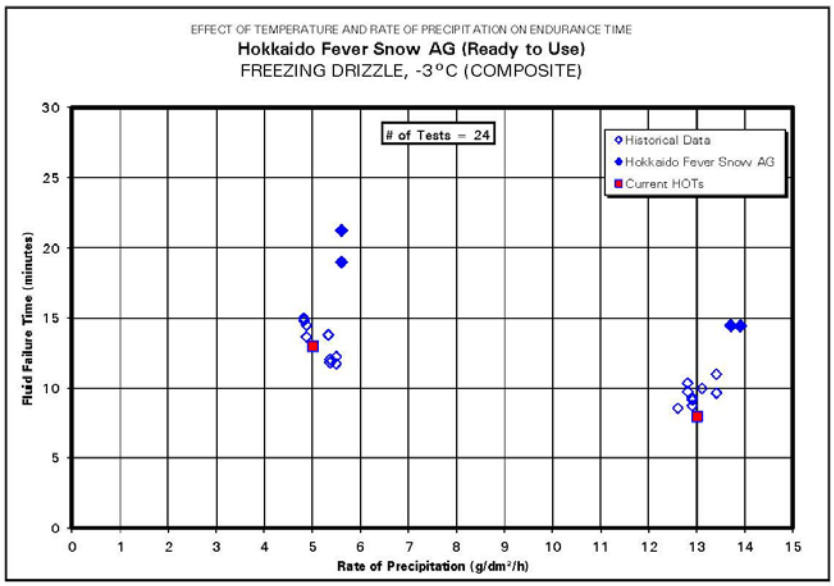


Figure 4.10: Freezing Drizzle, -3°C and Above, Composite Surface

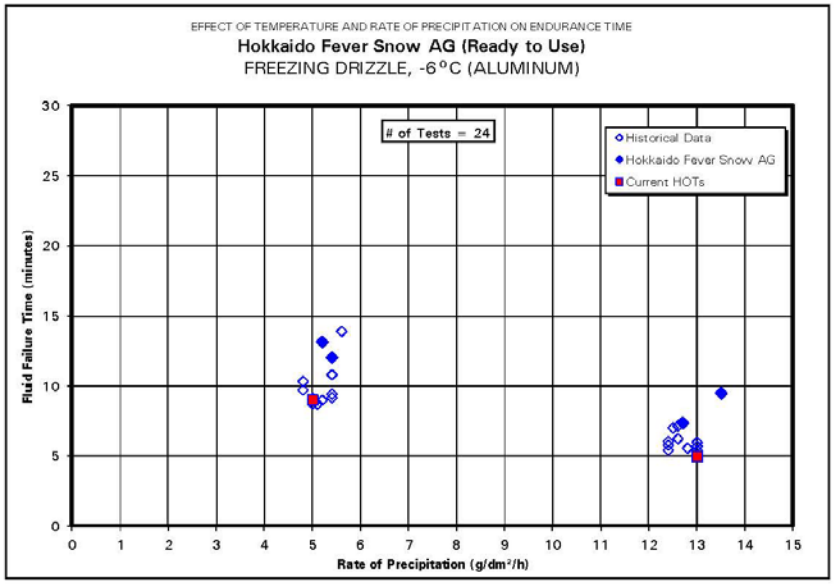


Figure 4.11: Freezing Drizzle, Below -3 to -6°C, Aluminum Surface

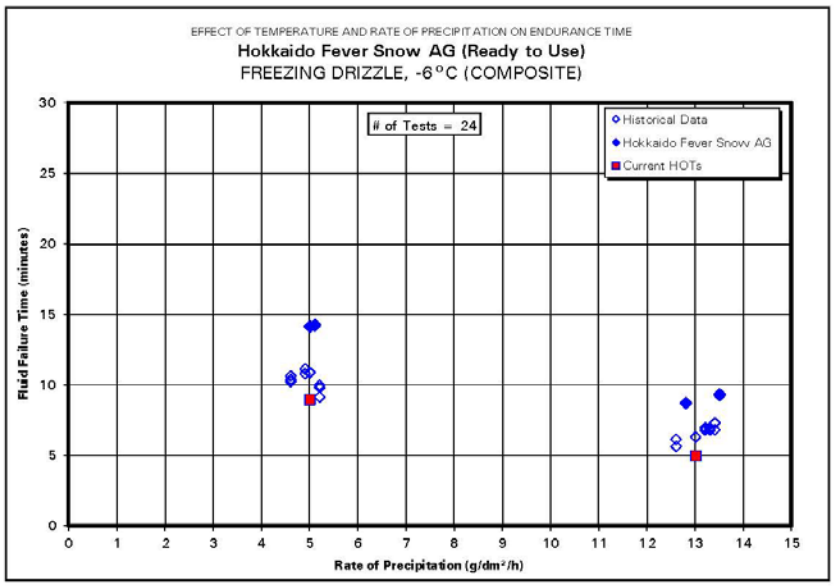


Figure 4.12: Freezing Drizzle, Below -3 to -6°C, Composite Surface

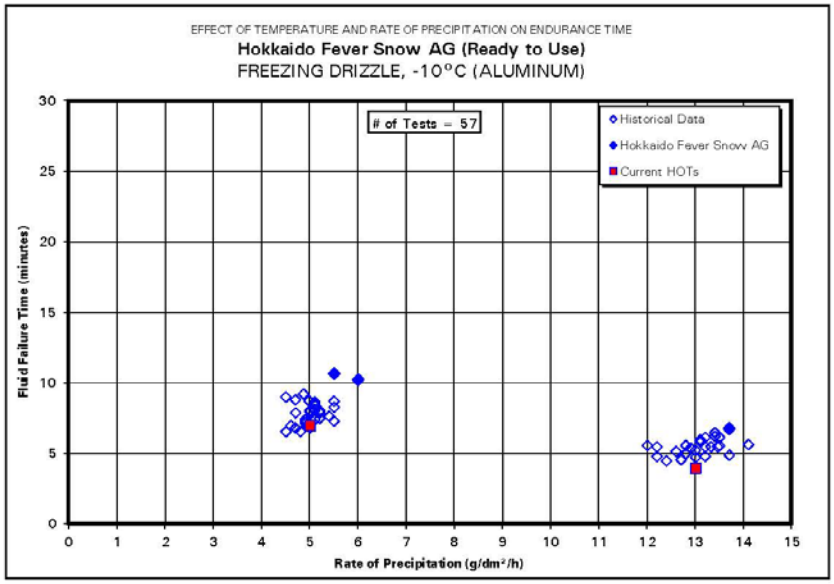


Figure 4.13: Freezing Drizzle, Below -6 to -10°C, Aluminum Surface

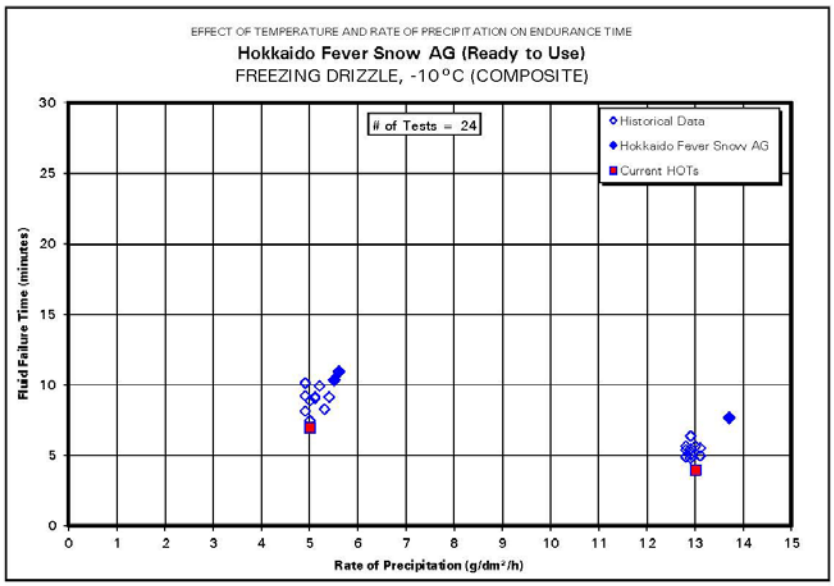


Figure 4.14: Freezing Drizzle, Below -6 to -10°C, Composite Surface

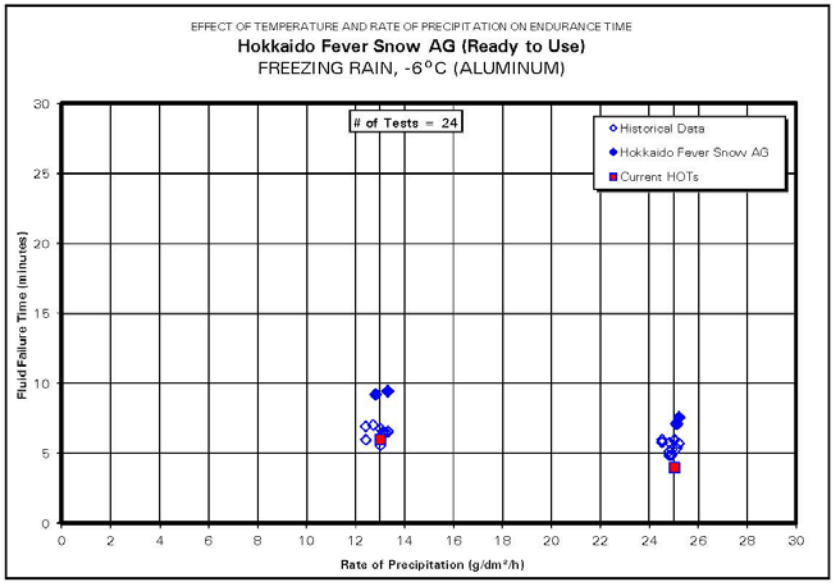


Figure 4.15: Light Freezing Rain, Below -3 to -6°C, Aluminum Surface

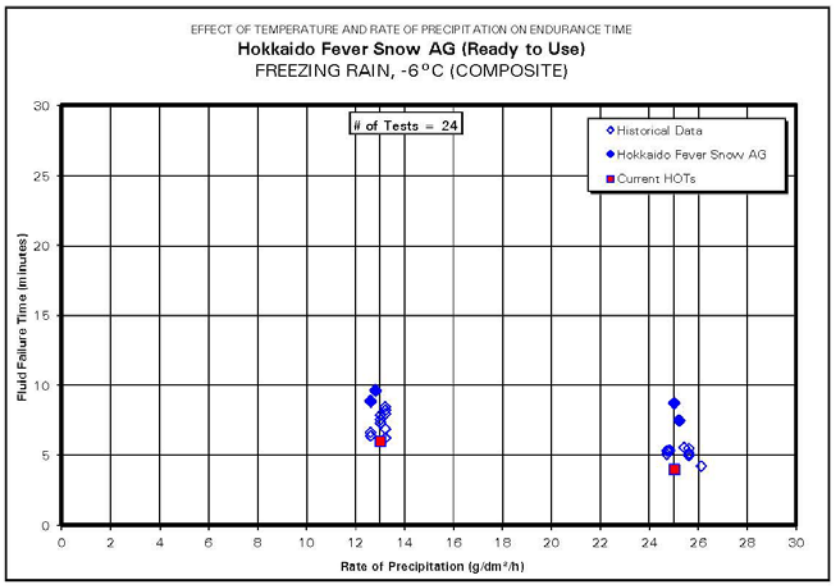


Figure 4.16: Light Freezing Rain, Below -3 to -6°C, Composite Surface

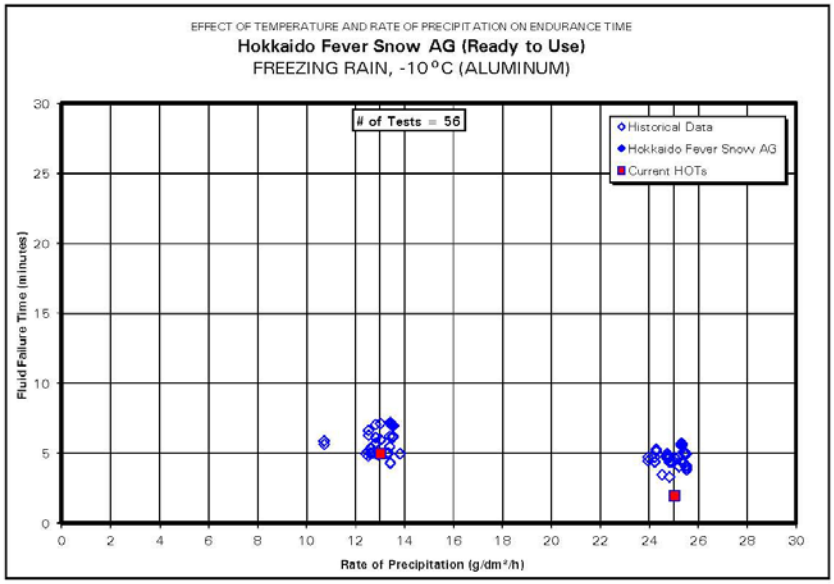


Figure 4.17: Light Freezing Rain, Below -6 to -10°C, Aluminum Surface

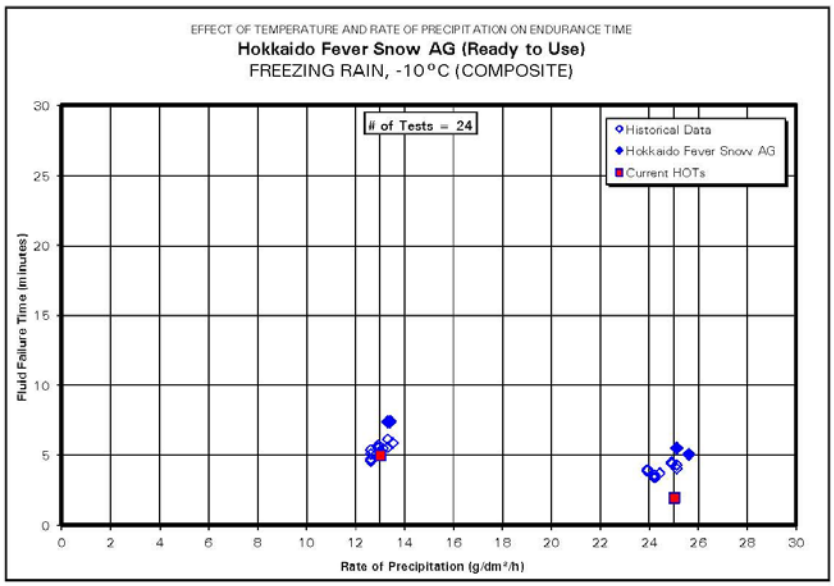


Figure 4.18: Light Freezing Rain, Below -6 to -10°C, Composite Surface

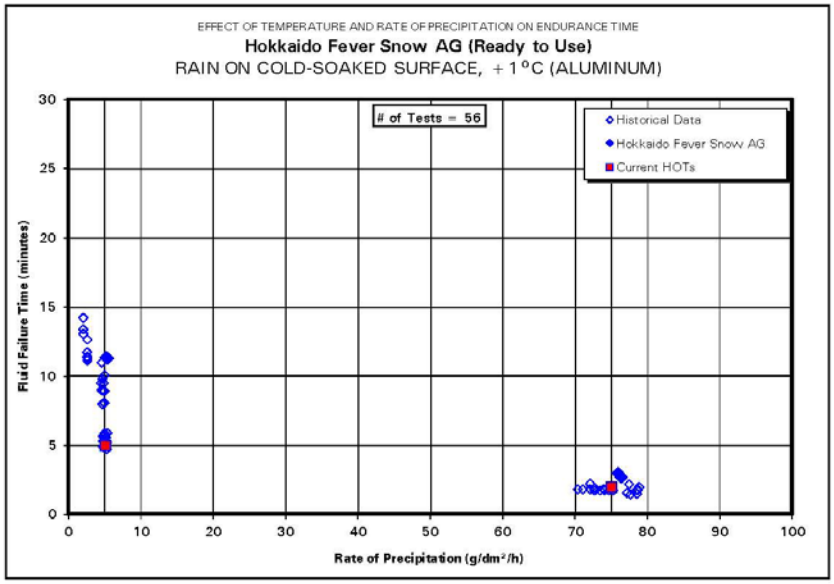


Figure 4.19: Rain on Cold-Soaked Surface, -3°C and Above, Aluminum Surface

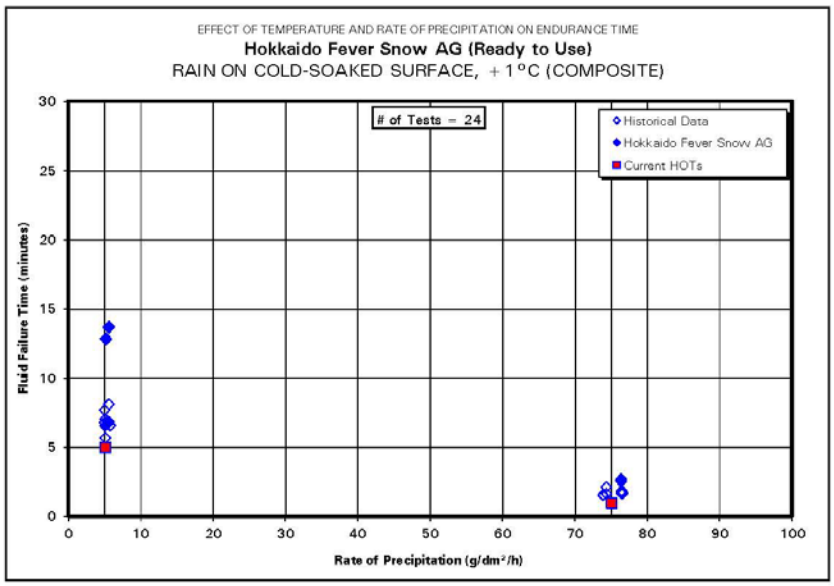


Figure 4.20: Rain on Cold-Soaked Surface, -3°C and Above, Composite Surface

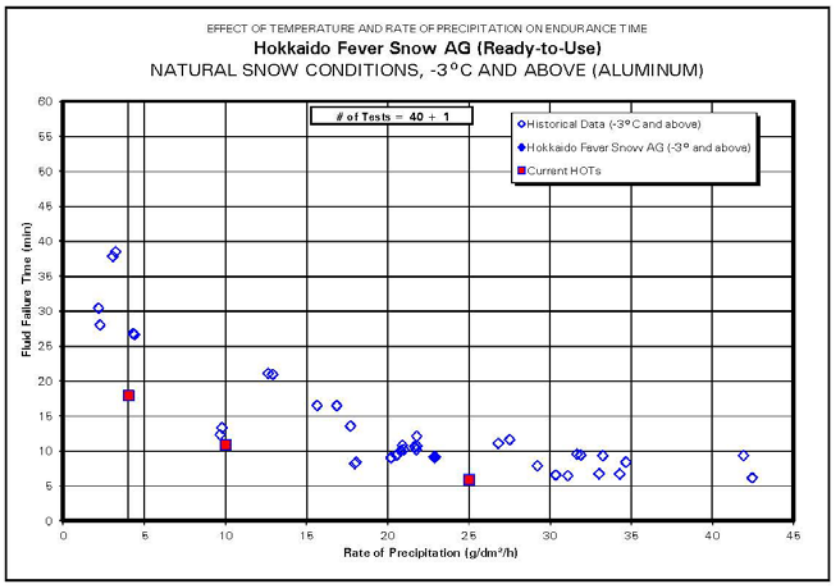


Figure 4.21: Natural Snow, -3°C and Above, Aluminum Surface

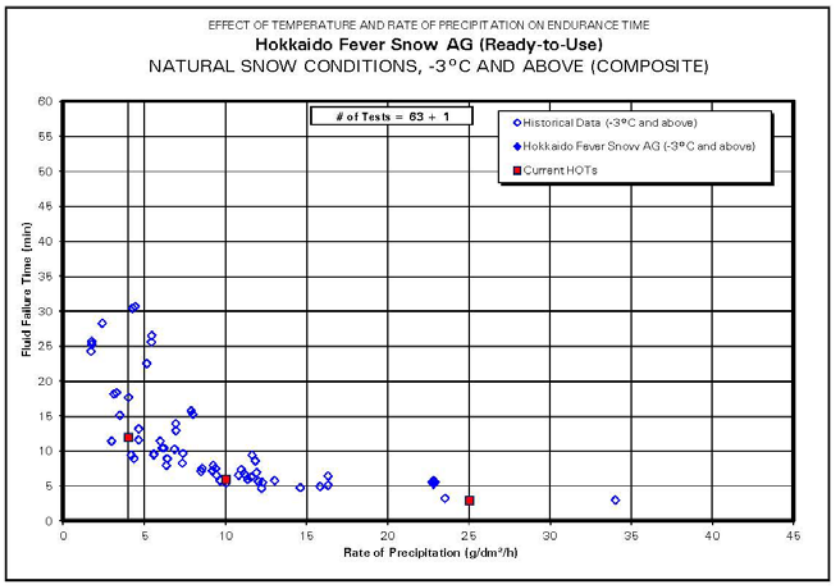


Figure 4.22: Natural Snow, -3°C and Above, Composite Surface

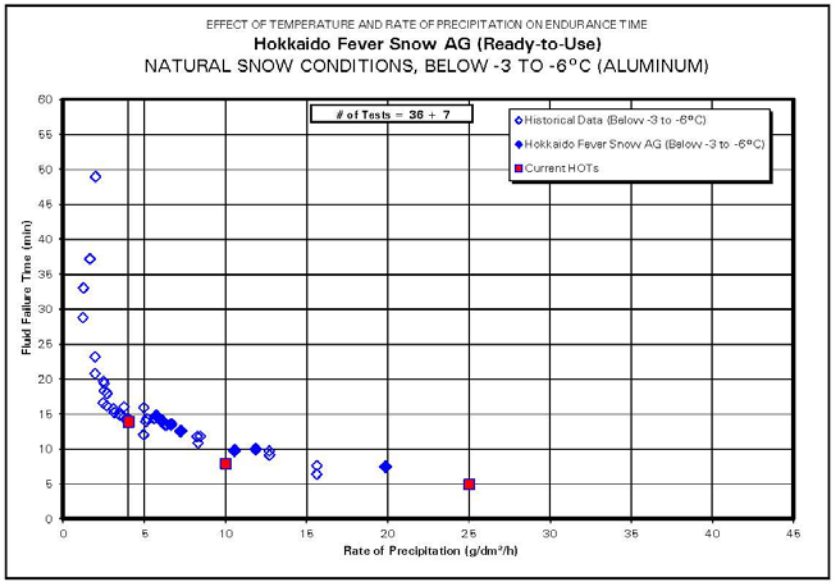


Figure 4.23: Natural Snow, Below -3 to -6°C, Aluminum Surface

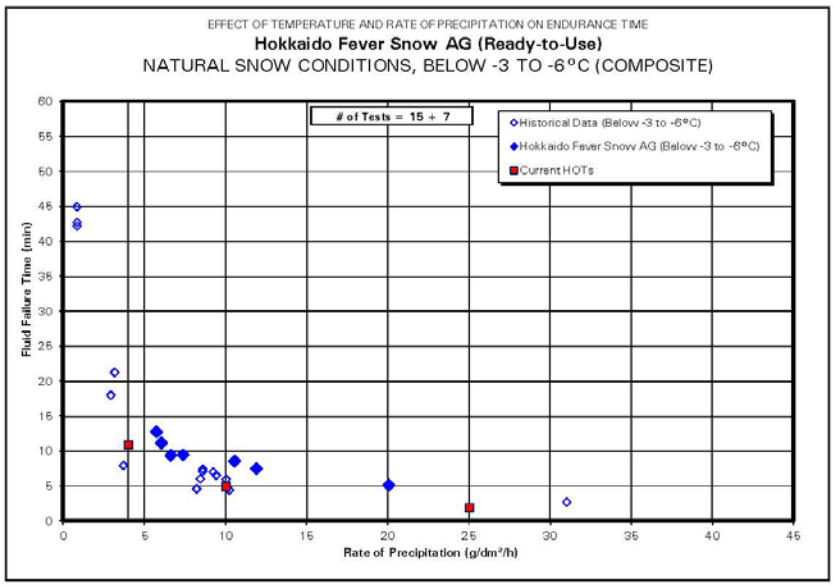


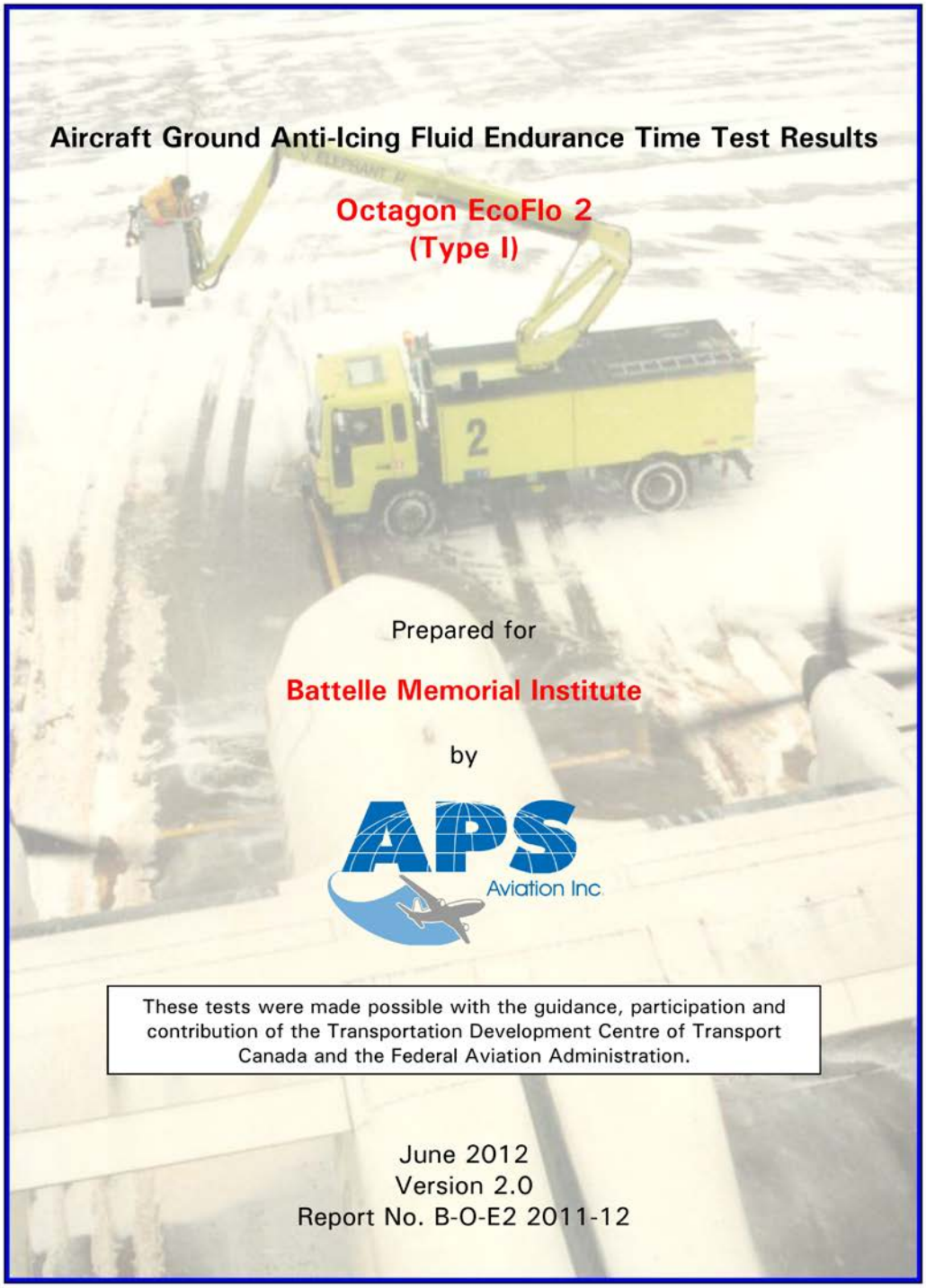
Figure 4.24: Natural Snow, Below -3 to -6°C, Composite Surface

This page intentionally left blank.

44

APPENDIX D

FLUID MANUFACTURER REPORT:
OCTAGON ECOFLO 2 (TYPE I)


Aircraft Ground Anti-Icing Fluid Endurance Time Test Results
Octagon EcoFlo 2
(Type I)
Prepared for
Battelle Memorial Institute
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.
June 2012
Version 2.0
Report No. B-O-E2 2011-12

Aircraft Ground Anti-Icing Fluid Endurance Time Test Results

Octagon EcoFlo 2
(Type I)

Prepared for

Battelle Memorial Institute

Prepared by: Stephanie Bendickson, Project Analyst — June 6, 2012 (Date)

Reviewed by: John D'Avirro, Program Manager, Eng. — June 6, 2012 (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.

June 2012
Version 2.0
Report No. B-O-E2 2011-12

FLUID IDENTIFICATION AND CHARACTERISTICS

Manufacturer:	Battelle Memorial Institute	
Fluid Test Name:	E2	
Fluid Commercial Name:	Octagon EcoFlo 2	
Fluid Type / Colour:	Type I / Orange	
Fluid Formulation:	Non-glycol	
Batch #:	52620-76	
Date of Receipt:	July 12, 2011	
Brix (Measured):	Concentrate:	> 50°
LOUT (Stated)	High Speed Test: Low Speed Test:	-29°C (65/35 dilution) not tested
WSET (from AMIL):	50/50:	4.9 minutes

This page intentionally left blank.

SUMMARY

The primary objective of this project was to measure the endurance time performance of Octagon EcoFlo 2 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).

The HOT 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 natural snow, artificial snow and simulated freezing fog, freezing drizzle, light freezing rain, and rain on cold soaked wing. Endurance time tests were performed at the National Research Council Canada (NRC) Climatic Engineering Facility (CEF) located in Ottawa, Ontario and at the APS Aviation Inc. (APS) test facility located at the Pierre-Elliott-Trudeau International Airport in Montreal, Quebec.

Endurance time testing was conducted with this fluid in simulated freezing precipitation and artificial snow in July 2011. The endurance times measured with the fluid were similar or superior to Type I fluids tested in past years, and it was concluded that Octagon EcoFlo 2 could be used as a Type I fluid with the generic Type I HOT guidelines. Version 1.0 of this report documented the July 2011 testing and was submitted in August 2011.

In the winter of 2011-12, endurance time testing was conducted with Octagon EcoFlo 2 in natural snow to complete the testing and verify the indoor snow test results. The endurance times measured in natural snow were similar to Type I fluids tested in past years, confirming the indoor results. Version 2.0 of this report includes the entire set of endurance time test results, including those in natural snow.

This page intentionally left blank.

TABLE OF CONTENTS

Page

1. INTRODUCTION 1

2. METHODOLOGY 3

2.1 Test Sites 3
2.2 Test Equipment 4
2.2.1 Calibration 4
2.2.2 Environmental Chamber Equipment 4
2.2.3 Test Surface Structures 4
2.2.4 Test Surface Materials 6
2.2.5 Test Stands 6
2.2.6 Collection Pans 7
2.2.7 NRC Sprayer Assembly 7
2.2.8 Refractometer 8
2.2.9 12-Hole Spreader 8
2.2.10 Fluids 8
2.3 Test Procedures 8
2.3.1 Test Protocol – Natural Snow Tests 9
2.3.2 Test Protocol – Artificial Snow Tests 9
2.3.3 Test Protocol – Simulated Precipitation Tests 9
2.3.4 End Condition Definitions 10
2.3.5 Precipitation Rate Measurement Procedures 10
2.4 Precipitation Rate Limits in Type I Endurance Time Testing 13
2.4.1 Freezing Fog 14
2.4.2 Freezing Drizzle 14
2.4.3 Light Freezing Rain 15
2.4.4 Rain on a Cold-Soaked Surface 15
2.4.5 Snow 15
2.5 Ambient Temperatures in Type I Endurance Time Testing 15
2.6 Freezing Precipitation Droplet Sizes 16
2.7 Summary of Freezing Precipitation Test Conditions 17
2.8 Analysis Methodology 18

3. DESCRIPTION OF DATA 27

3.1 Natural Snow Tests 27
3.2 Artificial Snow Tests 27
3.3 Freezing Fog Tests 27
3.4 Freezing Drizzle Tests 28
3.5 Light Freezing Rain Tests 28
3.6 Rain on Cold-Soaked Surface Tests 28
3.7 Fluid Thickness Tests 28
3.8 Summary of Tests Performed 29

4. RESULTS AND DISCUSSION 33

4.1 Data 33
4.2 Discussion 33

This page intentionally left blank.

LIST OF FIGURES

Page

Figure 2.1: APS Test Site at Montréal-Pierre-Elliott-Trudeau International Airport 3
Figure 2.2: Standard Test Plate Schematic 5
Figure 2.3: Cold Soak Box Schematic 5
Figure 2.4: Test Stand Setup Schematic 6
Figure 2.5: Schematic of Outdoor Precipitation Measurement Pan 7
Figure 2.6: Calculation of Outdoor Precipitation Rate 12
Figure 2.7: Precipitation Rate Limits Used in Endurance Time Testing 14
Figure 4.1: Freezing Fog, -3°C and Above, Aluminum Surface 34
Figure 4.2: Freezing Fog, -3°C and Above, Composite Surface 34
Figure 4.3: Freezing Fog, Below -3 to -6°C, Aluminum Surface 35
Figure 4.4: Freezing Fog, Below -3 to -6°C, Composite Surface 35
Figure 4.5: Freezing Fog, Below -6 to -10°C, Aluminum Surface 36
Figure 4.6: Freezing Fog, Below -6 to -10°C, Composite Surface 36
Figure 4.7: Freezing Fog, Below -10°C, Aluminum Surface 37
Figure 4.8: Freezing Fog, Below -10°C, Composite Surface 37
Figure 4.9: Freezing Drizzle, -3°C and Above, Aluminum Surface 38
Figure 4.10: Freezing Drizzle, -3°C and Above, Composite Surface 38
Figure 4.11: Freezing Drizzle, Below -3 to -6°C, Aluminum Surface 39
Figure 4.12: Freezing Drizzle, Below -3 to -6°C, Composite Surface 39
Figure 4.13: Freezing Drizzle, Below -6 to -10°C, Aluminum Surface 40
Figure 4.14: Freezing Drizzle, Below -6 to -10°C, Composite Surface 40
Figure 4.15: Light Freezing Rain, Below -3 to -6°C, Aluminum Surface 41
Figure 4.16: Light Freezing Rain, Below -3 to -6°C, Composite Surface 41
Figure 4.17: Light Freezing Rain, Below -6 to -10°C, Aluminum Surface 42
Figure 4.18: Light Freezing Rain, Below -6 to -10°C, Composite Surface 42
Figure 4.19: Rain on Cold-Soaked Surface, -3°C and Above, Aluminum Surface 43
Figure 4.20: Rain on Cold-Soaked Surface, -3°C and Above, Composite Surface 43
Figure 4.21: Natural Snow, -3°C and Above, Aluminum Surface 44
Figure 4.22: Natural Snow, Below -3 to -6°C, Aluminum Surface 44
Figure 4.23: Natural Snow, Below -3 to -6°C, Composite Surface 45
Figure 4.24: Artificial Snow, -3°C and Above, Aluminum Surface 45

LIST OF TABLES

Page

Table 2.1: Octagon EcoFlo 2 Dilution Table 8
Table 2.2: Definition of Weather Phenomenon 13
Table 2.3: Theoretical and Experimental MVDs 16
Table 2.4: Summary of Freezing Precipitation Test Conditions (Type I Fluids) 18
Table 3.1: Fluid Thickness Measurements 29
Table 3.2: Summary of Tests Performed 30

LIST OF PHOTOS

Page

Photo 2.1: APS Test Site - View from Test Pad 19
Photo 2.2: APS Test Site - View from Trailer 19
Photo 2.3: Outdoor View of NRC Climatic Engineering Facility 20
Photo 2.4: Inside View of NRC Climatic Engineering Facility 20
Photo 2.5: Test Plates Mounted on Stand 21
Photo 2.6: Cold-Soak / Leading Edge Thermal Equivalent Box 21

Photo 2.7: Collection Pans Used Indoors at the NRC 22
Photo 2.8: Sprayer Assembly 22
Photo 2.9: Sprayer Assembly in Use 23
Photo 2.10: Sprayer Nozzle 23
Photo 2.11: Hand Held Brixometer 24
Photo 2.12: Twelve Hole Spreader Used for Fluid Application 24
Photo 2.13: Standard Plate Setup for Type I Testing with Artificial Snowmaker 25

×

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
SAE	Society of Automotive Engineers, Inc.
TDC	Transportation Development Centre

This page intentionally left blank.

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 that Type I fluids formulated with glycol perform in a similar manner from an endurance time perspective. 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 that 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 **Octagon EcoFlo 2**, a new non-glycol based Type I fluid. 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).

This page intentionally left blank.

2

2. METHODOLOGY

Society of Automotive Engineers (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 was performed at the APS test site located at the Montréal-Pierre-Elliott-Trudeau International Airport. The location of the test site is shown on the plan view of the airport shown in Figure 2.1. Photos 2.1 and 2.2 show the test site; the site consists of two trailers and three test stand platforms. The APS test site is located near the Meteorological Services of Canada (a division of Environment Canada) automated weather observation station.

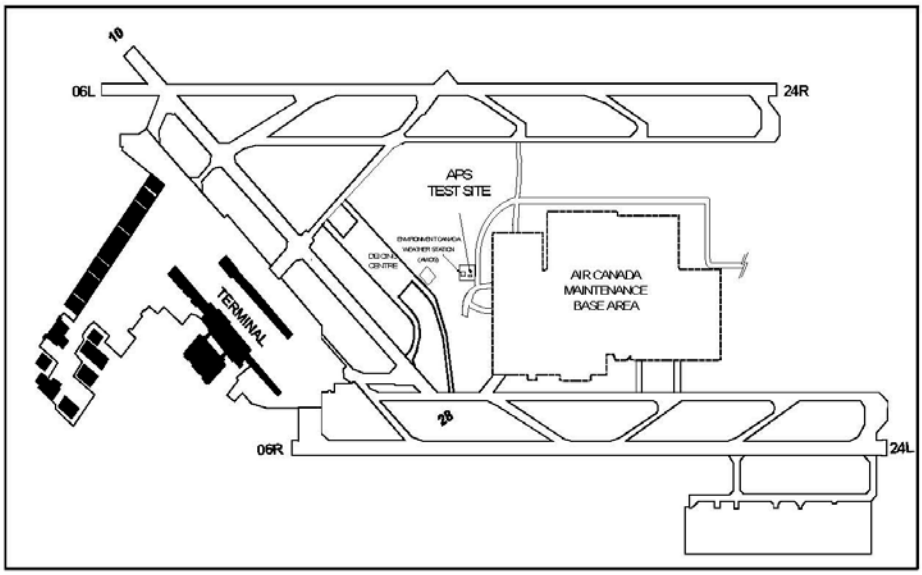


Figure 2.1: APS Test Site at Montréal-Pierre-Elliott-Trudeau International Airport

Tests under conditions of simulated freezing fog, freezing drizzle, light freezing rain and rain on cold soaked wing were 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 2.3.4) are achieved. Photo 2.5, taken outdoors at 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.

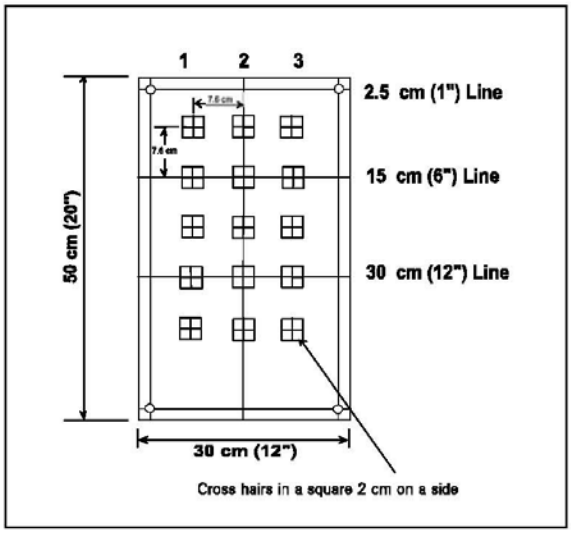


Figure 2.2: Standard Test Plate Schematic

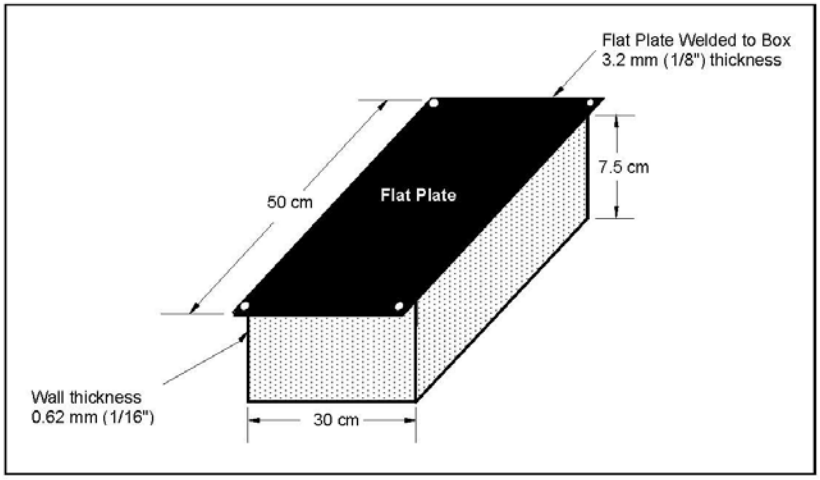


Figure 2.3: Cold Soak Box Schematic

2.2.4 Test Surface Materials

Extensive research has shown holdover 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 new 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.

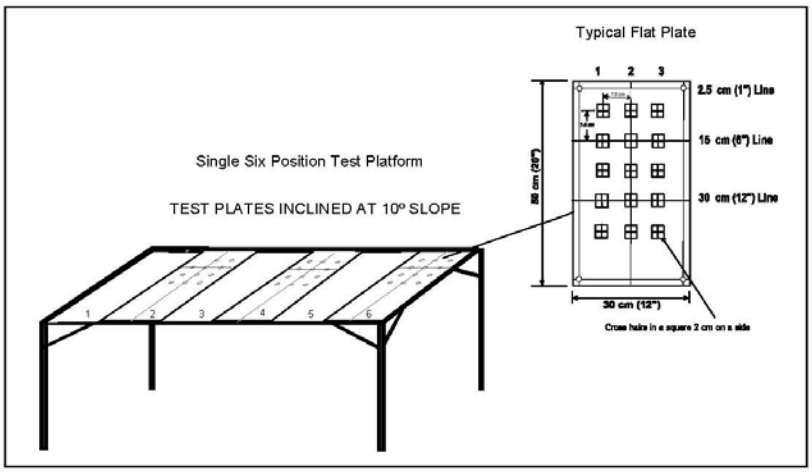


Figure 2.4: Test Stand Setup Schematic

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.

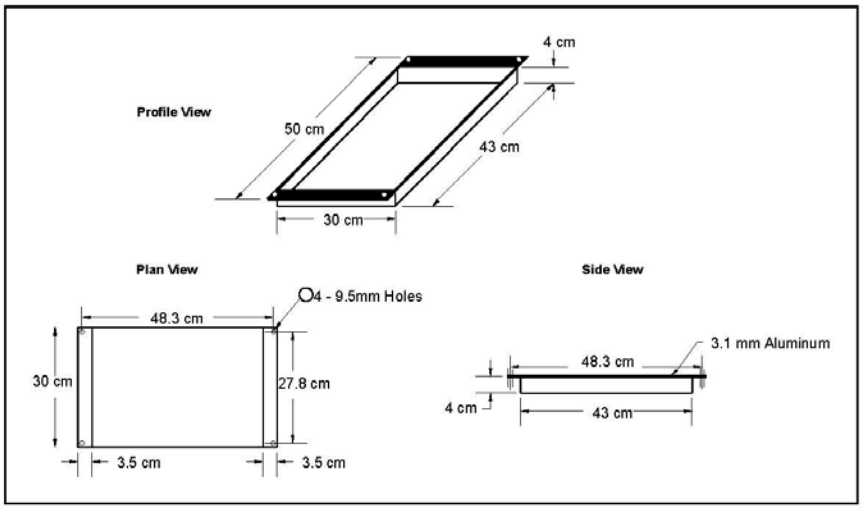


Figure 2.5: Schematic of Outdoor Precipitation Measurement Pan

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 was used to apply fluids during natural and artificial 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: Octagon EcoFlo 2 Dilution Table

Test Temp. (°C)	FFP (°C)	Fluid %	Brix (°)	Glycol for 4 L	Water for 4 L
+1	-9	28.5	19.0	1.1	2.9
-3	-13	36.7	24.0	1.2	2.8
-6	-16	42.0	27.0	1.3	2.7
-10	-20	48.0	30.5	1.4	2.6
-25	-35	59.5	37.0	1.5	2.5

2.3 Test Procedures

ARP5945 provides the procedure for endurance time testing of Type I fluids under natural precipitation conditions and simulated freezing 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, artificial snow and simulated freezing precipitation testing.

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 diluted to a freeze point 10°C below ambient temperature using information provided by the fluid manufacturer (see Table 2.1);
- 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 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 – Artificial Snow Tests

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 (shown in Photo 2.13);
- Fluid is diluted to a freeze point 10°C below ambient temperature using information provided by the fluid manufacturer (see Table 2.1);
- 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 simultaneously. The reference fluid is a Type I fluid that was used in the determination of the current Type I generic holdover times.

2.3.3 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);
- Cold-soak surface tests are conducted on filled cold-soak boxes (see Section 2.2.3);
- Fluid is diluted to a freeze point 10°C below ambient temperature using information provided by the manufacturer (see Table 2.1);
- Fluid is applied at a temperature of 20°C; 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. 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.

2.3.5.2 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) 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 2.4) 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 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.

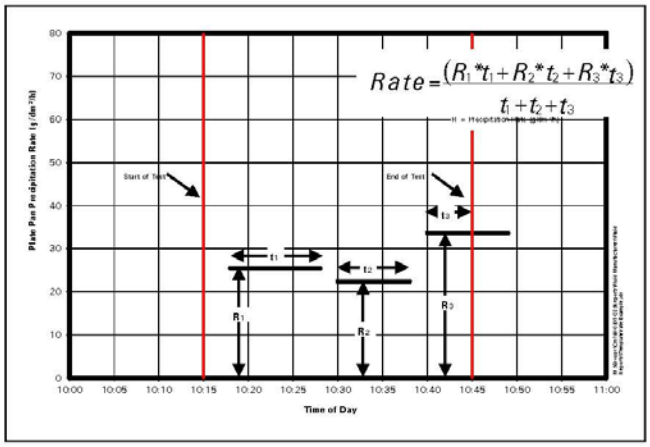


Figure 2.6: Calculation of Outdoor Precipitation Rate

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).

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 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)
Measured Intensity Light (-) Estimated Intensity	Up to 0.10 in/hr (2.5 mm or 25 gr/dm²/hr); Maximum 0.01 inch in 6 minutes From scattered drops that, regardless of duration, do not completely wet an exposed surface up to a condition where individual drops are easily seen.
Measured Intensity Moderate Estimated 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 Individual drops are not clearly identifiable; spray is observable just above pavement and other hard surfaces.
Measured Intensity Heavy (+) Estimated Intensity	More than 0.30 in/hr (7.6 mm or 76 gr/dm²/hr); More than 0.03 inch in 6 minutes 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)

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.

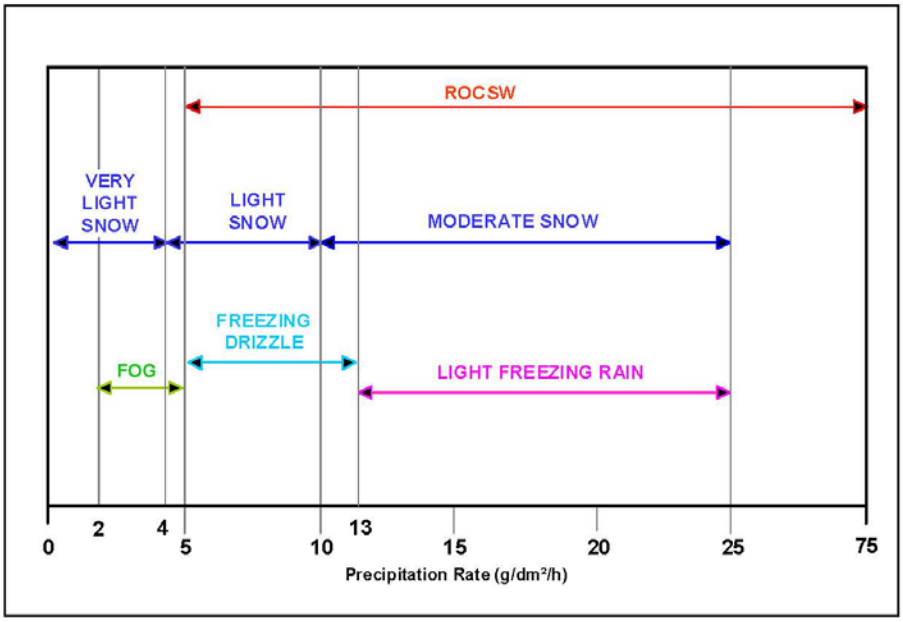


Figure 2.7: Precipitation Rate Limits Used in Endurance Time Testing

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/dm²/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/dm²/h. This range encompasses drizzle (5 to 13 g/dm²/h), light rain (13 to 25 g/dm²/h), and moderate rain (25 to 75 g/dm²/h).

2.4.5 Snow

The precipitation rate limits used to determine holdover times for Type I fluids in snow are as follows:

a) Very light snow: 4 g/dm²/h;
b) Light snow: 4 and 10 g/dm²/h; and
c) Moderate snow: 10 and 25 g/dm²/h.

Notably, Type II and Type IV holdover times are determined using the precipitation rate limits for moderate snow: 10 and 25 g/dm²/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 testing 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
- Artificial Snow: -3, -6, -10 and/or -25°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 2.3 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.

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)

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.

For simulated freezing precipitation and natural snow, the new fluid data is plotted on endurance time vs. rate of precipitation charts along with the historic fluid data and a visual examination determines if the new fluid's performance is similar or superior to the historical data.

For artificial snow, the endurance time of each test conducted with a new Type I fluid is compared to the endurance time of the baseline test conducted immediately after the test with a historical (baseline) Type I fluid. The data set must show that the new fluid has similar or superior endurance times relative to the baseline test.

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

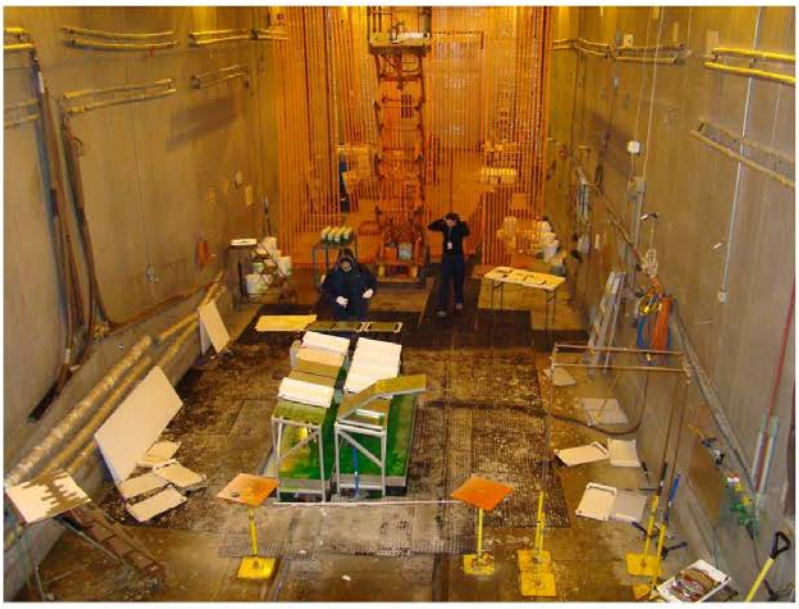


Photo 2.5: Test Plates Mounted on Stand



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

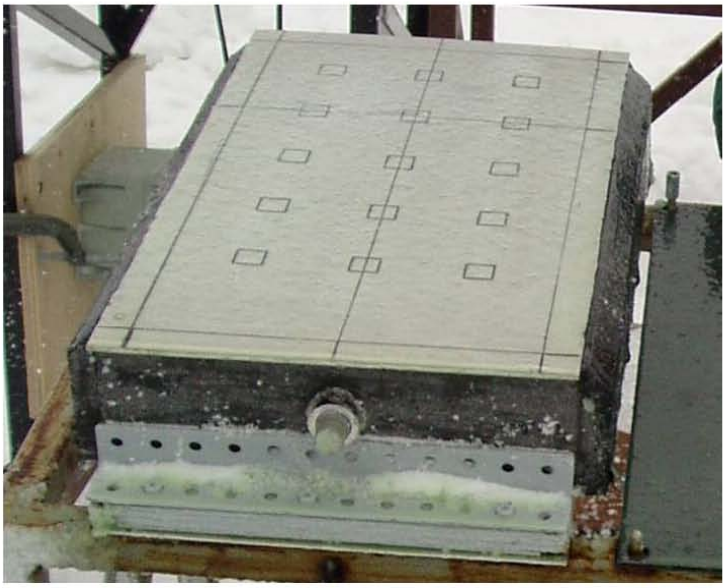


Photo 2.7: Collection Pans Used Indoors at the NRC



Photo 2.8: Sprayer Assembly



Photo 2.9: Sprayer Assembly in Use



Photo 2.10: Sprayer Nozzle

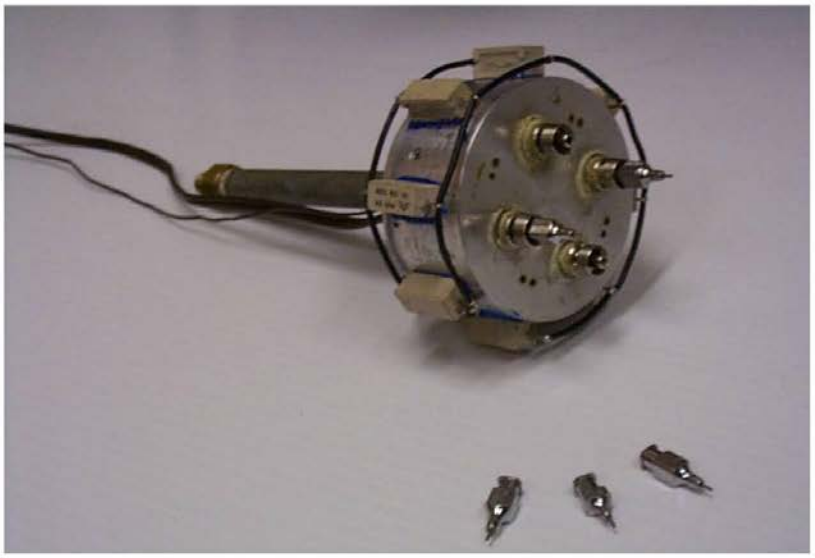


Photo 2.11: Hand Held Brixometer



Photo 2.12: Twelve Hole Spreader Used for Fluid Application



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



This page intentionally left blank.

26

3. DESCRIPTION OF DATA

This section provides a summary of the number of tests conducted. Breakdowns are provided for quantity of tests performed by precipitation type, fluid dilution, test surface and test temperature. A list of the tests conducted is provided in Table 3.2 at the end of this section.

3.1 Natural Snow Tests

Natural snow tests were conducted with this fluid in the winter of 2011-12 to verify the artificial snow test results. A total of 15 natural snow tests were conducted at the APS test site. The number of tests conducted is summarized below by temperature and test surface. For comparison purposes, simultaneous tests were conducted with a baseline Type I fluid.

Fluid Dilution	Test Surface	≥ -3°C	-3 to -6°C	-6 to -10°C	< -10°C
10°C Buffer	Aluminum	1	7	0	0
10°C Buffer	Composite	0	7	0	0

3.2 Artificial Snow Tests

Two tests were conducted with an artificial snowmaker at the APS test site in July 2011. Both tests were conducted on an aluminum surface at -3°C. For comparison purposes, the tests were repeated with a baseline Type I fluid.

Fluid Dilution	Test Surface	-3°C	-6°C	-10°C	-25°C
10°C Buffer	Aluminum	2	0	0	0

3.3 Freezing Fog Tests

Tests were conducted in freezing fog conditions at the NRC CEF in July 2011. The breakdown of tests conducted is summarized below by fluid dilution, test surface and test temperature.

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

3.4 Freezing Drizzle Tests

Tests were conducted in freezing drizzle at the NRC CEF in July 2011. The breakdown of tests conducted is summarized below by fluid dilution, test surface and test temperature.

Fluid Dilution	Test Surface	-3°C	-6°C	-10°C
10°C Buffer	Aluminum	4	4	4
10°C Buffer	Composite	4	4	4

3.5 Light Freezing Rain Tests

Tests were conducted in light freezing rain conditions at the NRC CEF in July 2011. The breakdown of tests conducted is summarized below by fluid dilution, test surface and test temperature.

Fluid Dilution	Test Surface	-3°C	-6°C	-10°C
10°C Buffer	Aluminum	0*	4	4
10°C Buffer	Composite	0*	4	4

** Type I fluids are not tested in 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

Tests were conducted in rain on cold-soaked surface conditions at the NRC CEF in July 2011. The breakdown of tests conducted is summarized below by fluid dilution, test surface and test temperature.

Fluid Dilution	Test Surface	+ 1°C
10°C Buffer	Aluminum	4
10°C Buffer	Composite	4

3.7 Fluid Thickness Tests

Fluid thickness tests were conducted at the NRC CEF in July 2011. The purpose of these tests was to measure the film thickness profile of Octagon EcoFlo 2

(mixed to a 10° buffer) under dry conditions. Two tests were performed at an ambient temperature of -3°C. The measurements are displayed in Table 3.1.

Table 3.1: Fluid Thickness Measurements

Measurement	Time After Application (mins)	Thickness (mm)	
		Run 1	Run 2
1	2	0.06	0.06
2	5	0.06	0.06
3	15	0.04	0.04
4	30	0.04	0.04

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 0.04 mm.

3.8 Summary of Tests Performed

A summary of the details of each test performed is provided in Table 3.2. The table includes the test number, date the test was conducted, fluid name and dilution, the precipitation type, the test surface, the air temperature, the measured precipitation rate and the measured endurance time.

Table 3.2: Summary of Tests Performed

Test No.	Date	Fluid Name	Fluid Dil.*	Precipitation Type	Test Surface	Test Temp. (°C)	Precip. Rate (g/dm²/h)	Endurance Time (min)
1	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Aluminum	-3.2	2.3	19.3
2	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Aluminum	-3.1	1.9	20.1
3	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Composite	-3.2	2.1	18.8
4	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Composite	-3.1	1.7	20.5
5	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Aluminum	-3.3	5.5	12.7
6	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Aluminum	-3.3	5.0	12.8
7	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Composite	-3.3	5.1	11.5
8	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Composite	-3.3	4.9	9.7
9R	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Aluminum	-5.9	2.1	14.3
10	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Aluminum	-6.0	2.0	16.9
10R	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Aluminum	-5.9	1.9	15.8
11	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Composite	-6.1	1.8	13.4
12	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Composite	-6.1	2.1	12.9
13	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Aluminum	-5.9	4.7	7.9
13R	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Aluminum	-6.1	4.7	9.7
14	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Aluminum	-5.9	4.9	9.7
15	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Composite	-5.9	4.7	7.7
16	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Composite	-5.9	4.7	8.5
17	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Aluminum	-9.9	1.9	13.1
18R	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Aluminum	-10.2	2.2	11.7
19	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Composite	-9.9	2.2	10.5
20	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Composite	-9.9	1.8	10.6
21	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Aluminum	-9.8	5.3	8.7
22	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Aluminum	-9.8	4.9	9.3
23	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Composite	-9.8	5.0	7.3
24	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Composite	-9.8	4.6	7.0
25	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Aluminum	-25.0	1.9	12.7
26	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Aluminum	-25.0	1.7	13.6
27	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Composite	-24.9	1.9	11.7
28	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Composite	-25.0	1.8	12.1
29	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Aluminum	-24.6	5.0	5.2
30	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Aluminum	-24.6	5.1	5.6
31	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Composite	-24.6	4.9	4.3
32	19-Jul-11	Octagon EcoFlo 2	10°B	Freezing Fog	Composite	-24.6	4.6	4.5
33	20-Jul-11	Octagon EcoFlo 2	10°B	Light Freezing Rain	Aluminum	-6.5	13.5	8.1
34	20-Jul-11	Octagon EcoFlo 2	10°B	Light Freezing Rain	Aluminum	-6.5	13.4	7.8
35	20-Jul-11	Octagon EcoFlo 2	10°B	Light Freezing Rain	Composite	-6.4	13.2	7.3
36	20-Jul-11	Octagon EcoFlo 2	10°B	Light Freezing Rain	Composite	-6.2	13.5	7.3
37	20-Jul-11	Octagon EcoFlo 2	10°B	Light Freezing Rain	Aluminum	-5.9	25.4	9.1
38	20-Jul-11	Octagon EcoFlo 2	10°B	Light Freezing Rain	Aluminum	-6.2	25.1	9.0
39	20-Jul-11	Octagon EcoFlo 2	10°B	Light Freezing Rain	Composite	-6.3	24.9	7.1
40	20-Jul-11	Octagon EcoFlo 2	10°B	Light Freezing Rain	Composite	-6.0	24.7	7.3

** 10°B = Fluid diluted to a freeze point 10°C below test temperature*

Table 3.2 (cont'd): Summary of Tests Performed

Test No.	Date	Fluid Name	Fluid Dil.*	Precipitation Type	Test Surface	Test Temp. (°C)	Precip. Rate (g/dm²/h)	Endurance Time (min)
41	21-Jul-11	Octagon EcoFlo 2	10°B	Light Freezing Rain	Aluminum	-9.4	12.5	5.2
42	21-Jul-11	Octagon EcoFlo 2	10°B	Light Freezing Rain	Aluminum	-10.2	12.8	5.7
43	21-Jul-11	Octagon EcoFlo 2	10°B	Light Freezing Rain	Composite	-9.4	12.8	5.0
44	21-Jul-11	Octagon EcoFlo 2	10°B	Light Freezing Rain	Composite	-10.0	12.5	5.8
45	21-Jul-11	Octagon EcoFlo 2	10°B	Light Freezing Rain	Aluminum	-10.2	24.5	5.5
46	21-Jul-11	Octagon EcoFlo 2	10°B	Light Freezing Rain	Aluminum	-10.1	25.1	4.5
47	21-Jul-11	Octagon EcoFlo 2	10°B	Light Freezing Rain	Composite	-10.0	24.2	4.8
48	21-Jul-11	Octagon EcoFlo 2	10°B	Light Freezing Rain	Composite	-10.2	24.6	5.3
49	20-Jul-11	Octagon EcoFlo 2	10°B	Freezing Drizzle	Aluminum	-3.0	4.9	14.1
50	20-Jul-11	Octagon EcoFlo 2	10°B	Freezing Drizzle	Aluminum	-3.0	4.7	15.0
51	20-Jul-11	Octagon EcoFlo 2	10°B	Freezing Drizzle	Composite	-3.0	4.8	16.7
52	20-Jul-11	Octagon EcoFlo 2	10°B	Freezing Drizzle	Composite	-3.0	4.8	15.5
53	20-Jul-11	Octagon EcoFlo 2	10°B	Freezing Drizzle	Aluminum	-3.4	12.8	11.7
54	20-Jul-11	Octagon EcoFlo 2	10°B	Freezing Drizzle	Aluminum	-3.4	12.7	12.8
55	20-Jul-11	Octagon EcoFlo 2	10°B	Freezing Drizzle	Composite	-3.4	12.7	10.3
56	20-Jul-11	Octagon EcoFlo 2	10°B	Freezing Drizzle	Composite	-3.4	12.8	11.8
57	20-Jul-11	Octagon EcoFlo 2	10°B	Freezing Drizzle	Aluminum	-6.5	5.1	12.4
58	20-Jul-11	Octagon EcoFlo 2	10°B	Freezing Drizzle	Aluminum	-6.5	4.9	11.6
59	20-Jul-11	Octagon EcoFlo 2	10°B	Freezing Drizzle	Composite	-6.5	4.9	11.4
60	20-Jul-11	Octagon EcoFlo 2	10°B	Freezing Drizzle	Composite	-6.5	4.8	10.9
61	20-Jul-11	Octagon EcoFlo 2	10°B	Freezing Drizzle	Aluminum	-6.3	13.1	5.9
62	20-Jul-11	Octagon EcoFlo 2	10°B	Freezing Drizzle	Aluminum	-6.2	12.9	6.9
63	20-Jul-11	Octagon EcoFlo 2	10°B	Freezing Drizzle	Composite	-6.2	12.7	7.3
64	20-Jul-11	Octagon EcoFlo 2	10°B	Freezing Drizzle	Composite	-6.2	12.9	6.8
65	21-Jul-11	Octagon EcoFlo 2	10°B	Freezing Drizzle	Aluminum	-10.0	5.1	8.5
66	21-Jul-11	Octagon EcoFlo 2	10°B	Freezing Drizzle	Aluminum	-10.1	5.5	9.1
67	21-Jul-11	Octagon EcoFlo 2	10°B	Freezing Drizzle	Composite	-10.0	5.2	8.8
68	21-Jul-11	Octagon EcoFlo 2	10°B	Freezing Drizzle	Composite	-10.3	4.8	8.8
69	21-Jul-11	Octagon EcoFlo 2	10°B	Freezing Drizzle	Aluminum	-9.0	13.7	5.7
70	21-Jul-11	Octagon EcoFlo 2	10°B	Freezing Drizzle	Aluminum	-9.0	13.0	5.8
71	21-Jul-11	Octagon EcoFlo 2	10°B	Freezing Drizzle	Composite	-9.0	13.3	6.4
72	21-Jul-11	Octagon EcoFlo 2	10°B	Freezing Drizzle	Composite	-9.0	12.7	4.6
73	21-Jul-11	Octagon EcoFlo 2	10°B	Cold Soak Box	Aluminum	1.6	5.1	5.6
74R	21-Jul-11	Octagon EcoFlo 2	10°B	Cold Soak Box	Aluminum	0.6	4.8	6.3
75	21-Jul-11	Octagon EcoFlo 2	10°B	Cold Soak Box	Composite	1.5	4.9	6.4
76	21-Jul-11	Octagon EcoFlo 2	10°B	Cold Soak Box	Composite	0.9	5.2	7.0
77	21-Jul-11	Octagon EcoFlo 2	10°B	Cold Soak Box	Aluminum	1.1	74.7	1.6
78	21-Jul-11	Octagon EcoFlo 2	10°B	Cold Soak Box	Aluminum	1.2	76.8	1.6
79	21-Jul-11	Octagon EcoFlo 2	10°B	Cold Soak Box	Composite	1.2	75.6	1.8
80	21-Jul-11	Octagon EcoFlo 2	10°B	Cold Soak Box	Composite	1.2	75.6	2.4
S1	26-Jul-11	Octagon EcoFlo 2	10°B	Artificial Snow	Aluminum	-3.0	10.0	10.8
S2	26-Jul-11	Octagon EcoFlo 2	10°B	Artificial Snow	Aluminum	-3.0	25.0	5.5

** 10°B = Fluid diluted to a freeze point 10°C below test temperature*

Table 3.2 (cont'd): Summary of Tests Performed

Test No.	Date	Fluid Name	Fluid Dil.*	Precipitation Type	Test Surface	Test Temp. (°C)	Precip. Rate (g/dm²/h)	Endurance Time (min)
7	17-Jan-12	Octagon EcoFlo 2	10°B	Natural Snow	Aluminum Box	-4.3	11.8	7.4
10	17-Jan-12	Octagon EcoFlo 2	10°B	Natural Snow	Composite Box	-4.3	11.8	5.7
13	17-Jan-12	Octagon EcoFlo 2	10°B	Natural Snow	Aluminum Box	-3.7	10.5	7.7
16	17-Jan-12	Octagon EcoFlo 2	10°B	Natural Snow	Composite Box	-3.7	10.5	6.3
19	17-Jan-12	Octagon EcoFlo 2	10°B	Natural Snow	Aluminum Box	-3.6	19.6	5.6
22	17-Jan-12	Octagon EcoFlo 2	10°B	Natural Snow	Composite Box	-3.6	19.8	3.8
25	17-Jan-12	Octagon EcoFlo 2	10°B	Natural Snow	Aluminum Box	-3.5	6.2	11.5
28	17-Jan-12	Octagon EcoFlo 2	10°B	Natural Snow	Composite Box	-3.5	6.2	9.4
31	26-Jan-12	Octagon EcoFlo 2	10°B	Natural Snow	Aluminum Box	-5.3	7.1	11.4
34	26-Jan-12	Octagon EcoFlo 2	10°B	Natural Snow	Composite Box	-5.3	7.2	6.9
37	26-Jan-12	Octagon EcoFlo 2	10°B	Natural Snow	Aluminum Box	-5.8	6.6	11.9
40	26-Jan-12	Octagon EcoFlo 2	10°B	Natural Snow	Composite Box	-5.8	6.6	6.5
43	26-Jan-12	Octagon EcoFlo 2	10°B	Natural Snow	Aluminum Box	-5.8	5.7	12.3
46	26-Jan-12	Octagon EcoFlo 2	10°B	Natural Snow	Composite Box	-5.7	5.7	7.6
123	3-Mar-12	Octagon EcoFlo 2	10°B	Natural Snow	Aluminum Box	-0.3	23.0	11.6

** 10°B = Fluid diluted to a freeze point 10°C below test temperature*

4. RESULTS AND DISCUSSION

The Octagon EcoFlo 2 endurance time test results with 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 Data

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 Octagon EcoFlo 2 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).

Figures 4.21 to 4.23 show the results of testing in natural snow. There is one chart for each snow cell in the Type I generic holdover time tables under which testing was conducted. The charts contain the same information as the freezing precipitation charts.

Figure 4.21 shows the results of testing in artificial snow. The chart shows the endurance times of Octagon EcoFlo 2 along with the endurance times of the Type I reference fluid that was tested immediately following Octagon EcoFlo 2.

4.2 Discussion

The data collected shows the endurance times Octagon EcoFlo 2 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 similarly to glycol based Type I fluids from an endurance time perspective and therefore can be used with the generic Type I HOT guidelines.

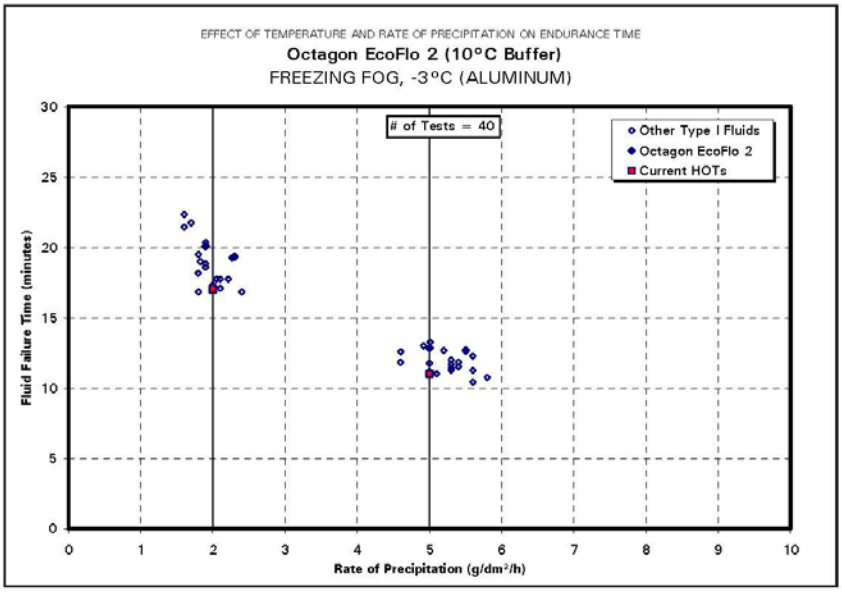


Figure 4.1: Freezing Fog, -3°C and Above, Aluminum Surface

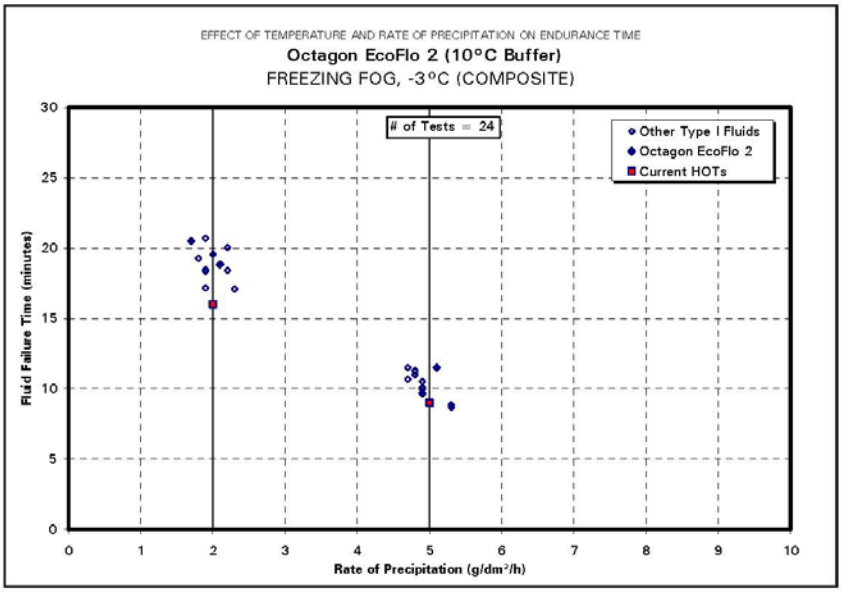


Figure 4.2: Freezing Fog, -3°C and Above, Composite Surface

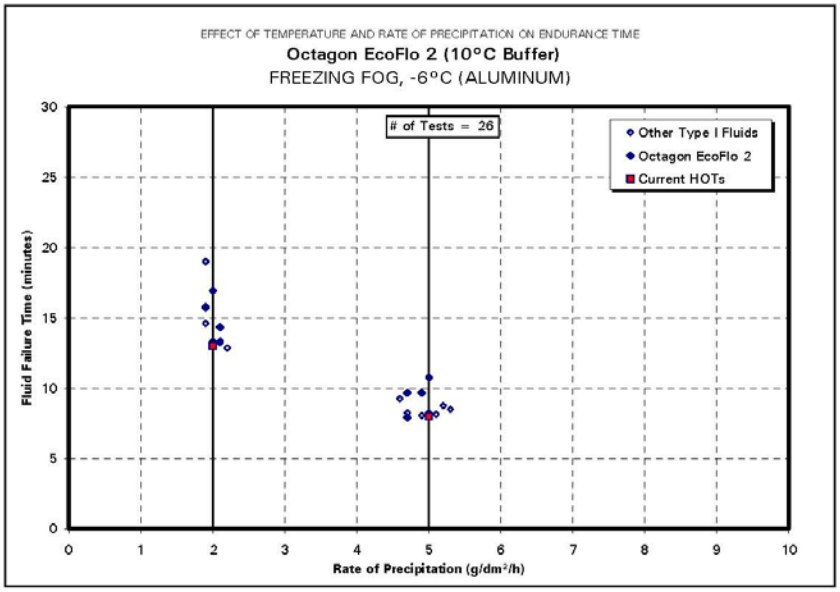


Figure 4.3: Freezing Fog, Below -3 to -6°C, Aluminum Surface

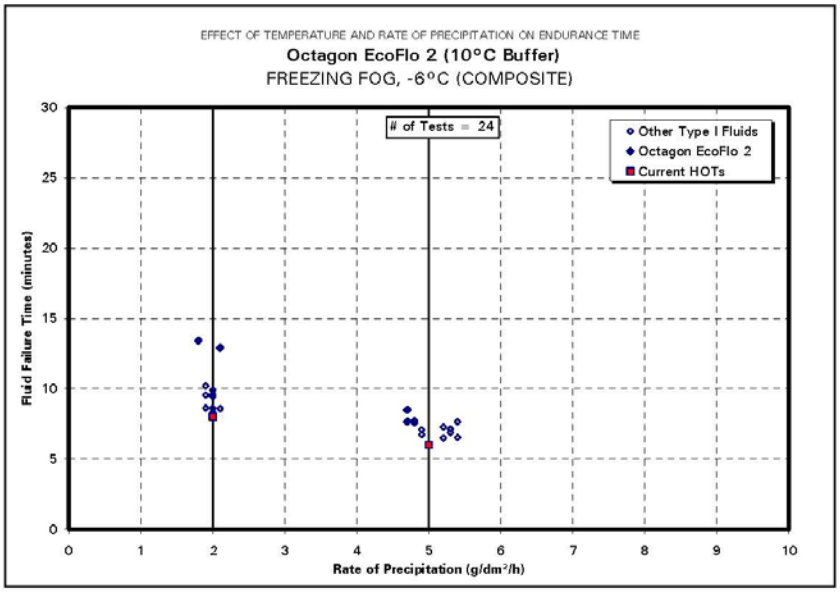


Figure 4.4: Freezing Fog, Below -3 to -6°C, Composite Surface

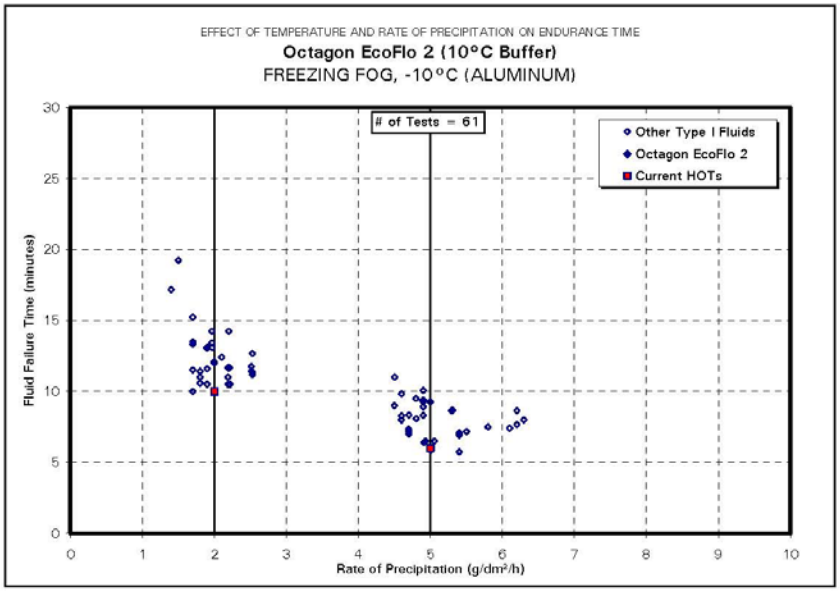


Figure 4.5: Freezing Fog, Below -6 to -10°C, Aluminum Surface

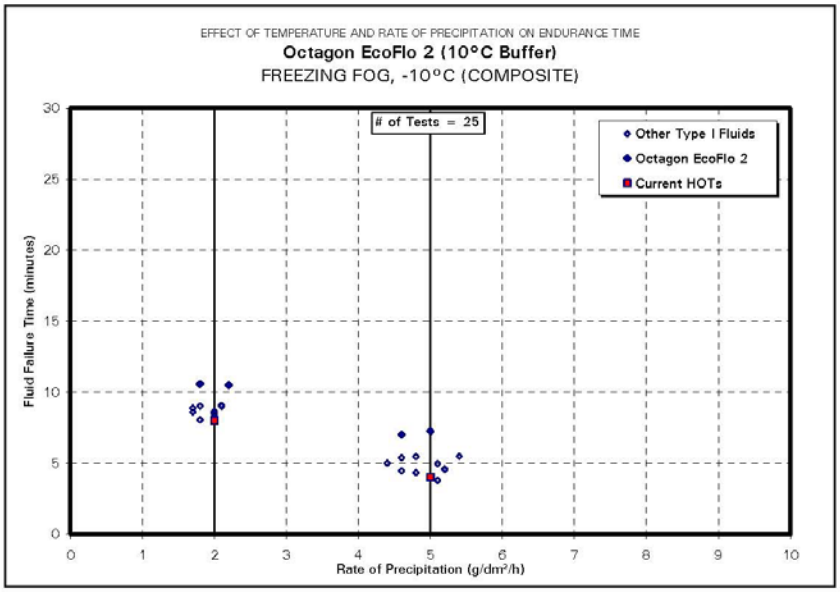


Figure 4.6: Freezing Fog, Below -6 to -10°C, Composite Surface

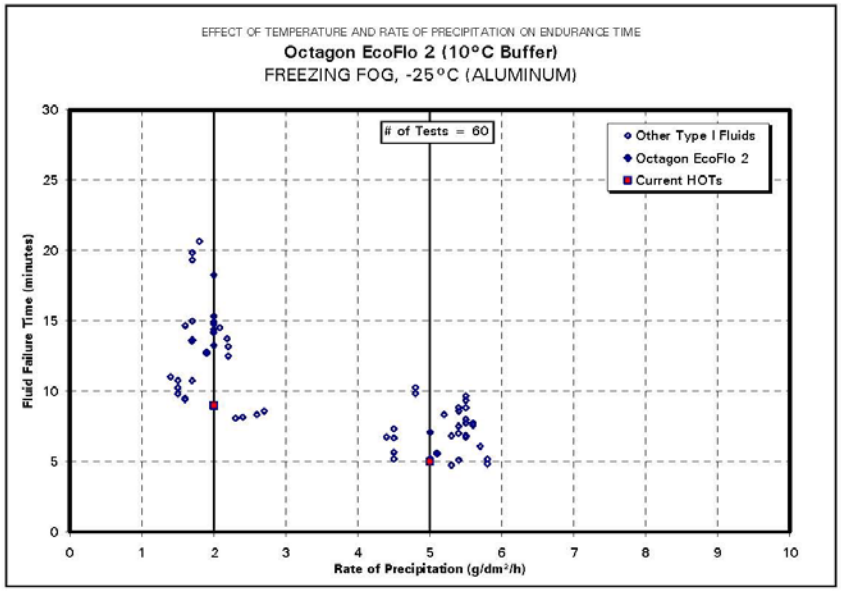


Figure 4.7: Freezing Fog, Below -10°C, Aluminum Surface

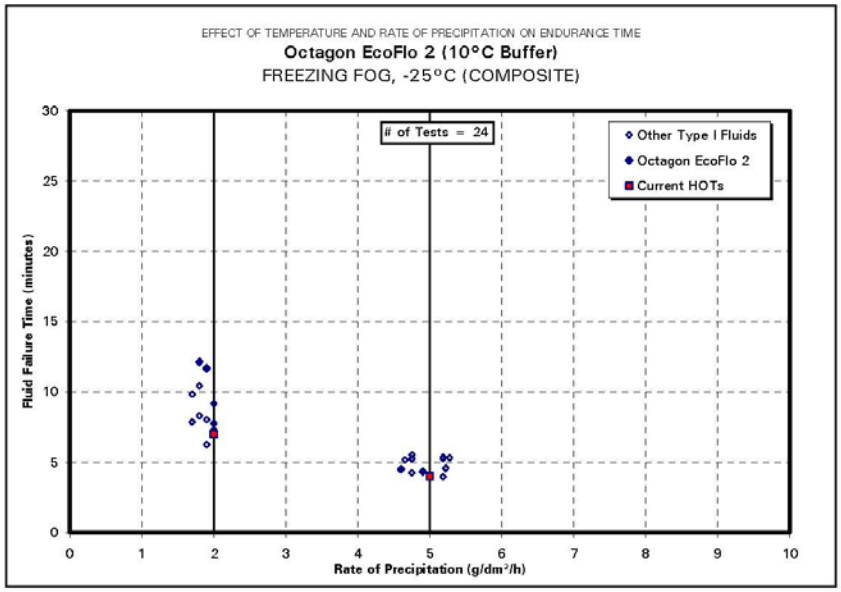


Figure 4.8: Freezing Fog, Below -10°C, Composite Surface

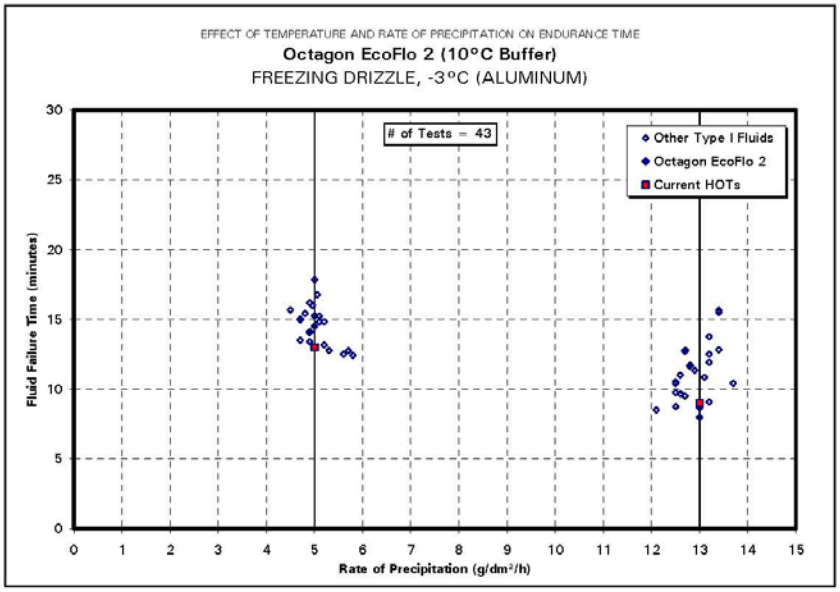


Figure 4.9: Freezing Drizzle, -3°C and Above, Aluminum Surface

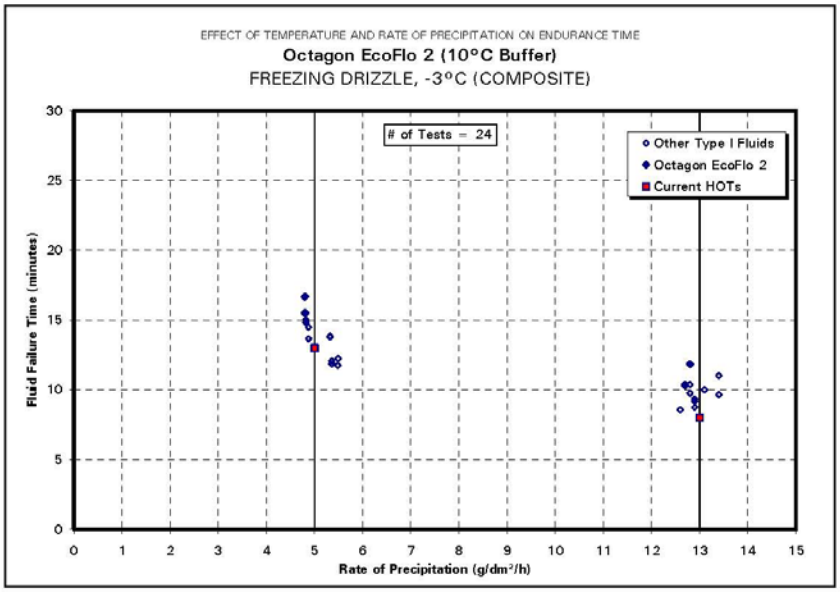


Figure 4.10: Freezing Drizzle, -3°C and Above, Composite Surface

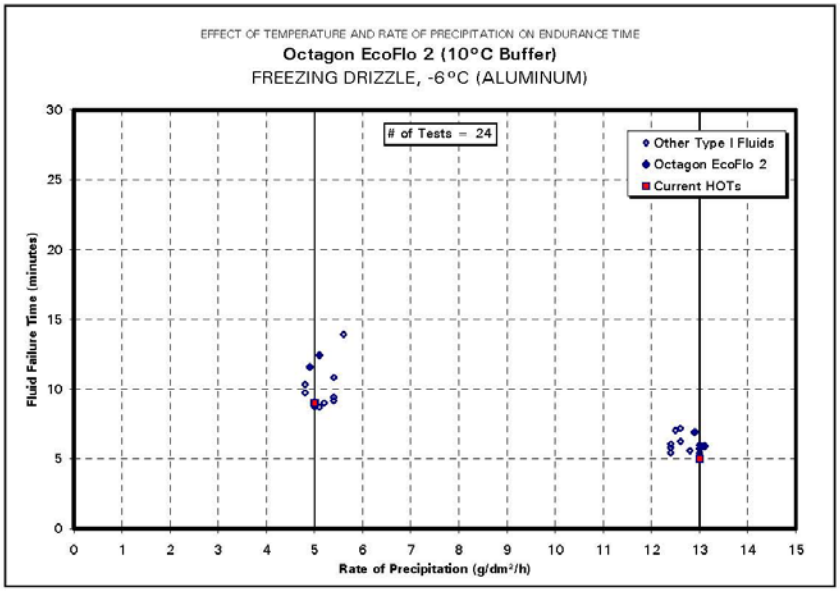


Figure 4.11: Freezing Drizzle, Below -3 to -6°C, Aluminum Surface

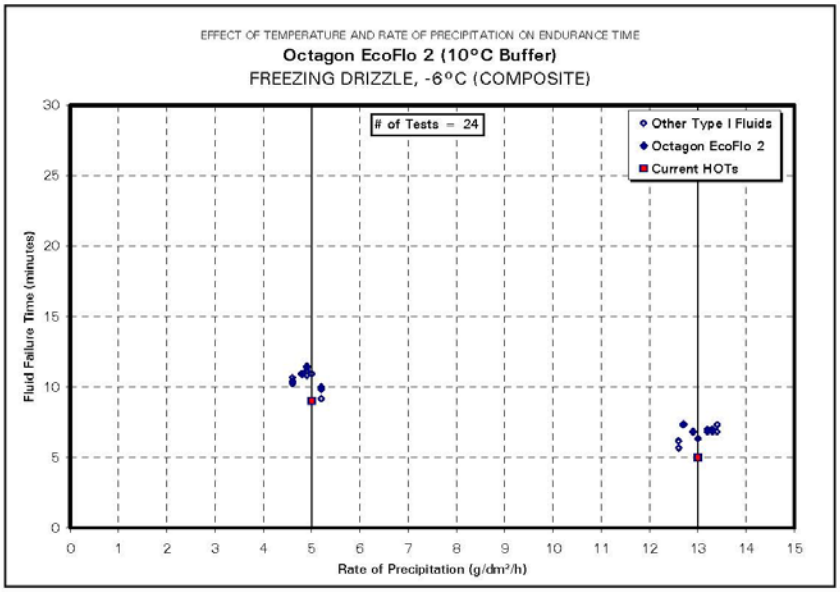


Figure 4.12: Freezing Drizzle, Below -3 to -6°C, Composite Surface

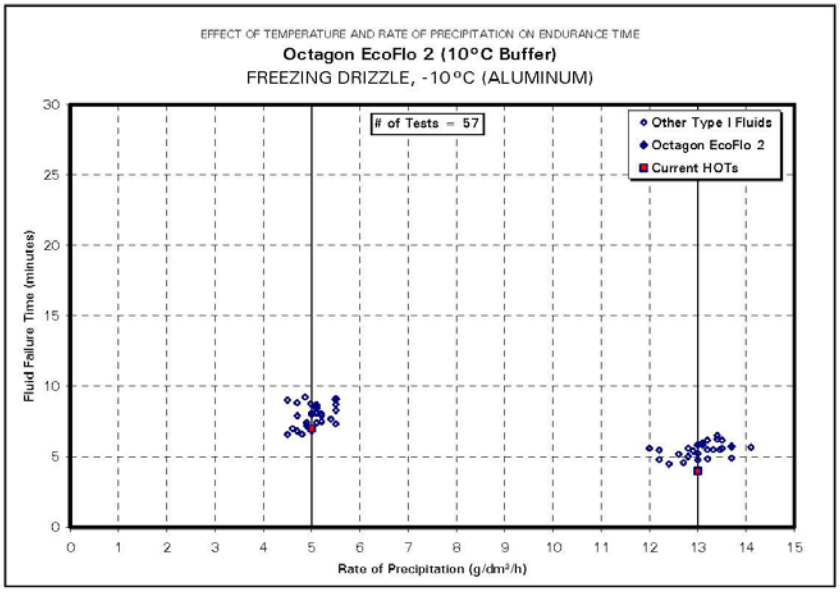


Figure 4.13: Freezing Drizzle, Below -6 to -10°C, Aluminum Surface

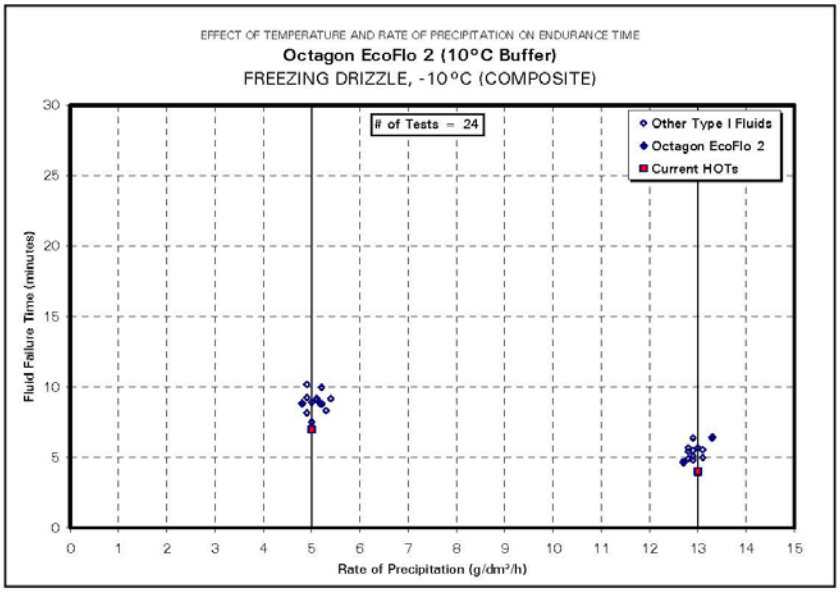


Figure 4.14: Freezing Drizzle, Below -6 to -10°C, Composite Surface

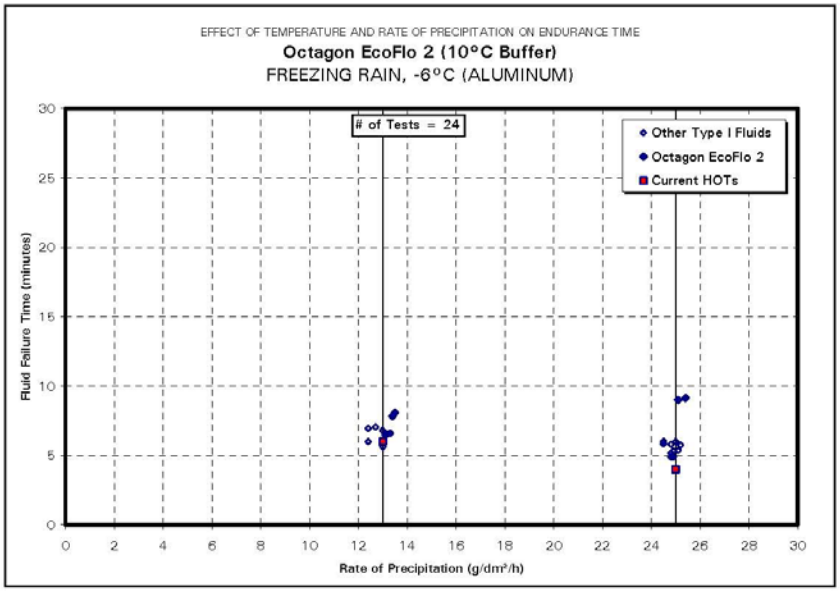


Figure 4.15: Light Freezing Rain, Below -3 to -6°C, Aluminum Surface

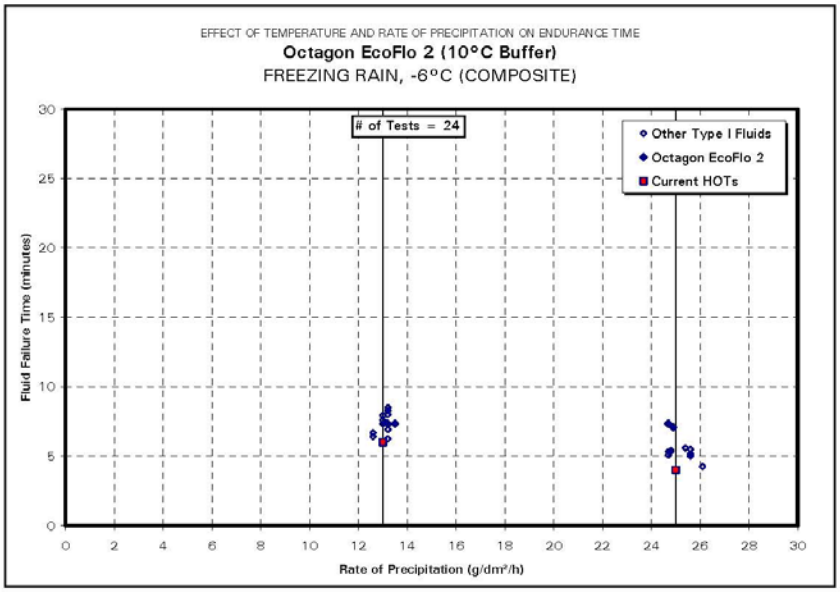


Figure 4.16: Light Freezing Rain, Below -3 to -6°C, Composite Surface

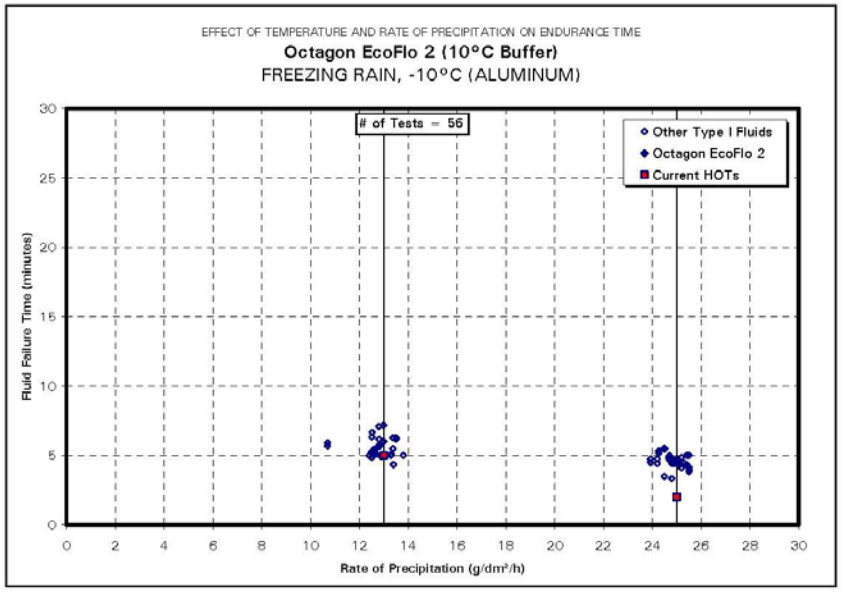


Figure 4.17: Light Freezing Rain, Below -6 to -10°C, Aluminum Surface

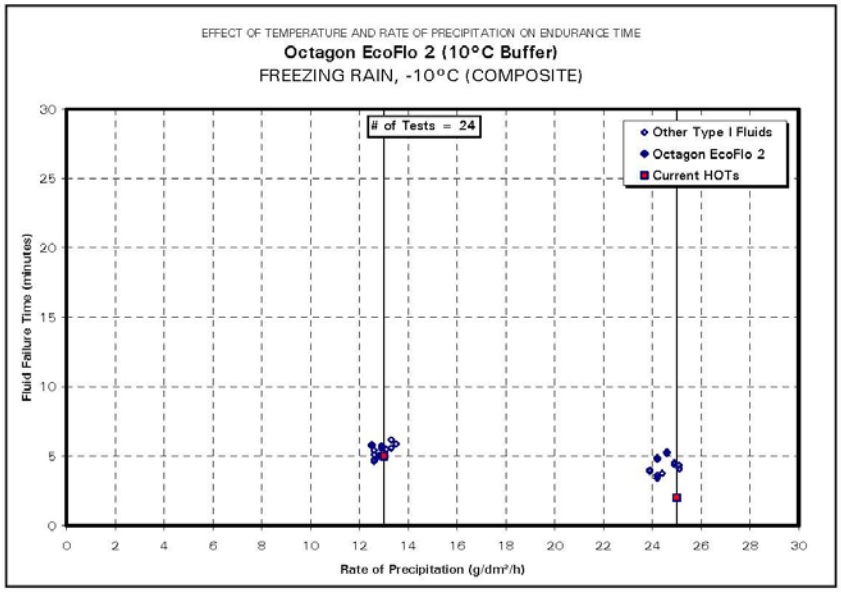


Figure 4.18: Light Freezing Rain, Below -6 to -10°C, Composite Surface

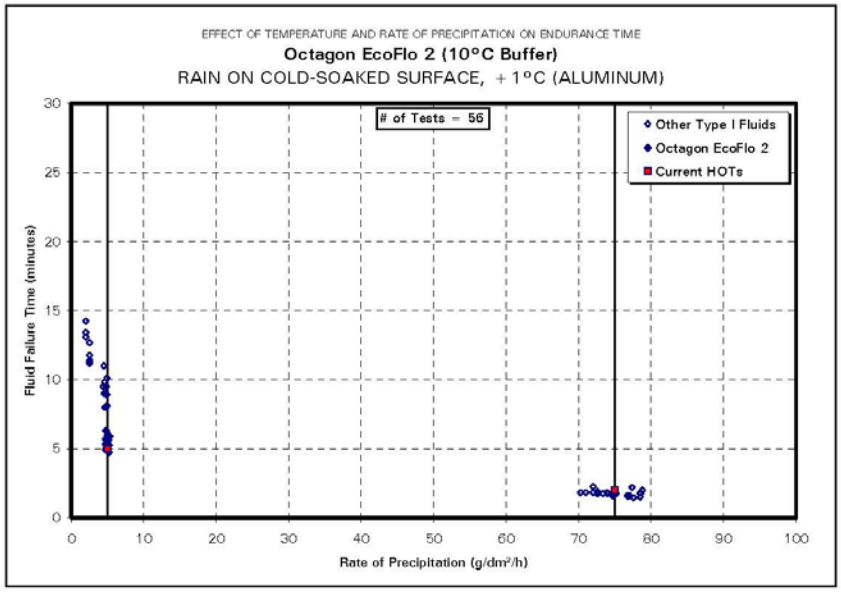


Figure 4.19: Rain on Cold-Soaked Surface, -3°C and Above, Aluminum Surface

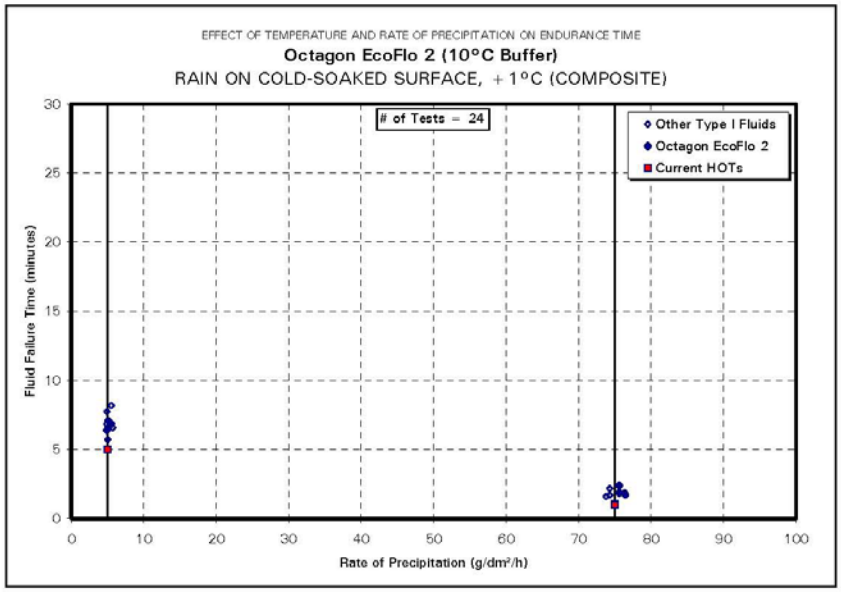


Figure 4.20: Rain on Cold-Soaked Surface, -3°C and Above, Composite Surface

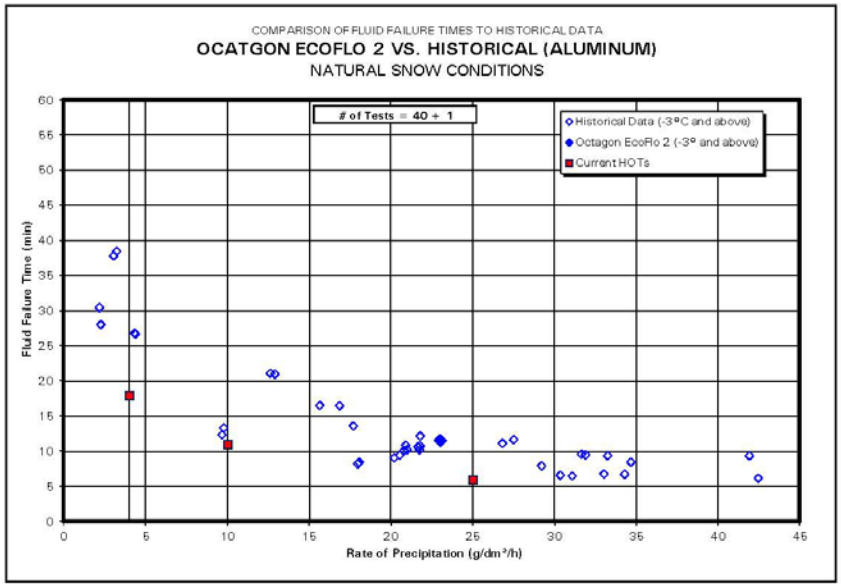


Figure 4.21: Natural Snow, -3°C and Above, Aluminum Surface

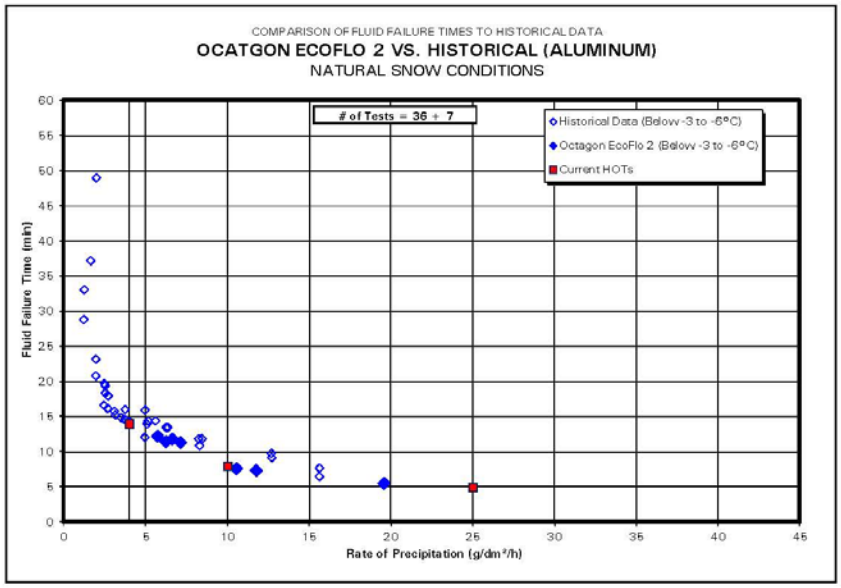


Figure 4.22: Natural Snow, Below -3 to -6°C, Aluminum Surface

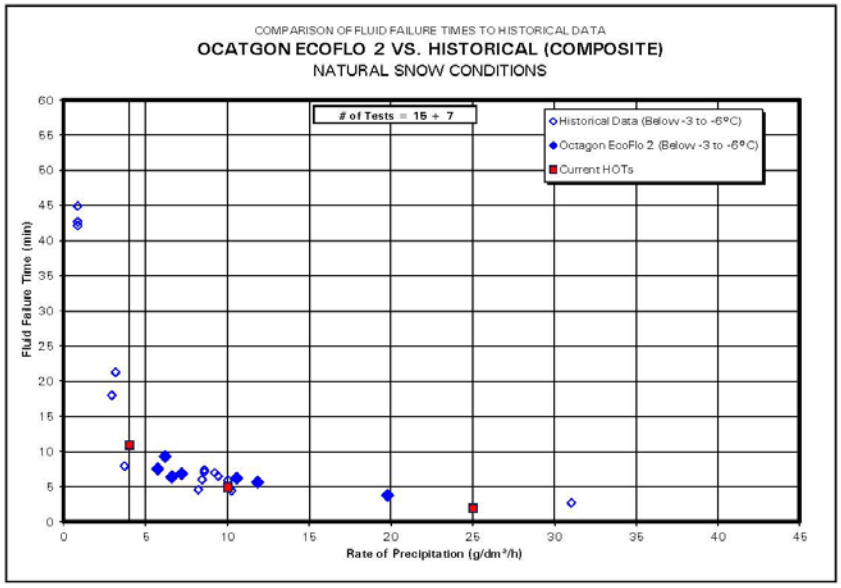


Figure 4.23: Natural Snow, Below -3 to -6°C, Composite Surface

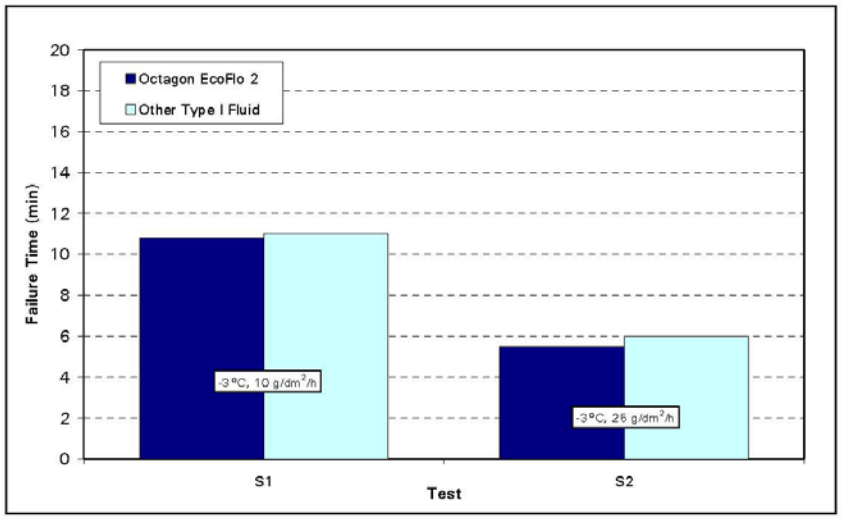
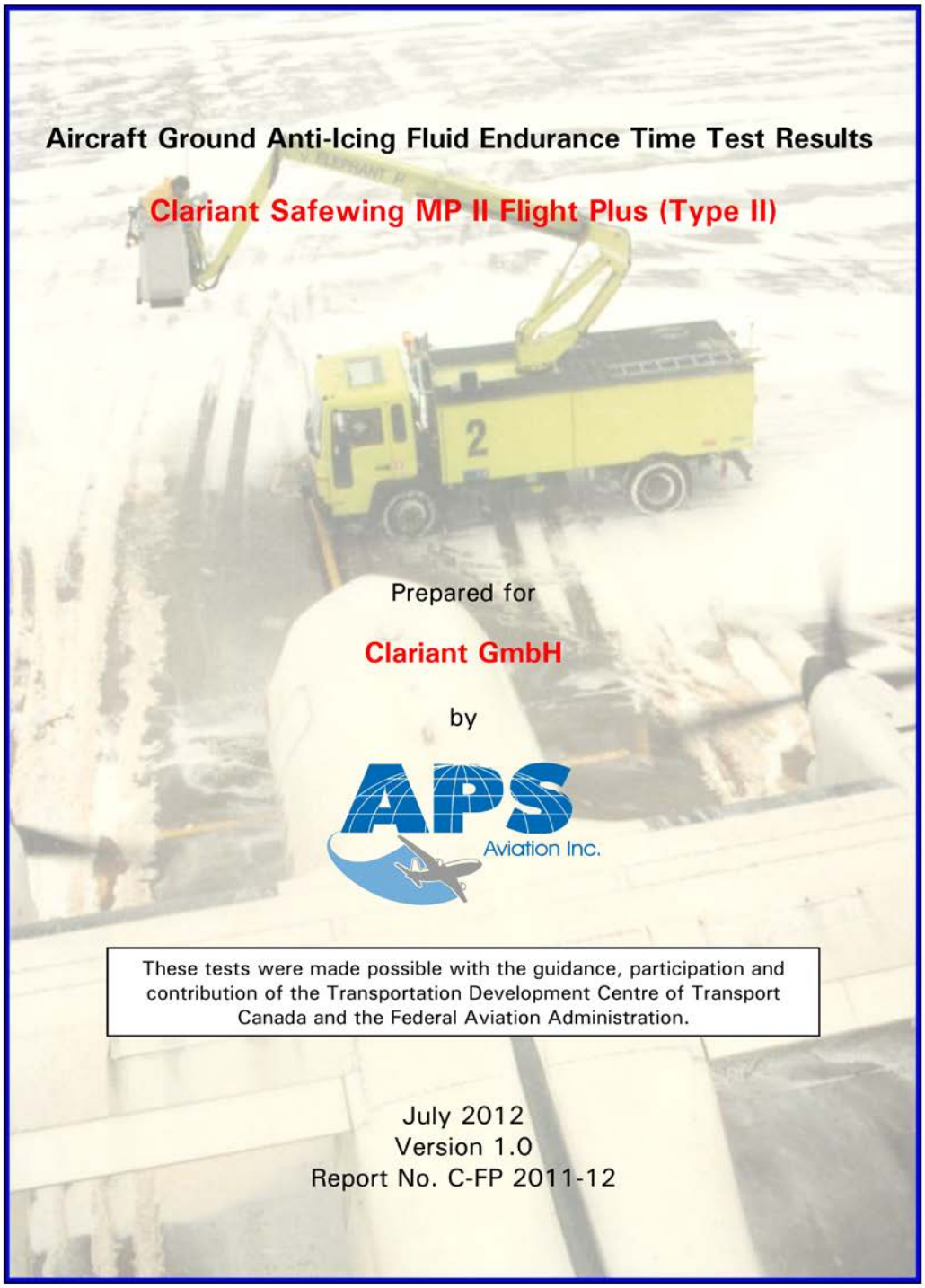


Figure 4.24: Artificial Snow, -3°C and Above, Aluminum Surface

This page intentionally left blank.

APPENDIX E

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.
July 2012
Version 1.0
Report No. C-FP 2011-12

Aircraft Ground Anti-Icing Fluid Endurance Time Test Results

Clariant Safewing MP II Flight Plus (Type II)

Prepared for

Clariant GmbH

Prepared by: _____ July 3, 2012
Stephanie Bendickson — Date
Project Analyst

Reviewed by: _____ July 3, 2012
John D'Avirro — Date
Program Manager, Eng.

These tests were made possible with the guidance, participation and contribution of the Transportation Development Centre of Transport Canada and the Federal Aviation Administration.

July 2012
Version 1.0
Report No. C-FP 2011-12

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

This page intentionally left blank.

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.

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.

Due to the late submission of this fluid and following unfavourable weather conditions in Montreal, sufficient data could not be collected to determine fluid-specific holdover times for the below -3 to -14°C snow cells. Generic values were therefore provided based on supplemental testing with an artificial snowmaker. The snowmaker tests determined generic holdover times can be used until further data is collected and fluid-specific holdover times can be derived.

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	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	1:05-2:00	1:25-2:00	0:45-1:00	0:15-2:00	
		75/25	2:35-4:00	0:55-1:35	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	GENERIC	0:35-1:25	0:35-0:55	CAUTION: No holdover time guidelines exist	
		75/25	0:30-1:45	GENERIC	0:25-1:10	0:30-0:45		
below -14 to -29	below 7 to -20.2	100/0	0:20-0:40	GENERIC				

This page intentionally left blank.

TABLE OF CONTENTS

Page

1. INTRODUCTION 1

2. METHODOLOGY 3

2.1 Test Sites 3
2.1.1 Natural Snow 3
2.1.2 Artificial Snow 3
2.1.3 Freezing Precipitation 5
2.2 Test Equipment 5
2.2.1 Calibration 5
2.2.2 Environmental Chamber Equipment 5
2.2.3 Test Surface Structures 5
2.2.4 Test Surface Materials 7
2.2.5 Test Stands 7
2.2.6 Collection Pans 7
2.2.7 NRC Sprayer Assembly 8
2.2.8 Fluids 8
2.3 Test Procedures 9
2.3.1 Test Protocol – Natural Snow Tests 9
2.3.2 Test Protocol – Artificial Snow Tests 9
2.3.3 Test Protocol – Simulated Precipitation Tests 9
2.3.4 End Condition Definitions 10
2.3.5 Precipitation Rate Measurement Procedures 10
2.4 Precipitation Rate Limits in Type II/IV Endurance Time Testing 13
2.4.1 Freezing Fog 14
2.4.2 Freezing Drizzle 14
2.4.3 Light Freezing Rain 14
2.4.4 Rain on a Cold-Soaked Surface 15
2.4.5 Snow 15
2.5 Ambient Temperatures in Type II/IV Endurance Time Testing 15
2.6 Freezing Precipitation Droplet Sizes 15
2.7 Summary of Freezing Precipitation Test Conditions 17
2.8 Analysis Methodology 18
2.8.1 Freezing Precipitation Data 18
2.8.2 Natural Snow Data 18
2.8.3 Rounding and Capping Protocols 19
2.8.4 Example 19

3. DESCRIPTION OF DATA 27

3.1 Freezing Fog Tests 27
3.2 Freezing Drizzle and Light Freezing Rain Tests 27
3.3 Rain on Cold-Soaked Surface Tests 28
3.4 Natural Snow Tests 28
3.5 Artificial Snow Tests 28
3.6 Fluid Thickness Tests 29

4. RESULTS AND DISCUSSION 35

4.1 Data 35
4.2 Holdover Time Table 35
4.2.1 Holdover Times in Snow, -3°C and Above, 75/25 Dilution 35
4.2.2 Holdover Times in Snow, Below -3 to -14°C 36
4.2.3 Holdover Times in Snow, Below -14°C to LOUT 36

4.2.4 Holdover Times in Frost 36
4.2.5 Fluid Viscosity 37
4.3 Discussion 37

LIST OF FIGURES

Page

Figure 2.1: APS Test Site at Montréal-Pierre-Elliott-Trudeau International Airport 4
Figure 2.2: Snow Test Site Locations 4
Figure 2.3: Standard Test Plate Schematic 6
Figure 2.4: Cold Soak Box Schematic 6
Figure 2.5: Test Stand Setup Schematic 7
Figure 2.6: Schematic of Outdoor Precipitation Measurement Pan 8
Figure 2.7: Calculation of Outdoor Precipitation Rate 12
Figure 2.8: Precipitation Rate Limits Used in Endurance Time Testing 14
Figure 2.9: Regression Method on Log-Log Chart – Type IV Neat, Freezing Rain 20
Figure 2.10: Regression Method on Standard Chart – Type IV Neat, Freezing Rain 20
Figure 3.1: Fluid Thickness Profiles of Clariant Safewing MP II Flight Plus 29
Figure 3.2: Final Fluid Thickness of Clariant Safewing MP II Flight Plus 29
Figure 4.1: Type II Neat – Natural Snow 38
Figure 4.2: Type II 75/25 – Natural Snow 38
Figure 4.3: Type II 50/50 – Natural Snow 39
Figure 4.4: Type II Neat – Freezing Drizzle 39
Figure 4.5: Type II 75/25 – Freezing Drizzle 40
Figure 4.6: Type II 50/50 – Freezing Drizzle 40
Figure 4.7: Type II Neat – Light Freezing Rain 41
Figure 4.8: Type II 75/25 – Light Freezing Rain 41
Figure 4.9: Type II 50/50 – Light Freezing Rain 42
Figure 4.10: Type II Neat – Freezing Fog 42
Figure 4.11: Type II 75/25 – Freezing Fog 43
Figure 4.12: Type II 50/50 – Freezing Fog 43
Figure 4.13: Type II Neat – Rain on Cold-Soaked Surface 44
Figure 4.14: Type II 75/25 – Rain on Cold-Soaked Surface 44
Figure 4.15: Type II Neat – Artificial Snow 45
Figure 4.16: Type II 75/25 – Artificial Snow 45

LIST OF TABLES

Page

Table 2.1: Definition of Weather Phenomenon 13
Table 2.2: Theoretical and Experimental MVDs 16
Table 2.3: Summary of Freezing Precipitation Test Conditions (Type II/IV Fluids) 17
Table 3.1: Summary of Tests Performed (Snow) 30
Table 3.2: Summary of Tests Performed (Freezing Precipitation) 32
Table 4.1: Regression Equation Coefficients for Clariant Safewing MP II Flight Plus 46
Table 4.2: Fluid Specific Holdover Time Guidelines – Clariant Safewing MP II Flight Plus 47

LIST OF PHOTOS

Page

Photo 2.1: APS Test Site - View from Test Pad 21
Photo 2.2: APS Test Site - View from Trailer 21
Photo 2.3: Mobile Test Site 22
Photo 2.4: Outdoor View of NRC Climatic Engineering Facility 22
Photo 2.5: Inside View of NRC Climatic Engineering Facility 23
Photo 2.6: Test Plates Mounted on Stand 23
Photo 2.7: Cold-Soak / Leading Edge Thermal Equivalent Box 24
Photo 2.8: Collection Pans Used Indoors at the NRC 24
Photo 2.9: Sprayer Assembly 25
Photo 2.10: Sprayer Assembly in Use 25
Photo 2.11: Sprayer Nozzle 26
Photo 2.12: Standard Plate Setup for Type I Testing with Artificial Snowmaker 26

This page intentionally left blank.

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

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 a fluid-specific holdover times for the fluid. These holdover times are expected to be published by regulators for use in the winter 2012-13 operating season.

This page intentionally left blank.

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 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

2.1.1 Natural Snow

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. These locations are 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.

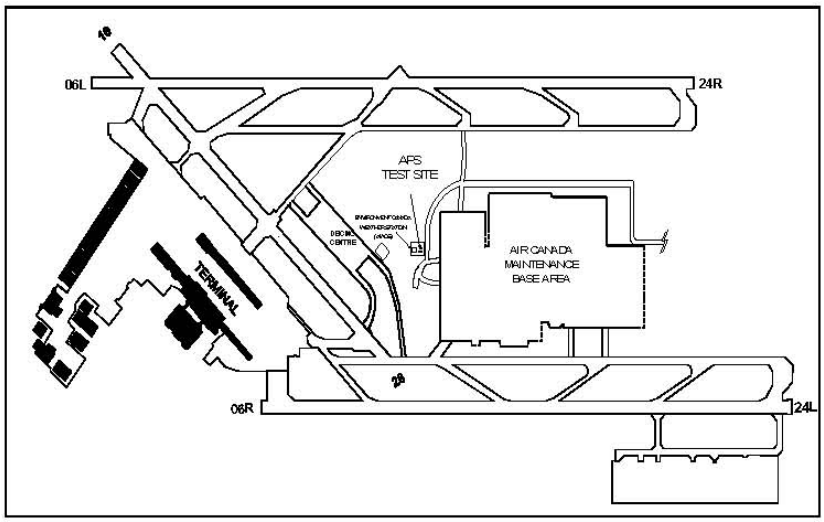


Figure 2.1: APS Test Site at Montréal-Pierre-Elliott-Trudeau International Airport

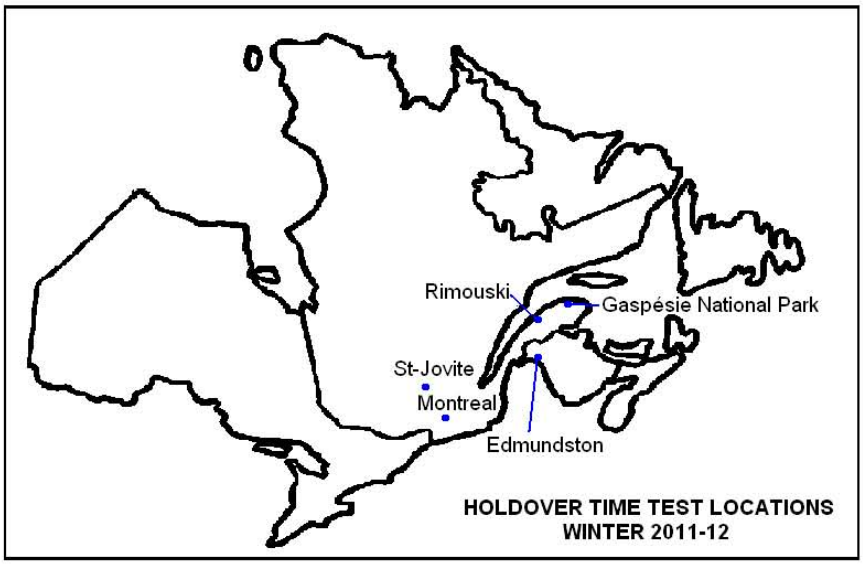


Figure 2.2: Snow Test Site Locations

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 2.3.4) 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.

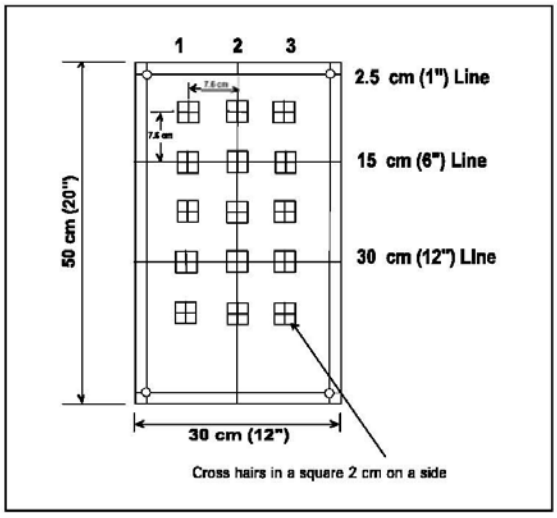


Figure 2.3: Standard Test Plate Schematic

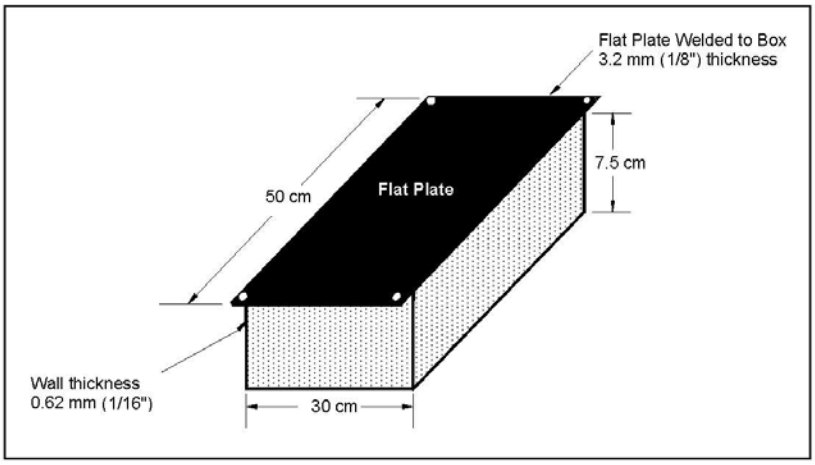


Figure 2.4: Cold Soak Box Schematic

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.

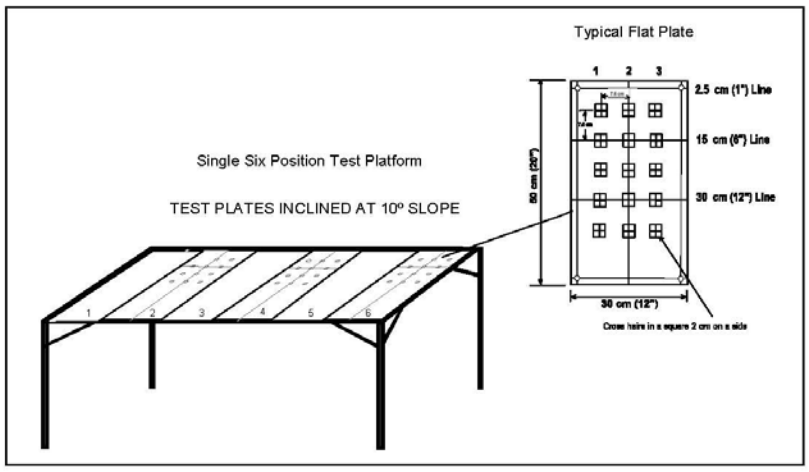


Figure 2.5: Test Stand Setup Schematic

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

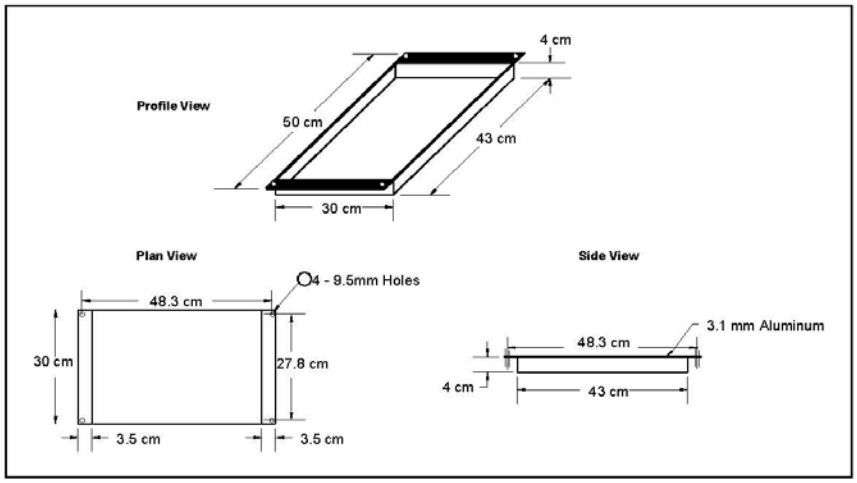


Figure 2.6: Schematic of Outdoor Precipitation Measurement Pan

2.2.7 NRC Sprayer Assembly

NRC developed an improved sprayer assembly, shown in Photos 2.9 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 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 2.3.4), 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 2.12);
- 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 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. 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.

2.3.5.2 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) 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.

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 2.6, 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.

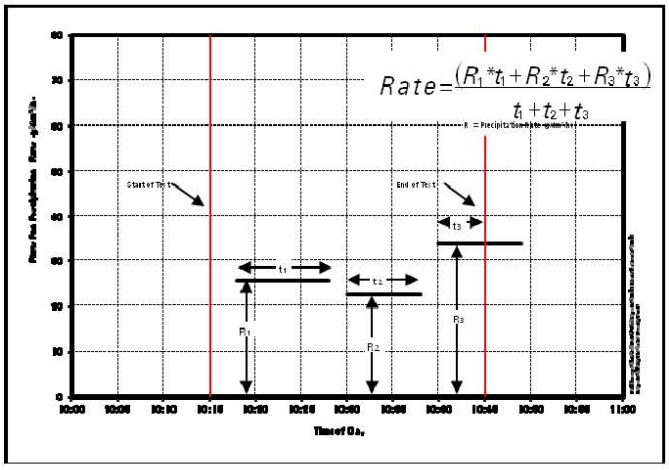


Figure 2.7: Calculation of Outdoor Precipitation Rate

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)
Measured Intensity	Up to 0.10 in/hr (2.5 mm or 25 gr/dm²/hr); Maximum 0.01 inch in 6 minutes
Light (-)	
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.
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
Moderate	
Estimated Intensity	Individual drops are not clearly identifiable; spray is observable just above pavement and other hard surfaces.
Measured Intensity	More than 0.30 in/hr (7.6 mm or 76 gr/dm²/hr); More than 0.03 inch in 6 minutes
Heavy (+)	
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)

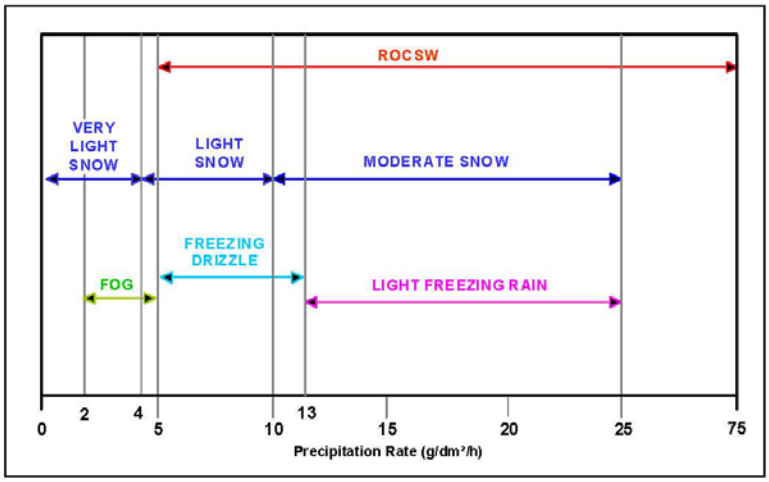


Figure 2.8: Precipitation Rate Limits Used in Endurance Time Testing

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/dm²/h. This range encompasses drizzle (5 to 13 g/dm²/h), light rain (13 to 25 g/dm²/h), and moderate rain (25 to 75 g/dm²/h).

2.4.5 Snow

The precipitation rate limits used to determine holdover times for Type II/IV fluids in snow are 10 and 25 g/dm²/h, which encompass moderate snow.

Notably, Type I/III holdover times are determined using these rates plus additional precipitation rate limits (3 and 4 g/dm²/h), which encompass light and very light 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:

- $t = 10^{l}R^{a}$, where

  t = Time (minutes)
  R = Rate of precipitation (g/dm²/h)
  l, 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:

- $t = 10^{l} R^{a} (2\text{-}T)^{b}$, where

t = Time (minutes)
R = Rate of precipitation (g/dm²/h)
I, a, b = coefficients determined from the regression.

The upper and lower HOT values for each cell are determined from the points at which the best-fit curve intersects the lower and upper precipitation limits, using the most restrictive (lowest) temperature for that cell. The calculated holdover times derived from this analysis are subject to the rounding and capping rules detailed in Subsection 2.8.3.

2.8.3 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.

2.8.4 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.

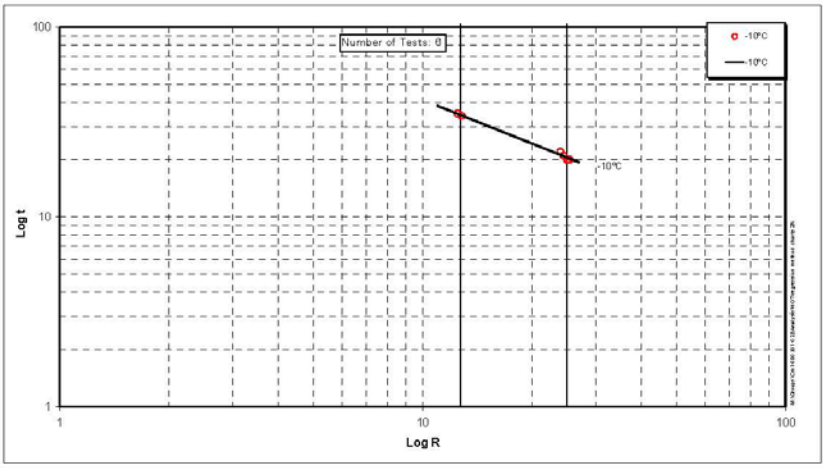


Figure 2.9: Regression Method on Log-Log Chart – Type IV Neat, Freezing Rain

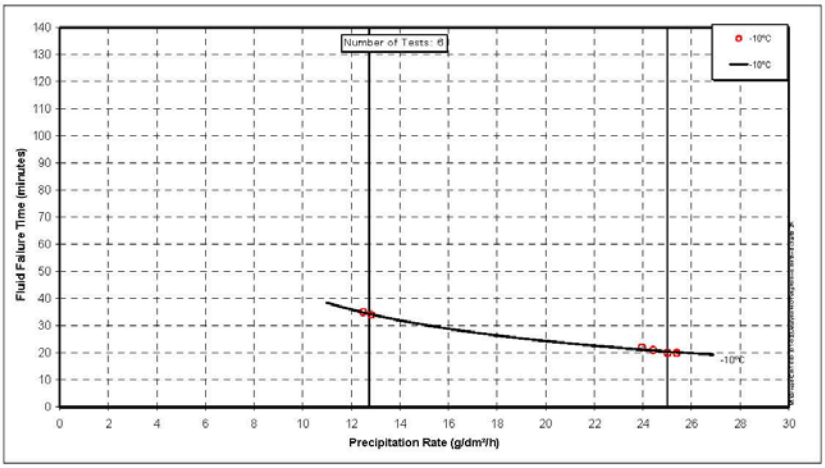


Figure 2.10: Regression Method on Standard Chart – Type IV Neat, Freezing Rain

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

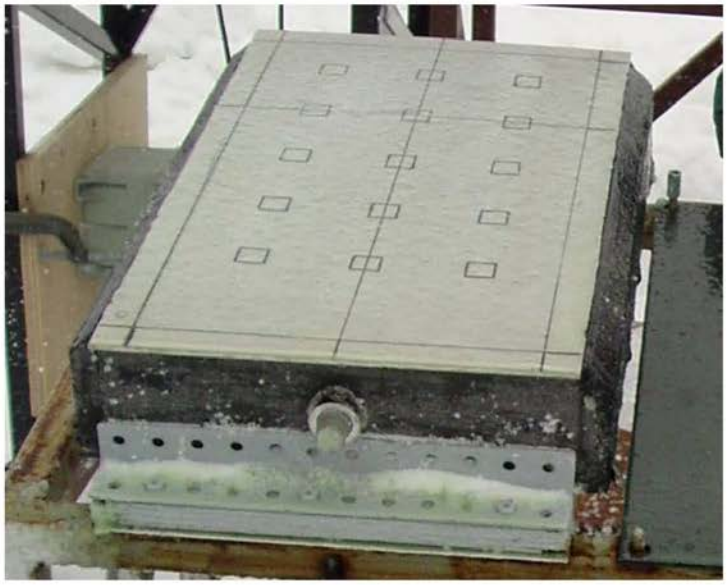


Photo 2.8: Collection Pans Used Indoors at the NRC



Photo 2.9: Sprayer Assembly



Photo 2.10: Sprayer Assembly in Use



Photo 2.11: Sprayer Nozzle

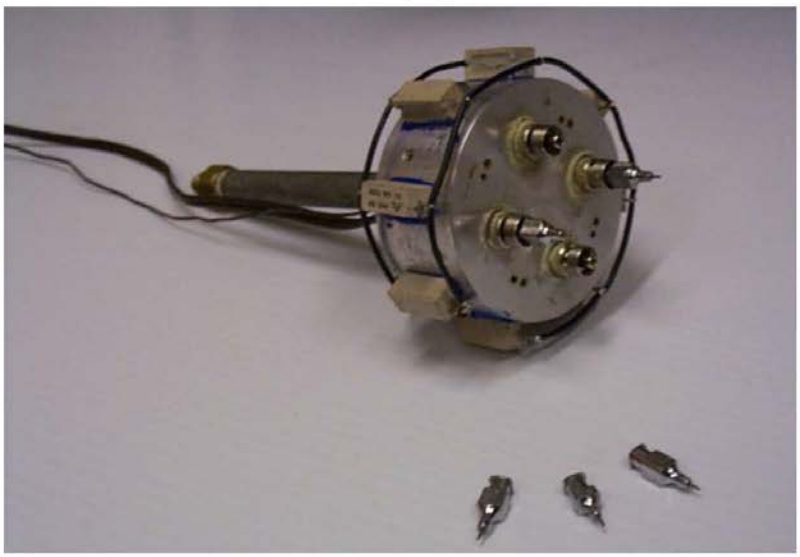


Photo 2.12: Standard Plate Setup for Type I Testing with Artificial Snowmaker



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) and a log of tests conducted in freezing precipitation (Table 3.2) 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	11	5	0
75/25	14	6	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 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.

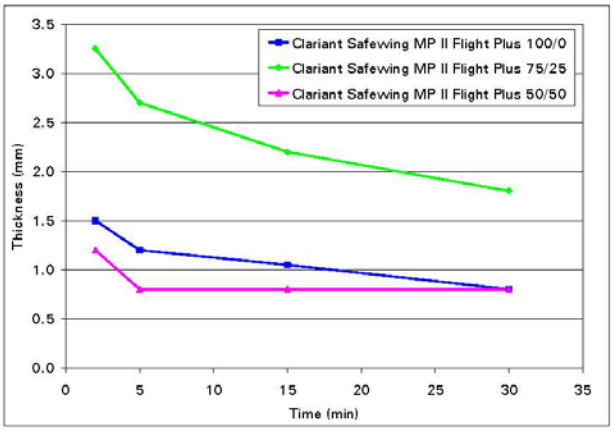


Figure 3.1: Fluid Thickness Profiles of Clariant Safewing MP II Flight Plus

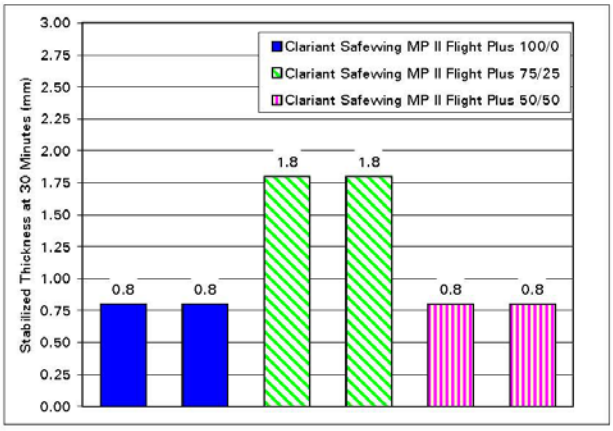


Figure 3.2: Final Fluid Thickness of Clariant Safewing MP II Flight Plus

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)
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
173	14-Mar-12	Natural	Edmundston, NB	MP II Flight Plus	50/50	-3.2	15.0	17.1

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)
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

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

This page intentionally left blank.

34

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.

4.2 Holdover Time Table

A fluid-specific HOT table for Clariant Safewing MP II Flight Plus is shown in Table 4.2 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 2012-13 FAA and TC HOT guidelines. Commercialization of this fluid will not affect the generic Type II holdover times.

4.2.1 Holdover Times in Snow, -3°C and Above, 75/25 Dilution

Regression analysis of the Neat and 75/25 natural snow data sets resulted in abnormal temperature trends; the regression curves showed endurance times increasing as temperature decreases. This is very likely the result of insufficient data being collected at lower temperatures (see Subsections 4.2.2 and 4.2.3).

Standard protocol dictates that holdover times be derived using the most restrictive temperature in the holdover time table temperature range. In these two cases warmer temperatures result in the most restrictive holdover times and therefore holdover times were calculated using the regression curves with a temperature input of +1°C. The +1°C regression curves are shown as dotted red lines in Figures 4.1 and 4.2.

If additional data is collected with this fluid (see Subsection 4.2.2), these regression curves and the resulting holdover times will be reanalysed.

4.2.2 Holdover Times in Snow, Below -3 to -14°C

Due to the late submission of this fluid for testing and subsequent unfavourable weather conditions in Montreal, sufficient natural snow data was not collected to derive fluid-specific values for the "Below -3 to -14°C" snow cells.

Supplemental testing was conducted with an artificial snowmaker to determine if the fluid could be used with the current generic Type II holdover times. As the data showed the endurance times to be equal to or greater than the generic holdover times (see Figure 4.15), regulators agreed that the generic holdover times could be used for this fluid in the in "Below -3 to -14°C" snow cells until additional data can be collected. It is expected this data will be collected in the winter of 2012-13.

4.2.3 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.

4.2.4 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.

4.2.5 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 has indicated it will commercialize Safewing MP II Flight 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.

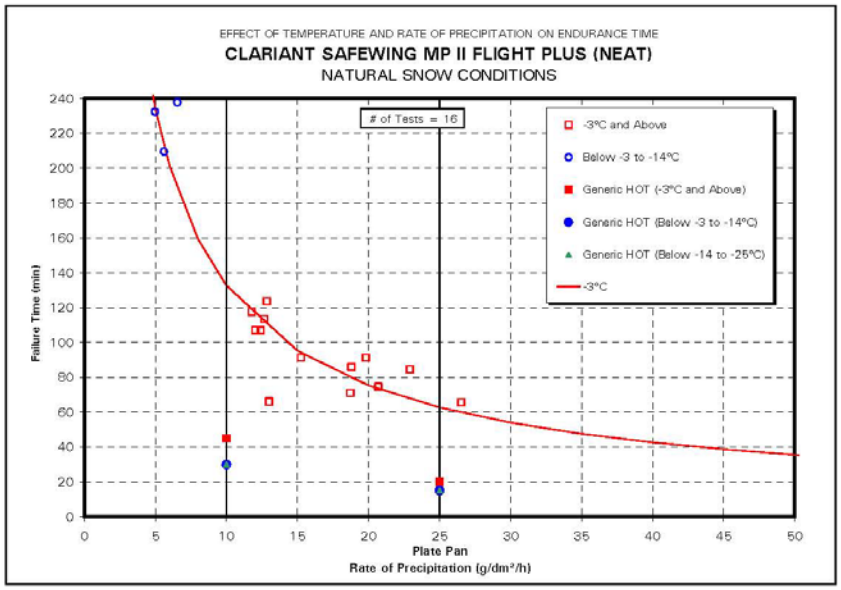


Figure 4.1: Type II Neat – Natural Snow

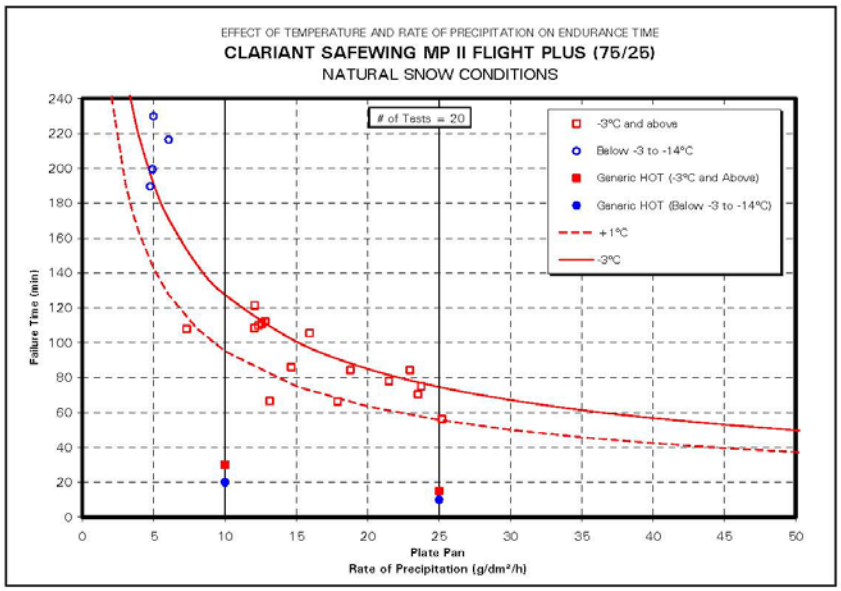


Figure 4.2: Type II 75/25 – Natural Snow

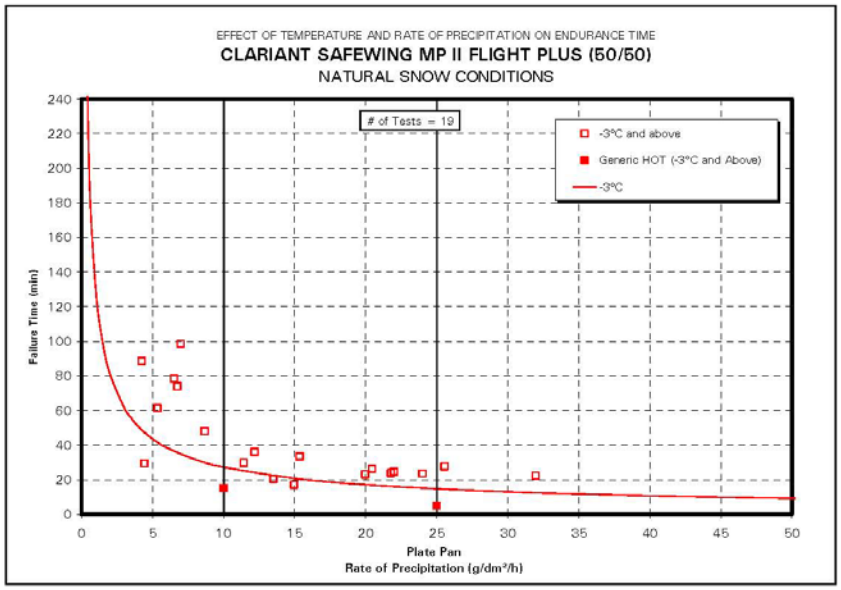


Figure 4.3: Type II 50/50 – Natural Snow

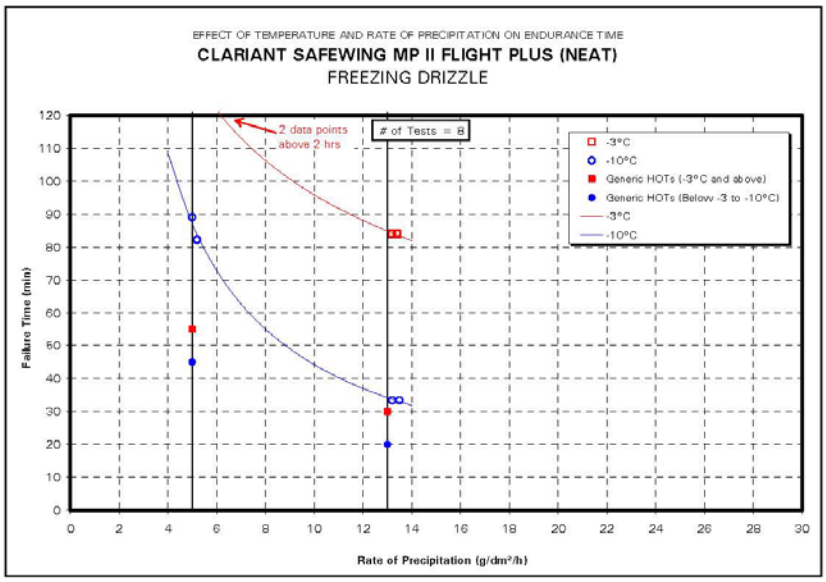


Figure 4.4: Type II Neat – Freezing Drizzle

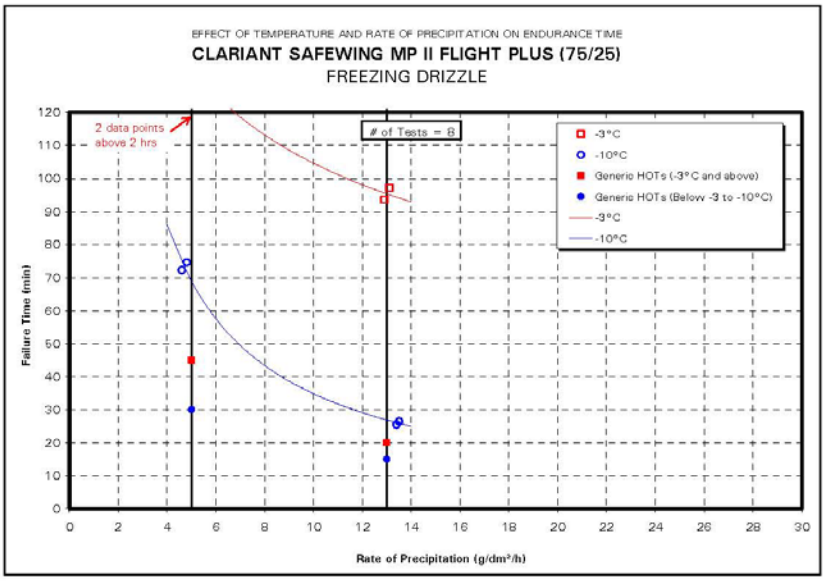


Figure 4.5: Type II 75/25 – Freezing Drizzle

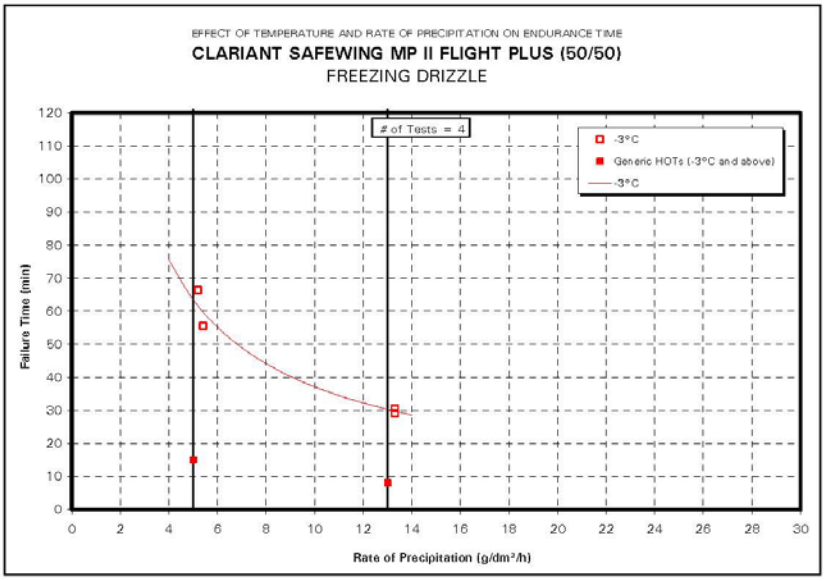


Figure 4.6: Type II 50/50 – Freezing Drizzle

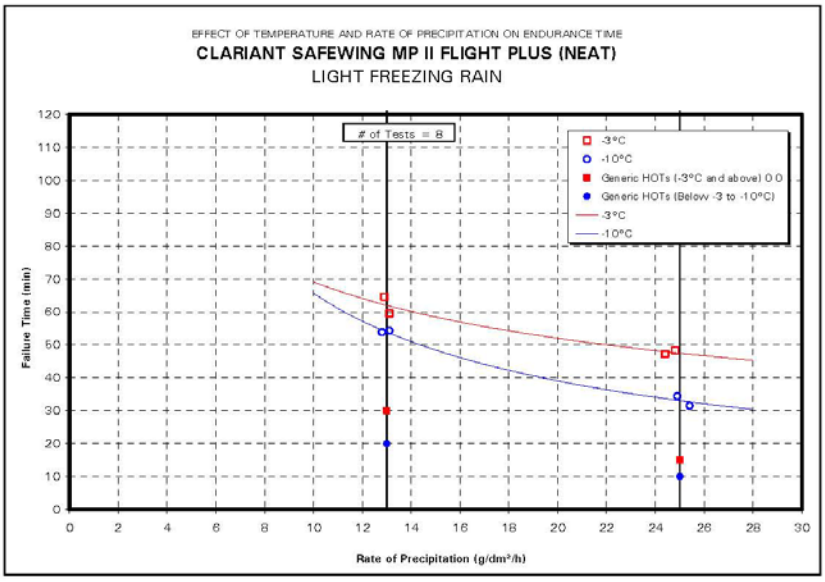


Figure 4.7: Type II Neat – Light Freezing Rain

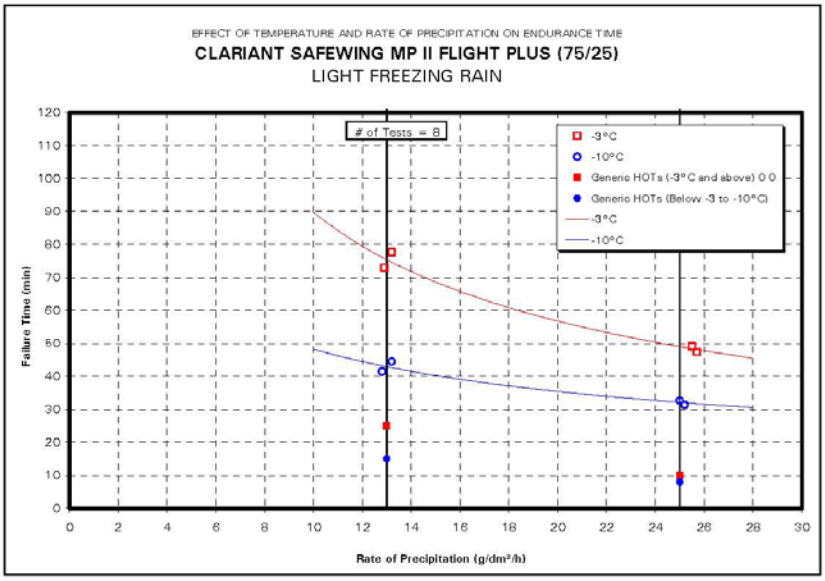


Figure 4.8: Type II 75/25 – Light Freezing Rain

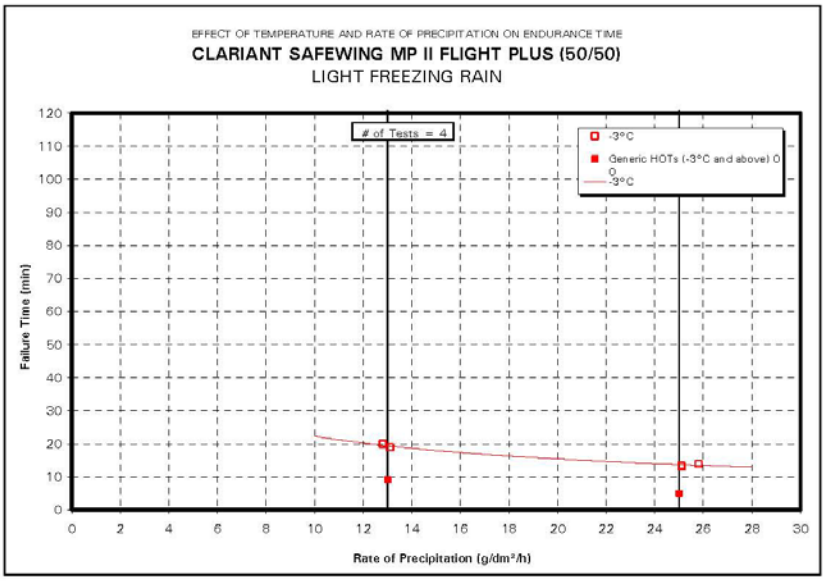


Figure 4.9: Type II 50/50 – Light Freezing Rain

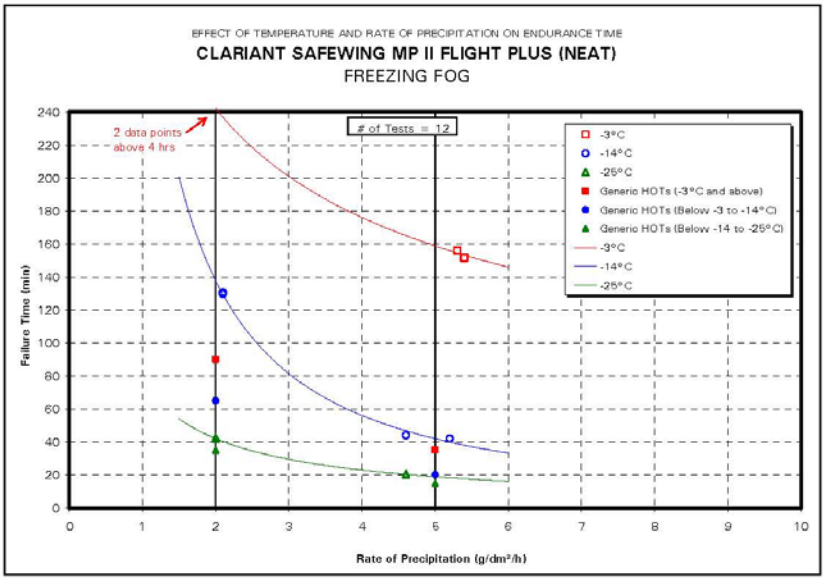


Figure 4.10: Type II Neat – Freezing Fog

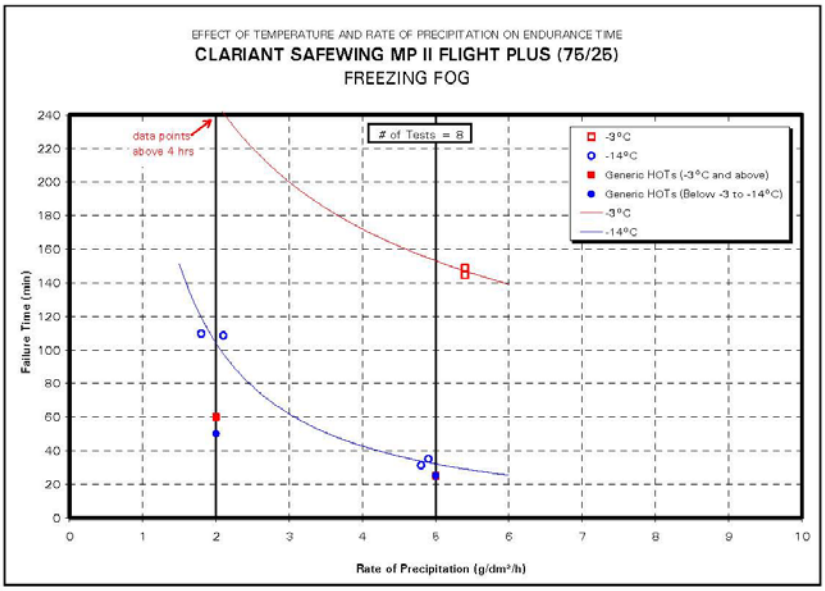


Figure 4.11: Type II 75/25 – Freezing Fog

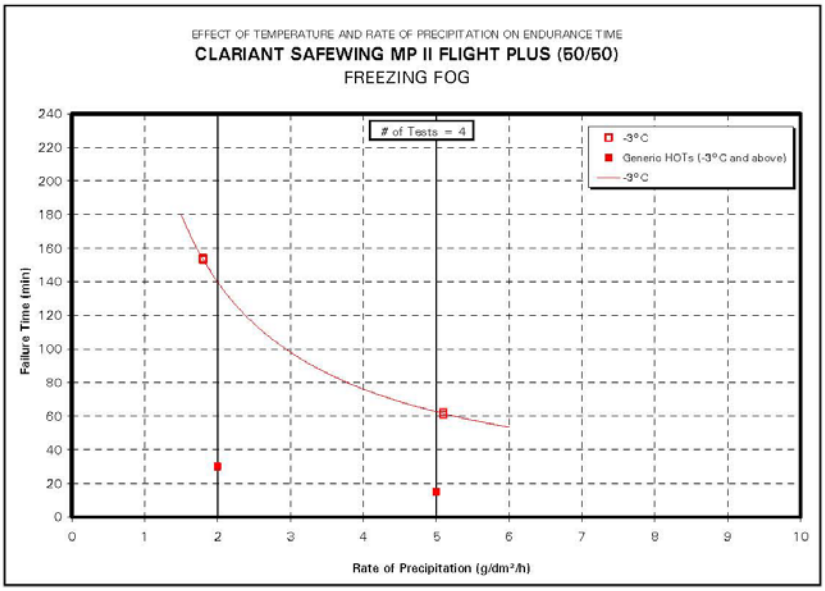


Figure 4.12: Type II 50/50 – Freezing Fog

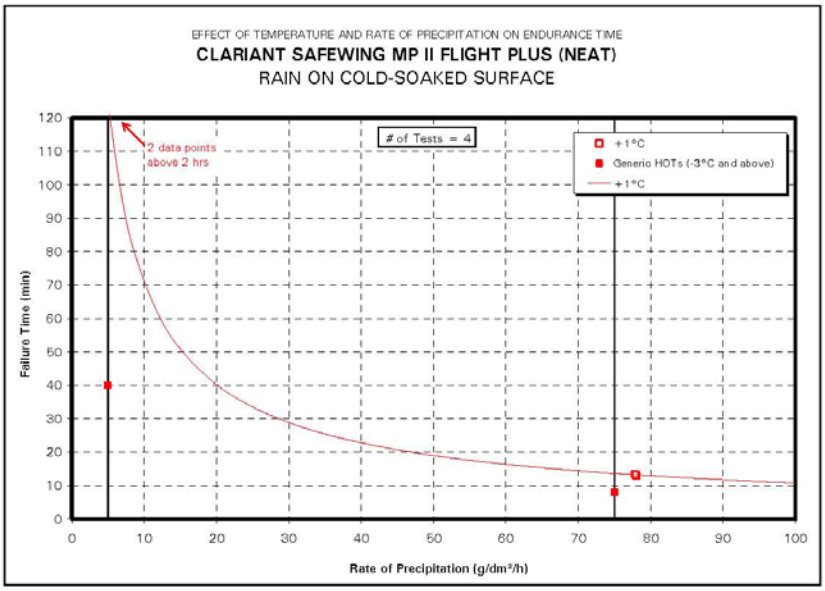


Figure 4.13: Type II Neat – Rain on Cold-Soaked Surface

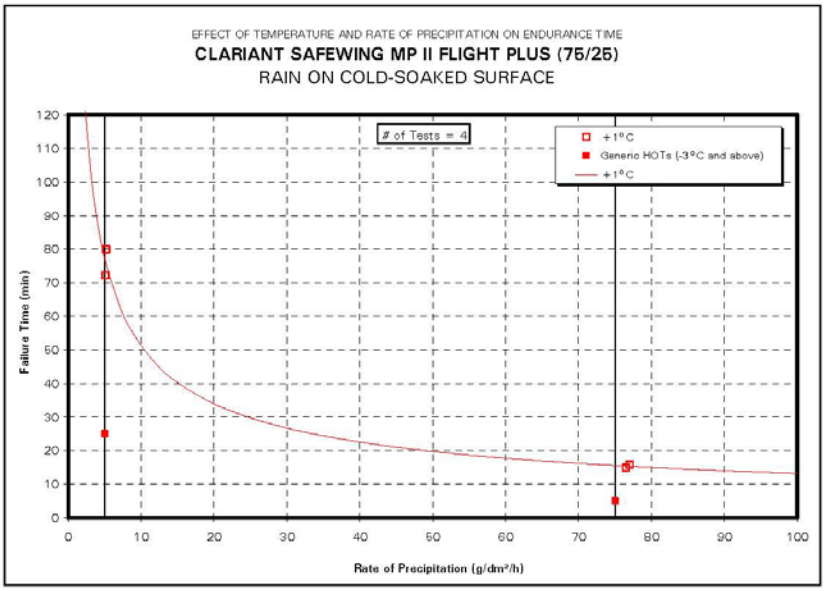


Figure 4.14: Type II 75/25 – Rain on Cold-Soaked Surface

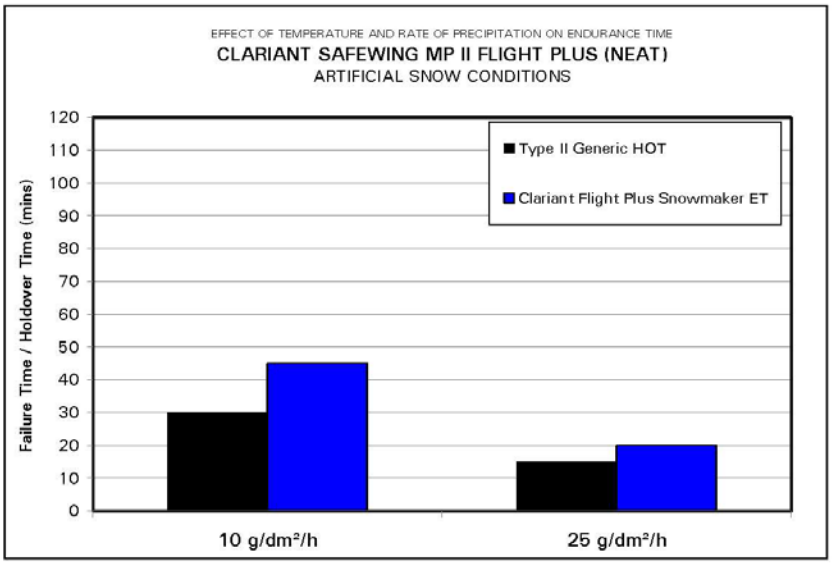


Figure 4.15: Type II Neat – Artificial Snow

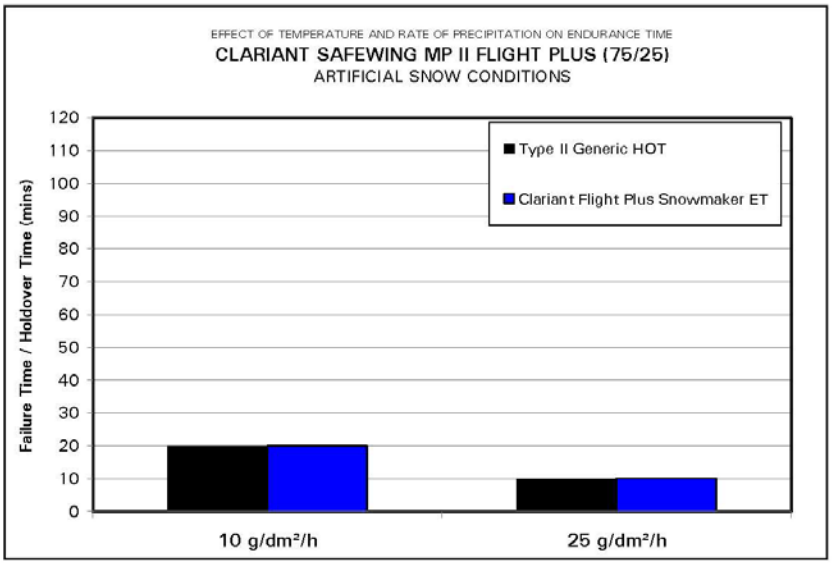


Figure 4.16: Type II 75/25 – Artificial Snow

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	84%	2.9794	-0.8180	-0.0556	16
Clariant Safewing MP II Flight Plus	75/25	85%	2.5612	-0.5834	0.0000	20
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 PLUS

CLARIANT TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2012-2013[1]
SAFEWING MP II FLIGHT PLUS

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

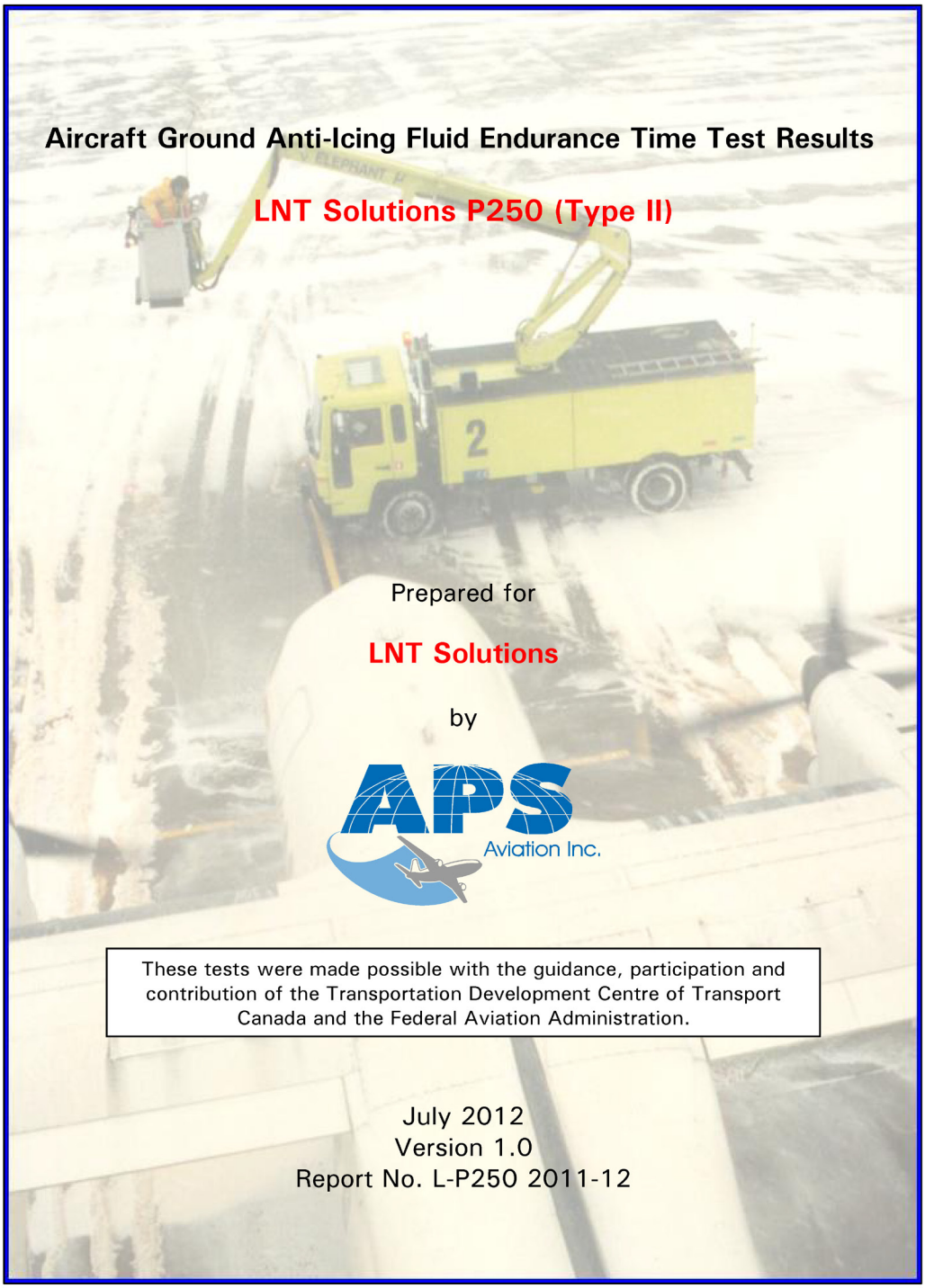
Outside Air Temperature[2]		Type II Fluid Concentration Neat Fluid/Water (Volume %/Volume %)	Approximate Holdover Times Under Various Weather Conditions (hours:minutes)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow, Snow Grains or Snow Pellets[3]	Freezing Drizzle[4]	Light Freezing Rain	Rain on Cold Soaked Wing[5]	Other[6]
-3 and above	27 and above	100/0	2:40 – 4:00	1:05 – 2:00	1:25 – 2:00	0:45 – 1:00	0:15 – 2:00	
		75/25	2:35 – 4:00	0:55 – 1:35	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	0:15 – 0:30	0:35 – 1:25[7]	0:35 – 0:55[7]	CAUTION: No holdover time guidelines exist	
		75/25	0:30 – 1:45	0:10 – 0:20	0:25 – 1:10[7]	0:30 – 0:45[7]		
below -14 to -29	below 7 to -20.2	100/0	0:20 – 0:40	0:15 – 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 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 F

FLUID MANUFACTURER REPORT:
LNT SOLUTIONS P250 (TYPE II)


Aircraft Ground Anti-Icing Fluid Endurance Time Test Results
LNT Solutions P250 (Type II)
Prepared for
LNT Solutions
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.
July 2012
Version 1.0
Report No. L-P250 2011-12

Aircraft Ground Anti-Icing Fluid Endurance Time Test Results

LNT Solutions P250 (Type II)

Prepared for

LNT Solutions

Prepared by: _____ July 3, 2012
Stephanie Bendickson — Date
Project Analyst

Reviewed by: _____ July 3, 2012
John D'Avirro — Date
Program Manager, Eng.

These tests were made possible with the guidance, participation and contribution of the Transportation Development Centre of Transport Canada and the Federal Aviation Administration.

July 2012
Version 1.0
Report No. L-P250 2011-12

FLUID IDENTIFICATION AND CHARACTERISTICS

Manufacturer:	LNT Solutions		
Fluid Test Name:	LNT 53563-40		
Fluid Commercial Name:	P250		
Fluid Type / Base / Colour:	Type II / Propylene Glycol / Green		
Batch #:	53563-40		
Date of Receipt:	March 20, 2012		
Brix (Measured):	Neat fluid:	36.25°	
	75/25 dilution:	28.5°	
	50/50 dilution:	19.0°	
Freeze Point (Stated):	Neat fluid:	not available	
	75/25 dilution:	not available	
	50/50 dilution:	not available	
LOUT (Stated):	Neat fluid:	not available	
	75/25 dilution:	not available	
	50/50 dilution:	not available	
Viscosity:	**Mfr Method[1]**	**Stated**	**Measured**
	Neat fluid:	4,500 cP	5,050 cP
	75/25 dilution:	4,800 cP	4,650 cP
	50/50 dilution:	3,400 cP	2,350 cP
	AIR9968 Method[1]	**Stated**	**Measured**
	Neat fluid:	4,500 cP	5,050 cP
	75/25 dilution:	4,800 cP	4,650 cP
	50/50 dilution:	3,400 cP	2,350 cP
WSET (from AMIL):	Neat fluid:	83 minutes	

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

This page intentionally left blank.

SUMMARY

The primary objective of this project was to measure the endurance time performance of LNT Solutions P250 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.

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.

Due to the late submission of this fluid and following unfavourable weather conditions in Montreal, sufficient data could not be collected to determine fluid-specific holdover times for the below -3 to -14°C snow cells. Generic values were therefore provided based on supplemental testing with an artificial snowmaker. The snowmaker tests determined generic holdover times can be used until further data is collected and fluid-specific holdover times can be derived.

LNT Solutions P250 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	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	1:45-3:00	0:50-1:10	1:20-1:40	0:40-1:05	0:20-1:30	
		75/25	1:00-1:45	0:30-0:50	0:35-1:05	0:20-0:35	0:10-1:15	
		50/50	0:25-0:40	0:10-0:15	0:15-0:25	0:07-0:15		
below -3 to -14	below 27 to 7	100/0	0:45-2:35	GENERIC	0:30-1:40	1:00-1:25	CAUTION: No holdover time guidelines exist	
		75/25	0:25-1:20	GENERIC	0:25-1:15	0:35-0:50		
below -14 to -29	below 7 to -20.2	100/0	0:20-0:45	GENERIC				

This page intentionally left blank.

TABLE OF CONTENTS

Page

1. INTRODUCTION 1

2. METHODOLOGY 3

2.1 Test Sites 3
2.1.1 Natural Snow 3
2.1.2 Artificial Snow 3
2.1.3 Freezing Precipitation 5
2.2 Test Equipment 5
2.2.1 Calibration 5
2.2.2 Environmental Chamber Equipment 5
2.2.3 Test Surface Structures 5
2.2.4 Test Surface Materials 7
2.2.5 Test Stands 7
2.2.6 Collection Pans 7
2.2.7 NRC Sprayer Assembly 8
2.2.8 Fluids 8
2.3 Test Procedures 9
2.3.1 Test Protocol – Natural Snow Tests 9
2.3.2 Test Protocol – Artificial Snow Tests 9
2.3.3 Test Protocol – Simulated Precipitation Tests 9
2.3.4 End Condition Definitions 10
2.3.5 Precipitation Rate Measurement Procedures 10
2.4 Precipitation Rate Limits in Type II/IV Endurance Time Testing 13
2.4.1 Freezing Fog 14
2.4.2 Freezing Drizzle 14
2.4.3 Light Freezing Rain 14
2.4.4 Rain on a Cold-Soaked Surface 15
2.4.5 Snow 15
2.5 Ambient Temperatures in Type II/IV Endurance Time Testing 15
2.6 Freezing Precipitation Droplet Sizes 15
2.7 Summary of Freezing Precipitation Test Conditions 17
2.8 Analysis Methodology 18
2.8.1 Freezing Precipitation Data 18
2.8.2 Natural Snow Data 18
2.8.3 Rounding and Capping Protocols 19
2.8.4 Example 19

3. DESCRIPTION OF DATA 27

3.1 Freezing Fog Tests 27
3.2 Freezing Drizzle and Light Freezing Rain Tests 27
3.3 Rain on Cold-Soaked Surface Tests 28
3.4 Natural Snow Tests 28
3.5 Artificial Snow Tests 28
3.6 Fluid Thickness Tests 29

4. RESULTS AND DISCUSSION 35

4.1 Data 35
4.2 Holdover Time Table 35
4.2.1 Holdover Times in Snow, -3°C and Above, Neat and 75/25 35
4.2.2 Holdover Times in Snow, Below -3 to -14°C 36
4.2.3 Holdover Times in Snow, Below -14°C to LOUT 36

4.2.4 Holdover Times in Frost 36
4.2.5 Fluid Viscosity 37
4.3 Discussion 37

LIST OF FIGURES

Page

Figure 2.1: APS Test Site at Montréal-Pierre-Elliott-Trudeau International Airport 4
Figure 2.2: Snow Test Site Locations 4
Figure 2.3: Standard Test Plate Schematic 6
Figure 2.4: Cold Soak Box Schematic 6
Figure 2.5: Test Stand Setup Schematic 7
Figure 2.6: Schematic of Outdoor Precipitation Measurement Pan 8
Figure 2.7: Calculation of Outdoor Precipitation Rate 12
Figure 2.8: Precipitation Rate Limits Used in Endurance Time Testing 14
Figure 2.9: Regression Method on Log-Log Chart – Type IV Neat, Freezing Rain 20
Figure 2.10: Regression Method on Standard Chart – Type IV Neat, Freezing Rain 20
Figure 3.1: Fluid Thickness Profiles of LNT Solutions P250 29
Figure 3.2: Final Fluid Thickness of LNT Solutions P250 29
Figure 4.1: Type II Neat – Natural Snow 38
Figure 4.2: Type II 75/25 – Natural Snow 38
Figure 4.3: Type II 50/50 – Natural Snow 39
Figure 4.4: Type II Neat – Freezing Drizzle 39
Figure 4.5: Type II 75/25 – Freezing Drizzle 40
Figure 4.6: Type II 50/50 – Freezing Drizzle 40
Figure 4.7: Type II Neat – Light Freezing Rain 41
Figure 4.8: Type II 75/25 – Light Freezing Rain 41
Figure 4.9: Type II 50/50 – Light Freezing Rain 42
Figure 4.10: Type II Neat – Freezing Fog 42
Figure 4.11: Type II 75/25 – Freezing Fog 43
Figure 4.12: Type II 50/50 – Freezing Fog 43
Figure 4.13: Type II Neat – Rain on Cold-Soaked Surface 44
Figure 4.14: Type II 75/25 – Rain on Cold-Soaked Surface 44
Figure 4.15: Type II Neat – Artificial Snow 45
Figure 4.16: Type II 75/25 – Artificial Snow 45

LIST OF TABLES

Page

Table 2.1: Definition of Weather Phenomenon 13
Table 2.2: Theoretical and Experimental MVDs 16
Table 2.3: Summary of Freezing Precipitation Test Conditions (Type II/IV Fluids) 17
Table 3.1: Summary of Tests Performed (Snow) 30
Table 3.2: Summary of Tests Performed (Freezing Precipitation) 32
Table 4.1: Regression Equation Coefficients for LNT Solutions P250 46
Table 4.2: Fluid Specific Holdover Time Guidelines – LNT Solutions P250 47

LIST OF PHOTOS

Page

Photo 2.1: APS Test Site - View from Test Pad 21
Photo 2.2: APS Test Site - View from Trailer 21
Photo 2.3: Mobile Test Site 22
Photo 2.4: Outdoor View of NRC Climatic Engineering Facility 22
Photo 2.5: Inside View of NRC Climatic Engineering Facility 23
Photo 2.6: Test Plates Mounted on Stand 23
Photo 2.7: Cold-Soak / Leading Edge Thermal Equivalent Box 24
Photo 2.8: Collection Pans Used Indoors at the NRC 24
Photo 2.9: Sprayer Assembly 25
Photo 2.10: Sprayer Assembly in Use 25
Photo 2.11: Sprayer Nozzle 26
Photo 2.12: Standard Plate Setup for Type I Testing with Artificial Snowmaker 26

This page intentionally left blank.

x

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

This page intentionally left blank.

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 **LNT Solutions P250**, a new Type II fluid. It describes the test methodology used, endurance time data collected, and analysis completed to derive a fluid-specific holdover times for the fluid. These holdover times are expected to be published by regulators for use in the winter 2012-13 operating season.

This page intentionally left blank.

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 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

2.1.1 Natural Snow

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.

LNT Solutions P250 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. These locations are 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.

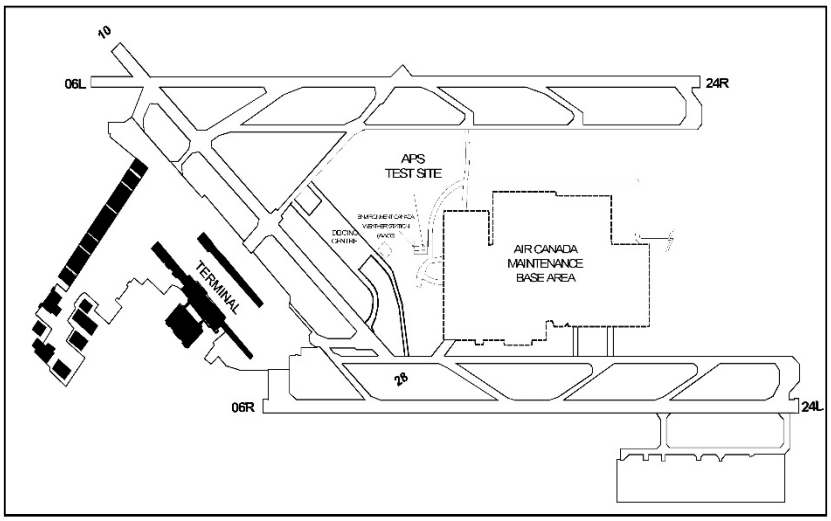


Figure 2.1: APS Test Site at Montréal-Pierre-Elliott-Trudeau International Airport

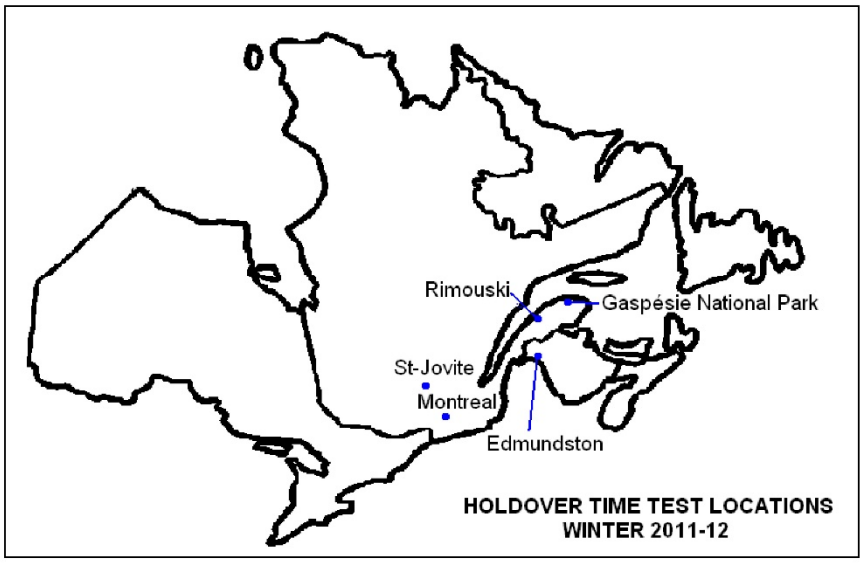


Figure 2.2: Snow Test Site Locations

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 2.3.4) 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.

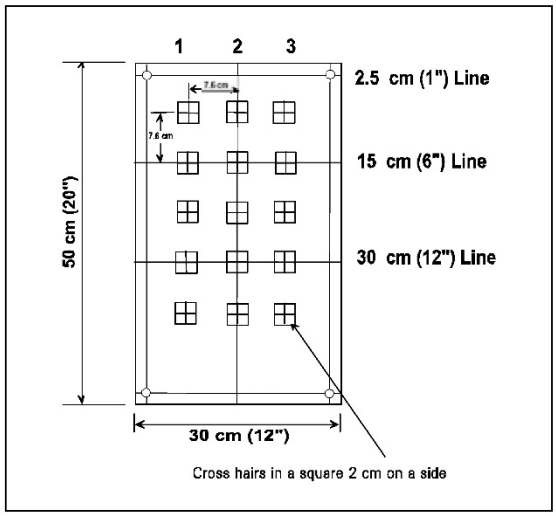


Figure 2.3: Standard Test Plate Schematic

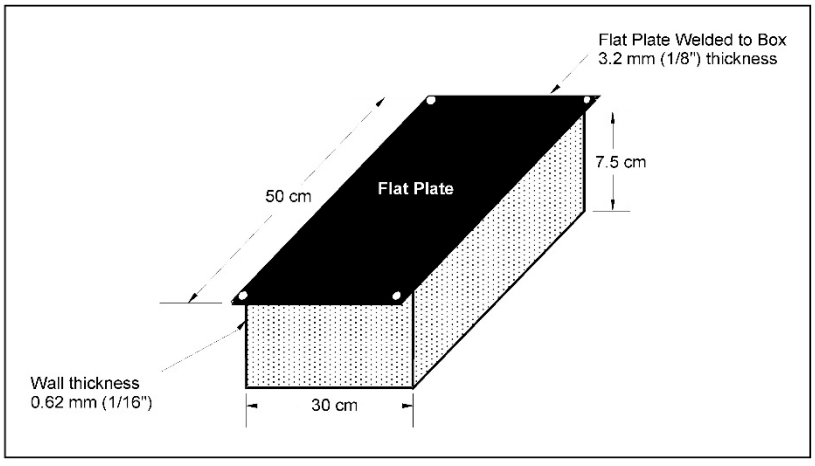


Figure 2.4: Cold Soak Box Schematic

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.

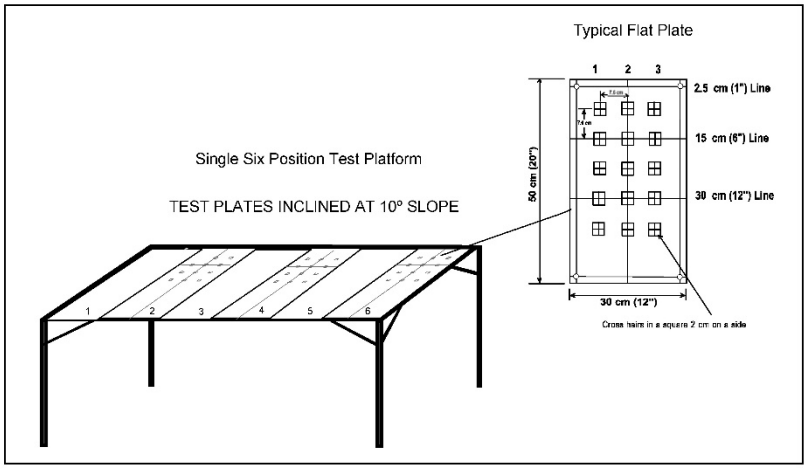


Figure 2.5: Test Stand Setup Schematic

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

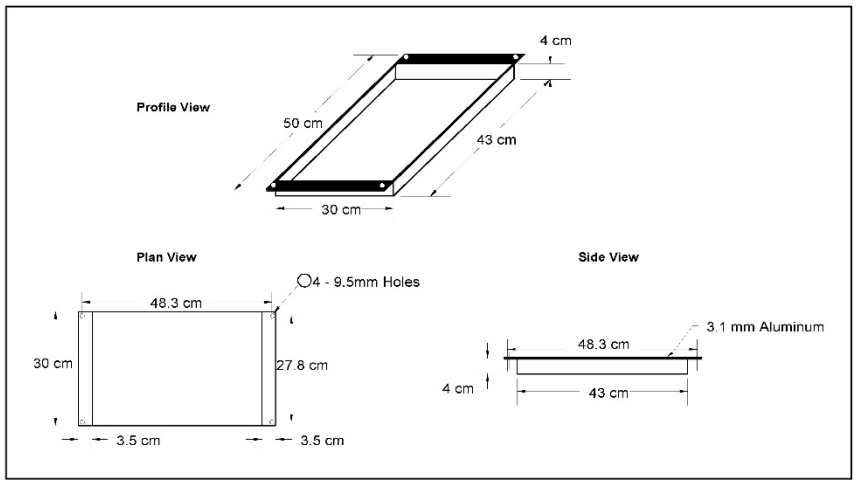


Figure 2.6: Schematic of Outdoor Precipitation Measurement Pan

2.2.7 NRC Sprayer Assembly

NRC developed an improved sprayer assembly, shown in Photos 2.9 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 LNT Solutions P250 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, 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 2.12);
- 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 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. 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.

2.3.5.2 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) 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.

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 2.6, 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.

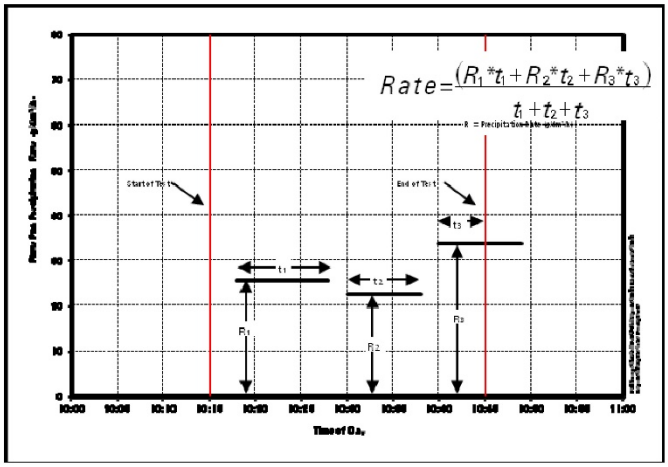


Figure 2.7: Calculation of Outdoor Precipitation Rate

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)
Measured Intensity Light (-)	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.
Measured Intensity Moderate	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.
Measured Intensity Heavy (+)	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)

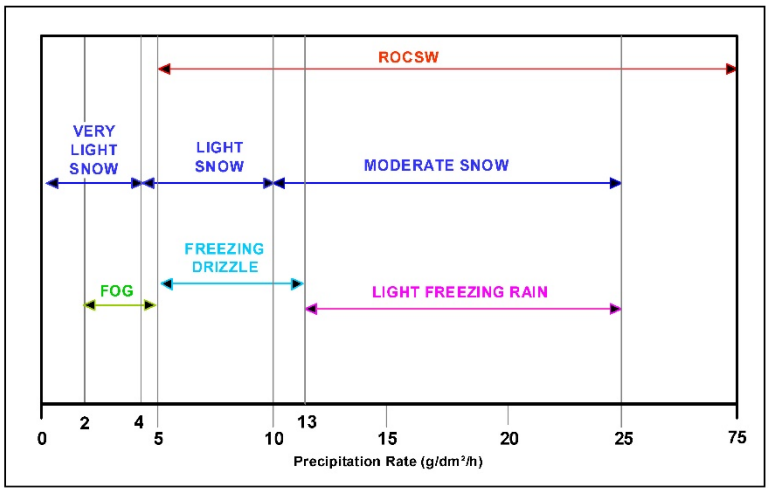


Figure 2.8: Precipitation Rate Limits Used in Endurance Time Testing

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 10 and 25 g/dm²/h, which encompass moderate snow.

Notably, Type I/III holdover times are determined using these rates plus additional precipitation rate limits (3 and 4 g/dm²/h), which encompass light and very light 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/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 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.

2.8.4 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/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.

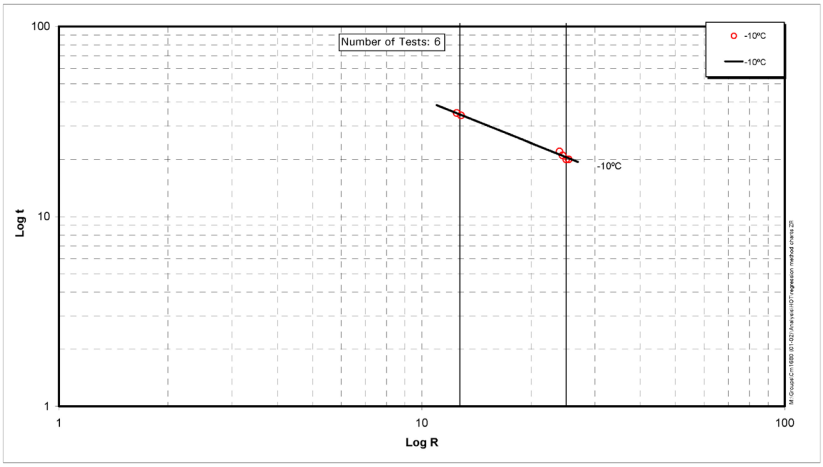


Figure 2.9: Regression Method on Log-Log Chart – Type IV Neat, Freezing Rain

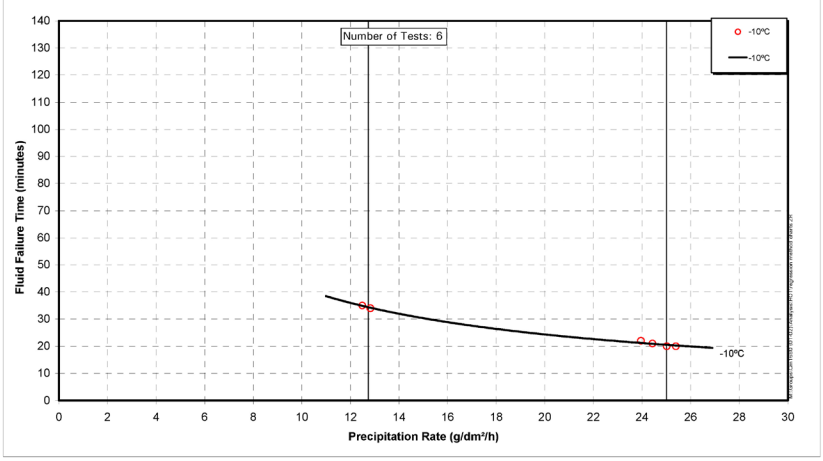


Figure 2.10: Regression Method on Standard Chart – Type IV Neat, Freezing Rain

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

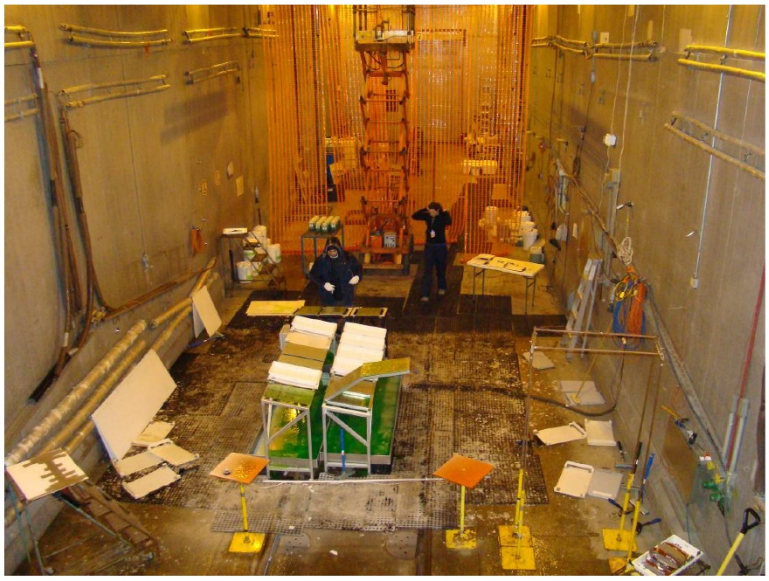


Photo 2.6: Test Plates Mounted on Stand



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

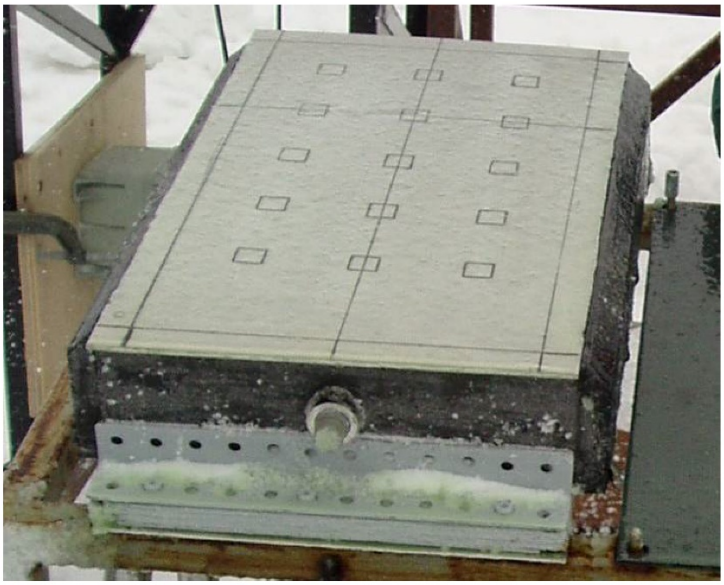


Photo 2.8: Collection Pans Used Indoors at the NRC



Photo 2.9: Sprayer Assembly



Photo 2.10: Sprayer Assembly in Use

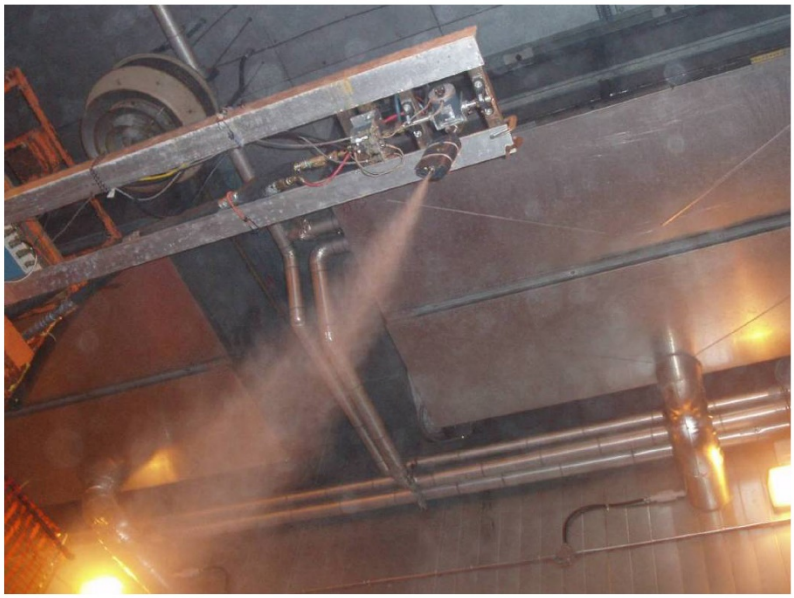


Photo 2.11: Sprayer Nozzle

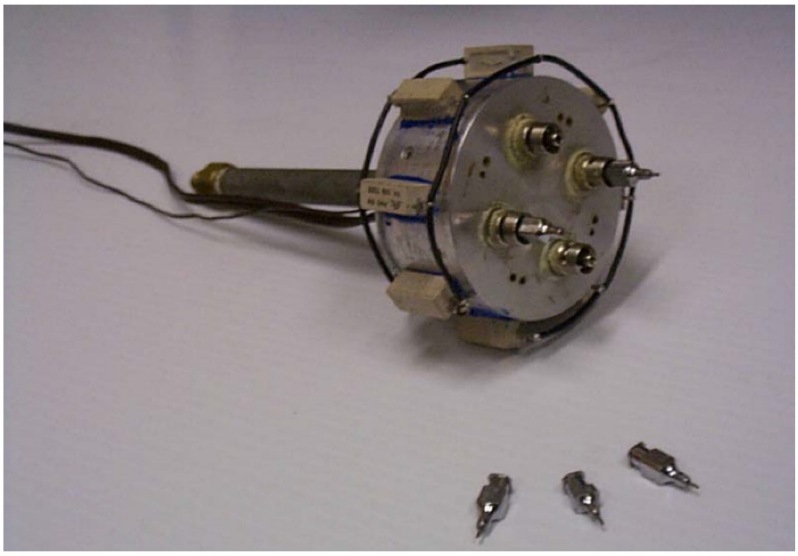


Photo 2.12: Standard Plate Setup for Type I Testing with Artificial Snowmaker



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) and a log of tests conducted in freezing precipitation (Table 3.2) 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	10	0	0
75/25	15	0	0
50/50	14	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 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.

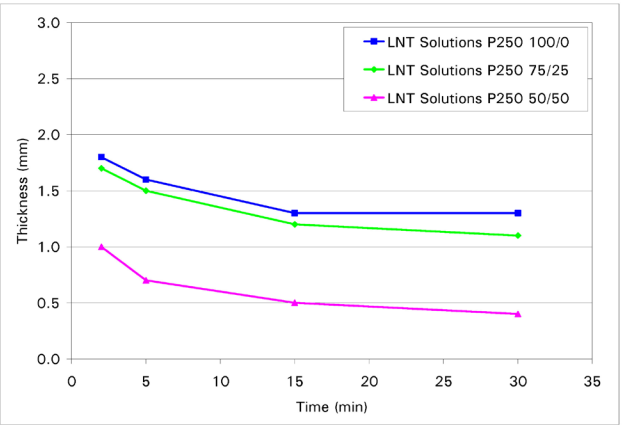


Figure 3.1: Fluid Thickness Profiles of LNT Solutions P250

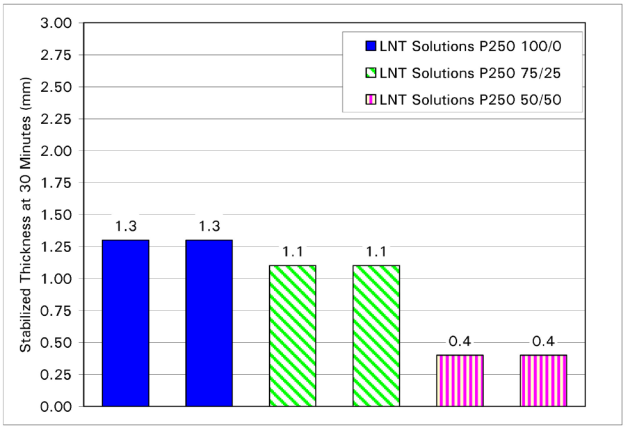


Figure 3.2: Final Fluid Thickness of LNT Solutions P250

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)
180	27-Mar-12	Natural	St-Jovite, QC	LNT P250	100/0	-2.3	10.2	103.2
181	27-Mar-12	Natural	St-Jovite, QC	LNT P250	75/25	-2.3	12.3	62.8
182	27-Mar-12	Natural	St-Jovite, QC	LNT P250	50/50	-2.2	4.3	30.3
187	28-Mar-12	Natural	St-Jovite, QC	LNT P250	75/25	-2.3	20.9	35.8
193	4-Apr-12	Natural	Rimouski, QC	LNT P250	100/0	-0.3	7.3	96.9
194	4-Apr-12	Natural	Rimouski, QC	LNT P250	75/25	-0.3	8.9	45.5
195	4-Apr-12	Natural	Rimouski, QC	LNT P250	50/50	-0.3	6.3	25.3
196	4-Apr-12	Natural	Rimouski, QC	LNT P250	100/0	-0.3	7.8	95.7
197	4-Apr-12	Natural	Rimouski, QC	LNT P250	75/25	-0.3	8.0	63.5
198	4-Apr-12	Natural	Rimouski, QC	LNT P250	50/50	-0.3	13.1	17.0
199	4-Apr-12	Natural	Rimouski, QC	LNT P250	50/50	-0.3	6.0	40.2
204	4-Apr-12	Natural	Rimouski, QC	LNT P250	75/25	-0.3	6.3	65.1
205	4-Apr-12	Natural	Rimouski, QC	LNT P250	50/50	-0.1	12.4	17.0
209	4-Apr-12	Natural	Rimouski, QC	LNT P250	75/25	-0.1	6.9	78.3
210	4-Apr-12	Natural	Rimouski, QC	LNT P250	50/50	-0.3	5.6	38.1
215	5-Apr-12	Natural	Gaspésie, QC	LNT P250	75/25	0.0	4.0	81.7
216	5-Apr-12	Natural	Gaspésie, QC	LNT P250	50/50	0.0	2.8	49.6
218	5-Apr-12	Natural	Gaspésie, QC	LNT P250	100/0	0.0	5.0	116.1
219	5-Apr-12	Natural	Gaspésie, QC	LNT P250	50/50	0.0	4.9	34.6
221	5-Apr-12	Natural	Gaspésie, QC	LNT P250	75/25	0.0	8.5	63.0
222	5-Apr-12	Natural	Gaspésie, QC	LNT P250	50/50	0.0	6.0	33.3
223	5-Apr-12	Natural	Gaspésie, QC	LNT P250	50/50	0.0	6.6	30.0
226	8-Apr-12	Natural	Gaspésie, QC	LNT P250	100/0	0.0	15.9	62.8
227	8-Apr-12	Natural	Gaspésie, QC	LNT P250	75/25	0.0	13.2	34.6
228	8-Apr-12	Natural	Gaspésie, QC	LNT P250	100/0	0.0	16.8	62.6
229	8-Apr-12	Natural	Gaspésie, QC	LNT P250	75/25	0.0	20.8	34.8
232	8-Apr-12	Natural	Gaspésie, QC	LNT P250	50/50	0.0	21.6	12.8
234	8-Apr-12	Natural	Gaspésie, QC	LNT P250	100/0	0.0	23.0	72.9
237	8-Apr-12	Natural	Gaspésie, QC	LNT P250	100/0	0.0	26.4	63.0
238	8-Apr-12	Natural	Gaspésie, QC	LNT P250	75/25	0.0	15.2	43.2
239	8-Apr-12	Natural	Gaspésie, QC	LNT P250	100/0	0.0	22.3	72.1
240	8-Apr-12	Natural	Gaspésie, QC	LNT P250	75/25	0.0	23.6	39.1
243	8-Apr-12	Natural	Gaspésie, QC	LNT P250	50/50	0.0	10.5	23.6
244	8-Apr-12	Natural	Gaspésie, QC	LNT P250	100/0	0.0	23.2	56.3
249	8-Apr-12	Natural	Gaspésie, QC	LNT P250	75/25	0.0	35.0	30.6
251	8-Apr-12	Natural	Gaspésie, QC	LNT P250	75/25	0.0	17.2	48.3
252	8-Apr-12	Natural	Gaspésie, QC	LNT P250	50/50	0.0	24.0	18.6
254	8-Apr-12	Natural	Gaspésie, QC	LNT P250	75/25	0.0	10.8	52.0

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)
256	8-Apr-12	Natural	Gaspésie, QC	LNT P250	50/50	0.0	10.8	25.7
A5	25-Apr-12	Artificial	Montreal	LNT P250	100/0	-14	10	30
A6	25-Apr-12	Artificial	Montreal	LNT P250	100/0	-14	25	15
A7	25-Apr-12	Artificial	Montreal	LNT P250	75/25	-14	10	20
A8	23-Apr-12	Artificial	Montreal	LNT P250	75/25	-14	25	10

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)
3	26-Mar-12	Freezing Fog	LNT P250	100/0	-26.0	2.1	45.3
4	26-Mar-12	Freezing Fog	LNT P250	100/0	-26.0	2.0	44.2
13	26-Mar-12	Freezing Fog	LNT P250	100/0	-25.9	4.7	22.5
14	26-Mar-12	Freezing Fog	LNT P250	100/0	-26.0	4.8	19.9
23	26-Mar-12	Freezing Fog	LNT P250	100/0	-13.9	2.2	139.2
24	26-Mar-12	Freezing Fog	LNT P250	100/0	-13.9	2.2	137.3
27	26-Mar-12	Freezing Fog	LNT P250	75/25	-13.9	1.9	93.3
28	26-Mar-12	Freezing Fog	LNT P250	75/25	-13.9	1.7	92.3
31	26-Mar-12	Freezing Fog	LNT P250	100/0	-14.2	5.2	44.3
32	26-Mar-12	Freezing Fog	LNT P250	100/0	-14.3	4.6	46.2
35	26-Mar-12	Freezing Fog	LNT P250	75/25	-14.2	4.9	29.0
36	26-Mar-12	Freezing Fog	LNT P250	75/25	-14.3	4.6	28.0
63	27-Mar-12	Freezing Fog	LNT P250	100/0	-2.5	1.9	188.2
64	27-Mar-12	Freezing Fog	LNT P250	100/0	-2.5	1.7	198.3
67	27-Mar-12	Freezing Fog	LNT P250	75/25	-2.6	1.8	104.0
68	27-Mar-12	Freezing Fog	LNT P250	75/25	-2.6	2.0	113.1
71	27-Mar-12	Freezing Fog	LNT P250	50/50	-2.5	2.1	36.0
72	27-Mar-12	Freezing Fog	LNT P250	50/50	-2.5	2.1	43.9
85	28-Mar-12	Freezing Fog	LNT P250	100/0	-2.9	5.3	102.1
86	28-Mar-12	Freezing Fog	LNT P250	100/0	-2.9	5.4	102.7
89	28-Mar-12	Freezing Fog	LNT P250	75/25	-3.0	5.4	62.0
90	28-Mar-12	Freezing Fog	LNT P250	75/25	-3.0	5.4	56.1
93	28-Mar-12	Freezing Fog	LNT P250	50/50	-3.0	5.0	25.0
94	28-Mar-12	Freezing Fog	LNT P250	50/50	-3.0	4.8	26.8
107	21-Mar-12	Light Freezing Rain	LNT P250	100/0	-10.4	12.9	84.0
108	21-Mar-12	Light Freezing Rain	LNT P250	100/0	-10.4	12.9	89.5
111	21-Mar-12	Light Freezing Rain	LNT P250	75/25	-10.4	13.1	52.3
112	21-Mar-12	Light Freezing Rain	LNT P250	75/25	-10.4	12.8	50.5
123	21-Mar-12	Light Freezing Rain	LNT P250	100/0	-10.2	25.1	57.2
124	21-Mar-12	Light Freezing Rain	LNT P250	100/0	-10.2	24.7	58.9
127	21-Mar-12	Light Freezing Rain	LNT P250	75/25	-10.0	25.3	30.8
128	21-Mar-12	Light Freezing Rain	LNT P250	75/25	-10.1	24.9	34.4
147	23-Mar-12	Light Freezing Rain	LNT P250	100/0	-2.9	13.1	67.7
148	23-Mar-12	Light Freezing Rain	LNT P250	100/0	-2.9	13.0	66.0
151	23-Mar-12	Light Freezing Rain	LNT P250	75/25	-2.9	13.4	35.9
152	23-Mar-12	Light Freezing Rain	LNT P250	75/25	-2.9	13.2	37.0
155	23-Mar-12	Light Freezing Rain	LNT P250	50/50	-3.1	13.1	11.7
156	23-Mar-12	Light Freezing Rain	LNT P250	50/50	-3.1	12.8	14.6

Table 3.2 (cont'd): Summary of Tests Performed (Freezing Precipitation)

Test No.	Date	Precipitation Type	Fluid Name	Fluid Dilution	Test Temp. (°C)	Icing Intensity (g/dm²/h)	Endurance Time (min)
165	23-Mar-12	Light Freezing Rain	LNT P250	100/0	-2.9	24.2	45.5
166	23-Mar-12	Light Freezing Rain	LNT P250	100/0	-2.9	24.2	37.5
169	23-Mar-12	Light Freezing Rain	LNT P250	75/25	-2.9	25.2	21.9
170	23-Mar-12	Light Freezing Rain	LNT P250	75/25	-2.9	24.9	22.2
173	23-Mar-12	Light Freezing Rain	LNT P250	50/50	-2.9	25.1	6.6
174	23-Mar-12	Light Freezing Rain	LNT P250	50/50	-2.9	24.8	9.5
183	21-Mar-12	Freezing Drizzle	LNT P250	100/0	-10.3	4.7	106.8
184	21-Mar-12	Freezing Drizzle	LNT P250	100/0	-10.3	4.7	108.0
187	21-Mar-12	Freezing Drizzle	LNT P250	75/25	-10.3	4.9	71.9
188	21-Mar-12	Freezing Drizzle	LNT P250	75/25	-10.3	5.1	74.2
200	21-Mar-12	Freezing Drizzle	LNT P250	100/0	-10.5	13.4	31.3
200R	21-Mar-12	Freezing Drizzle	LNT P250	100/0	-10.5	13.0	27.1
203	21-Mar-12	Freezing Drizzle	LNT P250	75/25	-10.5	13.3	23.1
204	21-Mar-12	Freezing Drizzle	LNT P250	75/25	-10.5	13.2	24.0
223	22-Mar-12	Freezing Drizzle	LNT P250	100/0	-2.5	5.2	107.6
224	22-Mar-12	Freezing Drizzle	LNT P250	100/0	-2.5	5.2	92.1
227	22-Mar-12	Freezing Drizzle	LNT P250	75/25	-2.5	5.6	57.8
228	22-Mar-12	Freezing Drizzle	LNT P250	75/25	-2.5	5.4	63.9
231	22-Mar-12	Freezing Drizzle	LNT P250	50/50	-2.5	5.4	27.0
232	22-Mar-12	Freezing Drizzle	LNT P250	50/50	-2.6	5.1	21.0
245	22-Mar-12	Freezing Drizzle	LNT P250	100/0	-2.5	13.5	75.4
246	22-Mar-12	Freezing Drizzle	LNT P250	100/0	-2.5	13.4	82.0
249	22-Mar-12	Freezing Drizzle	LNT P250	75/25	-2.5	13.1	32.4
250	22-Mar-12	Freezing Drizzle	LNT P250	75/25	-2.5	13.5	36.8
253	22-Mar-12	Freezing Drizzle	LNT P250	50/50	-2.5	13.1	14.1
254	22-Mar-12	Freezing Drizzle	LNT P250	50/50	-2.7	13.1	12.9
267	23-Mar-12	Cold Soak Box	LNT P250	100/0	1.1	4.6	96.1
268	23-Mar-12	Cold Soak Box	LNT P250	100/0	1.1	4.8	94.2
271	23-Mar-12	Cold Soak Box	LNT P250	75/25	1.2	4.8	73.1
272	23-Mar-12	Cold Soak Box	LNT P250	75/25	1.2	5.3	74.9
283	23-Mar-12	Cold Soak Box	LNT P250	100/0	0.8	76.3	21.0
284	23-Mar-12	Cold Soak Box	LNT P250	100/0	0.8	75.6	19.6
287	23-Mar-12	Cold Soak Box	LNT P250	75/25	0.8	74.7	10.1
288	23-Mar-12	Cold Soak Box	LNT P250	75/25	0.8	75.7	10.6

This page intentionally left blank.

34

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 LNT Solutions P250 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.

4.2 Holdover Time Table

A fluid-specific HOT table for LNT Solutions P250 is shown in Table 4.2 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 LNT Solutions intends to commercialize this fluid, it is expected this table will be published in the 2012-13 FAA and TC HOT guidelines. Commercialization of this fluid will not affect the generic Type II holdover times.

4.2.1 Holdover Times in Snow, -3°C and Above, Neat and 75/25

Regression analysis of the Neat and 75/25 natural snow data sets resulted in abnormal temperature trends; the regression curves showed endurance times increasing as temperature decreases. This is very likely the result of insufficient data being collected at lower temperatures (see Subsections 4.2.2 and 4.2.3).

Standard protocol dictates that holdover times be derived using the most restrictive temperature in the holdover time table temperature range. In these two cases warmer temperatures result in the most restrictive holdover times and therefore holdover times were calculated using the regression curves with a temperature input of +1°C. The +1°C regression curves are shown as dotted red lines in Figures 4.1 and 4.2.

If additional data is collected with this fluid (see Subsection 4.2.2), these regression curves and the resulting holdover times will be reanalysed.

4.2.2 Holdover Times in Snow, Below -3 to -14°C

Due to the late submission of this fluid for testing and subsequent unfavourable weather conditions in Montreal, sufficient natural snow data was not collected to derive fluid-specific values for the "Below -3 to -14°C" snow cells.

Supplemental testing was conducted with an artificial snowmaker to determine if the fluid could be used with the current generic Type II holdover times. As the data showed the endurance times to be equal to or greater than the generic holdover times (see Figure 4.15), regulators agreed that the generic holdover times could be used for this fluid in the in "Below -3 to -14°C" snow cells until additional data can be collected. It is expected this data will be collected in the winter of 2012-13.

4.2.3 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, LNT Solutions P250 has been given generic values in the "Below -14°C to LOUT" snow cell.

4.2.4 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 LNT Solutions P250.

4.2.5 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

LNT Solutions has indicated it will commercialize P250; 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.

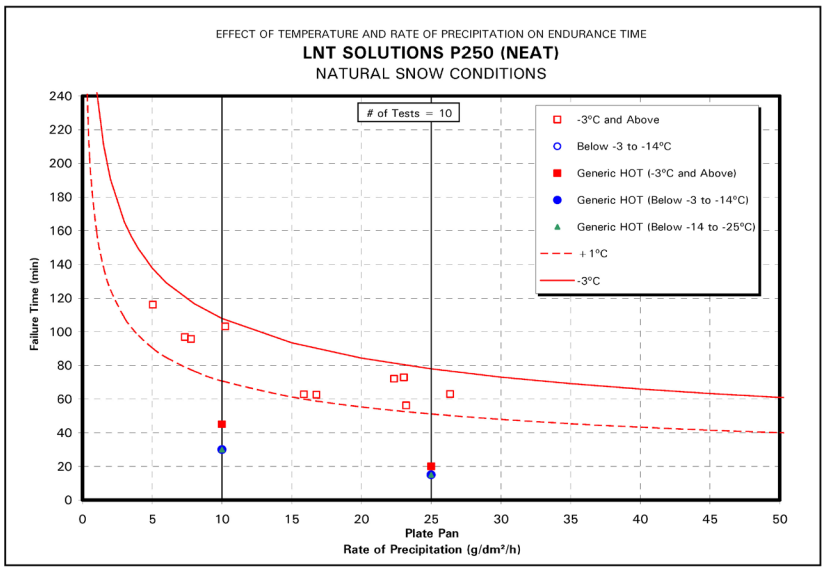


Figure 4.1: Type II Neat – Natural Snow

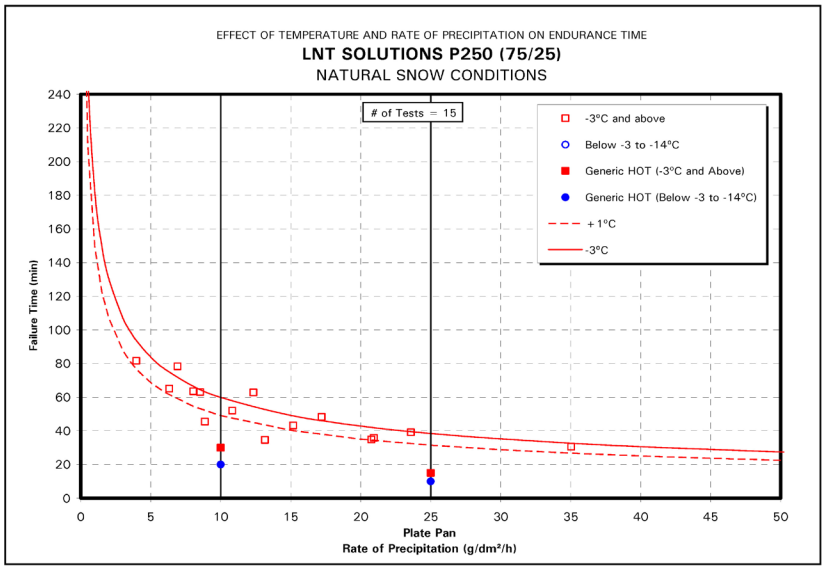


Figure 4.2: Type II 75/25 – Natural Snow

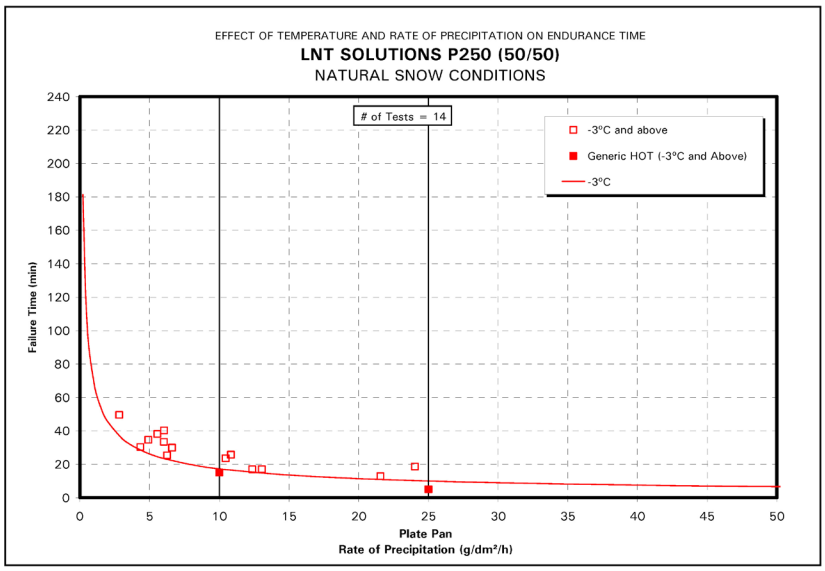


Figure 4.3: Type II 50/50 – Natural Snow

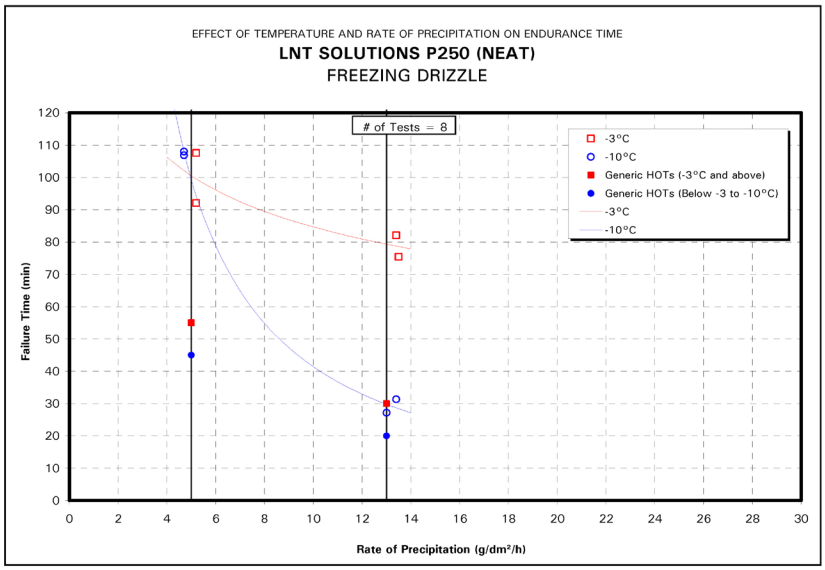


Figure 4.4: Type II Neat – Freezing Drizzle

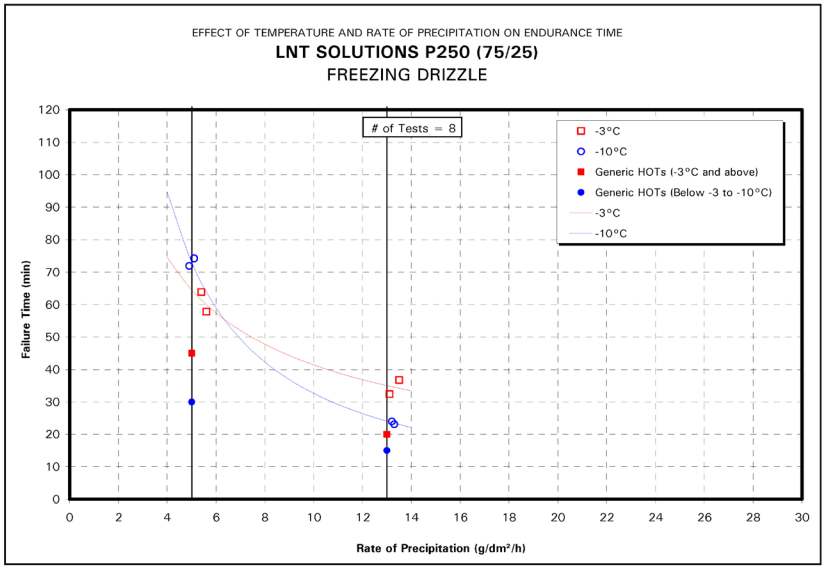


Figure 4.5: Type II 75/25 – Freezing Drizzle

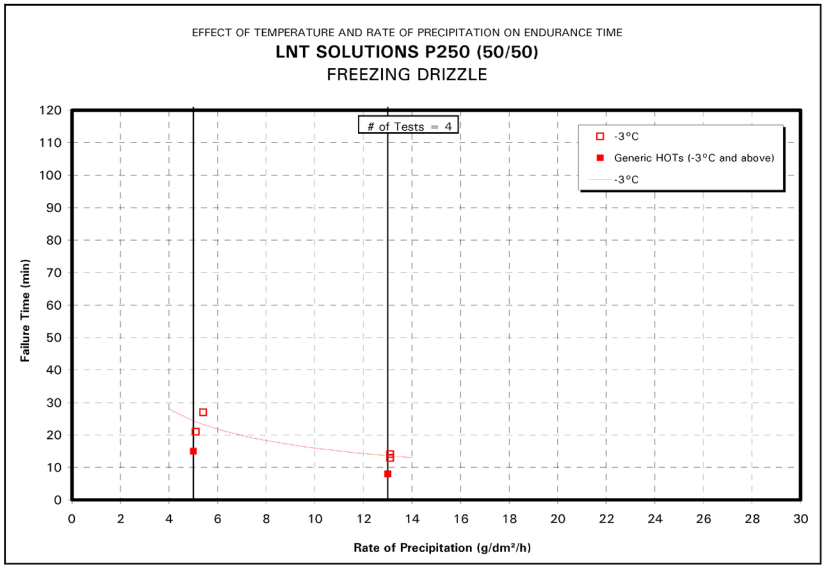


Figure 4.6: Type II 50/50 – Freezing Drizzle

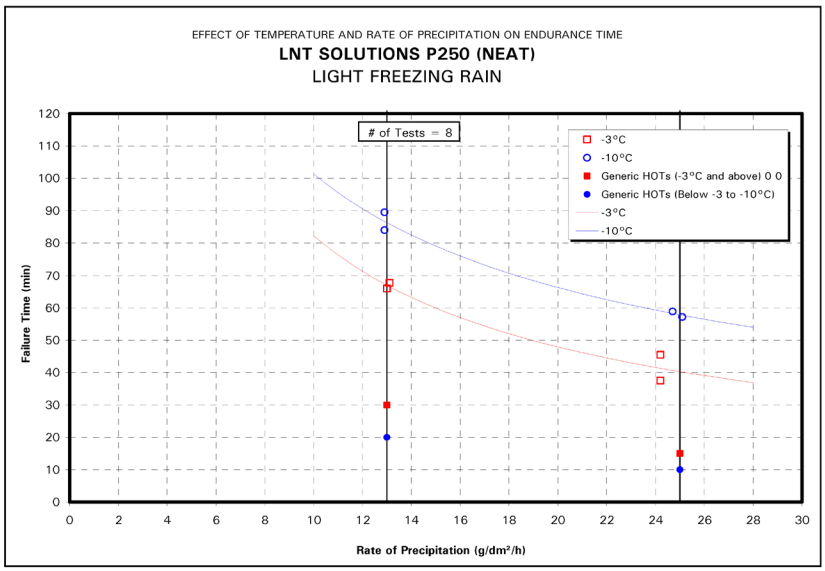


Figure 4.7: Type II Neat – Light Freezing Rain

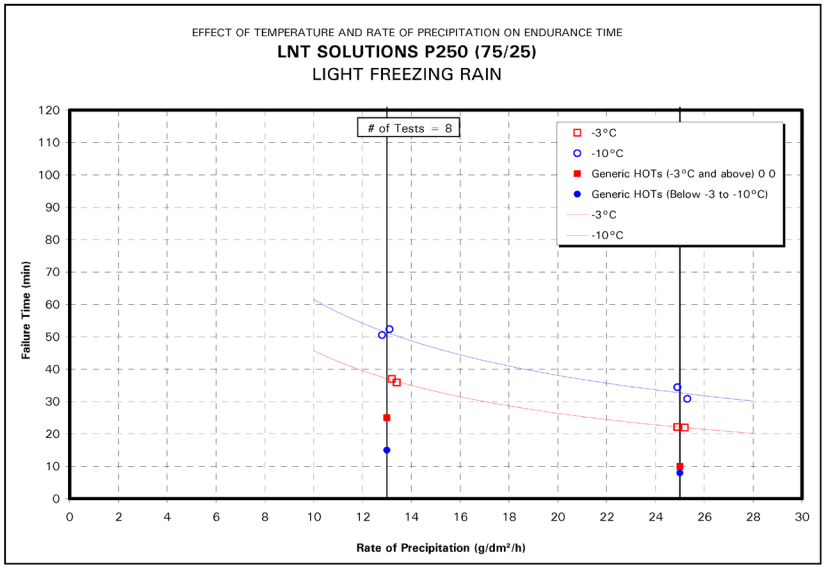


Figure 4.8: Type II 75/25 – Light Freezing Rain

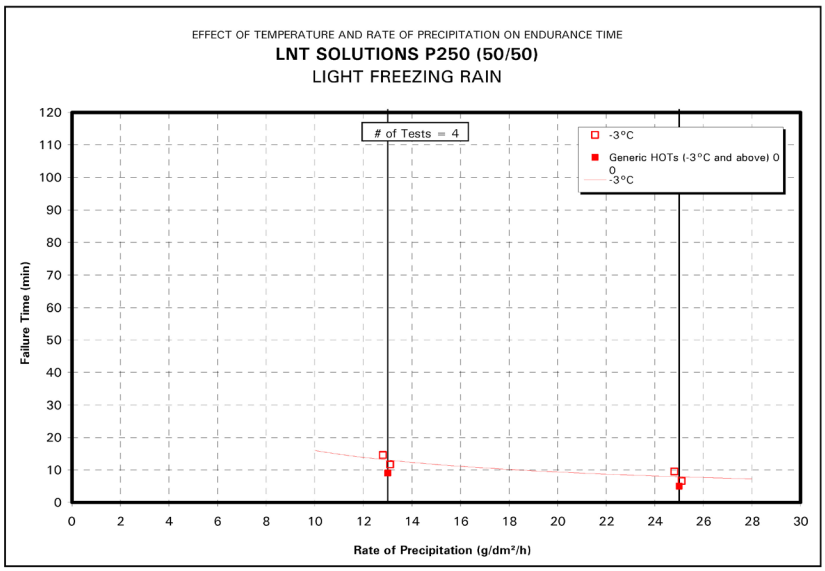


Figure 4.9: Type II 50/50 – Light Freezing Rain

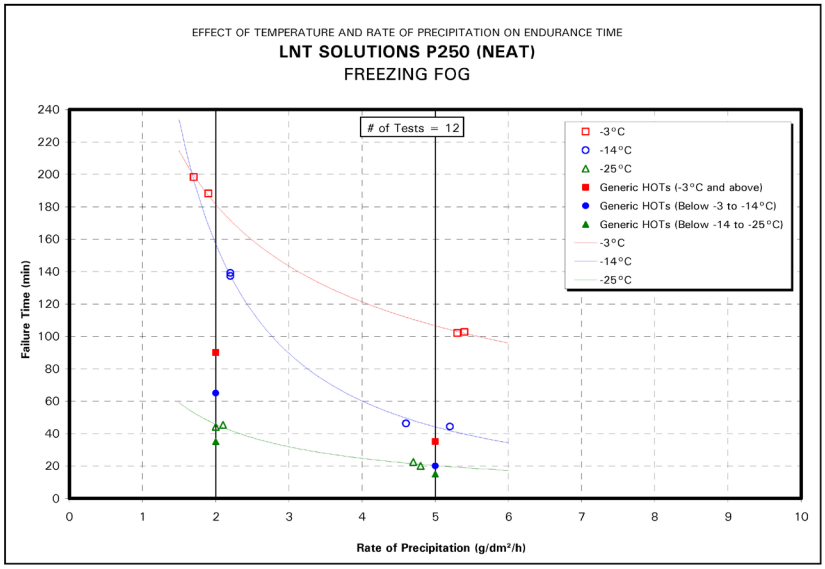


Figure 4.10: Type II Neat – Freezing Fog

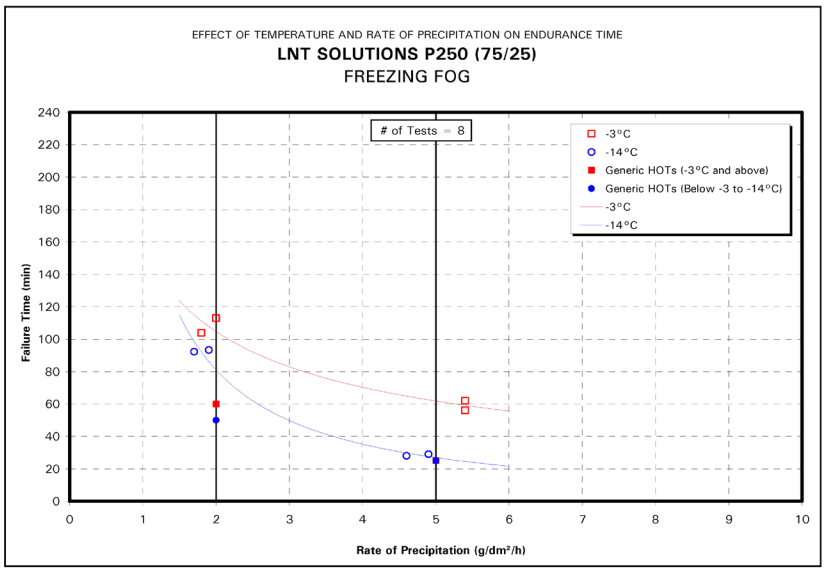


Figure 4.11: Type II 75/25 – Freezing Fog

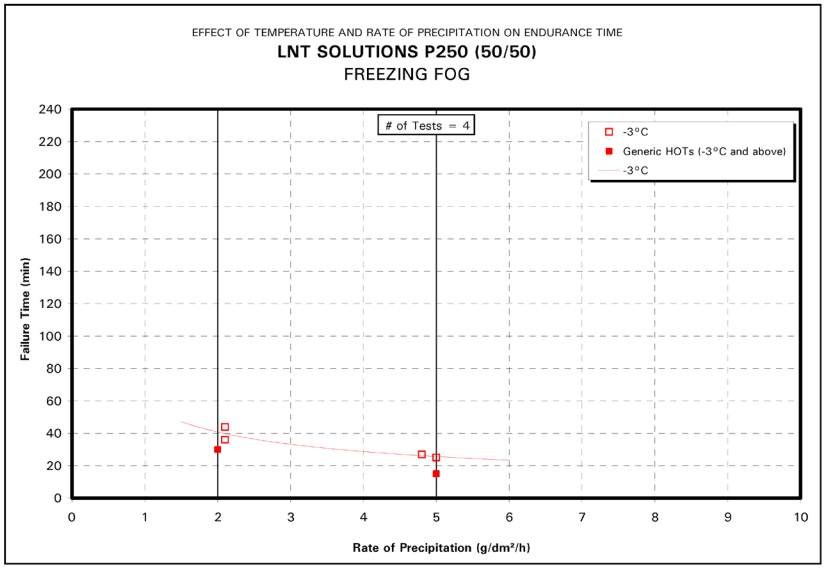


Figure 4.12: Type II 50/50 – Freezing Fog

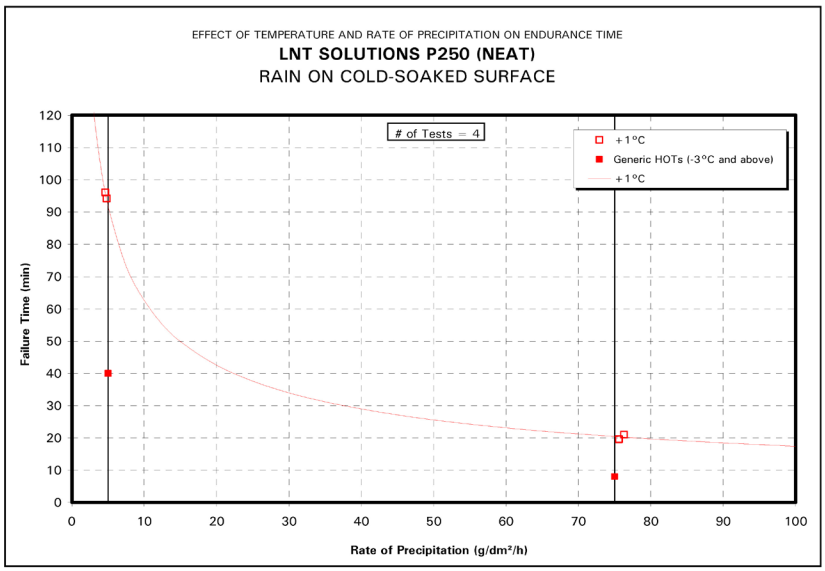


Figure 4.13: Type II Neat – Rain on Cold-Soaked Surface

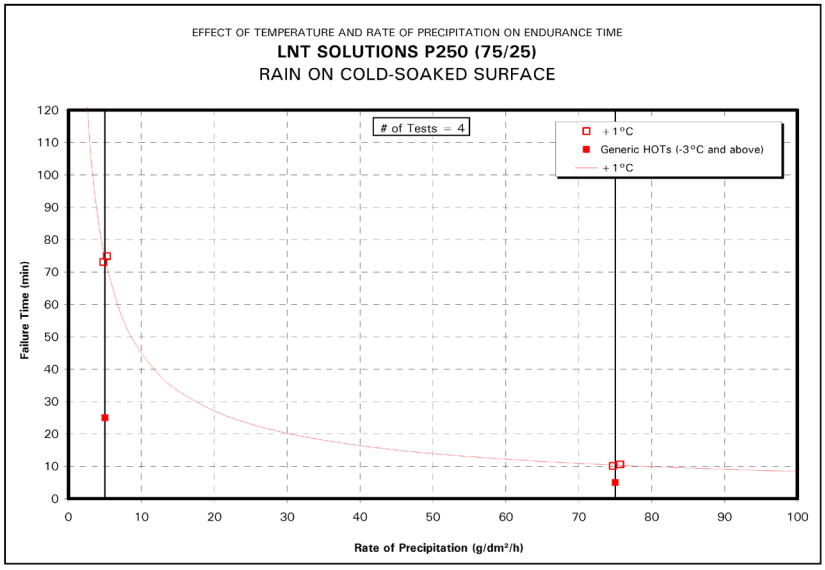


Figure 4.14: Type II 75/25 – Rain on Cold-Soaked Surface

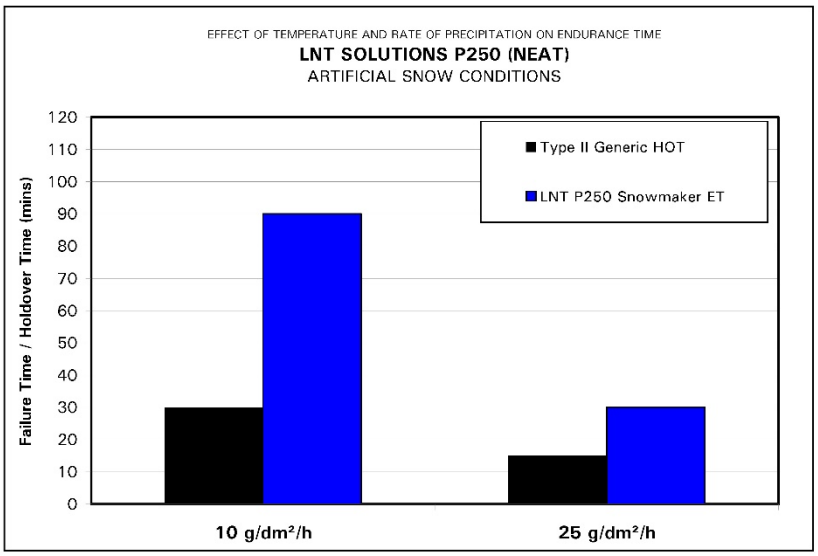


Figure 4.15: Type II Neat – Artificial Snow

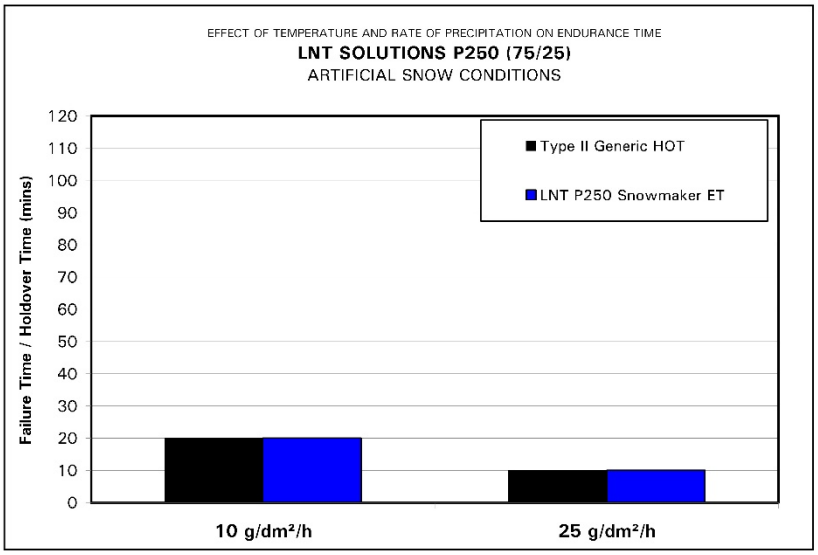


Figure 4.16: Type II 75/25 – Artificial Snow

Table 4.1: Regression Equation Coefficients for LNT Solutions P250

Natural Snow Conditions*

Fluid	Dil	R^2	Intercept (I)	Coeff. Rate (A)	Coeff. Tem (B)	Total Pts.
LNT Solutions P250	Neat	85%	2.2038	-0.3542	0.0000	10
LNT Solutions P250	75/25	79%	2.1746	-0.4841	0.0000	15
LNT Solutions P250	50/50	84%	2.0919	-0.6011	-0.3630	14

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.
LNT Solutions P250	Neat	-3°C	100%	2.4338	-0.5812	4
LNT Solutions P250	75/25	-3°C	96%	2.1935	-0.5752	4
LNT Solutions P250	50/50	-3°C	90%	1.7632	-0.5074	4
LNT Solutions P250	Neat	-14°C	99%	2.6127	-1.3848	4
LNT Solutions P250	75/25	-14°C	99%	2.2713	-1.2032	4
LNT Solutions P250	Neat	-25°C	99%	1.9281	-0.8904	4

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

Simulated Freezing Drizzle

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
LNT Solutions P250	Neat	-3°C	78%	2.1756	-0.2479	4
LNT Solutions P250	75/25	-3°C	96%	2.2567	-0.6394	4
LNT Solutions P250	50/50	-3°C	88%	1.8154	-0.6123	4
LNT Solutions P250	Neat	-10°C	99%	2.8773	-1.2599	4
LNT Solutions P250	75/25	-10°C	100%	2.6745	-1.1607	4

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

Simulated Light Freezing Rain

Fluid	Dil	Temp.	R^2	Intercept (I)	Coeff. Rate (A)	Total Pts.
LNT Solutions P250	Neat	-3°C	92%	2.6927	-0.7778	4
LNT Solutions P250	75/25	-3°C	100%	2.4529	-0.7931	4
LNT Solutions P250	50/50	-3°C	75%	1.9758	-0.7725	4
LNT Solutions P250	Neat	-10°C	99%	2.6161	-0.6106	4
LNT Solutions P250	75/25	-10°C	97%	2.4783	-0.6898	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.
LNT Solutions P250	Neat	+1°C	100%	2.3514	-0.5554	4
LNT Solutions P250	75/25	+1°C	100%	2.3800	-0.7274	4

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

Table 4.2: Fluid Specific Holdover Time Guidelines – LNT Solutions P250

TABLE 2-L-P250

LNT SOLUTIONS TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2012-2013[1]
P250

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	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	1:45 – 3:00	0:50 – 1:10	1:20 – 1:40	0:40 – 1:05	0:20 – 1:30	
		75/25	1:00 – 1:45	0:30 – 0:50	0:35 – 1:05	0:20 – 0:35	0:10 – 1:15	
		50/50	0:25 – 0:40	0:10 – 0:15	0:15 – 0:25	0:07 – 0:15	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:45 – 2:35	0:15 – 0:30	0:30 – 1:40[7]	1:00 – 1:25[7]		
		75/25	0:25 – 1:20	0:10 – 0:20	0:25 – 1:15[7]	0:35 – 0:50[7]		
below -14 to LOUT	below 7 to LOUT	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 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.**

This page intentionally left blank.

APPENDIX G

TRANSPORT CANADA AND FEDERAL AVIATION ADMINISTRATION 2012-13 HOLDOVER TIME GUIDELINES

TRANSPORT CANADA
HOLDOVER TIME (HOT) GUIDELINES
WINTER 2012-2013

Transport Canada
Holdover Time (HOT) Guidelines
Winter 2012-2013

Original Issue, July 2012
Revision 1.0, July 2012

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.

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*
1.0	July 2012	Correction of editorial error in the metric strict inequality symbols listed in the visibility table.	44	TC / APS

SUMMARY OF CHANGES FROM PREVIOUS YEAR

The principal changes from the previous year are briefly indicated herein.

Document Optimization for Use in Electronic Flight Bags

- This document has been indexed and optimized for better viewing in electronic flight bags (for example using iPads, Samsung tablets, etc.).

Active Frost

- The lowest temperature band in the Type I portion of the active frost table has changed from "below -21 to -25°C" to "below -21 to -25°C or LOUT". This change has been made to indicate that the Type I active frost holdover times can be used at temperatures below -25°C as long as the fluid LOUT is respected. Fluid LOUTs are listed in Table 10.

Type I Fluid

- The Type I HOT tables are unchanged.

Type II Fluid

- A fluid-specific HOT table has been created for the new Type II fluid LNT Solutions P250. The addition of this fluid did not impact the generic holdover times.
- A fluid-specific HOT table has been created for the new Type II fluid Clariant Safewing MP II Flight Plus. The addition of this fluid did not impact the generic holdover times.
- Two obsolete fluids, Clariant Safewing MP II 2025 ECO and Octagon E Max II, have been removed from the Type II guidelines. Removal of these fluids did not impact the generic holdover times.

Type III Fluid

- The Type III HOT table is unchanged.

Type IV Fluid

- Two obsolete fluids, Clariant Safewing MP IV 2001 and Dow Chemical UCAR ADF/AAF ULTRA+, have been removed from the Type IV guidelines. Removal of these fluids caused twelve increases to the generic Type IV fluid holdover times. Nine cells were affected.

Fluid Application Procedures

- Wording added to clarify the content of Tables 6 and 7 with respect to the time interval between the first and second step applications.
- Wording added in Table 6 to clarify that the minimum fluid application quantities and temperature apply to all conditions including active frost.

Ice Pellet Allowance Time Guidance

- The ice pellet allowance time values are unchanged.
- Clarification added to the operational guidelines Item 6 i) to identify additional precipitation conditions where OAT must not decrease.

Octagon Branded Fluid Names

- Due to the acquisition of the fluid manufacturing company Octagon Process by Clariant GmbH, fluids previously listed under the Octagon brand name are now listed under the Clariant brand name. These fluids include several Type I fluids (EcoFlo Concentrate, EcoFlo 2 Concentrate, Octaflo EF Concentrate, Octaflo EF-80, Octaflo EG Concentrate) and one Type IV fluid (Max-Flight 04).

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.

Add the following sentence immediately before the example of Sub-Paragraph 11.1.4.1.a "Estimating the Precipitation Rate":

This estimate applies to all Type I, II, III, and IV fluids.

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.

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 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.

HOLDOVER TIME (HOT) GUIDELINES FOR WINTER 2012-2013

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 PLUS	Clariant Type II Fluid Holdover Guidelines Safewing MP II FLIGHT PLUS
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-L-P250	LNT Solutions Type II Fluid Holdover Guidelines P250
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-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-4S	Kilfrost Type IV Fluid Holdover Guidelines ABC-4^{sustain}
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 2012-2013

TABLE 0

ACTIVE FROST HOLDOVER GUIDELINES FOR WINTER 2012-2013

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

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[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 is 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 2012-2013

TABLE 1-A

SAE TYPE I FLUID HOLDOVER GUIDELINES ON ALUMINUM WING SURFACES FOR WINTER 2012-2013[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	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	11 – 17	18	11 – 18	6 – 11	9 – 13	4 – 6	2 – 5	
below -3 to -6	below 27 to 21	8 – 13	14	8 – 14	5 – 8	5 – 9	4 – 6	CAUTION: No holdover time guidelines exist	
below -6 to -10	below 21 to 14	6 – 10	11	6 – 11	4 – 6	4 – 7	2 – 5		
below -10	below 14	5 – 9	7	4 – 7	2 – 4				

NOTES

1 Type I Fluid / Water Mixture is 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.**

Transport Canada Holdover Time Guidelines — Winter 2012-2013

TABLE 1-C

SAE TYPE I FLUID HOLDOVER GUIDELINES ON COMPOSITE WING SURFACES FOR WINTER 2012-2013[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	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	
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 is 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.**

Transport Canada Holdover Time Guidelines — Winter 2012-2013

TABLE 2-Generic

SAE TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2012-2013[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	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	
		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	CAUTION: No holdover time guidelines exist	
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 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 2012-2013

TABLE 2-A-E26

ABAX TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2012-2013[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	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	1:25 – 2:35	0:40 – 1:00	0:50 – 1:35	0:40 – 0:50	0:20 – 1:25	
		75/25	1:05 – 1:55	0:25 – 0:45	0:45 – 1:05	0:25 – 0:35	0:10 – 1:00	
		50/50	0:30 – 0:45	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	0:35 – 0:55	0:30 – 1:10[7]	0:15 – 0:35[7]		
		75/25	0:35 – 1:15	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	0:15 – 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 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-AS-CLEANWING II

AVIATION SHAANXI HI-TECH TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2012-2013[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	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	
		75/25	0:50 – 1:20	0:25 – 0:45	0:35 – 1:00	0:20 – 0:30	0:07 – 0:50	
		50/50	0:35 – 1:00	0:15 – 0:30	0:20 – 0:40	0:10 – 0:20	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:45 – 1:50	0:30 – 0:55	0:30 – 0:55[7]	0:20 – 0:25[7]		
		75/25	0:40 – 1:45	0:25 – 0:45	0:35 – 0:40[7]	0:20 – 0:25[7]		
below -14 to -29	below 7 to -20.2	100/0	0:20 – 0:50	0:15 – 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 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 2012-2013[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	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	3:30 – 4:00	1:00 – 1:35	1:20 – 2:00	0:45 – 1:25	0:10 – 1:30	
		75/25	1:50 – 2:45	0:40 – 1:20	1:10 – 1:30	0:30 – 0:55	0:06 – 0:50	
		50/50	0:55 – 1:45	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	0:40 – 1:05	0:35 – 1:30[7]	0:25 – 0:45[7]		
		75/25	0:25 – 1:05	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	0:15 – 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 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 PLUS

CLARIANT TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2012-2013[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	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	1:05 – 2:00	1:25 – 2:00	0:45 – 1:00	0:15 – 2:00	
		75/25	2:35 – 4:00	0:55 – 1:35	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	0:15 – 0:30	0:35 – 1:25[7]	0:35 – 0:55[7]		
		75/25	0:30 – 1:45	0:10 – 0:20	0:25 – 1:10[7]	0:30 – 0:45[7]		
below -14 to -29	below 7 to -20.2	100/0	0:20 – 0:40	0:15 – 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 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 2012-2013

TABLE 2-K-ABC-2000

KILFROST TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2012-2013[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	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	
		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	CAUTION: No holdover time guidelines exist	
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 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 2012-2013

TABLE 2-K-ABC-K+

KILFROST TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2012-2013[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	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	
		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[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 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-L-P250

LNT SOLUTIONS TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2012-2013[1]
P250

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	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	1:45 – 3:00	0:50 – 1:10	1:20 – 1:40	0:40 – 1:05	0:20 – 1:30	
		75/25	1:00 – 1:45	0:30 – 0:50	0:35 – 1:05	0:20 – 0:35	0:10 – 1:15	
		50/50	0:25 – 0:40	0:10 – 0:15	0:15 – 0:25	0:07 – 0:15	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:45 – 2:35	0:15 – 0:30	0:30 – 1:40[7]	1:00 – 1:25[7]		
		75/25	0:25 – 1:20	0:10 – 0:20	0:25 – 1:15[7]	0:35 – 0:50[7]		
below -14 to LOUT	below 7 to LOUT	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 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-N-FCY-2

NEWAVE AEROCHEMICAL TYPE II FLUID HOLDOVER GUIDELINES FOR WINTER 2012-2013[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	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	
		75/25	0:50 – 1:30	0:20 – 0:40	0:25 – 0:45	0:15 – 0:25	0:05 – 0:25	
		50/50	0:25 – 0:35	0:15 – 0:25	0:10 – 0:20	0:07 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:45 – 1:30	0:15 – 0:30	0:20 – 0:45[7]	0:15 – 0:20[7]		
		75/25	0:30 – 1:05	0:10 – 0:20	0:15 – 0:30[7]	0:08 – 0:15[7]		
below -14 to -28	below 7 to -18.4	100/0	0:25 – 0:35	0:15 – 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 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 2012-2013

TABLE 3

SAE TYPE III FLUID HOLDOVER GUIDELINES FOR WINTER 2012-2013

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	Snow, Snow Grains or Snow Pellets			Freezing Drizzle[3]	Light Freezing Rain	Rain on Cold Soaked Wing[4]	Other[5]
				Very Light[2]	Light[2]	Moderate				
-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 outside air temperatures below -9°C (15.8°F) to -10°C (14°F), these holdover times only apply to aircraft with a take-off profile conforming to the high speed aerodynamic test criterion (refer to Section 8.1.6.1 f) of TP 14052E). 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.**
- **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 2012-2013

TABLE 4-Generic

SAE TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2012-2013[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	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	1:45 – 3:10	0:40 – 1:20	0:50 – 1:30	0:35 – 0:55	0:10 – 1:15	
		75/25	1:00 – 1:45	0:30 – 0:55	0:40 – 1:05	0:25 – 0:40	0:09 – 0:50	
		50/50	0:20 – 0:35	0:07 – 0:15	0:10 – 0:20	0:07 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20 – 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 – 1:00[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 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 Cryotech Polar Guard, the temperature is limited to -23.5°C (-10.3°F) and for Lyondell Arctic Shield, the temperature is limited to -24.5°C (-12.1°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 2012-2013[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	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 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 2012-2013[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	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	3:20 – 4:00	1:10 – 1:50	1:25 – 2:00	1:00 – 1:25	0:10 – 1:55	
		75/25	2:25 – 4:00	1:20 – 1:40	1:55 – 2:00	0:50 – 1:30	0:10 – 1:40	
		50/50	0:25 – 0:50	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	1:10 – 1:50	0:25 – 1:25[7]	0:20 – 0:25[7]		
		75/25	0:30 – 1:10	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	0:15 – 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 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 2012-2013[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	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	1:25 – 2:00	2:00 – 2:00	1:10 – 1:30	0:20 – 2:00	
		75/25	2:05 – 3:15	1:05 – 2:00	1:50 – 2:00	1:00 – 1:20	0:20 – 2:00	
		50/50	0:55 – 1:45	0:25 – 1:15	0:35 – 1:10	0:25 – 0:35		
below -3 to -14	below 27 to 7	100/0	0:50 – 2:30	0:35 – 1:10	0:25 – 1:30[7]	0:20 – 0:40[7]	CAUTION: No holdover time guidelines exist	
		75/25	0:30 – 1:05	0:40 – 1:25	0:20 – 1:00[7]	0:15 – 0:30[7]		
below -14 to -26.5	below 7 to -15.7	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 IV fluid cannot be used.
3 Use light freezing rain holdover times in conditions of 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 2012-2013[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	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	4:00 – 4:00	1:05 – 1:45	1:30 – 2:00	1:00 – 1:40	0:15 – 1:40	
		75/25	3:40 – 4:00	1:00 – 1:45	1:40 – 2:00	0:45 – 1:15	0:10 – 1:45	
		50/50	1:25 – 2:45	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	0:50 – 1:20	0:35 – 1:40[7]	0:25 – 0:45[7]	CAUTION: No holdover time guidelines exist	
		75/25	0:40 – 1:20	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	0:15 – 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 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 2012-2013

TABLE 4-CR-PG

CRYOTECH TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2012-2013[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	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	
		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]	CAUTION: No holdover time guidelines exist	
		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 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.**

Transport Canada Holdover Time Guidelines — Winter 2012-2013

TABLE 4-CR-PG-A

CRYOTECH TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2012-2013[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	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	2:50 – 4:00	1:20 – 1:50	1:35 – 2:00	1:15 – 1:30	0:15 – 2:00	
		75/25	2:30 – 4:00	0:45 – 1:20	1:40 – 2:00	0:40 – 1:10	0:09 – 1:40	
		50/50	0:50 – 1:25	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	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	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	0:15 – 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 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 2012-2013[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	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	2:05 – 3:10	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	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	0:15 – 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 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-480

DOW CHEMICAL TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2012-2013[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	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 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 2012-2013[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	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	3:20 – 4:00	1:10 – 1:50	1:25 – 2:00	1:00 – 1:25	0:10 – 1:55	
		75/25	2:25 – 4:00	1:20 – 1:40	1:55 – 2:00	0:50 – 1:30	0:10 – 1:40	
		50/50	0:25 – 0:50	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	1:10 – 1:50	0:25 – 1:25[7]	0:20 – 0:25[7]		
		75/25	0:30 – 1:10	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	0:15 – 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 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-K-ABC-4S

KILFROST TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2012-2013[1]
ABC-4[sustain]

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	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	1:45 – 3:55	1:00 – 1:45	1:35 – 2:00	1:05 – 1:30	0:20 – 2:00	
		75/25	1:00 – 1:50	0:30 – 0:55	0:40 – 1:05	0:25 – 0:40	0:10 – 1:20	
		50/50	0:20 – 0:35	0:07 – 0:15	0:10 – 0:20	0:07 – 0:10	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:55 – 2:55	1:00 – 1:45	0:35 – 1:50[7]	1:05 – 1:25[7]		
		75/25	0:35 – 2:10	0:30 – 0:55	0:25 – 1:20[7]	0:15 – 0:40[7]		
below -14 to -29	below 7 to -20.2	100/0	0:40 – 1:00	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 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-K-ABC-S

KILFROST TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2012-2013[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	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	
		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	CAUTION: No holdover time guidelines exist	
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 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-K-ABC-S+

KILFROST TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2012-2013[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	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	2:10 – 4:00	1:15 – 2:00	1:50 – 2:00	1:05 – 2:00	0:25 – 2:00	
		75/25	1:25 – 2:40	0:45 – 1:15	1:00 – 1:20	0:30 – 0:50	0:10 – 1:20	
		50/50	0:30 – 0:55	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	1:00 – 1:45	0:25 – 1:35[7]	0:20 – 0:30[7]		
		75/25	0:45 – 1:50	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	0:15 – 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 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-L-ARCTIC Shield

LYONDELL TYPE IV FLUID HOLDOVER GUIDELINES FOR WINTER 2012-2013[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	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 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.**

Transport Canada Holdover Time Guidelines — Winter 2012-2013

TABLE 5

LIST OF FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE (2012-2013)

Table 5-1: 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	13-04-08
1-6	Aviation Shaanxi High-Tech Physical Co. Ltd.	Cleanwing I	15-12-19
1-7	Aviation Xi'an High-Tech Physical Co. Ltd.	KHF-1	15-08-16
1-8	*Beijing Phoenix Air Traffic Product Development and Trading Co.*	*CBSX-1*	*12-04-21* [3]
1-9	Beijing Wangye Aviation Chemical Product Co Ltd.	KLA-1	15-08-25
1-10	Beijing Yadilite Aviation Chemical Product Co. Ltd	YD-101 Type I	13-04-13
1-11	Clariant Produkte (Deutschland) GmbH	EcoFlo *(formerly Octagon EcoFlo)*	13-07-06
1-12	Clariant Produkte (Deutschland) GmbH	EcoFlo 2 *(formerly Octagon EcoFlo 2)*	13-07-25
1-13	Clariant Produkte (Deutschland) GmbH	Octaflo EF *(formerly Octagon Octaflo EF)*	14-03-25
1-14	Clariant Produkte (Deutschland) GmbH	Octaflo EF-80 *(formerly Octagon Octaflo EF-80)*	13-12-21
1-15	Clariant Produkte (Deutschland) GmbH	Octaflo EG *(formerly Octagon Octaflo EG)*	13-06-10
1-16	Clariant Produkte (Deutschland) GmbH	Safewing EG I 1996	12-06-10 [4]
1-17	Clariant Produkte (Deutschland) GmbH	Safewing EG I 1996 (88)	15-10-19
1-18	Clariant Produkte (Deutschland) GmbH	Safewing MP I 1938 ECO	16-06-26
1-19	Clariant Produkte (Deutschland) GmbH	Safewing MP I 1938 ECO (80)	16-07-09
1-20	Clariant Produkte (Deutschland) GmbH	Safewing MP I 1938 ECO (80) PreMix 55% i.g. ready-to-use	13-05-20
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 High Speed Aerodynamic Test 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.

TABLE 5 (cont.)

LIST OF FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE (2012-2013)

Table 5-1: Tested Type I De/Anti-icing Fluids (cont.) [1]			
#	COMPANY NAME	FLUID NAME	EXPIRY [2] (Y-M-D)
1-21	*Clariant Produkte (Deutschland) GmbH*	*Safewing MP I 1938 TF*	*08-08-21* [3]
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	14-07-03
1-24	Cryotech Deicing Technology	Polar Plus Concentrate	16-01-16
1-25	Cryotech Deicing Technology	Polar Plus (80)	13-09-28
1-26	Deicing Solutions LLC	Safetemp ES Plus	14-11-16
1-27	Dow Chemical Company	UCAR™ Aircraft Deicing Fluid Concentrate	15-09-09
1-28	Dow Chemical Company	UCAR™ ADF XL54	13-01-21
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	14-11-16
1-33	Hokkaido NOF Corporation	Fever Snow AG	13-07-26
1-34	Kilfrost Limited	DF Plus	15-08-30
1-35	Kilfrost Limited	DF Plus (80)	12-07-21 [4]
1-36	Kilfrost Limited	DF Plus (88)	15-08-30
1-37	Kilfrost Limited	DF sustain™	13-02-10
1-38	LNT Solutions	E188	13-09-29
1-39	LNT Solutions	P180	13-09-19
1-40	LNT Solutions	P188	13-09-30
1-41	Newave Aerochemical Co. Ltd.	FCY-1A	15-05-16
1-42	Shaanxi Cleanway Aviation Chemical Co., Ltd	Cleansurface I	13-08-02

[1] Concentrate fluids have also been tested at 50/50 (glycol/water) dilution.

[2] Expiry date is the earlier expiry date of the High Speed Aerodynamic Test 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.

TABLE 5 (cont.)

LIST OF FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE (2012-2013)

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	13-06-15
2-2	Aviation Shaanxi Hi-Tech Physical Chemical Co. Ltd.	Cleanwing II	13-07-26
2-3	*Clariant Produkte (Deutschland) GmbH*	*Safewing MP II 1951*	*11-05-20* [2]
2-4	Clariant Produkte (Deutschland) GmbH	Safewing MP II FLIGHT	12-06-03 [3]
2-5	Clariant Produkte (Deutschland) GmbH	Safewing MP II FLIGHT PLUS	Y-M-D [3]
2-6	Kilfrost Limited	ABC-3	12-08-05
2-7	*Kilfrost Limited*	*ABC-2000*	*10-07-21* [2]
2-8	Kilfrost Limited	ABC-K Plus	12-09-08 [3]
2-9	LNT Solutions	P250	Y-M-D [3]
2-10	Newave Aerochemical Co. Ltd.	FCY-2	13-05-18

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	12-05-28 [3]
4-5	Cryotech Deicing Technology	Polar Guard	12-08-30
4-6	Cryotech Deicing Technology	Polar Guard Advance	13-07-25
4-7	Dow Chemical Company	UCAR™ Endurance EG106 De/Anti-Icing Fluid	13-07-25
4-8	*Dow Chemical Company*	*UCAR™ FlightGuard AD-480*	*12-06-15* [2]
4-9	Dow Chemical Company	UCAR™ FlightGuard AD-49	13-04-14
4-10	*Kilfrost Limited*	*ABC-4^{sustain}*	*11-07-28* [2]
4-11	*Kilfrost Limited*	*ABC-S*	*11-07-06* [2]
4-12	Kilfrost Limited	ABC-S Plus	13-06-30
4-13	*Lyondell Chemical Company*	*ARCTIC Shield™*	*10-05-21* [2]

[1] Expiry date is the earlier expiry date of the High Speed Aerodynamic Test 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.

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.**

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

This visibility table applies to all Type I, II, III, and IV fluids.

Assume that the daytime visibility in snowfall is 1 statute mile and the temperature is -7°C. Based on these conditions, the snowfall intensity is light. This snowfall intensity is used to determine which holdover time guideline value is appropriate for the fluid in use.

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 [a] (mPa.s)	
		MANUFACTURER METHOD	AIR 9968 REVISION A METHOD
ABAX Ecowing 26	100/0	4 900 [e]	4 600 [g]
	75/25	2 200 [g]	2 200 [g]
	50/50	50 [g]	50 [g]
Aviation Shaanxi Hi-Tech Cleanwing II	100/0	4 650 [c]	4 500 [g]
	75/25	9 450 [c]	10 000 [g]
	50/50	10 150 [c]	10 200 [g]
Clariant Safewing MP II FLIGHT	100/0	3 340 [g]	3 340 [g]
	75/25	12 900 [l]	12 900 [l]
	50/50	11 500 [g]	11 500 [g]
Clariant Safewing MP II FLIGHT PLUS	100/0	3,650 [o]	3 100 [g]
	75/25	12,400 [o]	10 450 [g]
	50/50	7,800 [o]	7 050 [g]
Clariant Safewing MP II 1951	100/0	2 500 [b]	2 750 [g]
	75/25	2 900 [b]	3 000 [g]
	50/50	50 [b]	50 [g]
Kilfrost ABC-3	100/0	2 500 [c]	2 500 [j]
	75/25	2 000 [c]	2 000 [j]
	50/50	400 [c]	400 [j]
Kilfrost ABC-2000	100/0	2 350 [c]	2 350 [g]
	75/25	3 000 [c]	3 000 [j]
	50/50	1 000 [c]	1 000 [j]
Kilfrost ABC-K Plus	100/0	2 850 [c]	2 640 [g]
	75/25	12 650 [c]	12 650 [c]
	50/50	4 200 [c]	5 260 [g]
LNT Solutions P250	100/0	5 050 [g]	5 050 [g]
	75/25	4 650 [g]	4 650 [g]
	50/50	2 350 [g]	2 350 [g]
Newave Aerochemical FCY-2	100/0	7 000 [c]	8 920 [g]
	75/25	18 550 [c]	18 550 [c]
	50/50	6 750 [c]	7 030 [g]

Table 9-2: Type III De/Anti-Icing Fluids			
FLUID NAME	FLUID DILUTION	LOWEST ON-WING VISCOSITY [a] (mPa.s)	
		MANUFACTURER METHOD	AIR 9968 REVISION A METHOD
Clariant Safewing MP III 2031 ECO	100/0	30 [h]	Not Applicable
	75/25	55 [h]	Not Applicable
	50/50	10 [h]	Not Applicable

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 [a] (mPa.s)	
		MANUFACTURER METHOD	AIR 9968 REVISION A METHOD
ABAX AD-480	100/0	15 200 [e]	12 800 [c]
	75/25	16 000 [e]	12 400 [c]
	50/50	4 000 [e]	3 800 [g]
ABAX Ecowing AD-49	100/0	12 150 [k]	11 000 [g]
	75/25	30 700 [k]	32 350 [l]
	50/50	19 450 [k]	21 150 [l]
Clariant Max-Flight 04 *(formerly Octagon Max-Flight 04)*	100/0	5 540 [d]	5 540 [g]
	75/25	15 000 [g]	15 000 [g]
	50/50	5 200 [g]	5 200 [g]
Clariant Safewing MP IV LAUNCH	100/0	7 550 [g]	7 550 [g]
	75/25	18 000 [g]	18 000 [g]
	50/50	17 800 [g]	17 800 [g]
Cryotech Polar Guard	100/0	32 100 [m]	36 300 [l]
	75/25	24 200 [m]	27 800 [l]
	50/50	6 200 [m]	7 500 [g]
Cryotech Polar Guard Advance	100/0	4 400 [n]	4 050 [g]
	75/25	11 600 [n]	9 750 [g]
	50/50	80 [g]	80 [g]
Dow UCAR™ Endurance EG106	100/0	24 850 [f]	2 230 [g]
	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 [e]	12 800 [c]
	75/25	16 000 [e]	12 400 [c]
	50/50	4 000 [e]	3 800 [g]
Dow UCAR™ FlightGuard AD-49	100/0	12 150 [k]	11 000 [g]
	75/25	30 700 [k]	32 350 [l]
	50/50	19 450 [k]	21 150 [l]
Kilfrost ABC-4^{sustain}	100/0	18 400 [c]	18 400 [c]
	75/25	15 400 [c]	15 400 [c]
	50/50	4 700 [c]	5 050 [g]
Kilfrost ABC-S	100/0	17 000 [c]	17 000 [c]
	75/25	12 000 [c]	12 000 [c]
	50/50	2 000 [c]	2 000 [j]
Kilfrost ABC-S Plus	100/0	17 900 [c]	17 900 [c]
	75/25	18 300 [c]	18 300 [c]
	50/50	7 500 [c]	7 500 [j]
Lyondell ARCTIC Shield™	100/0	23 150 [i]	28 000 [c]
	75/25	21 700 [i]	22 100 [c]
	50/50	6 400 [i]	7 640 [g]

TABLE 9 (cont.)

LOWEST ON-WING VISCOSITY VALUES FOR DE/ANTI-ICING FLUIDS
(Table 9 endnotes)

NOTES

a 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.
b Brookfield Spindle SC4-34/13R, small sample adapter, 10 mL of fluid, at 20°C, 0.3 rpm, for 15 minutes 0 seconds.
c Brookfield Spindle LV2-disc with guard leg, 150 mL of fluid, at 20°C, 0.3 rpm, for 10 minutes 0 seconds.
d Brookfield Spindle LV1 with guard leg, 500 mL of fluid, at 20°C, 0.3 rpm, for 33 minutes 20 seconds.
e Brookfield Spindle SC4-34/13R, small sample adapter, 10 mL of fluid, at 20°C, 0.3 rpm, for 30 minutes 0 seconds.
f Brookfield Spindle SC4-31/13R, small sample adapter, 10 mL of fluid, at 0°C, 0.3 rpm, for 10 minutes 0 seconds.
g Brookfield Spindle LV1 with guard leg, 500 mL of fluid, at 20°C, 0.3 rpm, for 10 minutes 0 seconds.
h Brookfield Spindle LV0, UL-Adapter, 16 mL of fluid, at 20°C, 0.3 rpm, for 10 minutes 0 seconds.
i Brookfield Spindle SC4-31/13R, small sample adapter, 9 mL of fluid, at 20°C, 0.3 rpm, for 33 minutes 0 seconds.
j Brookfield Spindle LV1 with guard leg, 150 mL of fluid, at 20°C, 0.3 rpm, for 10 minutes 0 seconds.
k Brookfield Spindle SC4-31/13R, small sample adapter, 10 mL of fluid, at 20°C, 0.3 rpm, for 10 minutes 0 seconds.
l Brookfield Spindle LV-2 disc with guard leg, 500 mL of fluid, at 20°C, 0.3 rpm, for 10 minutes 0 seconds.
m Brookfield Spindle SC4-31/13R, small sample adapter, 9 mL of fluid, at 20°C, 0.3 rpm, for 10 minutes 0 seconds.
n Brookfield Spindle SC4-34/13R, small sample adapter, 10 mL of fluid, at 20°C, 0.3 rpm, for 10 minutes 0 seconds.
o Brookfield Spindle LV1, big sample adapter, 50 mL of fluid, at 20°C ,0.3 rpm, for 10 minutes 0 seconds.

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 is not lower than that listed.

TABLE 10

LOWEST OPERATIONAL USE TEMPERATURES[1] OF DE/ANTI-ICING FLUIDS (2012-2013)

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	Not tested[4]	**-31** for 71/29 dilution
ABAX DE-950 Colorless	Not tested[4]	**-24** for 60/40 dilution
AllClear Systems Lift-Off P-88	Not tested[4]	**-29.5** for 70/30 dilution
AllClear Systems Lift-Off E-188	Not tested[4]	**-41.5** for 70/30 dilution
Arcton Arctica DG ready-to-use	**-26** as supplied	**-26** as supplied
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)*	**-27** for 60/40 dilution	**-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.

TABLE 10 (cont.)

LOWEST OPERATIONAL USE TEMPERATURES[1] OF DE/ANTI-ICING FLUIDS (2012-2013)

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 Concentrate *(formerly Octagon Octaflo EF-80 Concentrate)*	**-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	**-44** 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 1938 TF	**-26.5** for 71/29 dilution	**-33.5** for 71/29 dilution
Clariant Safewing MP I ECO PLUS (80)	**-25** for 71/29 dilution	**-33** for 71/29 dilution
Clariant MP I SKY	Not tested[4]	**-31.5** for 71/29 dilution
Cryotech Polar Plus Concentrate	**-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 (2012-2013)

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
Kilfrost DF Plus	Not available[3]	**-32** for 69/31 dilution
Kilfrost DF Plus (80)	Not available[3]	**-31.5** for 69/31 dilution
Kilfrost DF Plus (88)	Not available[3]	**-32** for 63/37 dilution
Kilfrost DF^{sustain}™	**-36** for 68/32 dilution	**-41.5** for 68/32 dilution
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

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 (2012-2013)

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	-29
	75/25	-14
	50/50	-3
Kilfrost ABC-3	100/0	-27
	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 (2012-2013)

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-2000	100/0	-27.5
	75/25	-14
	50/50	-3
Kilfrost ABC-K Plus	100/0	-29
	75/25	-14
	50/50	-3
LNT Solutions P250	100/0	Not Available[3]
	75/25	Not Available[3]
	50/50	Not Available[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	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.

TABLE 10 (cont.)

LOWEST OPERATIONAL USE TEMPERATURES[1] OF DE/ANTI-ICING FLUIDS (2012-2013)

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	-14
	50/50	-3
Clariant Safewing MP IV LAUNCH	100/0	-28.5
	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
Dow UCAR™ Endurance EG106 De/Anti-Icing Fluid	100/0	-27
	75/25	Dilution Not Applicable
	50/50	Dilution Not Applicable
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.

TABLE 10 (cont.)

LOWEST OPERATIONAL USE TEMPERATURES[1] OF DE/ANTI-ICING FLUIDS (2012-2013)

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™ 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-4^{sustain}	100/0	-29
	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 2012-2013

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.

Transport Canada Holdover Time Guidelines — Winter 2012-2013

TABLE 11

ICE PELLET ALLOWANCE TIMES FOR WINTER 2012-2013

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.

	OAT -5°C and above	OAT less than -5°C to -10°C	OAT less than -10°C
Light Ice Pellets	50 minutes	30 minutes	30 minutes[1]
Moderate Ice Pellets	25 minutes[2]	10 minutes	10 minutes[1]
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[3]		
Light Ice Pellets Mixed with Moderate Rain	25 minutes[4]		
Light Ice Pellets Mixed with Light Snow	25 minutes	15 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes		

NOTES

1 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).
2 Allowance time is 15 minutes for propylene glycol (PG) fluids or when the fluid type is unknown.
3 No allowance times exist in this condition for temperatures below 0°C; consider use of light ice pellets mixed with light freezing rain.
4 No allowance times exist in this condition for temperatures below 0°C.

This page intentionally left blank.

FAA
HOLDOVER TIME GUIDELINES
WINTER 2012-2013

OFFICIAL FAA HOLDOVER TIME TABLES

WINTER 2012-2013

The information contained in this document is the FAA official guidance, Holdover Tables, and Allowance Times for use the Winter 2012- 2013. The content of this document is included by reference in the FAA Winter 2012 - 2013 Notice N 8900.TBD[1] that is published in FSIMS. The content of this document in conjunction with N 8900. TBD should be used as the official winter 2012-2013 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

[1] The Notice will be published shortly. Once published, "N 8900.TBD" will be changed to reflect the publication number.

2012-2013 Holdover Times Tables 8/1/12

SUMMARY OF CHANGES FROM 2012-2013

TYPE I FLUIDS. The Type I holdover time tables are unchanged. Previously, they had been 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.

The recent introduction of new aircraft constructed primarily of 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. As a result of extensive research and testing showing that holdover times of Type I fluids are shorter on composite surfaces than aluminum surfaces, holdover time values for composite surfaces have been developed and added to the Type I table and the Active Frost table .

The Type I fluid holdover times for composite surfaces (Table 1A) 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, LNT Solutions P250. The addition of this fluid did not impact the generic holdover times.

A fluid-specific HOT table has been added for an additional new fluid, Clariant Safewing MP II Flight Plus. The addition of this fluid did not impact the generic holdover times.

Two obsolete fluids, Clariant Safewing MP II 2025 Eco and Octagon E Max II have been removed from the Type II guidelines. Removal of these fluids did not impact the generic holdover times.

TYPE III FLUIDS. The Type III fluid HOT table values are unchanged.

TYPE IV FLUIDS. Two obsolete fluids, Clariant Safewing MP IV 2001 and Dow Chemical UCAR ADF/AAF Ultra+ have been removed from the Type IV guidelines. Removal of these fluids caused increases to twelve of the Type IV generic holdover times with nine cells being affected.

> **Note: Octagon Branded Fluid Names.** Due to the acquisition of the fluid manufacturing company Octagon Process by Clariant GmbH, fluids previously listed under the Octagon brand name are now listed under the Clariant brand name. These fluids include several Type I fluids (EcoFlo Concentrate, EcoFlo 2 Concentrate, Octaflo EF Concentrate, Octaflo EF-80, Octaflo EG Concentrate) and one Type IV fluid (Max-Flight 04).

ACTIVE FROST HOLDOVER TIMES. The lowest temperature band in the Type I portion of the active frost table has been changed from “below -21 to -25 ºC” to “below -21 to -25ºC or LOUT.” This change has been made to indicate that the Type I active frost holdover times can be

1

used at temperatures below -25ºC as long as the LOUT is not exceeded. Type I fluid LOUT's are listed in Table 7.1.

SNOWFALL VISIBILITY TABLE. Table 1C, Snowfall Intensities as a Function of Prevailing Visibility, has been modified from last year.

The snow intensity in the cell for night, temperature ≤ -1 ºC, and visibility 1 mile has been changed to moderate. The intensity in the cell for day, temperature > -1 ºC, and visibility 1 mile has also been changed to moderate.

New columns have been added for visibility 1 ½ and 1 ¾ mile. With these columns added, the table now provides snow intensities for all visibilities that are reported in the METARS in the United States.

FLUID APPLICATION PROCEDURES Wording was added to Tables 1B and 5 with respect to the time interval between the first and second step fluid applications. Wording was added to Table 1B to clarify that the minimum fluid application quantities and temperature apply to all conditions, including active frost.

ICE PELLET ALLOWANCE TIMES. The Ice Pellet Allowance Time (Table 9) values are unchanged for 2012-13. However, clarification added to the Ice Pellet Allowance Times section to identify additional precipitation conditions where OAT must not decrease.

EARLY FLUID FAILURE ON EXTENDED SLATS AND FLAPS. Additional research was conducted on this subject during the winter of 2012, and will resume for 2013. 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 Type I, II, III and IV fluids has been updated with revised information 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 Table 7. 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.
In the case of Types II, III, and IV fluids there can be multiple LOUTs to account for the neat (100/0) and the 50/50 and 75/25 dilutions. The LOUTs for these fluids are accounted for in the temperature bands which are an integral part of their holdover tables. If a fluid has a LOUT which is warmer than the lowest temperature in a particular band, this information will be noted on the appropriate table.

The LOUTs for Type I fluids are provided in Table 7-1 as well as the manufacturer specified fluid/ water concentration used to establish the LOUT for each fluid. This concentration should not be exceeded.

The LOUTs for undiluted Type II, Type III, and Type IV fluids (100/0) are provided in Tables 7-2 through 7-4 at the end of this document. The LOUTs for the 50/50, and 75/25 dilutions are shown in the fluid-specific holdover tables if the temperature is warmer than the lowest temperature in a given band.

As previously stated, for 2011-12 the fluid-specific LOUT data has been included in the corresponding HOTs.

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 will be 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 2012-13.

2012-2013 Holdover Times Tables 8/1/12

TABLE **PAGE**

Table 0. **SAE Type I, Type II, Type III, and Type IV** Fluids in Active Frost Conditions……....6

Table 1. **SAE Type I** Fluid Mixtures on Critical Aircraft Surfaces Composed Predominantly of **ALUMINUM** as a Function of Weather Conditions and Outside Air Temperature ..……..7

Table 1A. **SAE Type I** Fluid Mixtures on Critical Aircraft Surfaces Composed Predominantly of **COMPOSITES** as a Function of Weather Conditions and Outside Air Temperature …….....….8

Table 1B. **SAE Type I** Fluid Mixture Minimum Concentrations as a Function of Outside Air Temperature…….9

Table 1C. Snowfall Intensities as a Function of Prevailing Visibility……..…….....10

Table 2. **SAE Type II** Fluid Mixtures as a Function of Weather Conditions and Outside Air Temperature……..11

Table 2A. **ABAX (SPCA) ECOWING 26 Type II** Fluid Mixtures as a Function of Weather Conditions and Outside Air Temperature……..…….…….……12

Table 2B. **AVIATION SHAANXI HI-TECH CLEAN WING II Type II** Fluid Mixtures as a Function of Weather Conditions and Outside Air Temperature…….....13

Table 2C. **CLARIANT SAFEWING MP II FLIGHT Type II** Fluid Mixtures as a Function of Weather Conditions and Outside Air Temperature.....……..14

Table 2D. **CLARIANT SAFEWING MP II FLIGHT PLUS Type II** Fluid Mixtures as a Function of Weather Conditions and Outside Air Temperature …..……..…….....15

Table 2E. **KILFROST ABC-2000 Type II** Fluid Mixtures as a Function of Weather Conditions and Outside Air Temperature. ……..…..…….16

Table 2F. **KILFROST ABC-K PLUS Type II** Fluid Mixtures as a Function of Weather Conditions and Outside Air Temperature..…….……..……17

Table 2G. **LNT SOLUTIONS P250 Type II** Fluid Mixtures as a Function of Weather Conditions and Outside Air Temperature ……...18

Table 2H. **NEWAVE AEROCHEMICAL FCY-2 Type II** Fluid Mixtures as a Function of Weather Conditions and Outside Air Temperature. ……..…19

Table 3. **SAE Type III** Fluid Mixtures as a Function of Weather Conditions and Outside Air Temperature…….....……..20

Table 4. **SAE Type IV** Fluid Mixtures as a Function of Weather Conditions and Outside Air Temperature…….....……...21

Table 4A. **ABAX ECOWING AD-480** Fluid Mixtures as a Function of Weather Conditions and Outside Air Temperature…….....……22

Table 4B. **ABAX AD-49** Fluid Mixtures as a Function of Weather Conditions and Outside Air Temperature…...23

Table 4C. **CLARIANT MAX-FLIGHT 04(formerly Octagon Max Flight 04) Type IV** Fluid Mixtures as a Function of Weather Conditions and Outside Air Temperature……..……...24

Table 4D. **CLARIANT SAFEWING MP IV LAUNCH Type IV** Fluid Mixtures as a Function of Weather Conditions and Outside Air Temperature……..……..25

2012-2013 Holdover Times Tables 8/1/12

Table 4E. **CRYOTECH POLAR GUARD Type IV** Fluid as a Function of Weather Conditions and Outside Air Temperature…….....….....26

Tacle 4F. **CRYOTECH POLAR GUARD ADVANCE Type IV** Fluid as a Function of Weather Conditions and Outside Air Temperature…….....….....27

Table 4G. **DOW UCAR™ ENDURANCE EG106 Type IV** Fluid as a Function of Weather Conditions and Outside Air Temperature…….....……..….....28

Table 4H. **DOW UCAR™ FLIGHTGUARD AD-480 Type IV** Fluid Mixtures as a Function of Weather Conditions and Outside Air Temperature……..……..….....29

Table 4I. **DOW UCAR™ FLIGHTGUARD AD-49 Type IV** Fluid Mixtures as a Function of Weather Conditions and Outside Air Temperature……..……..….....30

Table 4J. **KILFROST ABC-4 SUSTAIN Type IV** Fluid Mixtures as a Function of Weather Conditions and Outside Air Temperature……..….....……31

Table 4K. **KILFROST ABC-S Type IV** Fluid Mixtures as a Function of Weather Conditions and Outside Air Temperature……..….....……..….....32

Table 4L. **KILFROST ABC-S PLUS Type IV** Fluid Mixtures as a Function of Weather Conditions and Outside Air Temperature……..……..….....33

Table 4M. **LYONDELL ARCTIC SHIELD™ Type IV** Fluid Mixtures as a Function of Weather Conditions and Outside Air Temperature…….....……..….....34

Table 5. FAA Guidelines for the Application of **SAE Type II, Type III, and Type IV** Fluid Mixtures…….…35

Table 6. Lowest On-wing Viscosity Values for Neat and Diluted **SAE Type II and Type IV** Fluids…….....36

Table 7. Lowest Operational Use Temperatures of Anti-Icing Fluids 2012-2013……..…….39

Table 8. List of Deicing/Anti-Icing Fluids Tested for Anti-Icing Performance and Aerodynamic Acceptance-Winter 2011-2012…….……..……..….....43

Table 9 Ice Pellet Allowance Times 2011 - 2012 48

Guidance/Information **PAGE**

Ice Pellet Allowance Times……46

Operations in Heavy Snow ……..…..49

2012-2013 Holdover Times Tables 8/1/12

TABLE 0. FAA GUIDELINES FOR HOLDOVER TIMES IN ACTIVE FROST, SAE TYPE I, TYPE II, TYPE III, AND TYPE IV FLUIDS

Outside Air Temperature		Approximate Holdover Times (hours:minutes)
		Active Frost
Degrees Celsius	Degrees Fahrenheit	Type 1 [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

NOTES:

1. Type I Fluid / Water Mixture is 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).
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 (-13F) 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.

2012-2013 Holdover Times Tables 8/1/12

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)							
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	Snow, Snow Grains or Snow Pellets			Freezing Drizzle*	Light Freezing Rain	Rain on Cold Soaked Wing**	Other‡
				Very Light†	Light†	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.

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 degrees Celsius (32 degrees Fahrenheit) only
‡ Heavy snow, ice pellets, moderate and heavy freezing rain, hail
† Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.

SAE Type I fluid/water mixture is 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.

7

2012-2013 Holdover Times Tables 8/1/12

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	Snow, Snow Grains or Snow Pellets			Freezing Drizzle*	Light Freezing Rain	Rain on Cold Soaked Wing**	Other‡
				Very Light†	Light†	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.

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 degrees Celsius (32 degrees Fahrenheit) only
‡ Heavy snow, ice pellets, moderate and heavy freezing rain, hail
† Use light freezing rain holdover times in conditions of very light or light snow mixed with light rain.

SAE Type I fluid/water mixture is 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.

8

2012-2013 Holdover Times Tables 8/1/12

TABLE 1B. FAA GUIDELINES FOR THE APPLICATION OF SAE TYPE I FLUID MIXTURE MINIMUM CONCENTRATIONS AS A FUNCTION OF OUTSIDE AIR TEMPERATURE

<table>
<tr><td rowspan="2">Outside Air Temperature (OAT)</td><td rowspan="2">One-step Procedure Deicing/Anti-icing[1]</td><td colspan="2">Two-step Procedure</td></tr>
<tr><td>First step: Deicing</td><td>Second step: Anti-icing [1, 2]</td></tr>
<tr><td>-3 °C (27 °F) and above</td><td rowspan="2">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</td><td>Heated water or a mix of fluid and water heated to 60 °C (140 °F) minimum at the nozzle</td><td rowspan="2">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</td></tr>
<tr><td>Below -3 °C (27 °F)</td><td>Freezing point of heated fluid mixture shall not be more than 3 °C (5 °F) above OAT</td></tr>
<tr><td colspan="4">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.)</td></tr>
<tr><td colspan="4">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.</td></tr>
</table>

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.

2012-2013 Holdover Times Tables 8/1/12

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	**Approximate Holdover Times Under Various Weather Conditions (hours: minutes)**					
Degrees Celsius	Degrees Fahrenheit	Neat-Fluid/Water (Volume %/Volume %)	Freezing Fog	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	0:35-1:30	0:20-0:45	0:30-0:55	0:15-0:30	0:08-0:40	
		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	CAUTION: No holdover time guidelines exist	
below -3 to -14	below 27 to 7	100/0	0:20-1:05	0:15-0:30	***0:20-0:45	***0:10-0:20		
		75/25	0:25-0:50	0:10-0:20	***0:15-0:30	***0: 08-0: 15		
Below -14 to -25 or LOUT	Below7 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.

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 °C (32 °F) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Heavy snow, ice pellets, moderate and heavy freezing rain, and hail
† Use light freezing rain holdover times in conditions of light snow mixed with light rain.

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.

11

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	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	1:25-2:35	0:40-1:00	0:50-1:35	0:40-0:50	0:20-1:25	
		75/25	1:05-1:55	0:25-0:45	0:45-1:05	0:25-0:35	0:10-1:00	
		50/50	0:30-0:45	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	0:35-0:55	***0:30-1:10	***0:15-0:35		
		75/25	0:35-1:15	0:25-0:40	***0:20-0:50	***0:15-0:25		
below -14 to -25	below 7 to -13	100/0	0:25-0:45	0:15-0:30				

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

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 °C (32 °F) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Heavy snow, ice pellets, moderate and heavy freezing rain, and hail
† Use light freezing rain holdover times in conditions of light snow mixed with light rain.

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.

2012-2013 Holdover Times Tables 8/1/12

TABLE 2B. FAA GUIDELINES FOR HOLDOVER TIMES AVIATION SHAANXI HI-TECH CLEAN WING 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	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	0:55-1:50	0:30-0:55	0:35-1:05	0:25-0:35	0:10-0:55	
		75/25	0:50-1:20	0:25-0:45	0:35-1:00	0:20-0:30	0:07-0:50	
		50/50	0:35-1:00	0:15-0:30	0:20-0:40	0:10-0:20		
below -3 to -14	below 27 to 7	100/0	0:45-1:50	0:30-0:55	***0:30-0:55	***0:20-0:25		CAUTION: No holdover time guidelines exist
		75/25	0:40-1:45	0:25-0:45	***0:35-0:40	***0:20-0:25		
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.

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 °C (32 °F) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Heavy snow, ice pellets, moderate and heavy freezing rain, and hail
† Use light freezing rain holdover times in conditions of light snow mixed with light rain.

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.

13

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	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	3:30-4:00	1:00-1:35	1:20-2:00	0:45-1:25	0:10-1:30	CAUTION: No holdover time guidelines exist
		75/25	1:50-2:45	0:40-1:20	1:10-1:30	0:30-0:55	0:06-0:50	
		50/50	0:55-1:45	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	0:40-1:05	***0:35-1:30	***0:25-0:45		
		75/25	0:25-1:05	0:20-0:40	***0:25-1:10	***0:20-0:35		
Below -14 to -29	Below 7 to -20.2	100/0	0:30-0:50	0:15-0:30				

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

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 °C (32 °F) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Heavy snow, ice pellets, moderate and heavy freezing rain, and hail
†Use light freezing rain holdover times in conditions of light snow mixed with light rain.

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.

2012-2013 Holdover Times Tables 8/1/12

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	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	1:05-2:00	1:25-2:00	0:45-1:00	0:15-2:00	CAUTION: No holdover time guidelines exist
		75/25	2:35-4:00	0:55-1:35	1:35-2:00	0:50-1:15	0:15-1:15	
		50/50	1;05-2:20	O;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	0:15-0:30	***0:35-1:25	***0:35-0:55		
		75/25	0;30-1:45	0;10-0:20	***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				

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

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 °C (32 °F) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Heavy snow, ice pellets, moderate and heavy freezing rain, and hail
†Use light freezing rain holdover times in conditions of light snow mixed with light rain.

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.

15

2012-2013 Holdover Times Tables 8/1/12

TABLE 2E. 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	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	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	***0:10-0:30		
		75/25	0:35-1:15	0:25-0:50	***0:25-0:55	***0:15-0:30		
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.

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 degrees Celsius (32 degrees Fahrenheit) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Heavy snow, ice pellets, moderate and heavy freezing rain, and hail
† Use light freezing rain holdover times in conditions of light snow mixed with light rain.

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.

16

2012-2013 Holdover Times Tables 8/1/12

TABLE 2F. 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	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	2:15-3:45	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	***0:15-0:35		
		75/25	0:25-1:25	0:35-1:05	***0:20-0:55	***0:09-0:30		
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.

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 degrees Celsius (32 degrees Fahrenheit) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Heavy snow, ice pellets, moderate and heavy freezing rain, and hail
† Use light freezing rain holdover times in conditions of light snow mixed with light rain.

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

17

2012-2013 Holdover Times Tables 8/1/12

TABLE 2G. FAA GUIDELINES FOR HOLDOVER TIMES LNT SOLUTIONS P250 FLUID MIXTURES TYPE II 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	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	1:45-3:00	0:50-1:10	1:20-1:40	0:40-1:05	0:20-1:30	CAUTION: No holdover time guidelines exist
		75/25	1:00-1:45	0:30-0:50	0:35-1:05	0:20-0:35	0:10-1:15	
		50/50	0:25-0:40	0:10-0:15	0:15-0:25	0:07-0:15		
below -3 to -14	below 27 to 7	100/0	0:45-2:35	0:15-0:30	***0:30-1:40	***1:00-1:25		
		75/25	0:25-1:20	0:10-0:20	***0:25-1:15	***0:35-0:50		
below 14 to LOUT	below 7 to LOUT	100/0	0:20-0:45	0:15-0:30				

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

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 degrees Celsius (32 degrees Fahrenheit) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Heavy snow, ice pellets, moderate and heavy freezing rain, and hail
† Use light freezing rain holdover times in conditions of light snow mixed with light rain.

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.

- LNT SOLUTIONS P250 TYPE II FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT

18

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	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	1:15-2:25	0:30-0:55	0:35-1:05	0:25-0:35	0:08-0:45	
		75/25	0:50-1:30	0:20-0:40	0:25-0:45	0:15-0:25	0:05-0:25	
		50/50	0:25-0:35	0:15-0:25	0:10-0:20	0:07-0:10		
below -3 to -14	below 27 to 7	100/0	0:45-1:30	0:15-0:30	***0:20-0:45	***0:15-0:20		CAUTION: No holdover time guidelines exist
		75/25	0:30-1:05	0:10-0:20	***0:15-0:30	***0:08-0:15		
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.

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 °C (32 °F) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Heavy snow, ice pellets, moderate and heavy freezing rain, and hail
† Use light freezing rain holdover times in conditions of light snow mixed with light rain.

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.

2012-2013 Holdover Times Tables 8/1/12

FAA TYPE III HOLDOVER TIME GUIDELINE

TABLE 3. FAA GUIDELINES FOR HOLDOVER TIMES SAE TYPE III FLUID MIXTURE AS A FUNCTION OF WEATHER CONDI 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**	**Snow, Snow Grains or Snow Pellets**			**Freezing Drizzle***	**Light Freezing Rain**	**Rain on Cold Soaked Wing****	**Other‡**
				VeryLight†	**Light†**	**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	
		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	CAUTION: No holdover time guidelines exist	
		***75/25	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.

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible

**This column is for use at temperatures above 0 °C (32 °F) only

***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

‡ Heavy snow, ice pellets, moderate and heavy freezing rain, and hail

† Use light freezing rain holdover times in conditions of light snow mixed with light rain.

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.

20

2012-2013 Holdover Times Tables 8/1/12

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	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	1:45-3:10	0:40-1:20	0:50-1:30	0:35-0:55	0:10-1:15	CAUTION: No holdover time guidelines exist
		75/25	1:00-1:45	0:30-0:55	0:40-1:05	0:25-0:40	0:09-0:50	
		50/50	0:20-0:35	0:07-0:15	0:10-0:20	0:07-0:10		
below -3 to -14	below 27 to 7	100/0	0:20-1:20	0:30-0:55	***0:20-1:00	***0:10-0:25		
		75/25♦	0:25-0:50	0:20-0:40	***0:15-1:00	***0:10-0:25		
below -14 to -25 or LOUT	below 7 to -13 or LOUT	100/0♦♦	0:15-0:40	0:15-0:30				

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

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 °C (32 °F) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Heavy snow, ice pellets, moderate and heavy freezing rain, and hail
† Use light freezing rain holdover times in conditions of light snow mixed with light rain.
♦ 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).
♦♦ For Cryotech Polar Guard, temperature is limited to -23.5 ºC (-10.3 ºF)F) 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.

21

2012-2013 Holdover Times Tables 8/1/12

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	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	2:00-3:30	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	***0:15-0:30		
		75/25	0:25-0:50	0:20-0:45	***0:25-1:05	***0:15-0:30		
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.

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 degrees Celsius (32 degrees Fahrenheit) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Heavy snow, ice pellets, moderate and heavy freezing rain, and hail
† Use light freezing rain holdover times in conditions of light snow mixed with light rain.

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.

22

2012-2013 Holdover Times Tables 8/1/12

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)					
Degrees Celsius	Degrees Fahrenheit		Freezing Fog	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	3:20-4:00	1:10-1:50	1:25-2:00	1:00-1:25	0:10-1:55	CAUTION: No holdover time guidelines exist
		75/25	2:25-4:00	1:20-1:40	1:55-2:00	0:50-1:30	0:10-1:40	
		50/50	0:25-0:50	0:15-0:25	0:15-0:30	0:10-0:15		
below -3 to -14	below 27 to 7	100/0	0:20-1:35	1:10-1:50	***0:25-1:25	***0:20-0:25		
		75/25	0:30-1:10	1:20-1:40	***0:15-1:05	***0:15-0:25		
below -14 to -26	below 7 to -14.8	100/0	0:25-0:40	0:15-0:30				

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

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 °C (32 °F) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Heavy snow, ice pellets, moderate and heavy freezing rain, and hail
† Use light freezing rain holdover times in conditions of light snow mixed with light rain.

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.

23

2012-2013 Holdover Times Tables 8/1/12

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	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	1:25-2:00	2:00-2:00	1:10-1:30	0:20-2:00	
		75/25	2:05-3:15	1:05-2:00	1:50-2:00	1:00-1:20	0:20-2:00	
		50/50	0:55-1:45	0:25-1:15	0:35-1:10	0:25-0:35		CAUTION: No holdover time guidelines exist
below -3 to -14	below 27 to 7	100/0	0:50-2:30	0:35-1:10	***0:25-1:30	***0:20-0:40		
		75/25	0:30-1:05	0:40-1:25	***0:20-1:00	***0:15-0:30		
below -14 to -26.5	below 7 to -15.7	100/0	0:20-0:45	0:15-0:30				

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

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 °C (32 °F) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Heavy snow, ice pellets, moderate and heavy freezing rain, and hail
† Use light freezing rain holdover times in conditions of light snow mixed with light rain.

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.

24

2012-2013 Holdover Times Tables 8/1/12

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	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	4:00-4:00	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	1:00-1:45	1:40-2:00	0:45-1:15	0:10-1:45	
		50/50	1:25-2:45	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	0:50-1:20	***0:35-1:40	***0:25-0:45		
		75/25	0:40-1:20	0:45-1:25	***0:25-1:10	***0:25-0:45		
below -14 to -28.5	below 7 to -19.3	100/0	0:30-0:50	0:15-0:30				

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

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 °C (32 °F) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Heavy snow, ice pellets, moderate and heavy freezing rain, and hail
† Use light freezing rain holdover times in conditions of light snow mixed with light rain.

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.

25

2012-2013 Holdover Times Tables 8/1/12

TABLE 4E. 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	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	2:15-3:30	0:50-1:30	1:15-2:00	0:50-1:15	0:15-1:25	
		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		CAUTION: No holdover time guidelines exist
below -3 to -14	below 27 to 7	100/0	0:45-1:45	0:30-0:55	***0:25-1:10	***0:15-0:35		
		75/25◆	0:35-1:30◆	0:20-0:40◆	0:25-1:05◆	0:20-0:30◆		
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.

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 °C (32 °F) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Heavy snow, ice pellets, moderate and heavy freezing rain, and hail
† Use light freezing rain holdover times in conditions of light snow mixed with light rain.
◆ 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.

26

TABLE 4F. 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	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	2:50-4:00	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	0:45-1:20	1:40-2:00	0:40-1:10	0:09-1:40	
		50/50	0:50-1:25	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	0:55-1:15	***0:35-1:35	***0:35-0:45		
		75/25	0:40-1:30	0:35-1:00	0:25-1:05	0:35-0:45		
Below -14 to -30.5	Below 7 to -22.9	100/0	0:25-0:50	0:15-0:30				

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

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 °C (32 °F) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Heavy snow, ice pellets, moderate and heavy freezing rain, and hail
† Use light freezing rain holdover times in conditions of light snow mixed with light rain.

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.

2012-2013 Holdover Times Tables 8/1/12

TABLE 4G. FAA GUIDELINES FOR HOLDOVER TIMES DOW 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	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	2:05-3:10	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		
		50/50	N/A	N/A	N/A	N/A		
below -3 to -14	below 27 to 7	100/0	1:50-3:20	0:30-1:05	***0:55-1:50	***0:45-1:10		
		75/25	N/A	N/A	N/A	N/A		
below -14 to -27	below 7 to -16.6	100/0	0:30-1:05	0:15-0:30				

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

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 degrees Celsius (32 degrees Fahrenheit) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Heavy snow, ice pellets, moderate and heavy freezing rain, and hail
† Use light freezing rain holdover times in conditions of light snow mixed with light rain.

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 UCAR ENDURANCE EG106 TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

28

2012-2013 Holdover Times Tables 8/1/12

TABLE 4H. FAA GUIDELINES FOR HOLDOVER TIMES DOW 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	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	2:00-3:30	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	***0:15-0:30		
		75/25	0:25-0:50	0:20-0:45	***0:25-1:05	***0:15-0:30		
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.

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 degrees Celsius (32 degrees Fahrenheit) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Heavy snow, ice pellets, moderate and heavy freezing rain, and hail
† Use light freezing rain holdover times in conditions of light snow mixed with light rain.

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 UCAR FLIGHTGUARD AD-480 TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

29

2012-2013 Holdover Times Tables 8/1/12

TABLE 4I. FAA GUIDELINES FOR HOLDOVER TIMES DOW UCAR™ 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	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	3:20-4:00	1:10-1:50	1:25-2:00	1:00-1:25	0:10-1:55	
		75/25	2:25-4:00	1:20-1:40	1:55-2:00	0:50-1:30	0:10-1:40	
		50/50	0:25-0:50	0:15-0:25	0:15-0:30	0:10-0:15		
below -3 to -14	below 27 to 7	100/0	0:20-1:35	1:10-1:50	***0:25-1:25	***0:20-0:25		CAUTION: No holdover time guidelines exist
		75/25	0:30-1:10	1:20-1:40	***0:15-:1:05	***0:15-0:25		
below -14 to -26	below 7 to -14.8	100/0	0:25-0:40	0:15-0:30				

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

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 °C (32 °F) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Heavy snow, ice pellets, moderate and heavy freezing rain, and hail
† Use light freezing rain holdover times in conditions of light snow mixed with light rain.

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 UCAR™ AD-49 TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

30

2012-2013 Holdover Times Tables 8/1/12

TABLE 4J. FAA GUIDELINES FOR HOLDOVER TIMES KILFROST ABC-4^{SUSTAIN} 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	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	1:45-3:55	1:00-1:45	1:35-2:00	1:05-1:30	0:20-2:00	
		75/25	1:00-1:50	0:30-0:55	0:40-1:05	0:25-0:40	0:10-1:20	
		50/50	0:20-0:35	0:07-0:15	0:10-0:20	0:07-0:10		CAUTION: No holdover time guidelines exist
below -3 to -14	below 27 to 7	100/0	0:55-2:55	1:00-1:45	***0:35-1:50	***1:05-1:25		
		75/25	0:35-2:10	0:30-0:55	***0:25-1:20	***0:15-0:40		
below -14 to -29	below 7 to -20.2	100/0	0:40-1:00	0:15-0:30				

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

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 degrees Celsius (32 degrees Fahrenheit) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Heavy snow, ice pellets, moderate and heavy freezing rain, and hail
† Use light freezing rain holdover times in conditions of light snow mixed with light rain

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-4 ^{SUSTAIN} TYPE IV FLUID USED DURING GROUND DEICING/ANTI-ICING IS NOT INTENDED FOR AND DOES NOT PROVIDE PROTECTION DURING FLIGHT.

31

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	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	2:35-4:00	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	***0:10-0:30		
		75/25	0:25-1:00	0:25-0:50	***0:20-1:10	***0:10-0:35		
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.

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 degrees Celsius (32 degrees Fahrenheit) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Heavy snow, ice pellets, moderate and heavy freezing rain, and hail
† Use light freezing rain holdover times in conditions of light snow mixed with light rain.

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.

2012-2013 Holdover Times Tables 8/1/12

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	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	2:10-4:00	1:15-2:00	1:50-2:00	1:05-2:00	0:25-2:00	
		75/25	1:25-2:40	0:45-1:15	1:00-1:20	0:30-0:50	0:10-1:20	
		50/50	0:30-0:55	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	1:00-1:45	***0:25-1:35	***0:20-0:30		
		75/25	0:45-1:50	0:35-1:00	***0:20-1:10	***0:15-0:25		
below -14 to -28	below 7 to -18.4	100/0	0:40-1:00	0:15-0:30				

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

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 °C (32 °F) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Heavy snow pellets, ice pellets, moderate and heavy freezing rain, and hail
† Use light freezing rain holdover times in conditions of light snow mixed with light rain

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.

33

2012-2013 Holdover Times Tables 8/1/12

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	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	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	***0:25-0:30		
		75/25◆	0:50-1:45◆	0:35-0:55◆	0:30-1:15◆	0:25-0:30◆		
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.

* Use light freezing rain holdover times if positive identification of freezing drizzle is not possible
** This column is for use at temperatures above 0 °C (32 °F) only
*** No holdover time guidelines exist for this condition below -10 °C (14 °F)
‡ Heavy Snow, ice pellets, moderate and heavy freezing rain, and hail
† Use light freezing rain holdover times in conditions of light snow mixed with light rain
◆ 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.

34

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.		

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 manufacturers' 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 manufacturers instructions and procedures should be followed.**

TABLE 6. LOWEST ON-WING VISCOSITY VALUES FOR ANTI-ICING FLUIDS
(See Page 39 for Table 6 Notes)

Table 6-1: Type II Anti-Icing Fluids			
FLUID NAME	FLUID DILUTION	LOWEST ON-WING VISCOSITY [a] (mPa.s)	
		MANUFACTURER METHOD	AIR 9968 REVISION A METHOD
ABAX Ecowing 26	100/0	4,900 [e]	4,600 [g]
	75/25	2,200 [g]	2,200 [g]
	50/50	50 [g]	50 [g]
Aviation Shaanxi High-Tech Cleanwing II	100/0	4,650 [c]	4,500 [g]
	75/25	9,450 [c]	10,000 [g]
	50/50	10,150 [c]	10,200 [g]
Clariant Safewing MP II Flight	100/0	3,340 [g]	3,340 [g]
	75/25	12,900 [i]	12,900 [l]
	50/50	11,500 [g]	11,500 [g]
Clariant Safewing MP II Flight Plus	100/0	3,650 [o]	3,100 [g]
	75/25	12,400 [o]	10,450 [g]
	50/50	7,800 [o]	7,050 [g]
Clariant Safewing MP II 1951	100/0	2,500 [b]	2, 750 [g] g
	75/25	2,900 [b]	3, 000 [g]
	50/50	50 [b]	50 [g]
Kilfrost ABC-3	100/0	2,500 [c]	2,500 [j]
	75/25	2,000 [c]	2,000 [j]
	50/50	400 [c]	400 [j]
Kilfrost ABC-2000	100/0	2,350 [c]	2,350 [g]
	75/25	3,000 [c]	3,000 [j]
	50/50	1,000 [c]	1,000 [j]
Kilfrost ABC-K Plus	100/0	2,850 [c]	2,640 [g]
	75/25	12,650 [c]	12,650 [c]
	50/50	4,200 [c]	5,260 [g]
LNT Solutions P250	100/0	5,050 [g]	5,050 [g]
	75/25	4,650 [g]	4,650 [g]
	50/50	2,350 [g]	2,350 [g]
Newave Aerochemical FCY-2	100/0	7,000 [c]	8,920 [g]
	75/25	18,550 [c]	18,550 [c]
	50/50	6,750 [c]	7,030 [g]

Table 6-2: Type III Anti-Icing Fluids			
FLUID NAME	FLUID DILUTION	LOWEST ON-WING VISCOSITY [a] (mPa.s)	
		MANUFACTURER METHOD	AIR 9968 REVISION A METHOD
Clariant Safewing MP III 2031 ECO	100/0	30 [h]	Not Applicable
	75/25	55 [h]	Not Applicable
	50/50	10 [h]	Not Applicable

Table 6-3 Type IV Anti-Icing Fluids			
FLUID NAME	FLUID DILUTION	LOWEST ON-WING VISCOSITY [a] (mPa.s)	
		MANUFACTURER METHOD	SAE AIR 9968 REVISION A METHOD
ABAX AD-480	100/0	15,200 [e]	12,800 [c]
	75/25	16,000 [e]	12,400 [c]
	50/50	4,000 [e]	3,800 [g]
ABAX Ecowing AD-49	100/0	12,150 [k]	11,000 [g]
	75/25	30,700 [k]	32,,350 [l]
	50/50	19,450 [k]	21,150 [l]
Clariant MaxFlight 04	100/0	5,540 [d]	5,540 [g]
	75/25	15,000 [g]	15,000 [g]
	50/50	5,200 [g]	5,200 [g]
Clariant Safewing MP IV Launch	100/0	7,550 [g]	7,550 [g]
	75/25	18,000 [g]	18,000 [g]
	50/50	17,800 [g]	17,800 [g]
Cryotech Polar Guard	100/0	32,100 [m]	36,300 [l]
	75/25	24,200 [m]	27,800 [l]
	50/50	6,200 [m]	7,500 [g]
Cryotech Polar Guard Advance	100/0	4,400 [n]	4,050 [g]
	75/25	11,600 [n]	9,750 [g]
	50/50	80 [g]	80 [g]
Dow UCAR Endurance EG106	100/0	24,850 [f]	2,230 [g]
	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 [e]	12,800 [c]
	75/25	16,000 [e]	12,400 [c]
	50/50	4,000 [e]	3,800 [g]
Dow UCAR FlightGuard AD-49	100/0	12,150 [k]	11,000 [g]
	75/25	30,700 [k]	32,,350 [l]
	50/50	19,450 [k]	21,150 [l]
Kilfrost ABC-4 SUSTAIN	100/0	18,400 [c]	18,400 [c]
	75/25	15,400 [c]	15,400 [c]
	50/50	4,700 [c]	5,050 [g]
Kilfrost ABC-S	100/0	17,000 [c]	17,000 [c]
	75/25	12,000 [c]	12,000 [c]
	50/50	2,000 [c]	2,000 [j]
Kilfrost ABC-S PLUS	100/0	17,900 [c]	17,900 [c]
	75/25	18,300 [c]	18,300 [c]
	50/50	7,500 [c]	7,500 [j]

Table 6-3 Type IV Anti-Icing Fluids (Continued)			
Lyondell Arctic Shield	100/0	23,150 [i]	28,000 [c]
	75/25	21,700 [i]	22,100 [c]
	50/50	6,400 [i]	7,640 [g]

NOTES

A. The SAE 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.

B. Brookfield Spindle SC4-34/13R, small sample adapter, 10 mL of fluid, at 20°C, 0.3 rpm, for 15 minutes 0 seconds.

C. Brookfield Spindle LV2-disc with guard leg, 150 mL of fluid, at 20°C, 0.3 rpm, for 10 minutes 0 seconds.

D. Brookfield Spindle LV1 with guard leg, 500 mL of fluid, at 20°C, 0.3 rpm, for 33 minutes 20 seconds.

E. Brookfield Spindle SC4-34/13R, small sample adapter, 10 mL of fluid, at 20°C, 0.3 rpm, for 30 minutes 0 seconds.

F Brookfield Spindle SC4-31/13R, small sample adapter, 10 mL of fluid, at 0°C, 0.3 rpm, for 10 minutes 0 seconds.

G. Brookfield Spindle LV1 with guard leg, 500 mL of fluid, at 20ºC, 0.3 rpm, for 10 minutes 0 seconds.

H.. Brookfield Spindle LV0, UL-Adapter, 16 mL of fluid, at 20ºC, 0.3 rpm, for 10 minutes 0 seconds.

I. Brookfield Spindle SC4-31/13R, small sample adapter, 9 mL of fluid, at 20°C, 0.3 rpm, for 33 minutes 0 seconds.

J. Brookfield Spindle LV1 with guard leg, 150 mL of fluid, at 20ºC, 0.3 rpm, for 10 minutes 0 seconds

K. Brookfield Spindle SC4-31/13R, small sample adapter, 10 mL of fluid, at 20ºC, 0.3 rpm, for 10 minutes 0 seconds

L. Brookfield Spindle LV-2 disc with guard leg, 500 mL of fluid at 20ºC, 0.3 rpm, for 10 minutes 0 seconds.

M. Brookfield Spindle SC4-31/13R, small sample adapter, 9ml of fluid at 20ºC, 0.3 rpm for 10 minutes 0 seconds.

N. Brookfield Spindle SC4-34/13R, small sample adapter, 10mL of fluid at 20°C, 0.3 rpm, for 10 minutes 0 seconds.

O. Brookfield Spindle LV-1, big sample adapter, 50ml of fluid at 20º C for 10 minutes 0 seconds.

SIGNIFICANCE OF TABLE 6. The viscosity values of the fluids in Table 6 are those provided by the fluid 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 of a fluid sample taken from the wing is not lower than the value listed here.

2012-2013 Holdover Times Tables 8/1/12

TABLE 7. LOWEST OPERATIONAL USE TEMPERATURES[1] OF ANTI-ICING FLUIDS (2012-2013)

(NOTES 1-4 are located on page 40-41)

TABLE 7-1: Type I Anti-Icing Fluids				
FLUID NAME	LOWEST OPERATIONAL USE TEMPERATURES WITH DILUTION PER CENT FLUID/WATER AT LOUT IN PARENTHESIS			
	LOW SPEED AERODYNAMIC TEST		HIGH SPEED AERODYNAMIC TEST	
	DEGREES CELSIUS	DEGREES FAHRENHEIT	DEGREES CELSIUS	DEGREES FAHRENHEIT
ABAX DE-950	Not tested[4]	Not tested[4]	-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	Not tested[4]	Not tested[4]	-29.5 (70/30)	-21.1 for 70/30 dilution
AllClear Systems Lift-Off E-188	Not Tested[4]	Not Tested[5]	-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
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)
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 Air Traffic Product Development and Trading Co.	Not tested[4]	Not tested[4]	-30 (60/40)	-22 (60/40)
Clariant EcoFlo Concentrate *(formerly Octagon EcoFlo Concentrate)*	-27 (60/40)	-16.6 (60/40)	-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)	-44 (70/30)	-47.2 (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 1938 TF	-26.5 (71/29)	-15.7 (71/29)	-33.5 (71/29)	-28.3 (71/29)
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	Not tested[4]	Not tested[4]	-31.5 (71/29)	-24.7 (71/29)

2012-2013 Holdover Times Tables 8/1/12

LOWEST OPERATIONAL USE TEMPERATURES[1] OF ANTI-ICING FLUIDS (2012-2013) (Continued)

FLUID NAME	LOWEST OPERATIONAL USE TEMPERATURES WITH DILUTION PER CENT FLUID/WATER AT LOUT IN PARENTHESIS			
	LOW SPEED AERODYNAMIC TEST2		HIGH SPEED AERODYNAMIC TEST2	
	DEGREES CELSIUS	DEGREES FAHRENHEIT	DEGREES CELSIUS	DEGREES FAHRENHEIT
Cryotech Polar Plus Concentrate	-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)
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
Kilfrost DF Plus	Not available[3]	Not available[3]	-32 (69/31)	-25.6 (69/31)
Kilfrost DF Plus (80)	Not available[3]	Not available[3]	-31.5 (69/31)	-24.7 (69/31)
Kilfrost DF Plus (88)	Not available[3]	Not available[3]	-32 (63/37)	-25.6 (63/37)
Kilfrost DF^{sustain}™	-36 (68/32)	-32.8 (68/32)	-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)

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.

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.
- 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 (100/0) Anti-Icing Fluids

Fluid Name	Lowest Operational Use Temperatures[1]	
	High Speed Aerodynamic Test[2]	
	Degrees Celsius	Degrees Fahrenheit
ABAX Ecowing 26	-25	-13
Aviation Shaanxi Hi-Tech Cleanwing II	-29	-20.2
Clariant Safewing MP II 1951	-28	-18.4
Clariant Safewing MP II Flight	-29	-20.2
Clariant Safewing MP II Flight Plus	-29	-20.2
Kilfrost ABC-3	-27	-16.6
Kilfrost ABC-2000	-27.5	-17.5
Kilfrost ABC-K Plus	-29	-20.2
LNT Solutions P250	Not available[3]	Not available[3]
Newave Aerochemical FCY-2	-28	-18.4

Table 7-3: Type III (100/0) Anti-Icing Fluids

Fluid Name	Lowest Operational Use Temperatures			
	Low Speed Aerodynamic Test		High Speed Aerodynamic Test	
	Degrees Celsius	Degrees Fahrenheit	Degrees Celsius	Degrees Fahrenheit
Clariant Safewing MP III 2031	-16.5	2.3	-29	-20.2

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.

3. Manufacturer has indicated fluid was not tested. Consult with the fluid manufacturer for further guidance.

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.

Table 7-4: Type IV (100/0) Anti-Icing Fluids

Fluid Name	Lowest Operational Use Temperatures[2]	
	High Speed Aerodynamic Test	
	Degrees Celsius	Degrees Fahrenheit
ABAX AD-480	-26	-14.8
ABAX Ecowing AD-49	-26	-14.8
Clariant Max-Flight 04 (formerly Octagon Max Flight 04)	-26.5	-15.7
Clariant Safewing MP IV LAUNCH	-28.5	-19.3
Cryotech Polar Guard	-23.5	-10.3
Cryotech Polar Guard Advance	-30.5	-22.9
Dow UCAR™ Endurance EG106 De/Anti-Icing Fluid	-27	-16.6
Dow UCAR™ FlightGuard AD-480	-26	-14.8
Dow UCAR™ FlightGuard AD-49	-26	-14.8
Kilfrost ABC-4^{sustain}	-29	-20.2
Kilfrost ABC-S	-28	-18.4
Kilfrost ABC-S PLUS	-28	-18.4
Lyondell ARCTIC Shield™	-24.5	-12.1

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).

3. Manufacturer has indicated fluid was not tested. Consult with the fluid manufacturer for further guidance.

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.

TABLE 8. LIST OF FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE-WINTER 2012-13
(NOTES 1-2 are located on page 45)

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
Aviation Shaanxi High-Tech Physical Co. Ltd.	Cleanwing I
Aviation Xi'an High-Tech	KHF-1
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 (formerly Octagon EcoFlo)
Clariant GmbH	EcoFlo 2 (formerly Octagon EcoFlo 2)
Clariant GmbH	Octaflo EF (formerly Octagon Octaflo EF)
Clariant GmbH	Octaflo EF 80 (formerly Octagon Octaflo EF-80)
Clariant GmbH	Octaflo EG (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
Chariant GmbH	Safewing MP I 1938TF
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
Cryotech Deicing Technology	Polar Plus Concentrate
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
Kilfrost	Kilfrost DF PLUS
Kilfrost	Kilfrost DF PLUS (80)
Kilfrost	Kilfrost DF PLUS (88)
Kilfrost	Kilfrost DF^{SUSTAIN} ™
LNT Solutions	E188
LNT Solutions	P180
LNT Solutions	P188
Newave Aerochemical Co. , Ltd	FCY-!A
Shanxi Cleanway Aviation Chemical Co. , Ltd.	Cleansurface I

TABLE 8. CONTINUED. LIST OF FLUIDS TESTED FOR ANTI-ICING PERFORMANCE AND AERODYNAMIC ACCEPTANCE-WINTER 2012-2013

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
Kilfrost	Kilfrost ABC-3
Kilfrost	Kilfrost ABC-2000
Kilfrost	Kilfrost ABC-K PLUS
LNT Solutions	P250
Newave Aerochemical Technology	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
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-4 SUSTAIN
Kilfrost	ABC-S
Kilfrost	ABC-S Plus
Lyondell Chemical Company	Shield™

2012-2013 Holdover Times Tables 8/1/12

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 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.

ICE PELLET ALLOWANCE TIMES
2012-2013

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:

- 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 0^0C, 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, section 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 2012 – 2013

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.

	OAT -5°C and above	OAT less than -5°C to -10°C	OAT less than -10°C
Light Ice Pellets	50 minutes	30 minutes	30 minutes[1]
Moderate Ice Pellets	25 minutes[2]	10 minutes	10 minutes[1]
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[3]		
Light Ice Pellets Mixed with Moderate Rain	25 minutes[4]		
Light Ice Pellets Mixed with Light Snow	25 minutes	15 minutes	
Light Ice Pellets Mixed with Moderate Snow	10 minutes		

NOTES

1. 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).
2. Allowance time is 15 minutes for propylene glycol (PG) fluids, or when the fluid type is unknown.
3. No allowance times exist for this condition for temperatures below 0 °C; consider use of light ice pellets mixed with light freezing rain.
4. No allowance times exist in this condition for temperatures below 0 °C

Operations in Heavy Snow 2012-2013 (No Change from 2011-2012 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 § 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 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.